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PREVENTING OCCUPATIONAL HEARING LOSS
— A PRACTICAL GUIDE —

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FOREWORD

Since the publication of *A Practical Guide to Effective Hearing Conservation Programs in the Workplace* in 1990, many things have changed, while some have not. Things remaining the same include the Hearing Conservation Amendment to the OSHA Noise Standard. The NIOSH hierarchy of controls endures and can be summarized as: 1) first, prevent or contain the escape of the hazardous workplace agent at its source (engineering control); 2) control exposure by relocating the worker to a safe area (administrative controls); and 3) control the exposure with barriers between the worker and the hazard (personal protective equipment). This hierarchy underscores the principle that the best of all prevention strategies is to have no exposure to agents that can cause or contribute to hearing loss. Corporations that have embarked upon buy-quiet programs are moving towards the creation of a workplace where there will be no harmful noise. Many companies are automating equipment or setting up procedures that can be operated by workers from a quiet control room free from harmful noise, chemical agents, and heat. When it is not possible to remove the harmful agent or relocate the worker to a safe area, the worker must be protected. In the arena of hearing loss prevention, protection is a many-faceted process that includes exposure assessment, provision of protective equipment, assessment of hearing with appropriate management and follow-up actions, worker education and training, and continuous evaluation of program effectiveness.

Some things which should have changed have not. There are no requirements for recording threshold shifts due to noise exposure, nor is there a national occupational audiometry register. Without these data, it is not possible to effectively track and evaluate the successes and failures of occupational hearing loss prevention programs.

Use of the term *occupational hearing loss* reflects a change since 1990. No longer is noise considered to be the only source of hearing loss associated with work. Exposures to chemicals, such as aromatic solvents and metals such as lead, arsenic, and mercury can result in hearing loss. Combined exposures to noise and chemicals can cause more hearing loss than exposure to either agent alone. Vibration and extreme heat are also potentially harmful to hearing when combined with noise. To better respond to the potential hearing hazards and hearing loss risk many of today's workers face, an additional ingredient (Hearing Loss Prevention Program Audit) has been added to the recommended approach for preventing hearing loss.

The emphasis on *prevention* rather than *conservation* also reflects a change. The shift from conservation to prevention is not minor. Conserving hearing means to sustain the hearing that is present, regardless of whether it is impaired or not. Prevention means to avoid creating hearing loss. Conservation can start when one is first exposed to an occupational agent that is potentially harmful to hearing. Prevention starts long before the first exposure. Conservation comes from a program that is created and imposed. An emphasis on prevention evolves from beliefs that it is not necessary to suffer an impairment, illness, or injury to hold a job and that it is within one's own purview to employ techniques, use behaviors, and rely upon personal protective equipment to prevent impairment, illness, or injury.

Finally, there have been substantial changes since 1990 related to the recommended definition of hazardous noise (85 vs 90 dBA), the use of the equal-energy principle in integrating noise exposures, and the definition of standard threshold shift (STS). The combined result of such changes as these has been to stir the core tenets of hearing loss prevention. To keep step with the new directions in hearing loss prevention, it became apparent that the time had come to recast the "*Practical Guide*."

No guide such as this could be assembled solely by a group of scientists in an agency. So, just as with *A Practical Guide to Effective Hearing Conservation Programs in the Workplace*, this updated document was prepared by consulting experts in preventing occupational hearing loss. They reviewed the prepared materials, and made suggestions for changes, deletions, and additions. It is our hope that the ideas contained in this guide will provide the inspiration to others to promote actions needed to protect a vital human function — hearing.

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EXECUTIVE SUMMARY

Hearing loss is one of the most pervasive occupational health problems in America today. Approximately 30 million workers are exposed on their jobs to noise levels or toxicants that are potentially hazardous to their hearing. Fortunately, noise-induced hearing loss can be reduced, or often eliminated, through the successful application of occupational hearing loss prevention programs.

A successful hearing loss prevention program benefits both the company and the affected employee. Employees are spared disabling hearing impairments and evidence suggests that they may experience less fatigue and generally better health. Ultimately, the company benefits from reduced medical expenses and worker compensation costs. In some cases there may be improved morale and work efficiency.

The existence of a hearing loss prevention program (even one that complies with government standards) does not guarantee the prevention of occupational hearing loss. Experiences with successful hearing loss prevention programs show that management needs to develop and adhere to certain policies from the start. These policies cover the integration of the hearing loss prevention program into the company's safety and health program, designation of a key individual (a "program implementor") with ultimate responsibility for the overall conduct of the program, standard operating procedures for each phase of the program, the proper identification and use of outside services, and the purchase of appropriate equipment.

This guide, developed by those having long, varied experience in hearing conservation practices, presents some of the important attributes of successful hearing loss prevention programs. Concepts and action items are presented in terms of the responsibilities of three groups of personnel: those representing management, those who implement the hearing loss prevention programs, and those who are affected by exposure to noise or ototoxic chemicals. Checklists are provided in the appendices to assist in evaluating hearing loss prevention programs on a step-by-step basis.

As presented in the original edition of "The *Practical Guide*," the seven basic components of a hearing loss prevention program consist of: (1) noise exposure monitoring, (2) engineering and administrative controls, (3) audiometric evaluation, (4) use of hearing protection devices, (5) education and motivation, (6) record keeping, and (7) program evaluation. To these, we now add an eighth: hearing loss prevention program audit.

Hearing Loss Prevention Program Audit

Ideally, a carefully conducted audit should be performed before any program to prevent hearing loss is put into place, or before any changes in an existing program are made. The audit should be performed on the system as it exists or doesn't exist. While it is not difficult to conduct an audit, it may require time to assemble the materials necessary to fully answer audit questions. The

questions in Appendix B, Program Evaluation Check List, can serve well for an audit, although for an initial audit the check list should be reordered. It is best to perform the audit from the top down with administrative issues addressed first. Administrative issues concern corporate responses to regulations, to good safety and health practices, to the need to develop or modify program policies, to assuring adequate resources, and to providing the necessary authority to those persons responsible for the day-to-day operation of the program. Aspects of hearing assessment, implementation of engineering and administrative controls, and supervisor involvement in the program should be considered. The system for monitoring audiometry and record keeping requires close attention since how the records of audiometry and other aspects of the program are maintained can make or break the program. Employee and management education should be planned and past successes and failures should be addressed. When noise cannot be reduced to the point where it is no longer a hearing hazard, a program for providing, fitting, training in the use of, and maintaining hearing protectors must be established. The hearing loss prevention program audit should be revisited annually so that strengths of the program may be identified and weaknesses may be addressed.

Monitoring for Hearing Hazards

As with any health hazard, it is important to characterize the hazard accurately and to identify the affected employees. Management should define the specific goals of the sound survey and make sure that operating procedures, as well as resources, are available for collecting and evaluating measurements of ototraumatic exposures. Since noise is the most widespread ototraumatic agent, this section will focus on noise exposure monitoring. However, other agents known to effect the auditory system, or to interact with noise should also be monitored. In the case of ototoxic chemicals, analytical procedures that specify the collection media, sample volume and chemicals analysis can be found, for an extensive number of compounds, in the NIOSH Manual of Analytical Methods (1994). The results of the noise and other measurements must be reported to the hearing loss prevention program implementor and to the employees in an understandable format. Hearing loss prevention program implementors need to coordinate closely with production employees to make sure that the measurements represent typical production or processing cycles and that noise and toxicant levels are adequately sampled. The program implementor should see that those who make the measurements closely follow the policies and procedures established by management, that the report explains the results clearly, and that employees are apprised of the results. Employees have the responsibility of sharing their knowledge about the production environment, the machinery, and specific operations with those who measure the exposures.

Engineering and Administrative Controls

Ideally, the use of engineering controls should reduce ototraumatic exposure to the point where the hearing hazard is significantly reduced or eliminated. It is especially important for companies to specify low noise levels when purchasing new or refurbished systems and equipment.

Management needs to identify controllable exposure sources, set goals for their control, and

prioritize allocated resources to accomplish these goals. Managers should also explore potential administrative controls, such as scheduling that will minimize exposure to noise and other ototraumatic agents, and providing quiet, clean, and conveniently located lunch and break areas. Program implementors must ensure that communication channels are open between management, noise control personnel, and production workers. The workers, in turn, need to communicate their concerns to management and those in charge of engineering control, and must learn to work safely in their environment by taking full advantage of the available controls.

Audiometric Evaluation

Audiometric evaluation is crucial to the success of the hearing loss prevention program, since it is the only way to determine whether occupational hearing loss is being prevented. Management must allocate sufficient time and resources to the audiometric program to allow accurate testing; otherwise, the resulting audiograms will be useless. Management should also select audiometric technicians and professional consultants with demonstrated competence in relating to employees as well as in performing their duties in the audiometric program. The program implementor must monitor the audiometric program including scheduling, testing, equipment maintenance and calibration, audiogram review, feedback to the employee, and referral. Effective communication and coordination among company personnel, health services, and employees are of utmost importance. Employees need to disclose information about ear problems and prior noise or toxicant exposures, or problems encountered in taking the audiometric test. They also need to follow up on any recommendations for treatment or further medical or audiologic evaluation.

Personal Hearing Protection Devices

In the absence of feasible engineering or administrative controls, personal hearing protection devices (often referred to as hearing protectors) remain the only means of preventing hazardous noise levels from damaging one's hearing. Unless great care is taken in establishing a hearing protector program, employees will often receive very little benefit from these devices. Each employee can react differently to the use of such devices, and a successful program should respond to individual needs. The primary managerial responsibilities are: to facilitate the procurement of appropriate hearing protection devices, to demonstrate commitment to the program (e.g., by modeling the use of these devices in appropriate situations), to provide the personnel and facilities to train employees in the proper and optimum use and care of hearing protection devices, and to enforce the use of hearing protectors. Program implementors need to be knowledgeable in the details of hearing protector evaluation, selection, and use, and must be able to impart this information and enhanced daily use skills to employees. Implementors need to encourage employees to ask questions and must help them solve any problems that may arise. Program implementors also should perform periodic on-site checks of the condition and performance of hearing protectors including availability of replacement devices as well as component elements that tend to deteriorate with use (such as earmuff cushions).

Employees must take responsibility for being fully informed about the need for hearing protection, wearing their hearing protectors correctly at all times, seeking replacements as necessary,

encouraging co-workers to use these devices, and communicating problems to their supervisors.

Education and Motivation

Education and motivation sessions are valuable for both management and employees so they will understand that a successful hearing loss prevention program takes commitment, communication, and cooperation. Management should set a high priority on regularly scheduled training sessions, and select articulate, knowledgeable, and enthusiastic instructors. The program implementor, or those who present the sessions, need to make their presentations short, simple, and highly relevant to employees and management. They need to encourage questions and open communication, and they must make sure that all problems receive prompt attention. Employees must contribute to their own education by raising questions and concerns, and by informing program implementors when specific procedures are impractical, suggesting alternatives when possible. If hearing loss prevention program personnel fail to provide adequate consideration or follow-up, employees should communicate their concerns to higher levels of management.

Record Keeping

Effective record keeping requires a committed and consistent approach. Each element of the hearing loss prevention program generates its own type of record (e.g., noise survey forms, audiograms, and medical histories), and much of this information needs to be integrated into the employee's health record. Historical record keeping is vital because injuries to hearing due to over exposures are rarely as evident as other types of occupational events; i.e., noise-induced hearing loss takes place very slowly over time. Therefore, complete documentation becomes vitally important when evaluators attempt to construct longitudinal records that pertain to an individual’s long-term exposures to noise and effectiveness questions concerning prevention and control measures.

Management's responsibility is to provide adequate resources for efficient record processing, review, and storage in addition to training program implementors and procuring outside services if necessary. Management must ensure that confidentiality of personal data is maintained, that hearing loss prevention program records are available to program implementors and government inspectors, and that each employee has access to his or her own files. Program implementors must see that the information entered into the records is accurate, legible, complete, and self-explanatory. They also should ensure that records are standardized, cross-referenced, and properly maintained. Employees should take advantage of the record keeping system by inquiring about their hearing status, especially at the time of the annual audiogram.

Program Evaluation

A thorough evaluation of all the hearing loss prevention program's components is necessary to determine the extent to which the hearing loss prevention program is really working, or if there are problems, which elements or departments need improvement. There are two basic approaches: (1) to assess the completeness and quality of the program's components, and (2) to

evaluate the audiometric data. The first approach may use checklists, such as those found in Appendices A and B, and the second consists of evaluating the results of audiometric tests, both for individuals and for groups of employees exposed to hearing hazards. Management should dedicate resources for hearing loss prevention program evaluation (i.e., trained individuals and computer facilities). In addition, managers must be willing to acknowledge and solve problems that arise. If program implementors are not knowledgeable in the mechanics of database analysis, the company should obtain training for the implementor or hire someone with these skills. Program implementors must also be committed to seeking out elusive information, and interacting with all members of the hearing loss prevention program team to identify and correct any deficiencies. As with many other aspects of the hearing loss prevention program, the employee's responsibility with respect to program evaluation is to provide feedback on the program's merits or shortcomings to the program implementor and management and to participate in the implementation of the improvements.

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INTRODUCTION

Occupational hearing loss is one of the most pervasive problems in today's occupational environment, affecting workers in manufacturing, construction, transportation, agriculture, and the military. Based on a NIOSH survey in the 1980s on exposed workers in all economic sectors and on the 1992 *Statistical Abstracts of the United States* accounting of production workers, it is thought that there are approximately 30 million American workers are exposed to hazardous noise levels alone or in combination with other ototraumatic agents that are potentially hazardous to their hearing. At present exposure limits, one in four will develop a permanent hearing loss as a result of their occupational exposure to these hazards. The gradual progression of hearing loss due to noise may be less dramatic than an injury resulting from a workplace accident, but it is a significant and permanent handicap for the affected individual. Loss of hearing denies people sensory experiences that contribute to the quality of their lives. For some, loss of hearing may impede their ability to be gainfully employed. This tragedy ***is*** preventable.

Through comprehensive and coordinated efforts on the part of managers, interested employees, and safety and health professionals, much has been learned over the last few decades about implementing hearing loss prevention programs. A good hearing loss prevention program has historically consisted of at least seven identifiable elements: monitoring hearing hazards, engineering and administrative controls, audiometric evaluation, personal hearing protective devices, education and motivation, record keeping, and program evaluation. To these seven elements, an eighth has been added that recognizes the need for a Hearing Loss Prevention Program Audit process. This is not a new process; it has typically been blended within the other program elements. Given all of the program elements that are essential to preventing hearing loss, adding an element that specifically addresses the program appraisal process seems warranted. This document summarizes the procedures involved in implementing these eight elements. They will be examined from the perspective of management, program implementors, and affected employees. The responsibilities of each category of participants will be outlined. The management category includes all of those in the position of generating or enforcing policy and authorizing the allocation of resources. Program implementors are those who are charged by management to make the hearing loss prevention program elements work, and the employees' category includes all persons who are exposed to hazardous levels of occupational noise and other ototraumatic agents.

The program is usually implemented by a team, whose composition and size tend to be related to the size of the company and the number of employees exposed to hearing hazards. Members of the team may include any or all of the following: physician, nurse, audiologist, industrial hygienist, company and/or union safety representative, hearing conservation technician, acoustical engineer, and the employee representative. The most important team members are the employees. While employees usually don’t fund the hearing loss prevention program, decide its policies, or oversee its day-to-day operation, they are absolutely key to the success of the program. When employees know that they are full members of the hearing loss prevention program team and they are the

keys to its success, they will usually work hard to see that all aspects of the program under their control are implemented. When employees feel that the program is being forced upon them, especially without their personal involvement and participation, they often react negatively and may work to circumvent the program.

It has become clear over recent years that the level of commitment displayed by management is directly related to the overall effectiveness of the hearing loss prevention program. A strong commitment to a hearing loss prevention program can be shown by following these policies:

- Strive for excellence in the program rather than just meeting minimal requirements.
- Ensure management and supervisors support hearing loss prevention goals and actively contribute to a safety climate that encourages and enables employees to engage in good hearing-health practices.
- Integrate the program into the overall company safety and health program.
- Educate and motivate employees, so that hearing loss prevention practices become an integral part of their behavior on and off the job.
- Designate a key person to serve as implementor/coordinator of the program.
- Strive for simplification and continuity of the program's operating procedures.
- Involve the employees in the process of developing and implementing hearing loss prevention programs.
- Establish quality assurance practices to make sure that all information used in the program is accurate and current.
- Review the program's effectiveness no less than annually and make modifications when needed.

The nature and scope of the hearing loss prevention program recommended in this text go beyond the minimal requirements of federal and state regulations. The objective here is not to reiterate regulatory requirements, although we urge all readers to become thoroughly familiar with the noise standards and regulations for compliance purposes. Instead, the objective is to convey some of the characteristics of a good hearing loss prevention program that are not necessarily found in regulations, and yet which contribute substantially to the program's success. However, to facilitate compliance with Federal regulations for occupational noise exposure, we have included an *OSHA Noise Standard Compliance Checklist* as Appendix A, and we have listed the pertinent provisions of the OSHA standard at the end of each section. In addition, for those who wish to pursue certain areas further, we have listed suggested readings at the end of each section, many of which can also be found in the expanded list of suggested readings in Appendix D. The reader's attention

should also be directed to: the checklist in Appendix B, which should be helpful in evaluating hearing loss prevention programs that are already in place; Appendix C, which gives a listing of audiovisual materials; and Appendix E, which lists resources in both government and the private sector for those who need further assistance.

As the title states, this is *a practical guide*, intended to assist employers and employees to develop and maintain hearing loss prevention programs that actually work, and are not just perfunctory measures. This guide is not meant to be technical in nature. The reader will find few formal citations to the scientific literature – only suggested readings at the end of each section. Support for the statements and recommendations made in the text are available in the scientific literature. The interested reader may pursue these concepts further in the suggested readings.

VALUE OF A GOOD HEARING LOSS PREVENTION PROGRAM

When a company has an effective hearing loss prevention program, everyone wins–the employers, the employees, and the safety and health professionals who implement the program. This guidebook is not about minimal programs that meet only the letter of the law. It is concerned with programs that are effective as well as efficient: those optimizing program elements that succeed in preventing hearing loss in a practical and cost-effective manner.

Employer Benefits

Hearing loss prevention programs are the law in that they are required by federal and state occupational safety and health agencies. Companies that do not comply with appropriate regulations are liable for citations and fines. Most employee compensation insurance carriers also advocate hearing loss prevention programs, and companies that do not protect their employees from hearing loss may find their premiums increasing. Aside from the legal and economic factors, conscientious employers will want to protect their employees from an unnecessary loss of hearing. Today, there is no reason why hearing impairment needs to be the outcome of a noisy job.

A good hearing loss prevention program is good business. It promotes good labor relations because employees know that management is concerned, and this type of concern may translate to improved productivity and product quality. Indeed, noise itself can have an adverse effect on productivity. For complex jobs and those requiring concentration, studies show that greater efficiency is linked to lower noise levels. Also, the ease and accuracy of communication is improved as noise levels are lowered. These benefits should prove to be cost-effective for management. Additionally, the conservation of hearing leads to the conservation of valuable employee resources. Studies of noisy companies that have implemented hearing loss prevention programs show reductions in accident rates, illnesses, and lost time. Versatility, adaptability, and promotability of employees are likely to be maintained when employees retain good hearing. Finally, morale may also benefit, which should lead to greater employee satisfaction and retention.

When the Occupational Safety and Health Administration's (OSHA) Hearing Conservation Amendment became effective in 1983, some employers were concerned about the possibility of a flood of claims for occupational hearing loss. However, no such flood has occurred, at least on a national scale. Of course, employers who take the appropriate preventive action now will greatly reduce the risk of future claims.

As with other effective health and safety measures, hearing loss prevention programs should also extend beyond the workplace. The company that encourages employees to take their earplugs home to wear during woodworking, target practice, or other noisy off-job activities is reducing the possibility of spurious work related claims, as well as educating the employees to the need for hearing loss prevention in recreational settings.

Finally, the company that places a high value on safety and health maintenance should evaluate the performance of managers responsible for hearing loss prevention programs and reward those whose programs succeed in preventing hearing loss. An effective hearing loss prevention program costs money to implement, but the necessary investment will produce a beneficial return.

Employee Benefits

The hearing loss prevention program's most obvious benefit to employees is that it saves their hearing and ability to communicate. Because occupational hearing loss creeps up slowly, many individuals are unaware of their impairment until it is too late. Moreover, occupational hearing loss represents permanent damage, i.e., it cannot be restored through medical/surgical treatment. A good hearing loss prevention program, however, can identify minor changes in hearing, and prevent deterioration to the point where it is permanent. Employees who have labored for 35 or 40 years deserve to enjoy their retirement; they should be able to socialize with family and friends, and listen to music and the sounds of nature. Hearing loss due to noise appears during the first five to ten years of exposure, so young workers are at most risk of noise-induced hearing loss. Preventing hearing loss for them benefits employees all through life, not just in retirement, since the ability to communicate is critical in all of our interpersonal relationships. When good hearing is a prerequisite for a job, an effective hearing loss prevention program will enable employees to sustain their hearing ability and thus continue to qualify for jobs (perhaps higher level) that have such requirements.

An additional benefit of an occupational hearing loss prevention program is that it can detect hearing loss that may be due to causes other than workplace noise exposure. Some individuals may suffer hearing loss due to impacted earwax, an ear infection, or possibly a more serious disease. Audiometric tests can help identify these non-noise related problems, and employees can be referred for the necessary medical attention. Therefore, prevention programs promote and contribute to concepts of overall hearing health as part of health-maintenance programs.

Another benefit reported by employees in companies with effective hearing loss prevention programs is that they generally feel better; less tired and irritable. They sometimes report that they sleep better at night, and they are no longer bothered by temporary reductions in hearing ability at the end of the day, or by the tinnitus (ringing in the ears) that often accompanies the development of noise-induced hearing loss. There is also evidence that long term noise exposure may contribute to stress-related disease, especially cardiovascular disease. By reducing noise, the chances of other health impairments are consequently controlled and reduced.

Noise reduction and maintenance of hearing sensitivity can benefit safety because employees are better able to communicate, and to hear alarms and warning shouts. Good hearing is essential for more subtle warning signals, such as a malfunctioning machine or the sounds of "roof-talk" in underground mines.

In summary, a good hearing loss prevention program is consistent with good health and good business. At a minimum, employees benefit with good hearing. Reductions in noise exposure may

also result in less fatigue and irritation, and possibly fewer stress-related health complaints. The company benefits from reduced worker compensation payments and medical expenses, and a reduced likelihood of an OSHA citation for hearing conservation violations. Reduced noise exposures also can be associated with improved employee morale, and, in some cases, higher production efficiency.

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POLICY NEEDS

Company policies relating to the hearing loss prevention program should be carefully planned and executed to benefit the affected employee and the employer. Experiences with successful hearing loss prevention programs show certain policy areas that management needs to address at the beginning:

1. Corporate environment should promote a safety culture where the employees are empowered to protect their own health and to facilitate the protection of the health of fellow workers.

2. Program policies should be based on effective practices rather than on minimum compliance with government regulations.

3. The hearing loss prevention program must be a functional part of the overall company safety and health program. It should not be a stand-alone, separately-budgeted operation.

4. A key individual (referred to as the program implementor for the rest of this guide) should have ultimate responsibility for the program. This person may not necessarily perform all of the functions of the hearing loss prevention program, but is in charge of the overall program. Experience with successful hearing loss prevention programs shows that a single individual often makes the crucial difference between success and failure. This person is often a nurse or an audiometric technician, but may be a safety and health officer, a supervisor, or a designated employee. This program implementor acts as the *conscience* and *champion* of the hearing loss prevention program. He or she focuses the attention of both management and employees on the hearing loss prevention program's policies and ensures that they take the necessary steps to implement them. The program implementor should also have stature in the hearing loss prevention program's organizational chart, with authority to make decisions, correct deficiencies, and enforce necessary actions.

5. The program implementor should work with management and employees to develop and implement hearing loss prevention plans and policies for an effective program. As a team leader, the program implementor should be given the authority to establish hearing loss prevention provisions that meet or exceed the letter and intent of OSHA’s noise control and hearing conservation regulations.

6. Employee and administrative compliance with the company's hearing loss prevention program policies and procedures should be a condition of employment.

7. Hearing loss prevention program policies should clearly describe standard operating procedures for each phase of the program. Specific policy statements should be

developed for the important elements of the program. For example, it should be company policy to require the participation of all noise-exposed employees in the audiometric program and to require the consistent and proper wearing of hearing protectors in posted areas, even if employees or supervisors are only passing through these areas. These requirements should be conditions of employment. Other important policy statements should be written to cover:

a. Adopting a prescribed schedule for monitoring of employee noise exposure levels and other risks, including ensuring that equipment and personnel training are appropriate to the task.

b. Counseling of employees immediately following each audiometric test, whether it is the initial, annual, retest, threshold-shift confirmation, or termination examination.

c. Determining the adequacy and correct use of hearing protection devices by on-site equipment checks.

d. Educating, training, and motivating employees to support the company's hearing loss prevention program provisions; assessing employee attitudes and assessing knowledge gained from periodic training.

e. Establishing a program of quality assurance for the performance of audiometry and management of audiometric records.

f. Reviewing audiometric data to verify the effectiveness of the hearing loss prevention program.

g. Encouraging employees to use company-provided hearing protectors for off-the-job exposure.

h. Purchasing hearing protectors, audiometers, noise measuring equipment, and quieter machinery. This policy should address the reasons why the program implementor responsible for the hearing loss prevention program, not the purchasing department, should have final decision about anticipated purchases.

8. Companies may have varying needs for services which they cannot undertake with in-house staff. These can include noise surveys, employee education, audiometric testing, medical counseling, or the fitting of hearing protection devices. Outside vendors or contractors should be selected carefully so their services complement the abilities of the company staff and functional conduct of the in-house program elements. Vendors must understand and agree to abide by the company's hearing loss prevention program policies and standards of operation. On-site personnel must supervise contractors to make sure that they carry out their obligations. Regardless of whether outside vendors or

contractors are used, responsibility for the program stays with the program implementor.

Companies that issue clearly defined hearing loss prevention policies, and then adhere to these policies consistently, will have smoothly running hearing loss prevention programs. Employees will be fully informed, will comprehend their functional role, and will know what is expected of them. Equipment will be appropriate, hearing protection will be used by the right people in the right places, and the program elements will be implemented in a timely fashion.

Further Reading

Royster LH, Royster JD [1991]. Hearing conservation programs. In: Harris CM, ed. Handbook of Acoustical Measurements and Noise Control. 3rd ed. New York: McGraw-Hill, Inc., Chapter 27.

Stewart AP [1988]. The comprehensive hearing conservation program. In: Lipscomb DM, ed. Hearing Conservation in Industry, Schools, and the Military. Boston, MA: Little, Brown and Co, Chapter 12.

HEARING LOSS PREVENTION PROGRAM AUDIT

Preventing occupational hearing loss is a complex matter, but it is often entered into without first assessing the assets available, the assets required, and the expected outcome of the program. Before any program to prevent hearing loss is put into place, or before any changes in an existing program are made, an audit should be performed on the system as it exists. Many companies decline to perform an audit because they either can't conceive of a need for it or don't recognize its value as the foundation of a successful program. A hearing loss prevention program audit should be considered as important to the outcome of the program as is a business plan to the success of the company.

While it is not difficult to conduct an audit, it may require time to assemble the materials necessary to fully answer audit questions. Thus, the audit is often best done in phases. The first phase should address whether or not the information needed to answer various questions is available. Then, after materials to support answers are available, the questions of the audit should be answered. There is no standard form available for a hearing loss prevention program audit, but the questions in Appendix B, Program Evaluation Check List, can serve well.

It is best to perform the audit from the top down, with administrative issues addressed first. In the United States, occupational safety and health programs historically have been driven by regulations. Thus, it is important to assure that the regulations for hearing loss prevention programs are being addressed by the program. At the same time, there needs to be a corporate recognition that addressing only regulatory issues will not create an effective program. Good safety and health practices need to be followed. The company policy must be developed and all who administer or participate in the program must be aware of the policies. Decisions need to be made as to who is responsible for providing facilities and materials for the hearing loss prevention program. Decisions also need to be made about who the program implementer or key person will be and guidelines for evaluating the effectiveness of that person need to be established. The role of supervisors in the program should be established. If front-line supervisors have a role, the role must be defined and procedures to notify supervisors and train them in their role should be established.

Hazard assessments should be addressed during the audit. The audit should determine if appropriate measurements have been taken. Methods should be developed to evaluate the results of hazard measurement. Who will notify employees and how they will be notified of the results of hazard measurement should be determined. It is important to identify the critical measurements that need to be taken and how often they should be repeated. A system should be developed to ensure that the results of hazard assessment are included in the affected employees' health records and into shop folders. The program implementor should also be aware of the assessment results.

Since the most effective means of preventing occupational hearing loss is to remove or control the hearing hazards, engineering and administrative controls should be evaluated heavily during the

audit. Hazard control priorities should be established. In the long run, addressing control matters in order of the level of hazard present will, over time, remove the hazards from the workplace. The cost-effectiveness of engineering and administrative controls must be considered in the audit. While it may not be feasible to control all of the hazards at once, it may be feasible to resolve one or two situations per year until all have been addressed. Most companies will not have hazard control expertise in house and will have to rely upon outside consultants and contractors. Provisions for the use of outside experts must be included in the audit.

Monitoring audiometry and related record keeping are critical parts of the hearing loss prevention program. Often, many companies assume that this is the simplest part of the program, and they are wrong. The training and experience of the supervisor of the audiometric testing program (this should be an audiologist or a physician) are important. It may be more efficient to contract out for the testing and record keeping services, but it will be necessary for the company's program implementor to be well versed in this aspect of the hearing loss prevention program regardless of who conducts the testing. Among matters to be considered for an internally or externally managed company are quality of the audiograms, access to prior audiograms by persons performing hearing testing, training and certification of audiometric technicians, adequacy of the testing environment, methods for determining changes in hearing status, communication of test results to employees, and follow-up procedures for those employees showing shifts in hearing.

Regular testing of employees' hearing is the most effective means of ascertaining that hearing loss is being prevented. But, there will be employees whose hearing does change for the worse. It may become necessary to refer these employees for further testing and evaluation. The audit should address no less than the following: clear referral policies; agreement between the company and consulting audiologists or physicians as to the expectations from a referral; establishment of mechanisms to ensure that employees needing evaluation or treatment actually receive the service; timely and accurate transmission of records between the company and the consulting audiologist or physician; and guidelines for providing evaluation and treatment for hearing loss or ear disease determined to be not related to hazard exposure at work.

Those employees exposed to hazardous noise will need to use hearing protectors. While seemingly simple, this can become a complicated aspect of the hearing loss prevention program. The audit should address the criteria for determining whether or not the use of hearing protectors is required. Types of hearing protection and sources should be addressed and if not implemented in a policy, the person(s) responsible for making the decisions should be identified. Hearing protectors need maintenance and replacement and how that is to be achieved should be a topic of the audit. The audit should also consider what to do about the employee who continues to show increasing hearing loss even though using hearing protection. Lastly, the audit should address the employee who refuses to use hearing protection when it is required or who wishes to use self-provided protection.

An effective hearing loss prevention program ensures that employees and management receive training and educational experiences. The audit should address the frequency of the training, how the training is provided, and what the training emphasis will be. For example, training may be

spaced over the year with some of it given by an instructor, some by reading materials, some by video tape or interactive computer program, and some by the audiometric technician at the time of the hearing test. The audit will help the company determine the resources needed for training, identifying those easily accessible and those that must be acquired.

Plans should be made in advance to evaluate the effectiveness of the hearing loss prevention program. Many companies find that after a couple of years of operating a program they have no idea if their efforts are having any effect. The audit should define what metrics will be used to determine if the program is successful or not. Once the metrics have been selected, the program implementor must make sure that all data collected support the evaluation strategy selected.

The hearing loss prevention program audit should be reviewed annually by the program implementor and appropriate managerial personnel. As the program grows and evolves, the audit will provide a mechanism to force into review all aspect of the program. By using the audit, it will be unlikely that any portion of the program will run ineffectively or incorrectly, since problems should be identified so that they may be remediated immediately.

Further Reading

Gasaway DC [1985]. Evaluating and fine-tuning the elements that comprise a program. In: Gasaway DC. Hearing Conservation: A Practical Manual and Guide. Englewood Cliffs, N.J.: Prentice Hall, Inc., Chapter 15.

MONITORING HEARING HAZARDS

As with any health hazard, it is of utmost importance to accurately determine the nature of the hearing hazard and to identify the affected employees. Those responsible for this aspect of the program must ensure that the exposures of all employees have been properly evaluated and that reevaluations are conducted when changes in equipment or operations significantly alter working conditions. Readers are encouraged to consult items no. 1-11, 49, and 56 in Appendix A to ensure compliance with the noise monitoring requirements in the OSHA standard. Also, the checklist entitled *Noise Measurement* in Appendix B should be helpful in designing and evaluating a noise monitoring program.

Recent evidence has indicated that aromatic solvents, metals, and petrochemicals may be associated with occupational hearing loss. Although studies are exploring the relationship between hearing loss and chemical exposures, there is insufficient information about this relationship to speculate on potential risk factors. Therefore, this section will focus on monitoring noise exposure, certainly the major factor associated with occupational hearing losses.

Hearing hazard exposure monitoring is conducted for various purposes including:

1. To determine whether hazards to hearing exist.

2. To determine whether noise presents a safety hazard by interfering with speech communication or the recognition of audible warning signals.

3. To identify employees for inclusion in the hearing loss prevention program.

4. To classify employees' noise exposures for prioritizing noise control efforts and defining and establishing hearing protection practices.

5. To evaluate specific noise sources for noise control purposes.

6. To evaluate the success of noise control efforts.

Various kinds of instrumentation and measurement methods may be used, depending on the type of measurements being conducted. The most common measurements are area surveys, dosimetry, and engineering surveys.

In an area survey, environmental noise levels are measured, using a sound level meter to identify work areas where employees' exposures are above or below hazardous levels, and where more thorough exposure monitoring may be needed. The result is often plotted in the form of a "noise map," showing noise level measurements for the different areas of the workplace.

Dosimetry involves the use of body-worn instruments (dosimeters) to monitor an employee's noise exposure over the work-shift. Monitoring results for one employee can also represent the exposures of other workers in the area whose noise exposures are similar. It may also be possible to use task-based exposure methods to represent the exposures of other workers in different areas whose exposures result from having performed the same task(s).

Engineering surveys typically employ more sophisticated acoustical equipment in addition to sound level meters. These may include octave-band analyzers and sound level recorders which furnish information on the frequency/intensity composition of the noise being emitted by machinery or other sound sources in various modes of operation. These measurements are used to assess options for applying engineering controls.

Management Responsibilities

Management must decide whether to contract with an external service provider or to purchase the necessary equipment and have the on-site staff trained to perform the sound survey. Because sound surveys should be performed periodically, it may be cost-effective to develop in-house expertise with the ability to schedule sound level checks (i.e., annually, whenever production machinery is added or changed, or when work processes are changed and have the potential for affecting noise levels).

Management should make sure that the individuals who monitor the noise are properly qualified to perform noise measurements, whether in-house personnel or contractors. A certified industrial hygienist can conduct most noise monitoring activities, although audiologists or technicians can do so if they have the necessary training and experience. Sound surveys for the purpose of selecting or evaluating engineering controls should involve an acoustical engineer.

This woman is measuring noise levels in a work area. She will also measure exposure levels by placing the microphone in the hearing zone of the workers.

A noise dosimeter measures and stores sound energy over time. It can be worn in the pocket, as shown, or attached to the belt. The microphone is positioned on the shoulder in the hearing zone of the wearer. The wearer goes about a normal work shift while wearing the dosimeter.

Management should also ensure that operating procedures for conducting and evaluating noise measurements are available, well defined, carefully documented, and closely followed. These procedures should specify the scheduling of surveys, the type of measurements to be made, instrument calibration procedures, sampling criteria, methods for recording data, and procedures for reporting results. Management can also support the monitoring process by ensuring personnel who are familiar with equipment and operations are available to assist in characterizing the samples as representative of "normal" operations.

Results of the noise measurements must be reported to the program implementor and to employees in an understandable, uniform format. Results of area measurements or noise exposure dosimetry should be placed in each employee's hearing loss prevention record. In addition, a summary of the survey results should be presented during education programs for management and employees.

Maintenance of noise control systems is critical to their success. If a drive unit is fitted with an enclosure to reduce the noise radiated into the immediate area, the enclosure will be effective only as long as it is kept closed and its seals are in good condition. Most seals deteriorate over time and need replacement. If bad seals are left in place, much of the noise reduction will be lost. The same applies to a belt driven system because the noise level will increase as the belts wear. Maintenance of the belts should be maintained so that the noise levels stay as low as possible. A punch press that is isolated from the floor by vibration dampers will become a contributor to the plant noise as the dampers compress with age. A schedule should be established for replacing such dampers.

Program Implementor Responsibilities

The program implementer should be involved with the sound survey activities from the planning stages to the completion of the survey. During the planning stage, the program implementer should coordinate activities between management and the sound surveyors with respect to agreeing upon the fundamental strategies to be used in conducting the sound surveys. The implementor should work closely with management to address the reason(s) for obtaining the measurements, such as: to define hazardous noise areas, to identify employees to be included in a hearing loss prevention program, or to evaluate specific machinery for noise control purposes. To ensure the noise measurement program answers relevant questions, implementors must have an awareness of the major factors that will influence the noise exposure monitoring results. For example, will area sampling, personnel sampling, or a combination of both be employed? What types of measurement equipment will be beneficial in characterizing the noise environment? Which areas or machines will be evaluated? Which workers and/or how many workers will need to be monitored? Will full shift or partial shifts be studied? Who will ensure measurements are made with equipment that has been suitably calibrated and that there is a suitable record of the calibration? What parameters will be used in obtaining measurements (e.g., exchange rate, weighting, dynamic range, criterion levels, and threshold levels, etc.) How will "borderline" results be handled?

The implementor should be actively involved in overseeing survey activities. In most cases, it will be important that noise measurements be representative of typical production cycles. Hence, the implementor should ensure the work processes are appropriately surveyed.

It is important that noise measurements are representative of typical production cycles. Hence, noise surveys should ensure adequate sampling of all work processes. When dosimetry is performed, make sure that employees wearing dosimeters are engaged in typical activities. Because employee cooperation and know-how is needed to obtain valid results, sound surveyors (those who measure the noise) must establish rapport with employees to benefit from their familiarity with the work environment and production process. By explaining the purpose of the measurements to employees and soliciting their help, surveyors can avoid errors, oversights, and possible mishandling of noise dosimeters by employees. Employees need to understand that realistic noise measurements are essential to plan noise control efforts and select appropriate hearing protection devices, and that they are helping themselves by helping the surveyors.

Program implementors must ensure that sound surveyors consistently follow the policies and procedures established by management with regard to the selection, maintenance, and calibration of instruments, measurement techniques, data analysis, and reporting. A good rule of thumb is to make the procedural description detailed enough so another person could reproduce the results. Comprehensive sound surveys may require additional instrumentation and greater detail than is necessary for basic surveys.

The report must present the results clearly. Results lead to recommendations, which are transformed into actions. The emphasis of the report may vary depending on the purpose of the survey (for example, OSHA compliance, documentation for worker compensation, or internal company hearing loss prevention program decision), so the writer should state the objectives and present the data relevant to these objectives. Because few report users will need or read every detail of the survey, it is critical to write a concise abstract for higher level management. A slightly longer summary should also be included for employees in the hearing loss prevention program. The body of the report should explain the calibration and measurement procedures, as well as the results, and detailed documentation (including the original data sheets) must be kept with the report in case it is needed for research, inspection by government representatives, or legal purposes.

A summary of the results of the survey should be available in the shop area hazards folder or in another convenient location. Copies of the noise maps should be readily available to the program implementor. The noise maps should be explained to the employees during their educational programs and posted for reference. Dosimeter wearers should be given the readings from the dosimeter they wore along with a short explanation of what the readings mean. If an area is labeled as requiring the use of hearing protection for all who enter, warning signs should be posted and appropriate hearing protectors should be available near the perimeter of the restricted area. Likewise, if a survey documents that a specific piece of equipment produces a hearing hazard, personal protection devices should be available both to those who operate the equipment as well as to those who may have to work in the immediate vicinity of the equipment.

Employee Responsibilities

Employees should assist those who make the measurements by sharing their knowledge about the work environment, the machinery in operation, and specific jobs. Employee assistance is especially critical to the success of engineering noise surveys where sound sources within a work process or a piece of equipment need to be evaluated, and only the employee knows the proper operation of the equipment. Employees also need to cooperate by maintaining their normal work routine when asked to wear dosimeters, so that the results will be representative of their actual exposures.

Sound levels often increase when equipment begins to wear or fails to receive appropriate maintenance. Also, changes in equipment placement may cause unintended effects on sound levels. When employees notice such changes, they need to inform the supervisory personnel or the program implementor that a change has occurred. A re-survey will be needed to evaluate the new sound levels and employee exposures whenever equipment or production changes occur.

OSHA Requirements

Code of Federal Regulations, Title 29, Chapter XVII, Part 1910, Subpart G, 1910.95: sections (a), (b), (c), (d), (e), (f), Appendix A, and Appendix G.

See checklist in Appendix A of this guidebook, items no. 1-11, 50, and 56.
See checklist in Appendix B of this guidebook, section entitled "Noise Measurement."

Further Reading

Earshen JJ [1986] Sound measurement: Instrumentation and noise descriptors. In: Berger EH, . Ward WD, Morrill JC, Royster LH eds. Noise and Hearing Conservation Manual 4th ed. Akron, OH: American Industrial Hygiene Assoc. Chapter 3.

Harris CM ed. [1991] Handbook of Acoustical Measurements and Noise Control 3rd ed. New York: McGraw-Hill, Inc.

Royster LH, Berger EH, Royster JD [1986]. Noise surveys and data analysis. In: Berger EH, Ward WD, Morrill JC, Royster LH, eds. Noise and Hearing Conservation Manual 4th ed. Akron, OH: American Industrial Hygiene Assoc. Chapter 4.

ENGINEERING AND ADMINISTRATIVE CONTROLS

Engineering and administrative controls are essential to achieve an effective hearing loss prevention program. Engineering and administrative controls represent the first two echelons in the NIOSH Hierarchy of Controls: 1) remove the hazard, 2) remove the worker. The use of these controls should reduce hazardous exposure to the point where the risk to hearing is eliminated or at least more manageable. Engineering controls are technologically feasible for most noise sources but their economic feasibility must be determined on a case-by-case basis. In some instances the application of a relatively simple noise control solution reduces the hazard to the extent that the other elements of the program, such as audiometric testing and the use of hearing protection devices, are no longer necessary. In other cases, the noise reduction process may be more complex, and must be accomplished in stages over a period of time. Even so, with each reduction of a few decibels, the hazard to hearing is reduced, communication is improved, and noise-related annoyance is reduced as well.

It is especially important that companies specify low noise levels when purchasing new equipment. Many types of previously noisy equipment are now available in noise-controlled versions, so a "buy quiet" purchase policy should not require new engineering solutions in many cases.

A summary of OSHA's requirements for engineering and administrative controls can be found in items no. 1-3 of Appendix A in this guidebook. Readers may obtain some practical guidance in the section entitled "Engineering and Administrative Controls" of Appendix B.

For hearing loss prevention purposes, engineering controls are defined as any modification or replacement of equipment, or related physical change at the noise source or along the transmission path (with the exception of hearing protectors) that reduces the noise level at the employee's ear.

Typical engineering controls involve:

1. Reducing noise at the source.
2. Interrupting the noise path.
3. Reducing reverberation.
4. Reducing structure-borne vibration.

Common examples of the implementation of such controls are:

1. Installing a muffler.
2. Erecting acoustical enclosures and barriers.
3. Installing sound absorbing material.
4. Installing vibration mounts and providing proper lubrication.

Assessing the applicability of engineering controls is a sophisticated process. First, the noise problem must be thoroughly defined. This necessitates measuring the noise levels and developing

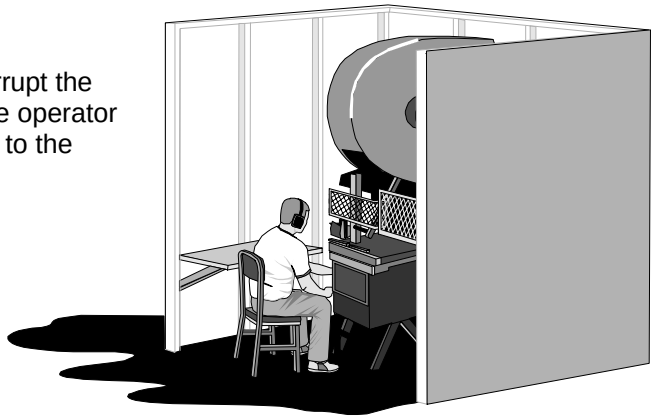
complete information on employee noise exposure and the need for noise reduction. Next, an approach to engineering control must be developed, requiring the identification of individual noise sources and an assessment of their contributions to the overall noise levels. Once identified and analyzed, the above controls can be considered. Those chosen will be influenced, to some extent, by the cost of purchasing, operating, servicing, and maintaining the control. For this reason, engineering, safety, and industrial hygiene personnel, as well as employees who operate, service, and maintain equipment, must be involved in the noise-control plan. Employees who work with the equipment on a daily basis will be able to provide valuable guidance on such important matters as the positioning of monitoring indicators and panels, lubrication and servicing points, control switches, and the proper location of access doors for operation and maintenance. It also may be desirable to obtain the services of an acoustical consultant to assist in the design, implementation, installation, and evaluation of these controls.

In the design and installation of engineering noise controls, ergonomics must be considered along with optimal work efficiency. For example, work posture (sitting, standing, bending) as well as existing environmental factors (lighting, heating, and cooling) must be considered. This is especially true with employee enclosures or booths. Lighting, heating, and cooling must ensure comfort and be sufficient to prevent reduction in efficiency and work quality. Enclosures should be of adequate size and have enough window area to prevent claustrophobia. Windows should be positioned carefully to enhance proper usage by employees, and the glass may need to be tilted to prevent glare. In situations where employees will be working on or around equipment fitted with engineering controls, it is important to explain to everyone involved why the controls should not be modified, removed, or otherwise defeated.

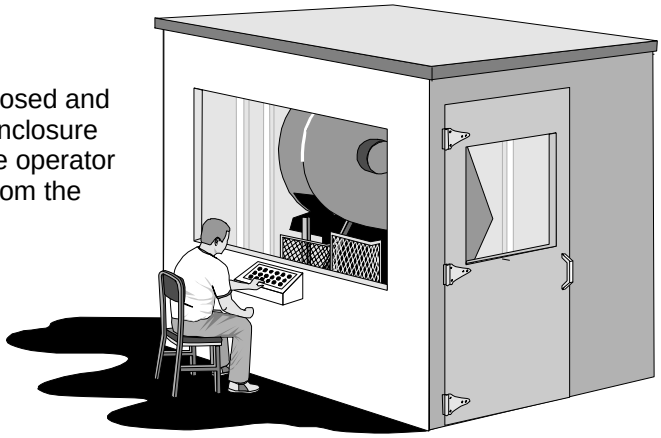
Administrative controls, defined as changes in the work schedule or operations which reduce noise exposure, may also be used effectively. Examples include operating a noisy machine on the second or third shift when fewer people are exposed, or shifting an employee to a less noisy job once a hazardous daily noise dose has been reached. Generally, administrative controls have limited use in industry because employee contracts seldom permit shifting from one job to another. Moreover, the practice of rotating employees between quiet and noisy jobs, although it may reduce the risk of substantial hearing loss in a few workers, may actually increase the risk of small hearing losses in many workers.

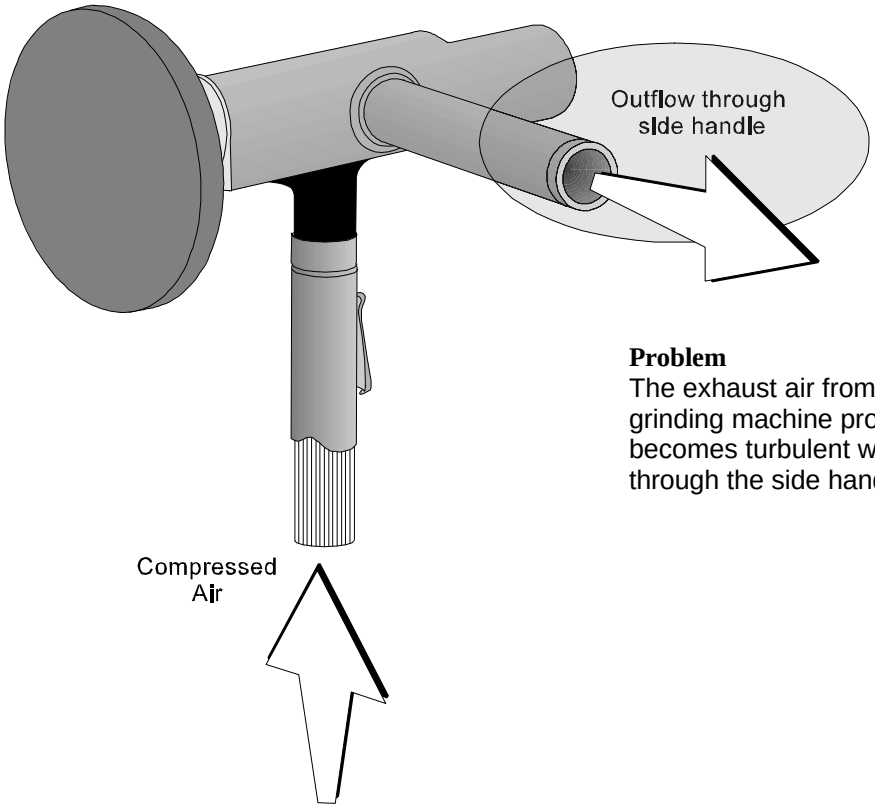
A more practical administrative control is to provide for quiet areas where employees can gain relief from workplace noise. Areas used for work-breaks and lunch rooms should be located away from noise. If these areas must be near the production line, they should be acoustically treated to minimize background noise levels. Much literature is available describing methods and procedures for noise measurement and analysis, instrumentation, engineering noise controls, performance characteristics of noise control materials, and case histories of the implementation of noise control solutions. Suggested readings are listed in Appendix D.

A partial enclosure as shown here will interrupt the noise path providing some reduction for the operator and even more for those in areas adjacent to the sources.



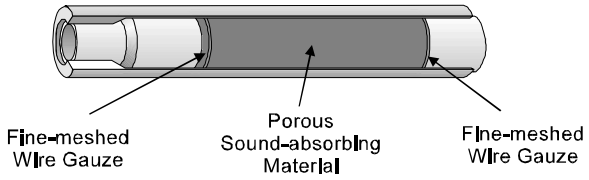
Often a machine may be completely enclosed and the operator may remain outside of the enclosure while the machine is operating. Thus, the operator and all others in adjacent areas benefit from the noise reduction.





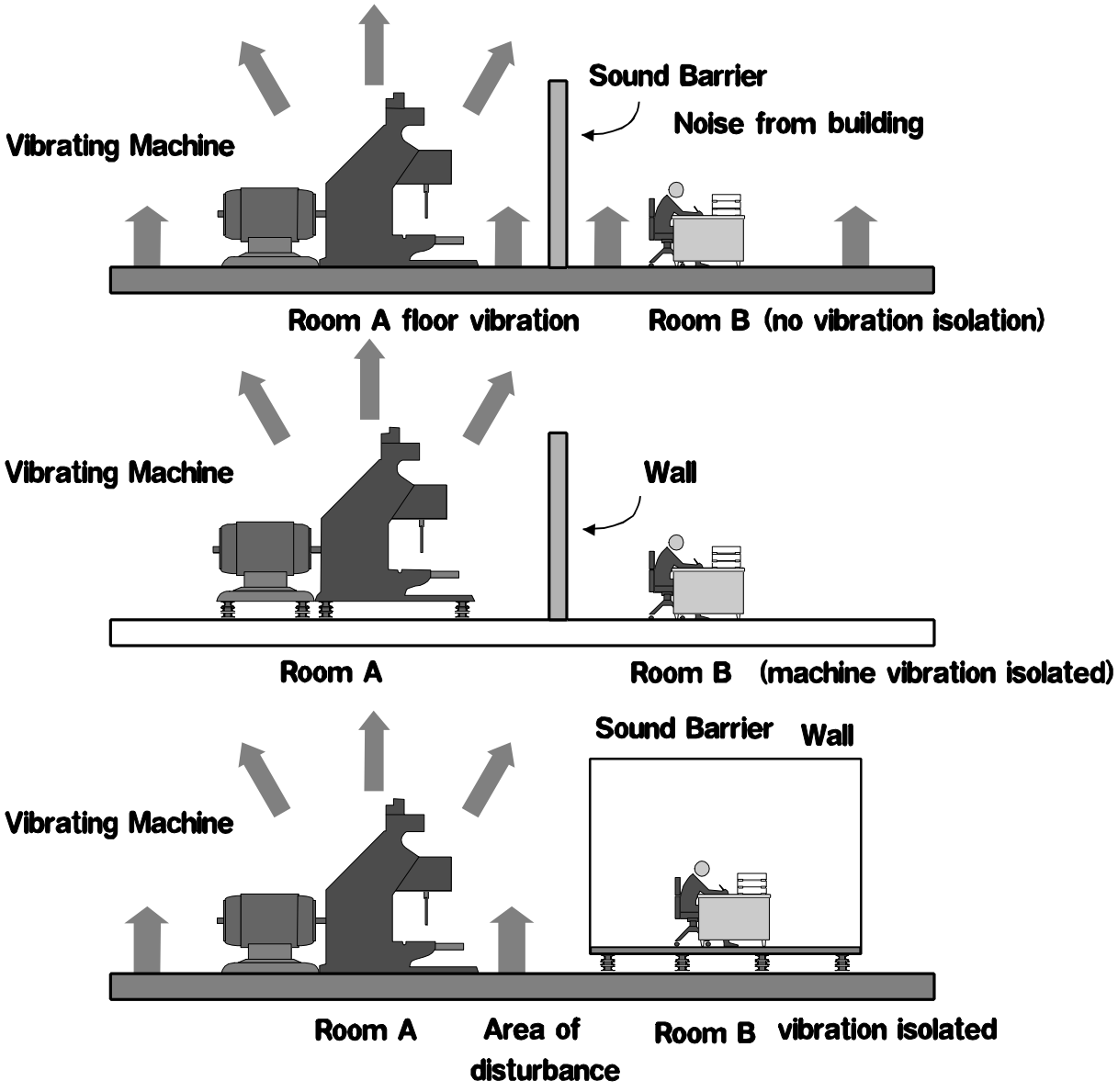
Problem
The exhaust air from a compressed air-driven grinding machine produces a loud noise. The air becomes turbulent while leaving the machine through the side handle

Control Measure
A new handle is filled with a porous sound-absorbing material fitted between two fine-mesh gauzes. Passage through the porous material breaks up the turbulence. The air stream leaving the handle is less disturbed and the exhaust noise is weaker. A muffler may also be used



Problem

Heavy vibrating machine creates noise as well as vibrating the floor to which it is attached. The sound barrier wall is ineffective for vibration because transmission of noise to office is through the floor



Control Measure

Isolation of the machine reduces the amount of vibration transmitted to the office area. Likewise, isolation of the office area from the main floor of the building will result in reduced vibration transmission. Effectiveness of sound barrier wall could be improved by mounting absorptive materials on the machine side of the wall

Management Responsibilities

Management's primary responsibilities are to make sure that potentially controllable noise sources are identified, and that priorities for controls are set and accomplished. For this purpose, management needs to allocate the appropriate resources and engage outside services or identify capable personnel in-house. It is also management's responsibility to see that any changes of equipment or process are done only after evaluation of their impact on employee noise exposure. The purchase of quieter new equipment can be very helpful, but is usually accomplished only with explicit specification, and occasionally some pressure on the equipment manufacturers. Sometimes the company must be willing to pay more for quieter equipment, but these expenditures should be cost-effective in the long run.

Often a noise-control effort may seem to be overwhelming. As a result, the company may decide that noise control is not feasible and rely on hearing loss prevention measures to prevent hearing loss. However, if noise sources are taken on one at a time, dealing with the noisiest or easiest to quiet sources first, the problem can become manageable over time so that hearing loss prevention measures will be needed only until the noise is reduced to a safe level. Many times two hazards can be ameliorated at once such as in the case of enclosing a noisy machine that generates high heat levels as well. The enclosure can trap the noise and the heat can be vented off to the outside. The time when workplace noise is no longer hazardous will be hastened if the control of noise from current sources is augmented by a “buy quiet” program.

Managers may need to commit resources for in-house development of technology to control exposure problems specific to their companies and processes. In some cases they may need to budget for maintenance of exposure control devices to prevent their deterioration over time. Finally, they should make sure that lunch and break areas are as free from hazards as reasonably possible, and that other avenues of administrative controls have been explored.

Program Implementor Responsibilities

One of the most important responsibilities of the hearing loss prevention program implementor is to make sure that management is aware of the need for engineering controls and their benefits. He or she should see that the company has thoroughly assessed the full potential for using both engineering and administrative controls.

Those who implement the hearing loss prevention program will probably not actually execute the exposure control solutions, but will provide a channel between the employees who operate the equipment, management, and the noise control specialists. It is the job of the implementor to make sure that communication lines are open, and that the equipment operators are consulted in control design. Program implementors will be responsible for making sure that employees understand the proper use of noise control devices, and for maintaining them in good condition.

Employee Responsibilities

Because the employees who operate or maintain and repair the equipment are often the ones who know most about the processes involved, they need to express their concerns and ideas to management, the program implementor, or the noise-control engineer, so that the noise-control devices will be as practical and effective as possible. Employees also have the responsibility of learning to operate their machines with the noise controls in place, of maintaining the controls properly, and of notifying the appropriate personnel when additional maintenance is needed.

OSHA Requirements

Code of Federal Regulations, Title 29, Chapter XVII, Part 1910, Subpart G, 1910.95: sections (a) and (b).

See checklist in Appendix A of this guidebook, items no. 1-3.
See checklist in Appendix B of this guidebook, section entitled "Engineering and Administrative Controls."

Further Reading

Beranek LL, ed.[1988] Noise and Vibration Control. revised. New York: McGraw Hill.

Bruce RD, Toothman EH [1986]. Engineering controls. In: Berger EH, Ward W.D, Morrill, JC, Royster LH, eds. Noise and Hearing Conservation Manual. 4th ed. Akron, OH: American Industrial Hygiene Assoc. Chapter 12.

Harris CM ed. [1991] Handbook of Noise Control. 3rd ed. New York: McGraw Hill, Chapters 26 and 30-41.

OSHA. [1980]. Noise Control: A Guide for Workers and Employers. Pub. No. 3048. Washington, D.C. U.S. Dept. of Labor/OSHA, Office of Information. .

AUDIOMETRIC EVALUATION

Audiometric evaluation is crucial to the success of the hearing loss prevention program in that it is the only way to determine whether occupational hearing loss is being prevented. When the comparison of audiograms shows temporary threshold shift (a temporary hearing loss after noise exposure), early permanent threshold shift, or progressive occupational hearing loss, it is time to take swift action to halt the loss before additional deterioration occurs. Because occupational hearing loss occurs gradually and is not accompanied by pain, the affected employee will not notice the change until a large threshold shift has accumulated. However, the results of audiometric tests can trigger changes in the hearing loss prevention program more promptly, initiating protective measures and motivating employees to prevent further hearing loss.

OSHA and NIOSH presently have differing definitions of the amount of change in hearing indicated by repeated audiometry that should trigger additional audiometric testing and related follow up. OSHA uses the term Standard Threshold Shift to describe an average change in hearing from the baseline levels of 10 dB or more for the frequencies of 2,000, 3,000, and 4,000 Hz. Upon finding the OSHA STS, certain actions are required including retest, evaluation of the adequacy of hearing protectors or requiring their use if not used until the STS event, and revision of baseline. NIOSH uses the term Significant Threshold Shift to describe a change of 15 dB or more at any frequency 500 through 6,000 Hz from baseline levels that is present on an immediate retest in the same ear and at the same frequency. NIOSH recommends a confirmation audiogram within 30 days with the confirmation audiogram preceded by a quiet period of at least 14 hours. The NIOSH STS, called 15 dB twice, same ear, same frequency, can only be tested if the baseline audiogram is available at the time of the annual audiometric test.

The reader is encouraged to consult Appendix A, items no. 12-30 and 52-54, for a summary of OSHA's requirements for audiometric evaluations. The sections entitled "Monitoring Audiometry" and "Referrals" in Appendix B's checklists also should be helpful.

For **maximum protection of the employees** (and for that matter, the company), audiograms should be performed on the following five occasions:

1. Pre-employment.
2. Prior to initial assignment in a hearing hazardous work area.
3. Annually as long as the employee is assigned to a noisy job (a time-weighted average exposure level equal to or greater than 85 dBA).[1]
4. At the time of reassignment out of a hearing hazardous job.

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[1]Noise-induced hearing loss can develop rapidly in workers exposed to relatively high noise levels on a daily basis. For example, the most susceptible ten percent of a population exposed to daily average unprotected noise levels of 100 dBA could be expected to develop hearing threshold shifts in excess of OSHA's criterion for standard threshold shift before the end of one year. This prediction can be made using the international standard, "Determination of Noise Exposure and Estimation of Noise-Induced Hearing Impairment" (see ISO, in Appendix D). Thus, it may be good practice to provide audiometry twice a year to workers exposed to more than 100 dBA.

5. At the termination of employment.

In addition, it is suggested that employees who are not exposed be given periodic audiograms as part of the company's health care program. The audiograms of these employees can be compared to those of the exposed employees whenever the overall effectiveness of the hearing loss prevention program is evaluated. In an optimally effective program, the two employee groups will show essentially the same amount of audiometric change.

Management Responsibilities

Managers should support the audiometric evaluation phase by allocating sufficient resources. Because the audiometric phase is sometimes the most expensive element of a hearing loss prevention program, it is prudent to set aside enough funds to provide for the performance of reliable hearing tests and the collection of accurate information. Noise is a HAZARDOUS agent. Management must ensure all employees (even mobile/itinerant workers) are included in the audiometric phase.

Management may opt to contract for audiometric services with an external source such as a mobile testing contractor or a local hearing clinic. Alternatively, management may choose to purchase audiometric equipment and train a company employee to perform audiometric testing on-site under the supervision of an audiologist or a qualified physician. The third option is to combine internal and external resources. The choice depends upon economic considerations as well as the size, policies, and geographical location of the company. If contract services are used, it is critically important that management still assign responsibility for overseeing the hearing loss prevention program to a key on-site individual. Whether the audiometric testing is performed internally or externally, the company will not receive the benefit of quality audiometric evaluations unless the following practices are adhered to:

1. The audiograms must be administered using properly calibrated audiometers in a sound-treated room with acceptable background sound levels during testing. Circumaural earphone enclosures (earphones inside earmuffs), which are designed to reduce external noise, should not be substituted for a sound treated room, and generally should not be used because of inherent problems with calibration and earphone placement.

2. The same type of audiometer (and preferably the same instrument) should be used from year to year. This may help prevent measurement variations caused by subtle differences among machine models/types or by the type of responses required from the person being tested.

3. The training of audiometric technicians should meet as a minimum the current requirements of the Council for Accreditation in Occupational Hearing Conservation. Use of microprocessor-controlled or computer-based audiometric equipment should **NOT** exempt a technician from receiving training.

4. All audiometric technicians should use the same testing methods for all of the company's employees.

5. All testing should be done under the supervision of an audiologist or a physician knowledgeable about hearing loss prevention.

Management should provide the audiometric technician with sufficient time to perform the tests thoroughly and to give noise-exposed employees proper attention. Because the audiometric session provides an ideal opportunity to motivate employees' concern for hearing loss prevention, technicians should have time to inform employees about their hearing status immediately after completing the audiogram and to check their hearing protection devices. When the technician is too hurried to do more than a rapid screening audiogram because of other duties, the employee correctly perceives that the exercise is performed only in response to regulatory requirements, without a sincere interest in protecting anyone's hearing. In such a situation employees often lose their motivation to participate in the hearing loss prevention program.

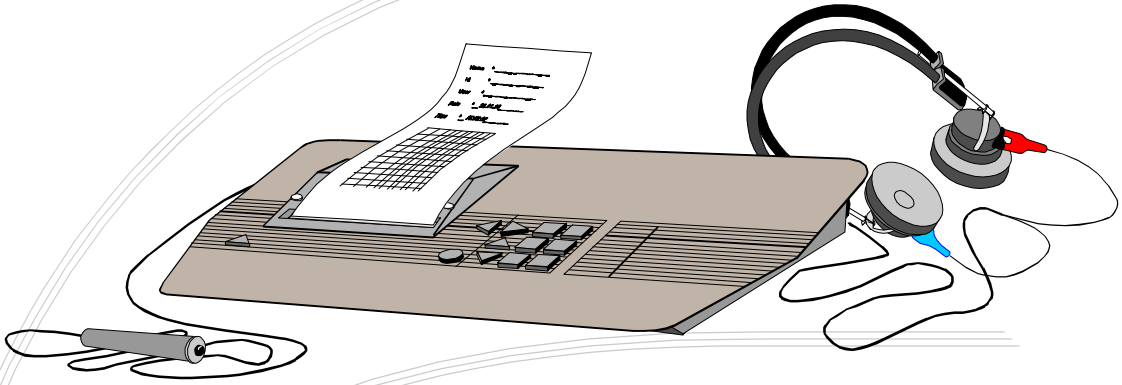
One of the best ways to assure the quality of the audiograms collected is to make prior audiograms for each employee available to the tester at the time of the test. If the tester's comparison of audiograms reveals a threshold shift (equal to 15 dB or more at any frequency), the tester can refit the earphones, reinstruct the employee, and conduct a retest. If the shift persists on the retest, the change can be considered as reliable. If not, the retest can be taken as the reliable test and it will be included in the record system and the first test will be discarded. It is estimated that as many as 70% of all audiograms showing shift will be resolved if the earphones are refitted, the employee is reinstructed, and a retest is administered at the time of the initial test. Management can facilitate quality assurance by providing the audiometric technician with time to conduct the retest and with authority to hold the employee back for a retest.

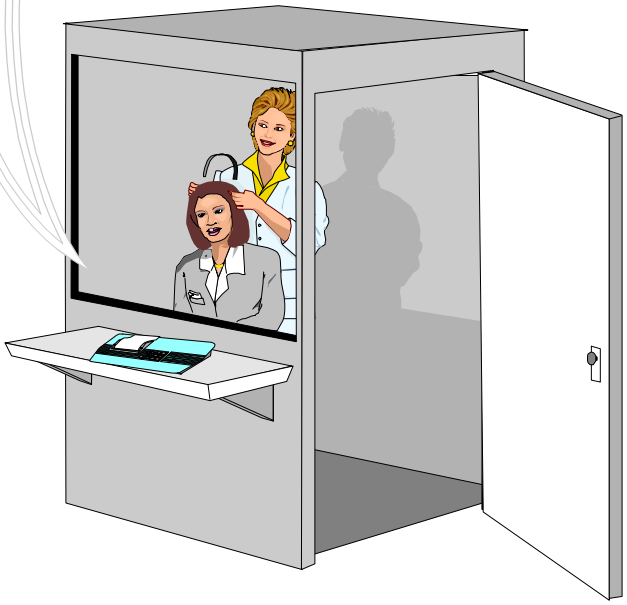
Management should also make sure that the individual who reviews the audiograms is a qualified professional with specific training and experience in the area of occupational hearing conservation. All employees, not just those with threshold shifts, should receive prompt written summaries of their current hearing status from the professional reviewer. Employees also should receive summaries of their hearing trends over time, along with recommendations for further evaluation or any extra precautions needed, such as more careful use of hearing protectors.

Program Implementor Responsibilities

The program implementor has important responsibilities in the audiometric testing phase of the hearing loss prevention program. This individual and the person conducting audiometric testing may be the same person, but if not, the program implementor must ensure that the person performing the audiometric testing is well-trained and carries out the necessary functions. The

A microprocessor audiometer with built-in printer can be used to test hearing automatically or can be operated manually to obtain an audiogram. Another type of audiometer used for automatic hearing testing is called self-recording





The person performing the hearing test should always place the earphones for an audiometric test

individual who performs the testing needs to demonstrate enthusiasm for the program and show sincere interest in each employee while carrying out his or her duties. The results of the hearing testing are most valuable to the employee if they are provided immediately following the test. The audiogram should be compared to the baseline or reference audiogram while the employee is watching. The employee should be advised that the audiogram either shows no change in hearing, implying that hearing loss prevention efforts are working for him or her, or that a change has occurred. If the hearing test shows a change, the employee should be returned to the test booth, be instructed in how to take the test, be refitted with earphones, and retested. If the second test confirms the change, the employee should be advised to have a confirmation audiogram within 30 days. The confirmation audiogram should be preceded by a quiet period of at least 14 hours and earmuffs or earplugs should not be used to achieve the quiet period. Regardless of whether or not there is a shift, the immediate feedback should also provide information to the employee as to how his or her hearing compares to others of the same age, gender, and race.

The program implementor should make sure that the records include the employee's auditory history, which is the history of diseases and disorders of hearing and balance, and related factors (such as diabetes and high blood pressure), and history of exposure to noise and other ototraumatic agents, both on and away from the job. This information provides the professional audiogram reviewer with insight concerning probable causes for threshold shifts and enhances specific recommendations for follow-up.

Annual audiometric examinations (but not baselines) should be scheduled well into the work shift so that comparisons with baseline audiograms will reveal any early indications of hearing loss or temporary threshold shifts due to hearing protector inadequacies. In the early stages of noise-induced hearing loss, noise exposure causes temporary shifts in hearing threshold level, which, if repeated on a regular basis, become permanent. By testing toward the end of the workday, rather than before or early into the workday, these temporary threshold shifts can be identified, and steps can be taken to counteract them. Interventions at this stage thus prevent subsequent, permanent hearing loss.

Direct contact between the person performing the audiometric testing and the employee during the hearing test provides the chance to intervene by checking the condition of the employee's hearing protector. The tester can observe whether the employee is using the device correctly, and reevaluate the adequacy of hearing protector selection, fit, and condition. The employee should be asked whether the hearing protector is performing in a satisfactory manner. If necessary, a new protector of a different size or type can be issued and the employee can be instructed in the proper care, fitting, and use of the device.

Daily functional and listening checks of audiometer function are critical if audiogram are to be accurate, and the program implementor must ensure that these checks are properly documented. To measure thresholds accurately, the test room must be quiet enough to meet appropriate American National Standards Institute requirements (ANSI S3.1-1991 or its successor), which is

especially important for employees with normal hearing. Complete audiometer calibrations should be scheduled annually, but the audiometer should not actually be adjusted unless it fails to meet standard tolerances. Too frequent adjustments add "seesaw" variability to the audiometric data, interfering with the interpretation of both individual and group hearing trends. To prevent another source of measurement variability, the same audiometer types should be used consistently rather than switching between models, and especially between types of audiometers (manual, self-recording, and microprocessor). Failure to follow these practices jeopardizes the validity of the audiometric data and may reduce employee protection as a consequence. If the audiometer is changed from one year to the next, the change should be noted in the audiometric records.

Program implementors should see that the audiometric record indicates:

1. The specific purpose of the audiometric examination: for example, baseline, annual, retest, threshold shift confirmation, or other.

2. The specific equipment used and most recent calibration date.

3. The name of the tester.

4. The date and time of day of the test (if there are work shifts, shift should be noted).

5. The auditory history information.

6. The hearing threshold values obtained.

7. The tester's judgment of the subject's response reliability.

8. The results of the hearing protector inspection and a record of any refitting, reissuing, or retraining.

9. The tester's comments, if any.

The program implementor must make sure that every baseline, annual, retest, and follow-up audiogram is reviewed. The supervising professional may set up criteria for the person conducting the audiometric tests or for a computer program to assess all records and identify only the remaining noteworthy records for review. Routine records are those depicting normal hearing or no significant hearing decrements or improvements for a given employee. Only the professional is qualified to revise the reference "baseline" audiogram, either because of improvements in hearing or because of a persistent decline in hearing level. The reviewer should look for threshold shifts at any test frequency, not just "standard threshold shifts" as defined by

OSHA[2], and for audiometric patterns indicative of medical problems. If the audiometric data indicate a degeneration of hearing, the reviewer must alert both the employee and management about these findings.

OSHA requires follow-up referrals under certain conditions (see item number 23 in Appendix A, and section (g)(8)(ii) in the OSHA noise standard). The program implementor must be familiar with these provisions, and must see that they are carried out. Sometimes medical referrals are necessary to determine the cause of a hearing loss, and medical treatment can be an important next step. Not all hearing losses are caused by occupational factors and sometimes medical intervention can be crucial to the worker's health.

Although OSHA regulations specify required follow-up actions when a standard threshold shift is identified, follow-up for smaller shifts in hearing is recommended for optimal protection. Studies of effective hearing loss prevention programs show procedures that go beyond the OSHA regulations. For example: 1) employees with "beginning" shifts (smaller than OSHA's standard shift) get a written notification or "alert" from the professional reviewer; 2) employees receive face-to-face counseling from on-site program implementors and, based on the reviewer's suggestions, retesting, reevaluation of hearing protector efficiency, and extra instruction in hearing protector use; and 3) individuals with possible medical conditions of the ear are counseled to seek evaluation and treatment from their own physicians, or they may be referred to a company physician or a health provider covered under the company's health-care program.

Employee Responsibilities

To help the professional reviewer interpret the audiogram, employees need to disclose relevant details of their ototraumatic exposure histories (on past jobs, in the military, and in hobbies and non-occupational activities). Employees should consider themselves partners with management. Employees must ensure accurate audiometry by cooperating with the audiometric test process, by keeping their appointment for hearing testing, and by carefully following the instructions of the hearing tester.

Employees should also provide histories of ear diseases, treatment, and current ear conditions, including signs of over-exposure to noise such as tinnitus (ringing in the ear). Employees who understand that audiometric findings will be used to help conserve their hearing, not to penalize or blame them, will respond more effectively to the audiometric listening task. Employees should let the audiometric tester know if the instructions are unclear, if tinnitus is interfering with audiometric responses, or if the audiometer produces sounds other than those described in the instructions.

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[2] OSHA defines a standard threshold shift as a change, relative to baseline, of 10 dB or more in the average hearing level at 2000, 3000, and 4000 Hz in either ear. NIOSH defines significant threshold shift as a 15 dB change, relative to baseline, at any of the frequencies 500, 1000, 2000, 3000, 4000, or 6000 Hz, demonstrated on a retest audiogram administered immediately after the audiogram that showed the shift for the same ear and same frequency.

Once the audiometric results have been reviewed, employees should actively cooperate with the program to protect their own hearing by following the recommendations of the professional supervisor. They should follow the employer's policies concerning the use of hearing protectors on and off the job, and should obtain any recommended medical evaluation or care.

OSHA Requirements

Code of Federal Regulations, Title 29, Chapter XVII, Part 1910, Subpart G, 1910.95: sections (g), (h), Appendix C, Appendix D, Appendix E, and
Appendix F.

See checklist in Appendix A of this guidebook, items no. 12-30, and 52-54.
See checklist in Appendix B of this guidebook, sections entitled "Monitoring Audiometry and Record Keeping" and "Referrals."

Further Reading

Gasaway DC [1985]. Hearing Conservation: A Practical Manual and Guide. Englewood Cliffs, NJ: Prentice-Hall, Chapters 10, 12, and 13.

Lipscomb DM [1988] Hearing testing and interpretation. In: Lipscomb DM ed. Hearing Conservation in Industry, Schools, and the Military. Boston, MA: Little, Brown and Co., Chapter 8.

Miller MH, Wilber LA [1991]. Hearing evaluation. In Harris CM ed. Handbook of Acoustical Measurements and Noise Control. 3rd ed. New York: McGraw-Hill, Inc., Chapter 19.

Morrill JC [1986]. Hearing measurement. In: Berger EH, Ward, WC, Morrill JC, Royster LH, eds. Noise and Hearing Conservation Manual 4th ed. Akron, OH: American Industrial Hygiene Assoc., Chapter 8.

Audiometric and Identification Information

Name _____

Soc. Sec. # ____ -__-____ Birth Date __/__/__ Gender M F (Circle)

Empl No: _____ Job Code _____ Dept No _____

Test Date __/__/__ Time __;__ Test Type _____ Time since last exposure ____ h

Exposure Level ___ dBA

Hearing Protector Activity

Yes ____ No ____

Issue ____

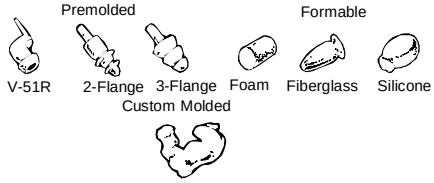
Reissue ____

Training ____

Retraining _____

Hearing Protector Used (Circle)

EARPLUGS



EAR CANAL CAPS

Unknown

EARMUFFS

Self-Reported Employee Histories

(Y/N) Medical History

_____Diabetes
_____Ear Surgery
_____Head Injury
_____High Fever
_____Measles
_____Mumps
_____Hypertension
_____Ringing in Ears
_____Ear Infection
_____Other

(Y/N) Hobby & Military History

_____ Hunt/Shoot
_____ Car racing
_____ Motorcycles
_____ Other Loud Vehicles
_____ Loud Music/Band
_____ Power Tools
_____ Other Noisy Hobbies
_____ Military Service
_____ Fire Weapon
_____ Other

(Y/N) Additional Information

_____Noisy 2nd Job
_____Noisy Past Job
_____Exposure to Solvents
_____Exposure to Metals
_____Difficulty Hearing
_____Hearing Aid
_____Recent Change in Hearing
_____See Physician About Ears
_____See Prior Histories
_____Other

Audiogram

Test Frequency

	500	1000	2000	3000	4000	6000	8000
Right Ear							
Left Ear							

Audiometer _____

Exhaustive Cal. Date __/__/__

Tester Identificaiton ___-__-____

Review Identification ___-__-____

Serial Number _____

Biological Cal. Date __/__/__

Test Reliability (Good, Fair, Poor) __

Audiogram Classification Code __ __ __

Comments _____

_____

PERSONAL HEARING PROTECTION DEVICES

A personal hearing protection device (or "hearing protector") is anything that can be worn to reduce the level of sound entering the ear. Earmuffs, ear canal caps, and earplugs are the three principal types of devices. Each employee reacts individually to the use of these devices, and a successful hearing loss prevention program should be able to respond to the needs of each employee. Making sure these devices protect hearing effectively requires the coordinated effort of management, the hearing loss prevention program operators, and the affected employees.

OSHA's requirements for hearing protectors are summarized as items no. 31-38 and 51 in Appendix A of this document. Useful guidance can also be found in Appendix B, in the section entitled "Hearing Protection Devices."

Management Responsibilities

Management has two roles in ensuring that hearing protection devices protect hearing effectively: facilitation and enforcement. Facilitation involves ensuring that program implementors obtain the types of devices they need. Management can do this by making sure the procurement department does not override the implementor's selections. Management must demonstrate its commitment to a truly effective hearing protection program, not one that exists just to comply with OSHA regulations. Employee participation in the selection of hearing protectors should be encouraged. Encouragement might take the form of providing safety-related bonuses (e.g., home/auto fire extinguisher, first aid kits, smoke alarms) as a “reward” for employees who use protection regularly and properly, and for *supervisors* who energetically support hearing protection policies. Management should extend its commitment to hearing protectors by requiring all personnel, including managers and visitors, to wear protectors in designated areas, and by encouraging employees to take hearing protectors home to use whenever engaging in noisy activities.

Management should give program implementors the opportunity to pilot-test hearing protectors on a few employees. This will greatly facilitate decisions relating to the selection and ultimate effectiveness of these devices. Hearing loss prevention program implementors should also be provided with resources and facilities to train employees in the use and care of hearing protectors.

Enforcing the use of hearing protectors is management's second vital role. Use of personal safety equipment, such as hearing protectors, must be clearly stated as a condition of employment, and management should be prepared to deal accordingly with those who violate the policy. Those who have decided not to wearing hearing protection in noisy areas also have decided not to work for the company.

Program Implementor Responsibilities

It is essential to the success of the program to have someone responsible for the selection of hearing protection devices and the supervision of their use. They must be able to evaluate and select appropriate devices for each employee, based on proper fit, the employee's noise exposure, hearing ability, communication needs, personal preferences and other constraints imposed by job tasks or work environment. Not every person can wear every hearing protector. Some people may be unable to wear certain types of earplugs because of the shape or size of their ear canals. Because of individual differences in the shapes and sizes of heads, some people will be unable to wear some earmuffs. Individual assessment of comfort and ability to tolerate prolonged use of a given device cannot be predicted and will vary widely between individuals. Also, some protectors may be incompatible with other safety and protective devices. Therefore, program implementors must make a variety of devices available. Preferably, program implementors should make available a set of devices that have been pilot-tested for effectiveness and employee acceptance. When fitting hearing protectors, attention needs to be given to each ear. It is not uncommon for a person to have right and left ear canals that are different sizes and must therefore be fitted with earplugs that are separately sized for each ear. Ear canals should be inspected to assure that no physical problems, such as infections or excessive ear wax, will compromise or complicate the use of hearing protectors.

Program implementors must be able to educate employees one-on-one about the proper use and care of hearing protectors. They must be sure that each employee can demonstrate competence in fitting and using the protector, and is familiar with replacement procedures. Program implementors should also encourage employees to ask questions and to seek help in resolving problems.

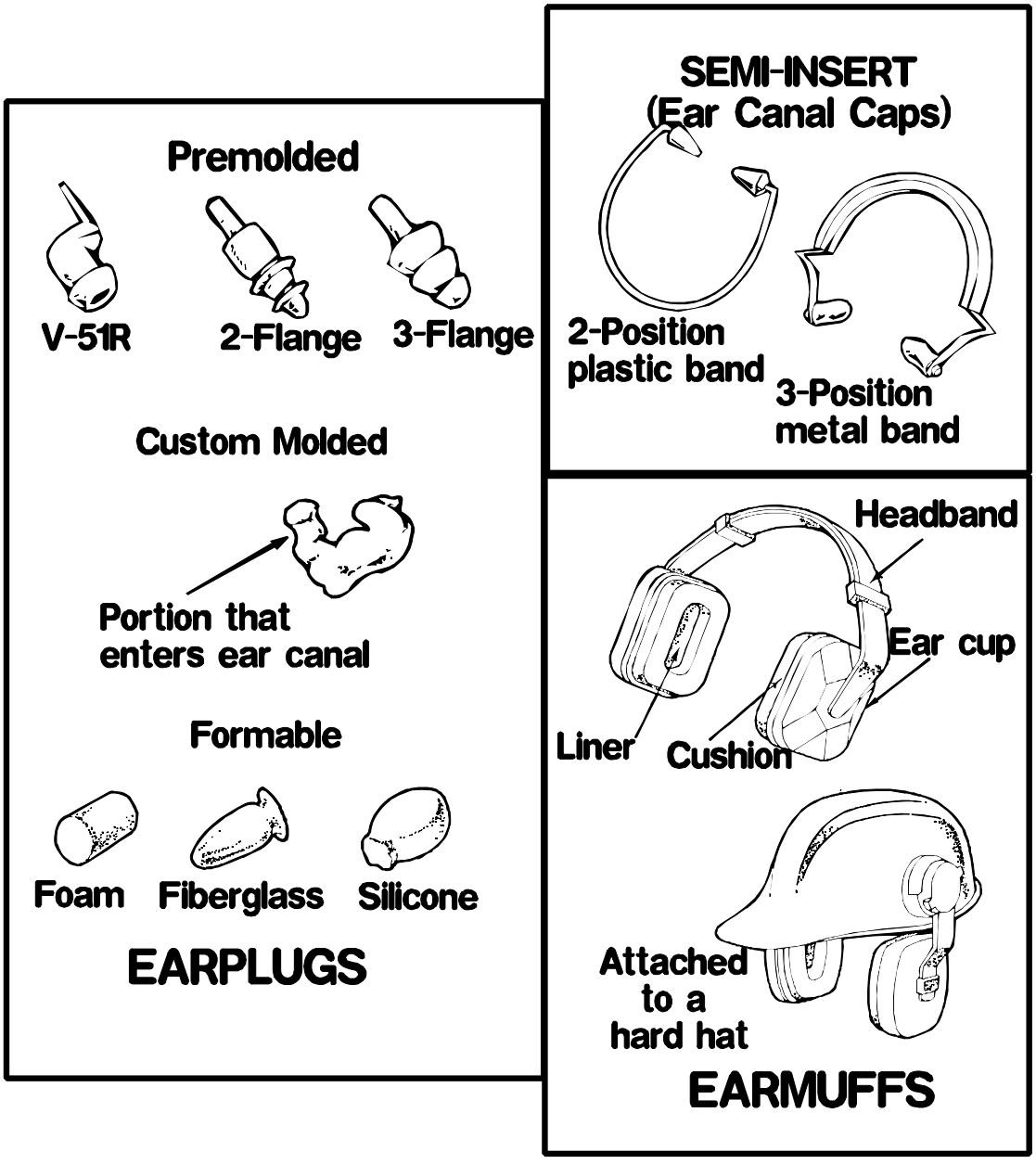
Another important aspect of a successful program is to perform on-site checks of the condition of the protectors, noting misuse or wearer "modification" that would diminish effectiveness of the protectors. Program implementors should have a ready supply of replacement protectors, and be prepared to work with those employees whose negative attitudes prevent them from using these devices properly and routinely. In an environment where a safety culture has been established, peer pressure in favor of protector use can be effective in helping to resolve these problems.

Program implementors should be alert for common pitfalls associated with use and care of hearing protectors. For example, motorcycle helmets, personal stereo headsets, swimmers earplugs, and hearing aids cannot be substituted for hearing protectors. Program implementors should be proactive in working with employees to avoid such pitfalls.

Employee Responsibilities

Employees, of course, are the focus of the hearing protection program, and must make efforts to be fully informed, to obtain help when necessary, and to assume responsibility for wearing their hearing protectors. Whenever the employee must work in hazardous noise, the employee becomes the first line of defense against hearing loss. Employees must consciously develop

personal habits and strategies for wearing their hearing protection. Otherwise, it becomes too easy to succumb to the constant barrage of opportunities to misuse personal hearing protectors, thereby risking exposure to harmful levels of noise.



Sketches of hearing protectors, including premolded, custom-molded, and formable earplugs and a "semi-insert" device (upper right): Earmuffs may require less individual sizing and fitting, but are heavier than earplugs. Helmet-mounted earmuffs solve the compatibility problem between the headband and the hard hat, but generally provide less protection.

How employees utilize personal hearing protection has a critical impact on hearing loss prevention. They must recognize the importance of wearing their hearing protector whenever they are exposed to hazardous noise. Wearing their hearing protector at all times simply cannot be overemphasized. As the graph on page 39 illustrates, removing a hearing protector for only a few minutes can dramatically reduce its effectiveness. Following manufacturers' instructions and wearing their hearing protector correctly is just as important as wearing their hearing protector consistently. To achieve the maximum benefit, employees ***must*** make sure they wear their protectors correctly. The bar charts on page 40 compare the Noise Reduction Rating hearing protectors can theoretically provide with the hearing protection employees typically obtain in the "real world" (Berger, Franks and Lindgren, 1994). The differences between the maximum protection theoretically possible, and the protection usually obtained in the "real world" are influenced by many factors. An employee's failure to correctly insert an earplug or adjust an earmuff, are arguably the chief culprits responsible for diminished real world hearing protection. Thus, even if an employee has been issued a correctly-sized hearing protector, and has been trained in its use and care, it is quite possible that he or she could receive little or no effective hearing protection because of faulty fit. Employees must resolve to wear their hearing protection correctly or they will greatly reduce its ability to prevent harmful noise from damaging their hearing.

Willful failure to wear hearing protection should be taken seriously. Employees should consider that management is responsible for ensuring compliance with health and safety requirements. Should employees fail to wear their hearing protection, management can be held accountable and may be cited and penalized for noncompliance with health and safety regulations.

Part of the employees' responsibility toward wearing their hearing protector is to cultivate a vigilant attitude about hearing protection. Employees should expect their hearing protectors to slip or work lose over a period of time. Throughout their work shift, employees must periodically check to see if they need to readjust or refit their protector in order to maintain a reliable fit.

Hearing protectors break and become worn. Employees also need to check their protector regularly and to seek repair or replacement whenever necessary. Lastly, they can help each other by encouraging their co-workers to use hearing protectors and to seek help when they have problems.

Employees must guard against acquiring a false sense of safety. As the discussion and figures in this section have illustrated, it is easy to misuse hearing protectors and greatly reduce their effectiveness. Employees **CAN** prevail over most hearing health hazards if they: 1) properly wear their hearing protectors, 2) exercise a commitment to wear their hearing protectors consistently, and 3) maintain their hearing protectors by repairing or replacing them when necessary.

OSHA Requirements

Code of Federal Regulations, Title 29, Chapter XVII, Part 1910, Subpart G, 1910.95: sections (a), (b), (I), (j), and Appendix B.

> See checklist in Appendix A of this guidebook, items no. 31-38 and 51.
> See checklist in Appendix B of this guidebook, section entitled "Hearing Protection Devices."

Further Reading

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Berger EH. [1986] Hearing protection devices. In: Berger EH, Ward WD, Morrill JC, Royster LH, eds. Noise and Hearing Conservation Manual. 4th ed. Akron, OH: American Industrial Hygiene Assoc., Chapter 10.

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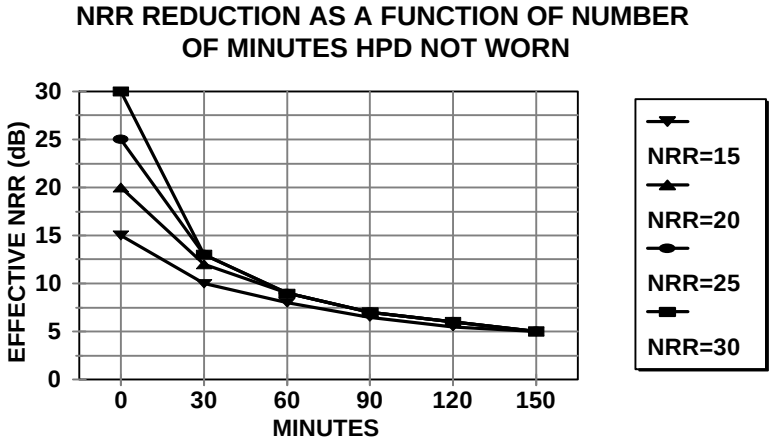
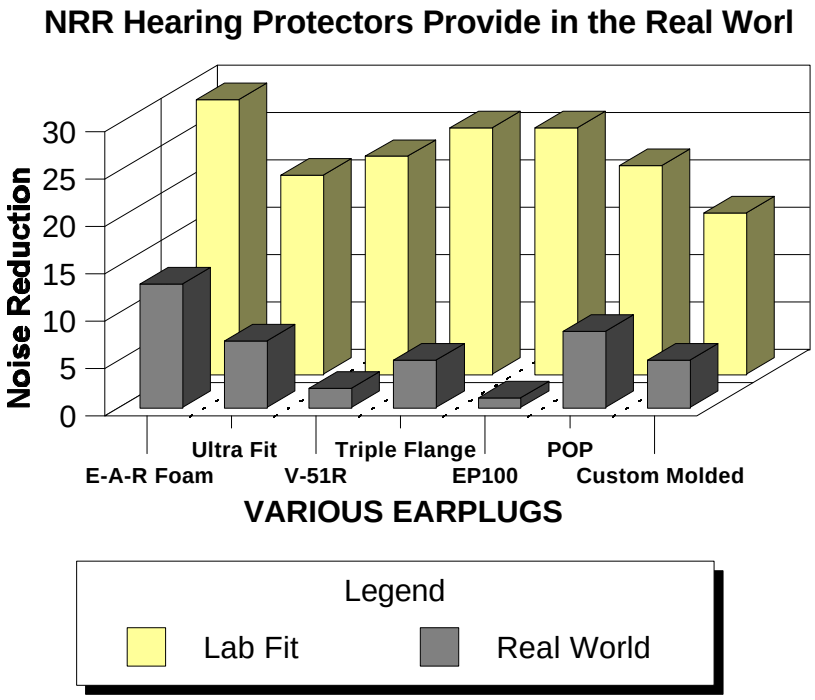
Franks JR, Themann CL, Sherris C. [1994] The NIOSH Compendium of Hearing Protection Devices. DHHS (NIOSH) Publication No. 95-105. Cincinnati, OH: National Institute for Occupational Safety and Health (1-800-35-NIOSH, press 1).

Nixon CW, Berger EH [1991]. Hearing Protection Devices. In: Harris CM, ed. Handbook of Acoustical Measurements and Noise Control 3rd ed. New York: McGraw Hill.

Royster LH Royster ,JD [1985]. Hearing protection devices. In: Feldman AS, Grimes CT, eds. Hearing Conservation in Industry. Baltimore, MD: Williams and Wilkins, .Chapter 6.




NRR Hearing Protectors Provide in the Real Worl
Noise Reduction
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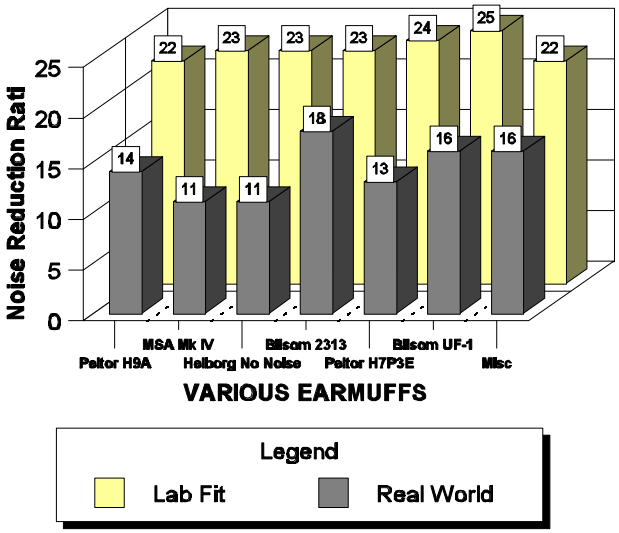
25
20
15
10
5
0
Ultra Fit
Triple Flange
POP
E-A-R Foam
V-51R
EP100
Custom Molded
VARIOUS EARPLUGS
Legend
Lab Fit
Real World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MSA Mk IV
Bilsom 2313
Bilsom UF-1
Peltor H9A
Helborg No Noise
Peltor H7P3E
Misc
VARIOUS EARMUFFS
Legend
Lab Fit
Real World

EDUCATION AND MOTIVATION

Training is a critical element of a good hearing loss prevention program. In order to obtain sincere and energetic support by management and active participation by employees, it is necessary to educate and motivate both groups. A hearing loss prevention program that overlooks the importance of education and motivation is likely to fail, because employees will not understand why it is in their best interest to cooperate, and management will fail to show the necessary commitment. Employees and managers who appreciate the precious sense of hearing and understand the reasons for and the mechanics of the hearing loss prevention program will be more likely to participate for their mutual benefit, rather than viewing the program as an imposition.

OSHA's requirements for training, education, and employee access to materials are summarized in items no. 39-41 in Appendix A, but it should be kept in mind that these are only minimal regulatory requirements. Readers should also consult the checklist in Appendix B, as well as the suggested readings at the end of this section and in Appendix D. A list of audiovisual materials is presented in Appendix C.

Management Responsibilities

Management must emphasize the importance of the educational phase of the hearing loss prevention program by setting a high priority on and requiring attendance at regular hearing loss prevention training sessions. Training sessions should be mandatory not only for noise-exposed employees, but also for the supervisors and managers responsible for noisy production areas. A manager should participate in each employee training session to outline company policies and to explain and model the company's commitment to the hearing loss prevention program.

The training program should consist of more than films and pamphlets. It must be tailored to the company's particular hearing loss prevention needs, and should include live presentations by articulate and knowledgeable speakers and hands-on practice sessions with hearing protectors. Hearing loss prevention presentations should be updated and presented at least annually, or more frequently if there is a significant turnover in employees. In addition to training sessions focussed specifically on hearing loss prevention, management should also require the inclusion of hearing health topics in regularly-scheduled general safety meetings. These general meetings may be brief "reminder" meetings held weekly or monthly that also serve to inform workers about progress made toward meeting the goals of the company's various safety programs. In this way, hearing health will become an integrated part of the overall health and safety climate of the workplace.

Management should make sure that the hearing loss prevention program's staff (audiometric technicians, hearing-hazard assessors, noise control experts, those who fit and issue hearing protection devices, and supervisors) have received detailed instructions in hearing loss prevention so that they are qualified to lead employee training sessions and comfortable with answering

employees' questions. Individuals who make the main presentations in the formal educational programs must be carefully selected to project genuine interest in the employees' welfare, and they must be speakers capable of gaining the employees' attention and respect. Peers can be particularly influential, and should be utilized whenever possible. For example, a senior worker who has sustained a hearing loss may be willing to share stories about his/her frustrations with communication difficulties in day-to-day activities. A powerful testimonial and behavioral modeling from a respected co-worker can be extremely effective in convincing other workers to improve their hearing loss prevention behaviors.

The periodic hearing loss prevention training sessions are best structured in small groups. Often groups will consist of a supervisor and the employees in that production unit. Because these individuals will have common noise exposures, they will fall under a common hearing protector policy, and they often feel comfortable enough with each other to ask questions freely and make constructive comments. Management must ensure that the questions and concerns raised during educational sessions receive thoughtful and prompt follow-up.

In some situations, it may be best to arrange separate educational sessions for employees and supervisors/managers of noisy departments. This will permit each group to discuss concerns relevant to their respective needs and responsibilities. However, at some point, representatives of both groups will need to work together to resolve concerns and implement the hearing loss prevention program. If necessary, a neutral facilitator can be chosen to assist in the process by attending both groups' meetings. This facilitator might be the company health and safety professional or an outside consultant hired by the company to assist with the training and motivation phase of the program.

Program Implementor Responsibilities

Because the program implementor is usually responsible for planning the educational sessions, and in some instances, may be the appropriate person to conduct sessions, it is extremely important that the program implementor have training that is current and relevant to the hearing loss prevention program. The type of training that the program implementor will need is often available at state, regional, and national conferences sponsored by safety or hearing conservation associations.

The program implementor should plan sessions that are limited in content to short, simple presentations of the most relevant facts. When stressing health promoting behaviors (such as consistently wearing hearing protection while working in noise) that will prevent something bad from happening *that has not yet happened*, research suggests that the focus should be on the real-life *losses* employees might expect if they don't act to protect their hearing. They might not be able to hear children's voices. They might not understand speech at a party, enjoy music and the sounds of nature, or perceive sounds that may convey other critical information—such as danger or equipment malfunctions. Another useful approach might be to explain audiometric results so employees can see how their hearing threshold levels compare to those of non-noise exposed individuals with normal hearing in their own age group. Once employees agree upon

why they need to conserve their hearing and how to monitor their audiogram results, the remainder of the program can focus on *how* to protect their hearing on and off the job through the effective use of hearing protection devices and good maintenance of engineering noise controls.

The program implementor needs to ensure that presenters tailor education and motivation sessions to each particular group of employees and their supervisors. It is important to accurately describe the group's noise exposures, the group audiometric results, the options available to them with respect to hearing protection devices, and the engineering controls in place or planned for their department. Other topics may include progress reports on the status of specific elements of the hearing loss prevention program, comparisons of company-wide audiometric results, reports on the use of hearing protectors by department, and responses to questions or concerns expressed by employees. Materials should be updated every year. New multimedia materials such as computer-based CD-ROM or CD-Interactive may be considered for use. Program implementors should ensure that films and pamphlets are used only as supplementary reinforcements for the live presentations, never as the whole program. Whenever possible, hands-on activities will facilitate learning. For example, workers can break into teams or small groups, and partners can help each other practice fitting various types of hearing protectors. Similarly, workers could initially break into small groups to brainstorm solutions to a particular noise problem in the plant, and then reconvene as a complete group to discuss the options and select a solution that is agreeable to the group. In this type of meeting, the program implementor would act as facilitator; guiding the workers through the various components of the meeting and coordinating the presentation of each group's suggestions.

Aside from formal educational presentations, program implementors should use every chance to remind employees and supervisors of the importance of the hearing loss prevention program and their active participation in it. One of the greatest opportunities to influence employee attitudes about hearing loss prevention occurs at the time of the annual audiometric test, when the program implementor or technician can compare the current thresholds to past results and check the fit and condition of hearing protection devices. Praise for employees with stable hearing and cautions for those with threshold shifts are effective if the comments come from a sincere and knowledgeable individual. Contrary to the approach suggested above for promoting prevention behaviors, research has suggested that when faced with detecting a health problem that may have already occurred (i.e., discovering a hearing loss), workers may respond best at this time to health messages stressing what they have to **gain** by engaging in behaviors that will preserve their remaining good hearing. Program implementors in this situation should stress how employees can act to *maintain their ability to hear* music, voices, warning signals, etc.

In effective hearing loss prevention programs, the program implementors interact with employees more than just once a year. They ask questions and make comments about the hearing loss prevention program whether meeting workers on the plant floor or in the halls and cafeteria - wherever contact is made. The goal is to make the hearing loss prevention program a visible and ongoing concern.

Employee Responsibilities

Employees must take responsibility for their hearing health by acting in accordance with company hearing loss prevention policies and contributing to their own education about hearing hazards. They must voice their concerns and questions about the hearing loss prevention program, inform program implementors when procedures are not practical, and suggest alternatives that would be more workable for their departments. Employees are an integral part of hearing loss prevention program, and can serve as presenters of information as well as consumers of information. They can help train each other in the proper use of engineering controls and hearing protectors, and have the responsibility to approach program facilitators and management with their health and safety concerns. These concerns should not have to wait until the regularly scheduled safety meetings, but should be expressed as soon as they arise. If hearing loss prevention program personnel fail to provide adequate consideration or follow-up, employees need to appeal to higher management until their concerns are addressed.

Rewards and Punishments

In the past, it has been very popular to suggest that management should reward workers who wear their hearing protectors and punish those who do not. In reality, research has noted that managers are sometimes greatly disappointed with the results of this type of behavior modification approach. Sometimes reward and punishment systems can foster destructive competitiveness between workers in a group as well as bitter animosity between work groups and the managers who supervise them. Specific rewards can lose their appeal over time, sometimes requiring management to continually "sweeten the pot" to maintain the desired behaviors. Additionally, management-designed reward systems can damage employees self-esteem and intrinsic motivation for performing their work well. This can lead to lowered productivity, declining quality of work, and a lack of motivation to apply oneself in that work situation. Workers who minimally follow the rules and put in their time may have simply decided that they have little personal responsibility for their contribution on the job. This type of apathy leads to negative attitudes toward work and the health programs associated with work, including hearing loss prevention.

There is a broad literature discussing the importance of an individual's perceptions of personal control in a wide variety of situations. It suggests that one reason why rewards sometimes fail to maintain desired behaviors is that workers perceive that they have little real control over their work and that management's system of doling out rewards and punishments controls their behavior on the job in a manipulative manner. Similarly, there are well documented negative side effects of relying on punishment to discipline workers for infraction of safety rules. While punishment may stop or discourage undesirable behavior when the behavior is closely monitored, it does not directly encourage desirable behaviors. Furthermore, in many settings, the punisher is also the person (usually a supervisor or the program implementor) who is responsible for administering rewards. This creates a difficult situation that might seriously diminish the effectiveness of rewards.

If an incentive system is in place or desired by management and the workers, a successful program can be developed with care. Both management and employees should agree on specific goals for the program. Both groups should work together to choose the rewards and sanctions that will apply to the program. As much as possible, the affected workers should set up the system and enforce it, otherwise management may damage the motivation and morale of the workers with inappropriate and unnecessary controls. In this way, workers can be encouraged to assume as much responsibility as feasible for their health and their work environment. They will look out for and police each other. This "bottom-up" approach is more likely to build camaraderie and group commitment to safety than the traditional "top-down," management centered approaches of the past.

OSHA Requirements

Code of Federal Regulations, Title 19, Chapter XVII, Part 1910, Subpart G, 1910.95: sections (k) and (l).

See checklist in Appendix A of this guidebook, items no. 39-41.
See checklist in Appendix B of this guidebook, section entitled "Training and Education."

Further Reading

Deci EL, Ryan RM [1985] Intrinsic Motivation and Self-Determination in Human Behavior. New York: Plenum Press.

Gasaway DC [1985] How to successfully educate, indoctrinate, and motivate workers. In: Gasaway DC. Hearing Conservation: A Practical Manual and Guide. Englewood Cliffs, NJ: Prentice-Hall, Inc., Chapter 6.

Royster JD, Royster LH [1990] Hearing Conservation Programs: Practical Guidelines for Success. Chelsea, MI: Lewis Publishers, Inc.

Schwarzer R, ed. [1992] Self-Efficacy: Thought Control of Action. Washington: Hemisphere Publishing Corporation.

Sevelius G [1984]. Noise and Hearing Conservation. Los Angeles, CA, Health and Safety Publications. 2265 Westwood Blvd., Los Angeles, CA, .

RECORD KEEPING

Records quite often get the least attention of any of the hearing loss prevention program's components. But audiometric comparisons, reports of hearing protector use, and the analysis of hazardous exposure measurements all involve the keeping of records. Unfortunately, records are often kept poorly because there is no organized system in place, and in many cases, those responsible for maintaining the records do not understand their value. People tend to assume that if they merely place records in a file or enter them into a computer, adequate record keeping procedures are being followed.

Many companies have found that their record keeping system was inadequate at the moment accurate information was most needed. This has often occurred during the processing of compensation claims. Problems can be avoided by implementing an effective record keeping system, in which: 1) management encourages that the system be kept active and accessible, 2) hearing loss prevention program implementors make sure that all of the information entered is accurate and complete, and 3) employees validate the information.

Hearing loss prevention program records should include all items for each phase of the program: 1) hearing loss prevention audit, 2) monitoring hearing hazards, 3) engineering and administrative controls, 4) audiometric evaluation, 5) personal hearing protective devices, 6) education and motivation, and 7) program evaluation. Each phase generates its own form of records, and the information from the various records must be considered in order to evaluate the effectiveness of the hearing loss prevention program.

OSHA's record keeping requirements can be found in items no. 45-49 of Appendix A in this document. For more information on this subject, readers may consult the recommended readings at the end of this section, as well as the checklists in Appendix B. The reader is also referred to the chapter on Emerging Trends and Technologies for a discussion of the use of optical card technologies to store and retrieve hearing loss prevention program records.

Management Responsibilities

Management should make available the facilities to store records and should provide sufficient resources to process them quickly and accurately. The forms or computer format used to gather information are the foundation of a good record keeping system. These forms should be designed so that necessary actions are triggered and then documented. If a company does not have the available resources to design a hearing loss prevention record keeping system compatible with the general safety and health record system, the company should turn to consultants for assistance.

Because hearing loss prevention program records can be complex, management should see that program implementors are fully trained in the record keeping system and its function. There should be working copies of records as well as archived copies. If an outside contractor keeps the records, a method should be established to ensure that original records are accurate, and are

returned and entered into the company's files in a timely fashion.

Hearing loss prevention records are medical records and, as such, deserve the same level of integrity and confidentiality as other medical records. The company needs to make sure that these records are accessible only to program implementors, affected employees or their designated representatives, and government inspectors. Increasingly, companies maintain all of their employee health and safety records in a computer system. The use of computers supports easy access and storage of data, provides for automatic triggering of actions based on the data contained in the records, and generates hard copies to be maintained as archives. Prudent managers will see that original copies of records pertaining to individual audiometry and hazard exposure monitoring are retained in personal medical or industrial hygiene folders.

The records should be made available at the time of audiometric testing. Having the audiogram available will allow an instantaneous check of the new audiogram with the others on record so that checks for threshold shift can be made and so that the reliability of the new audiogram can be assessed. Having information about hearing hazard exposure, hearing protector use, and related information available will allow the tester to make an accurate and timely report to the employee of the outcome of the evaluation as well as conduct the one-on-one training that is so important to hearing loss prevention program success.

Program Implementor Responsibilities

In most cases, hearing loss prevention program implementors will use a records system and associated forms that were developed by someone else, and must adapt their own procedures accordingly. The hearing loss prevention program implementor or operator must make sure that all information entered in the records is accurate, complete, legible, verifiable, and stated clearly so that the information does not need to be interpreted. If the operator discovers, while reviewing a record, that an employee's noise exposure level is not known, the measurements should be obtained and entered in the record. The same applies to other kinds of information. Also, there should be no blanks left in the form, since it is not possible to know whether a question did not apply or was overlooked. When blanks appear, they should be filled in or marked with NA for "not applicable" or INA for "information not available." Additional abbreviations should be avoided unless their meanings are clearly stated on the form in which they appear. Finally, original copies should always be available in an archive.

While management may provide the record keeping system and the necessary resources, the program implementors must ensure that the system works. The most important attributes of an effective record keeping system are standardization, maintenance, integration, and documentation. Standardization ensures commonality and consistency of data and format. Maintenance keeps records current and accurate. Integration of the recorded information allows the program implementor to assess the impact of the program on employees' hearing. Documentation of hearing loss prevention program elements permits analysis of long-range implications since cause-effect relationships associated with hazardous exposure levels only become evident over time.

Program implementors may wish to consider the following rule of thumb regarding how long records should be kept: Keep all records until you leave – then let the next person decide how long to keep the records. More practically, records should be kept for the length of employment plus 30 years, just as is standard practice with medical records. Thus, it is important for the program implementor to have resources for adequate records storage facilities be they computer-based or in hard copies.

Employee Responsibilities

Employee hearing loss prevention records should be available and accessible, especially at the time of regularly scheduled hearing tests. This is the ideal time for employees to check on the status of their hearing, and to pass along their comments on the hearing loss prevention program. Workers have a vested interest in the accuracy, validity, and accessibility of their hearing loss prevention and other medical records. Once they have been properly counseled, they should sign each audiogram to identify it as their own, and to signify that they are aware of any changes in hearing. They should also verify the accuracy of their medical history, any non-occupational noise and chemical-exposure history, and past and current personal or work-related information.

OSHA Requirements

Code of Federal Regulations, Title 19, Chapter XVII, Part 1910, Subpart G, 1910.95: section (m).

See checklist in Appendix A of this guidebook, items no. 42-49.
See checklist in Appendix B of this guidebook, section entitled "Monitoring Audiometry and Record Keeping."

Further Reading

Franks JR [1988] Management of hearing conservation data with microcomputers. In: Lipscomb DM, ed. Hearing Conservation in Industry, Schools, and the Military. Boston, MA: Little, Brown and Co., Chapter 9.

Gasaway DC [1985]. Using documentation to enhance monitoring efforts. In: Gasaway DC. Hearing Conservation: A Practical Manual and Guide. Englewood Cliffs, NJ: Prentice-Hall, Inc., Chapter 11.

PROGRAM EVALUATION

The primary goal of any hearing loss prevention program must be to reduce, and eventually to eliminate, hearing loss due to workplace exposures. While management may have the best intentions of implementing this goal and a company's hearing loss prevention program may have the appearance of being complete and complying with OSHA's requirements, the program may not achieve this goal. A thorough evaluation of the effectiveness of all of the program's components is necessary to determine the extent to which the hearing loss prevention program is really working.

Management and program implementors should conduct periodic program evaluations to assess compliance with federal and state regulations and to make sure hearing is being conserved. There are two basic approaches to follow in program evaluation: (1) assess the completeness and quality of the program's components, and (2) evaluate the audiometric data. The first approach can be implemented using checklists, such as those found in Appendices A and B. Appendix A can be used to assess compliance with each provision of OSHA's noise standard, and Appendix B is useful for identifying gaps in the program which could limit the program's effectiveness. Checklists such as these can serve as important tools in the evaluation process.

The second approach is to evaluate the results of audiometric tests, both for individuals and for groups of exposed employees. Each individual's current test should be compared to the baseline test to see if an OSHA standard threshold shift or NIOSH significant threshold shift[3] has occurred. Previous audiograms for that individual should be inspected also and compared to each other and to the current test results to identify hearing loss progressions that may not have reached the severity of the OSHA standard threshold shift.

Audiometric data for groups of noise-exposed employees should also be evaluated using criteria other than the OSHA standard threshold shift. This usually involves statistical procedures to assess variability in population hearing levels, and usually requires computerized audiometric data. A well protected exposed population will show the same hearing levels as a non-exposed population, when matched for age and other factors. Different manifestations of variability can provide information on the extent to which workers are losing their hearing, and can assist in pointing out the trouble spots in the hearing loss prevention program. For further information on audiometric database analysis, readers should consult the suggested readings at the end of this section.

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[3] OSHA's definition of a standard threshold shift is a change, relative to baseline, of 10 dB or more in the average hearing level at 2000, 3000, and 4000 Hz in either ear. NIOSH's definition of significant threshold shift is a 15 dB change at any of the frequencies 500, 1000, 2000, 3000, 4000, or 6000 Hz, demonstrated on a repeat audiogram for the same ear and same frequency, with the retest being administered immediately after the audiogram that showed the shift as compared to the baseline audiogram.

In addition, a working group of the American National Standards Institute has drafted guidelines for analyzing audiometric data to evaluate hearing loss prevention program effectiveness–ANSI S12.13, *Draft Standard for Evaluating the Effectiveness of Hearing Conservation Programs*. The procedures of this standard are most useful in determining that the audiometric data are consistent and lack much variability; that the database has integrity. If year-to-year audiograms show changes that are due to poor audiometry and not to changes in hearing, it will be impossible to use the audiometric data to determine whether or not the hearing loss prevention program is successful.

The reader is also referred to the chapter on Emerging Trends and Technologies for a discussion of the use of attitude surveys to assess the effectiveness of hearing loss prevention intervention strategies.

Management Responsibilities

Management needs to dedicate sufficient resources for a comprehensive program evaluation to the program implementor responsible for the hearing loss prevention program. Management should see that this individual is adequately trained to conduct hearing loss prevention programs and to analyze data. Management must ensure that periodic evaluations of the program actually take place.

Managers need to be committed to act on the outcome of the program evaluation. They must be willing to acknowledge and solve the problems which may require the dedication of both financial resources and personnel. They must also be willing to institute and carry out disciplinary measures for noncompliance. Another important responsibility of management is to be attentive to the comments and reactions of exposed employees and to make use of their feedback during the program evaluation.

Program Implementor Responsibilities

Program implementors must be willing to commit the time and resources needed to conduct a thorough evaluation. They need to be able to perform the mechanics of audiometric database analysis, or they must be willing to engage the assistance of an outside contractor or consultant. They should look for *early* threshold shifts, such as the NIOSH significant threshold shift, and not wait until the shift becomes as severe as an OSHA standard threshold shift.

Those who perform the program evaluation must be willing to ask questions, seek out elusive information, and interact with all members of the hearing loss prevention program team. For example, they may need to call for audiometric retests, make sure that recommendations for treatment or evaluation have been followed, and to assure that necessary changes in hearing protection have been implemented. They must communicate their findings to management and to the affected employees.

Employee Responsibilities

As with many other components of the hearing loss prevention program, the primary responsibility of employees is to provide feedback to the program implementor and to management. For effective program evaluation to take place employees need to communicate their hearing loss prevention problems, and explain why they are unwilling or unable to wear their hearing protectors. They need to make their needs known to higher management if they are unable to obtain replacement hearing protectors. Employees should notify the technician or audiologist if they have a problem understanding the instructions for taking the audiometric test, and they should report any medical problem that affects their hearing. Finally, they need to draw attention to changes in the noise levels produced by their equipment, or any malfunctioning noise control devices. Evaluation of the program, just like the conduct of the program, requires a team effort.

Further Reading

ANSI [1991] Draft Standard for the Evaluation of Hearing Conservation Program Effectiveness. New York, NY American National Standards Institute. ANSI S12.13

Melnick W [1984]. Evaluation of industrial hearing conservation programs: A review and analysis. American Industrial Hygiene Assoc. Journal, 45:459B467

Royster LH, Royster JD [1988] Getting started in audiometric database analysis. Seminars in Hearing 9: 325B337..

Royster JD, Royster LH [1986]. Audiometric database analysis. In: Berger EH, Ward WD, Morrill JC, Royster LH, eds. [1986] Noise and Hearing Conservation Manual. 4th ed. Akron, OH: American Industrial Hygiene Assoc., Chapter 9.

EMERGING TRENDS AND TECHNOLOGIES

The domain of hearing loss prevention embraces many technical disciplines: hearing science, audiology, industrial hygiene, occupational health, psychology, sociology, electroacoustics, and mechanical engineering, to name a few. Each of these is a dynamic specialty. Within any of these fields, what constituted "standard practice" only a few years ago is unlikely to be today's standard. It follows that today's standards will also evolve. Because hearing loss prevention represents the integration of many vibrant elements, it too, must change. Indeed, the fact that this guide has been revised only five years after its initial publication verifies this change. This section has been included to give the reader a preview of technologies or concepts that may influence future hearing loss prevention programs. It is not intended to serve as an exhaustive resource of emerging technologies, nor are any of the concepts discussed below even certain to affect hearing loss prevention. By highlighting a few concepts, the authors hope to dispel any notion that hearing loss prevention is a "mature" technology and to encourage the reader to anticipate and even participate in the evolution of this field.

Record Keeping and Audiometric Monitoring

The information explosion and the challenges associated with information management are being met by the introduction of advanced technologies. There is no doubt that the record keeping element of future hearing loss prevention programs will reflect the application of these technologies. The following discussion identifies just one example of a new technology and how its use can expand the reach of hearing loss prevention programs not only in terms of workers served but also with respect to the types of services provided.

Present approaches for storing and retrieving hearing loss prevention records work well in some, but not all situations. Many workers (e.g., construction workers) routinely move from job to job. Other workers may do part time work, work that is migratory in nature, or be self-employed. Traditional record management techniques may be impractical for these workers. Emerging information management hardware and software can provide solutions to the problems associated with managing the records of a mobile or itinerant workforce. In particular, optical card technology may be useful in developing hearing loss prevention programs that serve these workers.

About the size of a credit card, an optical card has a storage capacity of up to 6 megabytes (the equivalent of more than 2,400 pages of typewritten text). Each optical card can therefore accommodate all data fields and records pertinent to a worker's participation in a hearing loss prevention program. By comparison, the typical 3.5" floppy disk can store only 1.4 megabytes of data and a so-called smart card can hold only 256 kilobytes of data. Each optical card will be able to contain all records of occupational and non-occupational noise/solvent exposure histories, relevant medical histories, training records, protective equipment use histories, and related medical records from previous evaluations. Unlike a floppy disk, an optical card is small enough and sturdy enough to be carried in a wallet like a credit card. Also, the data stored on the optical

card enjoys a high degree of security. The worker controls access to the card through use of a personal identification number (PIN) in the same manner that access to a bank card is controlled. Because of its large storage capacity, the optical card can be formatted to provide multiple areas, each accessed by a different PIN.

Although optical card technology offers significant advances in storage capacity and data security, its most significant benefit may be its potential to facilitate the provision of audiometric monitoring services for a mobile or itinerant workforce such as construction and agricultural workers. Historically, such workers have, at best, had access to personal hearing protective devices. Perhaps a fortunate minority may have even received training in the use and care of their hearing protectors. They almost certainly would not have been served by an audiometric monitoring component of a hearing loss prevention program. By its very nature, audiometric monitoring is a longitudinal process. It is understandable that there would be little practical incentive to establish an audiometric monitoring program for a transient work force. Recall that current hearing loss prevention programs are site-based; all aspects of the program stay with the site. If a worker leaves, his/her audiometric and noise exposure records remain at the site. By contrast, an optical card will be in the possession of the worker. When the worker changes jobs, the worker will carry his/her "records" to the next job. The continuity of care for a worker would be assured whether s/he received hearing health services from one or many occupational health care providers. Such continuity of care would make it feasible to establish an audiometric baseline and monitor the hearing of a mobile or itinerant worker. Finally, optical card technology can enable the development of creative approaches in which either the worker or management or both adopt responsibility for procuring audiometric test services.

Another use for the optical card may be the storage of noise samples taken during exposure assessment efforts. The card can store an entire digitized noise sample, especially if appropriate data compression strategies are used. The card, built within a sound level meter, could be written to as noises are measured and then used for a variety of projects from exposure assessment for the individual worker to noise control engineering.

A Holistic Approach to Hearing Loss Prevention: Looking at Factors Other Than Noise

Occupational hearing loss prevention has focused almost entirely on the prevention of disorders due to noise exposure. Since noise has been one of the most widespread occupational hazards, this attention has been justifiable. Other factors may affect hearing or interact with noise.

Many environmental hazards are usually observed in work environments. Combined with other organizational and psychosocial stressors, they are potentially hazardous to health. It has been observed that a worker may be exposed to as many as nine concurrent hazards, and the average worker is exposed to 2 to 3 hazardous agents simultaneously. Even considering only chemicals, the number of agents used and possible combinations is substantial.

It may be inappropriate to restrict the term occupational hearing loss to a synonym for noise-induced hearing loss, even though the two terms previously have been used as such. Ototoxic properties have been identified among at least three classes of industrial chemicals: metals, solvents and asphyxiants. The indication that occupational chemicals could alter auditory function by either ototoxicity, neurotoxicity, or a combination of both processes, has serious implications. It is plausible to expect that if these chemicals were present in the workplace in sufficiently high concentrations, these could affect hearing despite the lack of occupational exposure to noise. It is important that those involved in hearing loss prevention take into account exposure to chemicals during the various phases of the process (monitoring for hazards, assessing hearing, controlling exposures).

Currently, ototoxic properties of industrial chemicals and interactions between them and noise have only been investigated for a very small number of substances. This poses an obstacle for the appraisal of risk. When specific ototoxicity information is not available on the chemical in question, the program implementor should then gather information on the agent's general toxicity, neurotoxicity and complaints from exposed populations. As the ototoxic properties of chemicals are more thoroughly explored, it may be advisable to derive new hearing damage risk criteria that address the risk associated with exposure to noise and/or chemicals.

Task-Based Exposure Assessment

For many workers, (e.g., those in the construction trades) an 8 hour time-weighted average (TWA) represents a complex mixture of events. While the TWA is an extremely useful metric, it may be of limited use in predicting the exposure of workers with frequently changing environments and/or who perform multiple tasks of variable duration. The Task-Based Exposure Assessment Model (T-BEAM) may prove useful in developing a rational approach for health and safety professionals who must deal with these types of noise exposures. The T-BEAM concept uses work tasks as the central organizing principle for collecting descriptive information on variables used to assess the hearing hazard for a worker. T-BEAM methods are also being developed not only to characterize hazardous noise, but also the hazards associated with occupational exposures to asbestos, lead, silica, and solvents.

To apply the T-BEAM process, the hazardous agent to be studied is first identified - in this case, noise. Next, "experts" (e.g., journeymen), who are familiar with the processes associated with a given occupation, develop a list of tasks associated with each process. This becomes the basis for a hazardous task inventory which may then be used in developing approaches for surveying the tasks. The results of the ensuing task surveys are then applied towards developing intervention strategies. As might be the case with traditional surveys, the results could be used to prioritize candidates for engineering controls as well as for assessing tasks where engineering controls have already been applied. Because a T-BEAM survey is focused on tasks instead of shifts or areas, the survey results can be used to protect workers from hazards associated with specific tasks. Consider the case of a worker who frequently changes job sites and whose main noise exposure comes from the intermittent use of power tools or machinery. Assume the worker's equipment produces a 100-dB(A) noise level. Under present OSHA guidelines, a two-hour cumulative

exposure would equate to a 100% dose. Continuing with this example, assume that some days the worker uses this equipment for two hours or more. A hazard survey conducted on such days would identify this worker for inclusion in a hearing loss prevention program. A hazard survey conducted on other days might not. In situations such as these, the task rather than the shift should be the focus of intervention strategies.

This approach is conceptually analogous to how other intermittent noise exposures are addressed. A police officer may only be exposed to hazardous noise in the course of periodic weapons training. Nevertheless, during weapons training the officer is provided hearing protectors, instructed in their proper use and may well be enrolled in an audiometric monitoring program. Many manufacturing operations require persons walking through hazardous noise areas to wear hearing protectors. The point is, a singular focus on the time-weighted average should not be the sole basis for decisions regarding hearing loss prevention measures. Workers engaged in tasks in which they are routinely exposed to hazardous noise or ototoxic agents should be included in hearing loss prevention activities.

The above examples point to the need for an alternate method for use in situations where current dosimetry or area monitoring may not identify workers exposed to hazardous noise. Current studies are assessing approaches for developing hazardous task inventories for individual occupations and crafts within the construction industry. To be effective, a hazardous task inventory must classify distinctive tasks, should quantify time-to-task parameters, and be able to account for the effects of adjacent noise. If research demonstrates T-BEAM methods are effective, hazardous task inventory's can be used to establish databases representing the occupational hazards associated with many trades. Such databases would enable one to characterize a worker's exposure profile without requiring an individual hazard assessment survey. Although, at least for noise, the exposure profile may not be able to predict the specific exposure for an individual worker, it still may be possible to categorize a worker as having no risk, having some risk, or having substantial risk of hazardous noise exposure. Such categorization could be used to select an efficient intervention strategy based on and tailored to the degree of risk predicted for the worker.

New Directions in Theories About Self-Protective Behavior

With a wealth of research and published information available to guide the development of effective hearing loss prevention programs, why do some workers in apparently quality programs simply fail to protect themselves? In the past, popular models of health behavior such as the Health Belief Model and the Theory of Reasoned Action have tried to explain this phenomenon by tending to emphasize characteristics and beliefs of the individual worker. For example, a particular worker might hold attitudes or beliefs that conflict with the tenets of the safety program, e.g., "I'm not susceptible to noise-induced hearing loss, so why bother with protectors" or "Protectors interfere with warning signals...better to be deaf than dead!" While still useful as integral parts of newer models, these person-centered models have not adequately addressed many other factors now known to contribute to safe work behavior.

Newer models of health behavior currently under development stress interdisciplinary viewpoints and may contain parameters that focus on the interaction of environmental, psychological, and social determinants of behavior. Social aspects such as shared values and beliefs, the social relationship in which a specific behavior occurs, and the physical context of the behavior have taken on new importance. In particular, the issue of "safety climate" in the workplace is receiving renewed interest. Safety climate can be broadly defined as the general level of safety awareness and commitment among management and workers in the organization. The safety climate guides relevant behavior in the workplace by serving as a central point of reference for decision-making by workers and management about safety concerns. While the construct of safety climate is still somewhat ambiguous, it is anticipated that current research will successfully define the relevant factors that determine safety climate and influence workplace behavior.

One recent report has attempted to incorporate safety climate into a model of employee adherence to safety precautions. In this model, organizational safety climate depends upon such factors as explicit company safety policies and organizational attitudes and responses toward safety concerns. Worker characteristics (such as knowledge about health risks), availability of personal protective equipment in the work area, provision of employee feedback with respect to adherence to the safety program, and the social and physical environment of the workplace also contribute to worker adherence to safety practices.

In a study of medical personnel and adherence to universal precautions (to protect against HIV transmission), it was noted that providing extensive knowledge-based training and adequate supplies of personal protective equipment *was not enough* to lead to greater adherence to universal precautions (DeJoy, et al., 1995). Maximal adherence depended upon establishing an organizational safety climate, embraced by the workers as well as management, that supported and fostered strict adherence to safety precautions. Such a climate develops when management and workers take ownership for their safety program, and thereby facilitate and reinforce its provisions. Many prior studies designed around the health belief/promotion models have noted that perceived barriers or job hindrances have a strong influence on worker adherence to safety rules. In this new model, it was reported that "Job hindrances was the strongest predictor of adherence to universal precautions, and safety climate was the best predictor of job hindrances."

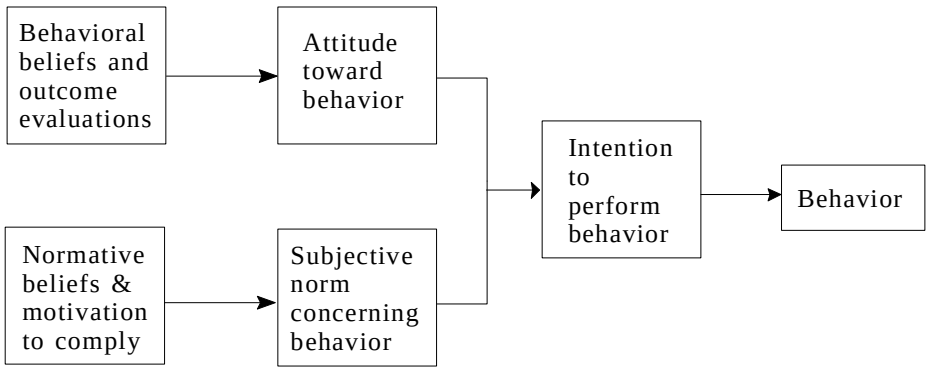
Most hearing loss prevention professionals agree that passive protection of workers from hearing loss by applying engineering controls to diminish hazards in the workplace is a preferred approach. However, in many occupational settings, protecting the workforce from hearing loss and other occupational hazards ultimately depends upon personal protective equipment (e.g., personal hearing protectors) and the voluntary actions of the hazard-exposed workers. Training programs for these workers will continue to be very important, but the expanding research findings suggest that such programs may need to include more than factual presentations about mechanisms involved in hearing loss and how to properly wear personal protective equipment. Training programs in the future may increasingly concentrate on 1) modifying the organizational climate, and 2) providing workers with the skills and strategies they need to take responsibility for managing their own health by collectively uncovering and reducing barriers to safe work behavior.

Use of Survey Tools to Evaluate Hearing Loss Prevention Program Effectiveness

The Health Promotion Model states that one's behavior concerning health risk is the direct result of one's beliefs about the risk. One's actions to avoid a health risk are strongly related to (1) how firmly one believes he or she will benefit from the steps taken to protect oneself (i.e., how effective the protective measures are believed to be), (2) the amount of control one has over one's health, and (3) one's beliefs regarding the barriers to adopting protective behaviors. The Health Belief Model subscribes to these principles and also considers one's perceptions of susceptibility, (i.e., belief about one's vulnerability or risk of personal harm), "seriousness"of the health threat, and the consequences of inaction when predicting behavior to avoid a health risk.

The Theory of Reasoned Action attempts to predict behavior by understanding an individual's beliefs and attitudes towards the behavior in question. It is believed that these elements in concert

Theory of Reasoned Action



with motivational and normative factors contribute to a person's intention to perform a certain behavior. The intention to perform a certain behavior in turn, corresponds directly with the behavior. The figure above diagrams the relationships between each of these elements.

These theories of health behavior are being applied towards methods for assessing the effectiveness of hearing loss prevention programs. The conventional methods for assessing the effectiveness of a hearing loss prevention program rely primarily on audiometric data to determine whether year-to-year variability or incidence of significant threshold shift has exceeded a criterion value. While this approach will yield crucial information, it is not without its limitations. In particular, it requires substantial passage of time in order to accumulate sufficient audiometric data to make the necessary appraisals. Alternative approaches are examining the use of self-administered surveys to assess workers' pre- and post-intervention beliefs, attitudes and

behavioral intentions toward protecting themselves from occupational noise-induced hearing loss. Such approaches assume that once given adequate knowledge and resources a correlation exists between attitudes regarding hearing loss prevention, intentions to act in ways that will prevent hearing loss, and actual behavior to prevent hearing loss. This assumption draws upon the Theory of Reasoned Action: i.e., behavior can be predicted by surveying attitudes and intentions. It also draws upon the Health Promotion Model and Health Beliefs Model: use of hearing protectors can be predicted by surveying workers' beliefs about (1) their ability to prevent hearing loss, (2) their evaluation of hearing loss as a threat, (3) their susceptibility to hearing loss, and (4) their ability to overcome barriers to hearing protector use.

Current research is studying the value of behavioral survey tools as resources for assessing the effectiveness of hearing loss prevention programs. If survey tools can successfully predict the behaviors of interest, they would offer the distinct advantage of enabling a comparison of worker convictions before and after intervention without requiring the substantial passage of time that accompanies an audiometric monitoring process. In addition, they could be directly applied in developing training and education programs that address worker's beliefs, attitudes and intentions regarding hearing loss prevention. This should enhance the efficiency and effectiveness of training/education.

Further Reading

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APPENDIX A

OSHA NOISE STANDARD COMPLIANCE CHECKLIST*

PURPOSE

This checklist summarizes the OSHA noise standard. It is intended to assist companies conducting hearing loss prevention program evaluations to assess compliance with OSHA requirements and to determine program effectiveness. **It is not intended to be used as a substitute for the OSHA Standard**. Items listed under "comments" represent current NIOSH recommendations that differ from the OSHA Standard.

REFERENCE

Refer to OSHA Standard 29 CFR 1910.95(a)-(p) with accompanying appendices A-I, Occupational Noise Exposure Standard for the standard's specific requirements: Code of Federal Regulations, Title 29, Chapter XVII, Part 1910, Subpart G. (See also 36 FR 10466 and 10518, May 29, 1971; Amended 46 FR 4078-4179, Jan. 16, 1981; Revised 48 FR 9776-9785, Mar. 8, 1983).

No.	29 CFR 1910.95 Requirement	Paragraph No.	NIOSH Recommendation
	PROTECTION AGAINST NOISE		
1	Must be provided when sound levels exceed 90-dBA time-weighted average measured with slow response and 5 dB exchange rate	(a)	Must be provided when sound levels exceed *85-dBA TWA with a 3 dB exchange rate.*
	CONTROLS		
2	Feasible engineering or administrative controls for employees exceeding TWA 90 dBA	(b)(1)	*Feasible engineering or administrative controls for employees exceeding 85 dBL_{eqA}*
3	Impulse or impact noise should not exceed 140 dB peak sound pressure level	(b)(2)	
	PROGRAM		
4	Include employees whose noise exposures exceed 85 dB TWA with 5-dB exchange rate	(c)(1) (c)(2)	85 dBL_{Aeg} (3-dB exchange rate)
	MONITORING		
5	Conduct noise monitoring when 85-dBA TWA equaled or exceeded with 5 dB exchange rate	(d)(1)	Conduct noise monitoring when 85-dBA TWA equaled or exceeded with *3 dB exchange rate*

No.	29 CFR 1910.95 Requirement	Paragraph No.	NIOSH Recommendation
6	Use representative personal monitoring for highly mobile workers, significantly varying sound levels, and impulse noise exposure	(d)(1)(ii)	
7	Include all continuous, intermittent, and impulsive sound levels from 80-130 dBA in measurements	(d)(2)(I)	
8	Calibrate equipment	(d)(2)(ii)	
9	Repeat monitoring when noise exposure increases significantly	(d)(3)	
	EMPLOYEE NOTIFICATION		
10	Notify employees of noise monitoring results when exposure is at or above 85 dBA TWA with 5 dB exchange rate	(e)	*3 dB exchange rate*
	OBSERVATION OF MONITORING		
11	Employees or their representatives may observe noise monitoring	(f)	
	AUDIOMETRIC TEST PROGRAM		
12	Audiometric testing *available* to employees exposed at or above 85 dBA TWA	(g)(1)	Testing *required*.
13	Tests performed by professional or by competent technician *(certification recommended)*	(g)(3)	Use of *micro-processor* audiometers does not *exempt* technician from certification
14	Audiograms meet 1910.95 Appendix C requirements	(g)(4)	
	BASELINE AUDIOGRAM		
15	Establish within 6 months or within *l year* if using mobile van	(g)(5)(I)(ii)	W/in 30 days of enrollment in hearing loss prevention program.
16	14 hour-period without workplace noise before baseline (hearing protection *can* be substituted)	(g)(5)(iv)	Hearing protection *cannot* be substituted
17	Notify employees to avoid high non-occupational noise levels before baseline	(g)(5)(iv)	

No.	29 CFR 1910.95 Requirement	Paragraph No.	NIOSH Recommendation
	ANNUAL AUDIOGRAM		
18	Provide for all employees exposed at or above 85 dBA TWA with 5 dB exchange rage	(g)(6)	Provide for all employees exposed at or above 85 dBA TWA with 3 dB exchange rate
	AUDIOGRAM EVALUATION		
19	Compare each annual test to baseline for validity and to see if standard threshold shift (STS) exists (10 dB average at 2000, 3000, and 4000 Hz)	(g)(7)(I)	Hearing Loss Prevention Program effectiveness indicated by no more than 5% of workers showing significant threshold shift (15 dB twice, same ear, same frequency)
20	If STS, retest within *30 days (optional)*	(g)(7)(ii)	*Immediate* re-test; if retest the same, schedule for 30-day confirmation audiogram
21	Audiologist, otolaryngologist, or physician reviews problem audiograms and determines need for further evaluation	(g)(7)(iii)	
	FOLLOW-UP		
22	Notify employees with STS in writing within *21 days*	(g)(8)(I)	*Immediat*e notification
23	Actions to be taken (unless physician determines that STS is not work-related): Provide employees with hearing protectors (if not already wearing), train in care and use, and require them to be worn º Refit and retrain employees already using protectors º Refer as necessary for clinical evaluations or additional testing º Inform employees with non-work related ear problems of need for otologic exam	(g)(8)(ii)	All employees exposed to 85 dB TWA with 3 dB exchange rate use hearing protection
	REVISION OF BASELINE		
24	Annual audiogram may become baseline as per OSHA criteria	(g)(9)	

No.	29 CFR 1910.95 Requirement	Paragraph No.	NIOSH Recommendation
	STANDARD THRESHOLD SHIFT		
25	Definition - change relative to baseline of *10 dB or more in average* hearing level at 2000,3000, and 4000 Hz, either ear. Allowance for aging *optional* - Appendix F	(g)(10)	A shift of *15 dB* or more at .500, 1000, 2000, 3000, 4000, or 6000 Hz in either ear; and the same shift at the same test frequency in the same ear on an immediate retest. No correction allowance for aging
	AUDIOMETRIC TEST REQUIREMENTS		
26	Each ear tested at frequencies of 500, 1000, 2000, 3000, 4000, and 6000 Hz	(h)(1)	Test also at *8000 Hz*
27	Audiometers meet ANSI S3.6-*1969*	(h)(2)	ANSI S3.6-1996.
28	Pulsed-tone and self-recording audiometers meet Appendix C requirements	(h)(3)	ANSI S3.6-1996
29	Test rooms meet *Appendix D* requirements	(h)(4)	Test rooms meet specifications of ANSI S3.1-1989
30	Audiometer calibration includes: º Functional checks before each day's use º Acoustical check annually according to Appendix E º Exhaustive calibration every 2 years	(h)(5)	.
	HEARING PROTECTORS		
31	*Available* to all employees exposed at or above 85 dBA TWA and replaced as necessary	(I)(1)	*Worn* at 85 dBA and above regardless of exposure time
32	Worn by employees when: º Exposed to 90 dBA TWA or above º Exposed to 85 dBA TWA or above when - no baseline after 6 months, or - STS occurs	(I)(2)	
33	Employees select from a variety of suitable hearing protectors	(I)(3)	
34	Employees trained in care and use	(I)(4)	
35	Employer ensures proper initial fitting and supervises correct use	(I)(5)	

No.	29 CFR 1910.95 Requirement	Paragraph No.	NIOSH Recommendation
	HEARING PROTECTOR ATTENUATION		
36	Evaluate attenuation for specific noise environments according to *Appendix B*	(j)(1)	Derate the NRR by 25% for earmuffs, 50%, for formable slow-recovery foam earplugs and & 75% for all other earplugs
37	Attenuate to at least *90 dBA*, or 85 dBA if STS experienced	(j)(2) (j)(3)	Attenuate to *85 dBA*
38	Re-evaluate attenuation as necessary	(j)(4)	
	TRAINING PROGRAM		
39	Provide training to employees exposed to 85 dBA TWA or above	(k)(1)	
40	Repeat annually and update materials	(k)(2)	
41	Training includes: º Effects of noise on hearing º Purpose of hearing protectors, advantages, disadvantages, attenuation; instructions on selection, fit, use, and care º Purpose and procedures of audiometric testing	(k)(3)	
	ACCESS		
42	Copies of OSHA standard available to employees or their representatives and posted in workplace	(l)(1)	
43	Information provided by OSHA available to employees	(l)(2)	
44	All records provided on request to employees, former employees, representatives, and OSHA	(m)(4)	
	RECORD KEEPING		
45	Maintain accurate records of noise exposure measurements	(m)(1)	

No.	29 CFR 1910.95 Requirement	Paragraph No.	NIOSH Recommendation
46	Maintain audiometric records with the following information: º Employee name and job classification º Date of audiogram º Examiner's name º Date of last acoustic or exhaustive calibration º Employee's most recent noise exposure assessment º Background noise levels in audio test rooms	(m)(2)	
47	Retain all noise exposure records for at least 2 years	(m)(3) (I)	
48	Retain all audiometric test records at least for duration of employment	(m)(3) (ii)	Retain all audiometric test records at least for duration of employment *plus 30 years*
49	Transfer all records to successor employer	(m)(5)	
	MANDATORY OSHA APPENDICES		
50	*Noise Exposure Computation*	Appen. A	*85 dBA 3 dB exchange*
51	Methods for Estimating the Adequacy of Hearing Protector Attenuation	Appen. B	*Derated NRR*
52	Audiometric Measuring Instruments	Appen. C	
53	Audiometric Test Rooms	Appen. D	Type 1 SLMs in accordance with ANSI S3.1-1991, Type 2 SLMs designed since 1989 may be substituted in most cases. Test room background noise levels must be equal to or less than ears-covered levels of ANSI S3.1-1991
54	Acoustic Calibration of Audiometers	Appen. E	

No.	29 CFR 1910.95 Requirement	Paragraph No.	NIOSH Recommendation
	NON-MANDATORY OSHA APPENDICES		
55	Calculations and Application of Age Corrections to Audiograms	Appen. F	*No* age correction for calculating STS
56	Monitoring Noise Levels	Appen. G	
57	Availability of Referenced Documents	Appen. H	
58	Definitions	Appen. I	

* Much of this material as been adapted from Gasaway, D. C. Evaluating and fine-tuning the elements that comprise a program. Chapter 15 in D. C. Gasaway, Hearing Conservation: A Practical Manual and Guide, Prentice Hall, Inc.: Englewood Cliffs, N.J., 1985.

APPENDIX B

PROGRAM EVALUATION CHECKLIST

Training and Education

Failures or deficiencies in hearing conservation programs (hearing loss prevention programs) can often be traced to inadequacies in the training and education of noise-exposed employees and those who conduct elements of the program.

1. Has training been conducted at least once a year?

2. Was the training provided by a qualified instructor?

3. Was the success of each training program evaluated?

4. Is the content revised periodically?

5. Are managers and supervisors directly involved?

6. Are posters, regulations, handouts, and employee newsletters used as supplements?

7. Are personal counseling sessions conducted for employees having problems with hearing protection devices or showing hearing threshold shifts?

Supervisor Involvement

Data indicate that employees who refuse to wear hearing protectors or who fail to show up for hearing tests frequently work for supervisors who are not totally committed to the hearing loss prevention programs.

1. Have supervisors been provided with the knowledge required to supervise the use and care of hearing protectors by subordinates?

2. Do supervisors wear hearing protectors in appropriate areas?

3. Have supervisors been counseled when employees resist wearing protectors or fail to show up for hearing tests?

4. Are disciplinary actions enforced when employees repeatedly refuse to wear hearing protectors?

Noise Measurement

For noise measurements to be useful, they need to be related to noise exposure risks or the prioritization of noise control efforts, rather than merely filed away. In addition, the results need to be communicated to the appropriate personnel, especially when follow-up actions are required.

1. Were the essential/critical noise studies performed?

2. Was the purpose of each noise study clearly stated? Have noise-exposed employees been notified of their exposures and apprised of auditory risks?

3. Are the results routinely transmitted to supervisors and other key individuals?

4. Are results entered into health/medical records of noise exposed employees?

5. Are results entered into shop folders?

6. If noise maps exist, are they used by the proper staff?

7. Are noise measurement results considered when contemplating procurement of new equipment? Modifying the facility? Relocating employees?

8. Have there been changes in areas, equipment, or processes that have altered noise exposure? Have follow-up noise measurements been conducted?

9. Are appropriate steps taken to include (or exclude) employees in the hearing loss prevention programs whose exposures have changed significantly?

Engineering and Administrative Controls

Controlling noise by engineering and administrative methods is often the most effective means of reducing or eliminating the hazard. In some cases engineering controls will remove requirements for other components of the program, such as audiometric testing and the use of hearing protectors.

1. Have noise control needs been prioritized?

2. Has the cost-effectiveness of various options been addressed?

3. Are employees and supervisors apprised of plans for noise control measures? Are they consulted on various approaches?

4. Will in-house resources or outside consultants perform the work?

5. Have employees and supervisors been counseled on the operation and maintenance of noise control devices?

6. Are noise control projects monitored to ensure timely completion?

7. Has the full potential for administrative controls been evaluated? Are noisy processes conducted during shifts with fewer employees? Do employees have sound-treated lunch or break areas?

Monitoring Audiometry and Record Keeping

The skills of audiometric technicians, the status of the audiometer, and the quality of audiometric test records are crucial to hearing loss prevention program success. Useful information may be ascertained from the audiometric records as well as from those who actually administer the tests.

1. Has the audiometric technician been adequately trained, certified, and recertified as necessary?

2. Do on-the-job observations of the technicians indicate that they perform a thorough and valid audiometric test, instruct and consult the employee effectively, and keep appropriate records?

3. Are records complete?

4. Are follow-up actions documented?

5. Are hearing threshold levels reasonably consistent from test to test? If not, are the reasons for inconsistencies investigated promptly?

6. Are the annual test results compared to baseline to identify the presence of an OSHA standard threshold shift?

7. Is the annual incidence of standard threshold shift greater than a few percent? If so, are problem areas pinpointed and remedial steps taken?

8. Are audiometric trends (deteriorations) being identified, both in individuals and in groups of employees? (NIOSH recommends no more than 5% of workers showing 15 dB Significant Threshold Shift, same ear, same frequency.)

9. Do records show that appropriate audiometer calibration procedures have been followed?

10. Is there documentation showing that the background sound levels in the audiometer room were low enough to permit valid testing?

11. Are the results of audiometric tests being communicated to supervisors and managers as well as to employees?

12. Has corrective action been taken if the rate of no-shows for audiometric test appointments is more than about 5%?

13. Are employees incurring STS notified in writing within at least 21 days? (NIOSH recommends immediate notification if retest shows 15 dB Significant Threshold Shift, same ear, same frequency.)

Referrals

Referrals to outside sources for consultation or treatment are sometimes in order, but they can be an expensive element of the hearing loss prevention program, and should not be undertaken unnecessarily.

1. Are referral procedures clearly specified?

2. Have letters of agreement between the company and consulting physicians or audiologists been executed?

3. Have mechanisms been established to ensure that employees needing evaluation or treatment actually receive the service (i.e., transportation, scheduling, reminders)?

4. Are records properly transmitted to the physician or audiologist, and back to the company?

5. If medical treatment is recommended, does the employee understand the condition requiring treatment, the recommendation, and methods of obtaining such treatment?

6. Are employees being referred unnecessarily?

Hearing Protection Devices

When noise control measures are infeasible, or until such time as they are installed, hearing protection devices are the only way to prevent hazardous levels of noise from damaging the inner ear. Making sure that these devices are worn effectively requires continuous attention on the part of supervisors and program implementors as well as noise-exposed employees.

1. Have hearing protectors been made available to all employees whose daily average noise exposures are 85 dBA or above? (NIOSH recommends requiring HPD use if noises equal or exceed 85 dBA regardless of exposure time.)

2. Are employees given the opportunity to select from a variety of appropriate protectors?

3. Are employees fitted carefully with special attention to comfort?

4. Are employees thoroughly trained, not only initially but at least once a year?

5. Are the protectors checked regularly for wear or defects, and replaced immediately if necessary?

6. If employees use disposable hearing protectors, are replacements readily available?

7. Do employees understand the appropriate hygiene requirements?

8. Have any employees developed ear infections or irritations associated with the use of hearing protectors? Are there any employees who are unable to wear these devices because of medical conditions? Have these conditions been treated promptly and successfully?

9. Have alternative types of hearing protectors been considered when problems with current devices are experienced?

10. Do employees who incur noise-induced hearing loss receive intensive counseling?

11. Are those who fit and supervise the wearing of hearing protectors competent to deal with the many problems that can occur?

12. Do workers complain that protectors interfere with their ability to do their jobs? Do they interfere with spoken instructions or warning signals? Are these complaints followed promptly with counseling, noise control, or other measures?

13. Are employees encouraged to take their hearing protectors home if they engage in noisy non-occupational activities?

14. Are new types of or potentially more effective protectors considered as they become available?

15. Is the effectiveness of the hearing protector program evaluated regularly?

16. Have at-the-ear protection levels been evaluated to ensure that either over or under protection has been adequately balanced according to the anticipated ambient noise levels?

17. Is each hearing protector user required to demonstrate that he or she understands how to use and care for the protector? The results documented?

Administrative

Keeping organized and current on administrative matters will help the program run smoothly.

1. Have there been any changes in federal or state regulations? Have hearing loss prevention program's policies been modified to reflect these changes?

2. Are copies of company policies and guidelines regarding the hearing loss prevention program available in the offices that support the various program elements? Are those who implement the program elements aware of these policies? Do they comply?

3. Are necessary materials and supplies being ordered with a minimum of delay?

4. Are procurement officers overriding the hearing loss prevention program implementor's requests for specific hearing protectors or other hearing loss prevention equipment? If so, have corrective steps been taken?

5. Is the performance of key personnel evaluated periodically? If such performance is found to be less than acceptable, are steps taken to correct the situation?

6. Safety: Has the failure to hear warning shouts or alarms been tied to any accidents or injuries? If so, have remedial steps been taken?

APPENDIX C

AUDIOVISUAL MATERIALS

The following list of films, computer software and videotapes concerned with occupational noise and hearing loss prevention is arranged in alphabetical order by producer or distributor. It is an updated summary of information from several sources, including E.H. Berger's Appendix II: "Annotated Listing of Noise and Hearing Conservation Films and Videotapes" in E.H. Berger, W.D. Ward, J.C. Morrill, and L.H. Royster (Eds.): Noise and Hearing Conservation Manual, 4th ed., American Industrial Hygiene Assoc., Akron, OH, 1986. This list is current as of May, 1995.

This list does not contain ratings or annotations, and the presence or absence of any film or videotape does not reflect the endorsement or judgement of the National Institute for Occupational Safety and Health.

Better Hearing Institute (800) 327-9355
5021-B Backlick Road
Annadale, VA 22003

"People vs. Noise" 27 min VHS

Bilsom International, Inc. (813) 683-9164
5300 Region Court
Lakeland, FL 33801

"SOS" 10 min VHS

BNA Communications (301) 948-0540
9439 Key West Ave.
Rockville, MD 20850

"Can You Hear Me?" 14 min VHS, Beta, 16mm

Cabot Safety Corporation (800) 225-9038
5457 W. 79th Street
Indianapolis, IN 46268-9998

"It's Up To You" 12 min VHS
"Less Than A Minute" 6 min VHS
"How to Use Expandable Foam Earplugs" 6 min VHS

"The National Hearing Quiz" 28 min VHS

Colorado Hearing and Speech Center (303) 322-1871
Industrial Division
4280 Hale Parkway
Denver, CO 80220

"Stick It In Your Ear" 15 min VHS or film

Consulting Audiological Associates (312) 804-0550
1915 N. Harlem Ave.
Chicago, IL 60635

"Industrial Hearing Conservation Employee Program" 22 min VHS

Creative Media Development, Inc. (503) 223-6794
710 S.W. Ninth Ave
Portland, OR 97205

"Hear For A Lifetime" 16 min VHS or U-matic

Educational Resources, Inc. (800) 333-8822
P.O. Box 1257
Lexington, SC 29071-1257

"Noise? You're in Control" 14 min VHS, Beta, U-matic

Encyclopedia Britannica Education Corporation (312) 347-7000
310 S. Michigan Avenue (800) 621-3900
Chicago, IL 60604

"The Ears and Hearing" 22 min VHS
"Noise Polluting the Environment" 16 min VHS

Industrial Training Systems Corp. (800) 568-8788
1303 Marsh Lane
Carrollton, TX 75006

"Sound Advice" 17 min VHS
"Hear Today, Gone Tomorrow" 12 min VHS
"Noise-Induced Hearing Loss: No Second Chance" 17 min VHS
"Hearing Conservation" 6 min VHS
"Mentor/Computer Assisted Training" IBM PC 5-1/4" or 3-1/2"

Interactive Media Communications, Inc. (617) 890-7707
100 5th Avenue
Waltham, MA 02154

"Hearing Conservation Training Program" 23 min VHS
"Hearing Conservation Interactive Computer Training Program" CD-ROM and IBD (Laser Disk)

International Film Bureau, Inc (312) 427-4545
332 S. Michigan Avenue
Chicago, IL 60604

"Listen While You Can" 21 min VHS and 16 mm
"Hearing Conservation" 22 min VHS and 16 mm
"Noise" 22 min VHS and 16 mm
"The Noise Was Deafening" 21 min VHS and 16 mm
"I Can't Hear" 21 min VHS and 16 mm
"Protecting Your Hearing in a Noisy World" 14 min VHS and 16 mm
"Hearing Conservation and Safety" 13 min VHS

The Marcom Group Ltd. (800) 654-2448
4 Denny Road
Wilmington, DE 19809

"Hearing Conservation and Safety" 15 min VHS
"Now Hear This" 15 min VHS

Media Resources, Inc. (800) 666-0106
2614 Fort Vancouver Way (206) 693-3344
Vancouver, WA 98661-3997

"Hearing Protection" 19 min VHS

Mine Safety Appliances Co. (800) 672-2222
121 Gamma Drive
Pittsburgh, PA 15238

"Now Hear This" 15 min VHS

University of Toronto (416) 978-8720
IMS Creative Communications
Faculty of Medicine
1 Kings College Circle
Toronto, Ontario, CANADA M5S 1A8

"Let's Hear It" 28 min VHS, film, U-matic

APPENDIX D

SUGGESTED READING

Ajzen I, Fishbein M [1980]. Understanding Attitudes and Predicting Behavior. Englewood Cliffs, NJ: Prentice Hall.

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APPENDIX E

RESOURCES

Government Agencies

NIOSH

Education and Information Division
National Institute for Occupational
Safety and Health
4676 Columbia Parkway
Cincinnati, OH 45226-1998
1-800-35-NIOSH (1-800356-4674)
http://www.cdc.gov/niosh/homepage.html

Information about a wide range of occupational health and safety problems, and requests for health hazard evaluations

OSHA

Office of Information and Public Affairs
Occupational Safety and Health Administration
U.S. Department of Labor
200 Constitution Ave. N.W.
Washington, DC 20210
(202) 219-7334
http://www.osha.gov/

Technical assistance with occupational health and safety problems, and for information about complying with OSHA regulations

Current lists of the On-Site Consultation Project Directory may be requested to obtain free consultations.

OSHA Regional Offices

Region I - Boston (Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont)

U.S. Dept. Labor - OSHA
133 Portland St., 1st Floor
Boston, MA 02114
(617) 565-7164

Region II - New York City (New Jersey, New York, and Puerto Rico)

U.S. Dept. Labor - OSHA
201 Varick St., Room 670
New York, NY 10014
(212) 337-2326

Region III - Philadelphia (Delaware, District of Columbia, Maryland, Pennsylvania, Virginia, and West Virginia)

U.S. Dept. Labor -OSHA
Gateway Building, Suite 2100
3535 Market Street
Philadelphia, PA 19104
(215) 596-1201

Region IV - Atlanta (Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, and Tennessee)

U.S. Dept. Labor - OSHA
1375 Peachtree St. N.E., Suite 587
Atlanta, GA 30367
(404) 347-3573

Region V - Chicago (Illinois, Indiana, Michigan, Minnesota, Ohio, and Wisconsin)

U.S. Dept. Labor - OSHA
32nd Floor, Room 3244
230 So. Dearborn St.
Chicago, IL 60604
(312) 353-2220

Region VI - Dallas (Arkansas, Louisiana, New Mexico, Oklahoma, and Texas)

U.S. Dept. Labor - OSHA
525 Griffin St., Room 602
Dallas, TX 75202
(214) 767-4731

Region VII - Kansas City (Iowa, Kansas, Missouri, and Nebraska)

U.S. Dept. Labor - OSHA
1100 Main Suite 800
Kansas City, MO 64105
(816) 426-5861

Region VIII - Denver (Colorado, Montana, North Dakota, South Dakota, Utah, and Wyoming)

U.S. Dept. Labor - OSHA
1999 Broadway Suite 1960
Denver, CO 80202
(303) 391-5858

Region IX - San Francisco (American Samoa, Arizona, California, Guam, Hawaii, Nevada, Trust Territory of the Pacific Islands)

U.S. Dept. Labor - OSHA
71 Stevenson St., Suite 420
San Francisco, CA 94105
(415) 744-6670

Region X - Seattle (Alaska, Idaho, Oregon, and Washington)

U.S. Dept. Labor - OSHA
1111 3rd Avenue Suite 715
Seattle, WA 98101-3212
(206) 442-5930

Professional Associations

º American Industrial Hygiene Assoc. 2700 Prosperity Ave., Suite 250 Fairfax, VA 22031 (703)849-8888	Books and manuals on occupational subjects, list of consultants in all areas of industrial hygiene, including noise
º American Speech-Language-Hearing Assoc. 10801 Rockville Pike Rockville, MD 20852 (301)897-5700	Information on the availability of audiologists who provide industrial audiology services

º Council for Accreditation in Occupational Hearing Conservation 611 East Wells St. Milwaukee, WI 53202 (414) 276-5338	Information on certification programs for occupational hearing conservationists (technicians), and the availability of accredited training courses
º National Council of Acoustical Consultants 66 Morris Ave. Suite 1A Springfield, NJ 07081 (201) 564-5859	Directory of acoustical consultants including specialists in noise control engineering
º National Hearing Conservation Association 611 East Wells St. Milwaukee, WI 53202 (414) 276-5338	Directory of hearing conservation service providers located throughout the nation; only professional organization that advocates solely for the prevention of occupational hearing loss
º National Safety Council 1121 Spring Lake Drive Itaska, IL 60143-3201 (800) 621-7615 (708) 285-1315	Films and publications relating to noise control and hearing conservation, and for general safety and industrial hygiene information

APPENDIX F

TERMS COMMON TO HEARING LOSS PREVENTION

There are many terms common to hearing loss prevention that are used in this document, books, and journal articles. The reader should find the definitions in this section to be helpful. These definitions, while accurate, were written in as non-technical a fashion as possible.

ACOUSTIC TRAUMA	A single incident which produces an abrupt hearing loss. Welding sparks (to the eardrum), blows to the head, and blast noise are examples of events capable of producing acoustic trauma. (See also ototoxic and ototraumatic.)
ACTION LEVEL	The sound level which when reached or exceeded necessitates implementation of activities to reduce the risk of noise-induced hearing loss. OSHA currently uses an 8-hour time weighted average of 85 dBA as the criterion for implementing an effective hearing conservation program.
ATTENUATION: Real Ear Attenuation at Threshold (REAT)	A standardized procedure for conducting psychoacoustic tests on human subjects designed to measure sound protection features of hearing protective devices. Typically, these measures are obtained in a calibrated sound field, and represent the difference between subjects' hearing thresholds when wearing a hearing protector vs when not wearing the protector.
ATTENUATION: Real-World	Estimated sound protection provided by hearing protective devices as worn in "real-world" environments.
BASELINE AUDIOGRAM	A valid audiogram against which subsequent audiograms are compared to determine if hearing thresholds have changed. The baseline audiogram is preceded by a quiet period so as to obtain the best estimate of the person’s hearing at that time.
CONTINUOUS NOISE	Noise of a constant level as measured over at least one second using the "slow" setting on a sound level meter. Note, that a noise which is intermittent, e.g., on for over a second and then off for a period would be both variable *and* continuous
CONTROLS: Administrative	Efforts, usually by management, to limit workers' noise exposure by modifying workers' schedule or location, or by modifying the operating schedule of noisy machinery.

CONTROLS: Engineering	Any use of engineering methods to reduce or control the sound level of a noise source by modifying or replacing equipment, making any physical changes at the noise source or along the transmission path (with the exception of hearing protectors).
dB (DECIBEL)	The unit used to express the intensity of sound. The decibel was named after Alexander Graham Bell. The decibel scale is a logarithmic scale in which 0 dB approximates the threshold of hearing in the mid frequencies for young adults and in which the threshold of discomfort is between 85 and 95 dB SPL and the threshold for pain is between 120 and 140 dB SPL.
DOSIMETER	When applied to noise, refers to an instrument that measures sound levels over a specified interval, stores the measures, and calculates the sound as a function of sound level and sound duration and describes the results in terms of, dose, time-weighted average and (perhaps) other parameters such as peak level, equivalent sound level, sound exposure level, etc.
EQUAL-ENERGY RULE	The relationship between sound level and sound duration based upon a 3 dB exchange rate, i.e., the sound energy resulting from doubling or halving a noise exposure's duration is equivalent to increasing or decreasing the sound level by 3 dB, respectively.
ERGONOMICS	The study or measurement of how work is done as it relates to worker fatigue, discomfort or injury.
EXCHANGE RATE	The relationship between intensity and dose. OSHA uses a 5-dB exchange rate. Thus, if the intensity of an exposure increases by 5 dB, the dose doubles. Sometimes, this is also referred to as the doubling rate. The U.S. Navy uses a 4-dB exchange rate; the U.S. Army and Air Force use a 3-dB exchange rate. NIOSH recommends a 3-dB exchange rate. Note that the equal-energy rule is based on a 3 dB exchange rate.
HAZARDOUS NOISE	Any sound for which any combination of frequency, intensity, or duration is capable of causing permanent hearing loss in a specified population.
HAZARDOUS TASK INVENTORY	A concept based on using work tasks as the central organizing principle for collecting descriptive information on a given work hazard. It consists of a list(s) of specific tasks linked to a database containing the prominent characteristics relevant to the hazard(s) of interest which are associated with each task.

HEARING DAMAGE RISK CRITERIA	A standard which defines the percentage of a given population expected to incur a specified hearing loss as a function of exposure to a given noise exposure.
HEARING HANDICAP	A specified amount of permanent hearing loss usually averaged across several frequencies which negatively impacts employment and/or social activities. Handicap is often related to an impaired ability to communicate. The degree of handicap will also be related to whether the hearing loss is in one or both ears, and whether the better ear has normal or impaired hearing.
HEARING LOSS	Hearing loss is often characterized by the area of the auditory system responsible for the loss. For example, when injury or a medical condition affects the outer ear or middle ear (i.e. from the pinna, ear canal, and ear drum to the cavity behind the ear drum - which includes the ossicles) the resulting hearing loss is referred to as a **conductive** loss. When an injury or medical condition affects the inner ear or the auditory nerve that connects the inner ear to the brain (i. e., the cochlea and the VIIIth cranial nerve) the resulting hearing loss is referred to as a **sensorineural** loss. Thus, a welder's spark which damaged the ear drum would cause a conductive hearing loss. Because noise can damage the tiny hair cells located in the cochlea, it causes a sensorineural hearing loss.
HEARING LOSS PREVENTION PROGRAM AUDIT	An assessment performed prior to putting a hearing loss prevention program into place or before changing an existing program. The audit should be a top-down analysis of the strengths and weaknesses of each aspect of the program.
HTL (HEARING THRESHOLD LEVEL)	The hearing level, above a reference value, at which a specified sound or tone is heard by an ear in a specified fraction of the trials. Hearing threshold levels have been established so that 0 dB HTL reflects the best hearing of a group of persons.
Hz (HERTZ)	The unit measurement for audio frequencies. The frequency range for human hearing lies between 20 Hz and approximately 20,000 Hz. The sensitivity of the human ear drops off sharply below about 500 Hz and above 4,000 Hz.

IMPULSIVE NOISE	Used to generally characterize impact or impulse noise which is typified by a sound which rapidly rises to a sharp peak and then quickly fades. The sound may or may not have a "ringing" quality (such as a striking a hammer on a metal plate or a gunshot in a reverberant room). Impulsive noise be repetitive, or may be a single event (as with a sonic boom). Note: if impulses occur in very rapid succession (such as with some jack hammers), the noise would not be described as impulsive.
LOUDNESS	The subjective attribute of a sound by which it would be characterized along a continuum from 'soft' to 'loud'. Although this as a subjective attribute, it depends primarily upon sound pressure level, and to a lessor extent, the frequency characteristics and duration of the sound.
MATERIAL HEARING IMPAIRMENT	As defined by OSHA, a material hearing impairment is an average hearing threshold level of 25 dB HTL at the frequencies of 1000, 2000, and 3000 Hz.
NOISE	Any unwanted sound.
NOISE DOSE	The noise exposure expressed as a percentage of the allowable daily exposure. For OSHA, a 100% dose would equal an 8-hour exposure to a continuous 90 dBA noise; a 50% dose would equal an 8-hour exposure to an 85 dBA noise or a 4-hour exposure to a 90 dBA noise. If 85 dBA is the maximum permissible level, then an 8-hour exposure to a continuous 85 dBA noise would equal a 100% dose. If a 3 dB exchange rate is used in conjunction with an 85 dBA maximum permissible level, a 50% dose would equal a 2-hour exposure to 88 dBA or an 8-hour exposure to 82 dBA.
NOISE-INDUCED HEARING LOSS	A sensorineural hearing loss that is attributed to noise and for which no other etiology can be determined.
NRR (NOISE REDUCTION RATING)	The NRR is a single-number rating method which attempts to describe a hearing protector based on how much the overall noise level is reduced by the hearing protector. When estimating A-weighted noise exposures, it is important to remember to *first* subtract 7 dB from the NRR and then subtract the remainder from the A-weighted noise level. The NRR theoretically provides an estimate of the protection that should be met or exceeded by 98% of the wearers of a given device. In practice, this does not prove to be the case, so a variety of methods for "de-rating " the NRR have been discussed.
OTOTOXIC	A term typically associated with the sensorineural hearing loss resulting from therapeutic administration of certain prescription drugs.

OTOTRAUMA-TIC	A broader term than ototoxic. As used in hearing loss prevention, refers to any agent (e.g., noise, drugs, or industrial chemicals) which has the potential to cause permanent hearing loss subsequent to acute or prolonged exposure. (See also acoustic trauma.)
PERMISSIBLE EXPOSURE LIMIT	OSHA-permissible limits; presently 90 dBA. A time-weighted average exposure that must not be exceeded during any 8-hour work shift of a 40-hour work week
PRESBYCUSIS	The gradual increase in hearing loss that is attributable to the effects of aging, and not related to medical causes or noise exposure.
SENSORI-NEURAL HEARING LOSS	A hearing loss resulting from damage to the inner ear (from any source).
SOCIACUSIS	A hearing loss related to non-occupational noise exposure.
SOUND LEVEL METER (SLM)	A device which measures sound and provides a readout of the resulting measurement. Some provide only A-weighted measurements, others provide A- and C-weighted measurements, and some can provide weighted, linear, and octave (or narrower) band measurements. Some SLMs are also capable of providing time-integrated measurements.
SPL (SOUND PRESSURE LEVEL)	A measure of the ratio of the pressure of a sound wave relative to a reference sound pressure. Sound pressure level in decibels is typically referenced to 20 µPa. When used alone, (e.g., 90 dB SPL) a given decibel level implies an unweighted sound pressure level.
STS	**Standard Threshold Shift:** OSHA uses the term to describe 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. Used by OSHA to trigger additional audiometric testing and related follow up. **OR** **Significant Threshold Shift:** NIOSH uses this term to describe a change of 15 dB or more at any frequency, 500 through 6000 Hz, from baseline levels that is present on an immediate retest in the same ear and at the same frequency. NIOSH recommends a confirmation audiogram within 30 days with the confirmation audiogram preceded by a quiet period of at least 14 hours.
TLV (THRESHOLD LIMIT VALUE)	A guideline provided by the American Conference of Governmental Industrial Hygienists to denote the exposure, which when reached or exceeded, may be hazardous. For noise the TLV is 85 dBA and the exchange rate is 3 dB.

TWA (TIME WEIGHTED AVERAGE)

A value, expressed in dBA, which is computed so that the resulting average would be equivalent to an exposure resulting from a constant noise level over an 8-hour period

THRESHOLD SHIFT

Audiometric monitoring programs will encounter two types of changes in hearing sensitivity, i.e. threshold shifts: permanent threshold shift (**PTS**) and temporary threshold shift (**TTS**). As the names imply, any change in hearing sensitivity which is persistent is considered a PTS. Persistence may be assumed if the change is observed on a 30-day follow-up exam. Exposure to loud noise may cause a temporary worsening in hearing sensitivity (i.e., a TTS) that may persist for 14 hours (or even longer in cases where the exposure duration exceeded 12 to 16 hours). Hearing health professionals need to recognize that not all threshold shifts represent decreased sensitivity, and not all temporary or permanent threshold shifts are due to noise exposure. When a permanent threshold shift can be attributable to noise exposure, it may be referred to as a noise-induced permanent threshold shift (**NIPTS**).

WEIGHTED MEASURE-MENTS

Two weighting curves are commonly applied to measures of sound levels to account for the way the ear perceives the "loudness" of sounds. **A-weighting:** A measurement scale that approximates the "loudness" of tones relative to a 40 dB SPL 1000 Hz reference tone. A-weighting has the added advantage of being correlated with annoyance measures and is most responsive to the mid frequencies, 500 to 4000 Hz..

C-weighting: A measurement scale that approximates the "loudness" of tones relative to a 90 dB SPL 1000 Hz reference tone. C-weighting has the added advantage of providing a relatively "flat" measurement scale which includes very low frequencies.