

**A PRACTICAL GUIDE TO EFFECTIVE HEARING CONSERVATION PROGRAMS
IN THE WORKPLACE**

Edited by

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PREFACE

Hearing conservation programs can comply with the letter of the law (meaning the OSHA standard) and yet be ineffective in preventing work-related noise-induced hearing loss. Consequently, in 1988, NIOSH convened a group of hearing conservation experts to consider ways for achieving more effective hearing conservation programs. This guide sets forth the concepts and techniques which this distinguished body of experts has found to be consistent with successful hearing conservation programs. The document is not meant to be a technical treatise, but rather a practical guidebook, which should be useful to those who want to make sure that their hearing conservation programs actually are effective. It is intended for use by employers, middle management personnel, health and safety professionals, union health and safety representatives, noise-exposed employees, and other interested or affected parties concerned with hearing conservation.

NIOSH continues to support engineering controls as the most effective defense against the hazards of noise. We consider them an integral component of any effective hearing conservation program. In many instances, however, the application of engineering controls is not feasible, due to economic or practical considerations. When noise control is not feasible, or until controls can be installed, other aspects of the hearing conservation program must be emphasized. This guide discusses engineering controls only briefly, and concentrates in some detail on those factors which promote effectiveness in the non-engineering aspects of hearing conservation programs. It is our hope that the ideas contained in this guide will promote the actions needed to protect a vital human function - hearing.

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EXECUTIVE SUMMARY

Noise is one of the most pervasive occupational health problems in America today. Approximately nine million workers are exposed on their jobs to noise levels 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 conservation programs (HCPs).

A successful HCP benefits both the company and the affected employee. Employees are spared handicapping 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 HCP (even one that complies with government standards) does not guarantee the prevention of noise-induced hearing loss. Experience with successful HCPs shows that management needs to develop and adhere to certain policies from the start. These policies cover the integration of the HCP 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 HCPs. Concepts and action items are presented in terms of the responsibilities of three groups of personnel: those representing management, those who implement the HCPs, and the affected or noise-exposed employees. Checklists are provided in the appendices to assist in evaluating HCPs on a step-by-step basis.

The seven basic components of a HCP 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.

Noise Exposure Monitoring

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 noise measurements. The results of the noise measurements must be reported to the HCP implementor and to the employees in an understandable format. HCP implementors need to coordinate closely with production employees to make sure that the measurements represent typical production cycles and that noise levels are adequately sampled. Program implementors 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 noise.

Engineering and Administrative Controls

The use of engineering controls should reduce noise 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 equipment.

Management needs to identify controllable noise sources, set goals for noise control, and allocate resources to accomplish these goals. Managers should also explore potential administrative controls, such as scheduling that will minimize noise exposure, and quiet and conveniently located lunch and break areas. Program implementors must ensure that communication channels are open between management, noise control personnel, and equipment operators. The equipment operators, in turn, need to communicate their thoughts to management and those in charge of noise control, and must learn to operate and maintain their equipment to take full advantage of the noise controls.

Audiometric Evaluation

Audiometric evaluation is crucial to the success of the HCP, since it is the only way to determine whether noise-induced hearing loss is being prevented by the prescribed hearing conservation actions. 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 is of utmost importance. Employees need to disclose information about ear problems and prior noise exposures, or problems encountered in taking the audiometric test. They also need to follow up on any recommendations for treatment or further evaluation.

Hearing Protection Devices

In the absence of feasible engineering or administrative controls, 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 the use of these devices in appropriate situations), to provide the personnel and facilities to train employees in the 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 to employees. Implementors need to encourage employees to ask questions and to 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.

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 HCP takes commitment, communication, and cooperation. Management should set a high priority on regularly scheduled training sessions, and select articulate, knowledgeable, and enthusiastic instructors. Program implementors, or those who present the sessions, need to make their presentations short, simple, and highly relevant. They need to encourage questions and the expression of concerns, 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 HCP 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 HCP generates its own type of records (e.g., noise survey forms, audiograms, and medical histories) and much of this information needs to be integrated into the employee's health record. 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 HCP 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 HCP's components is necessary to determine the extent to which the HCP is really working, or if there are problems, which elements or departments are at fault. 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 noise-exposed employees. Management should dedicate resources for HCP 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 data base analysis, the company must hire someone with these skills. Program implementors must also be committed to seeking out elusive information, and interacting with all members of the HCP team to identify and correct any deficiencies. As with many other aspects of the HCP, 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.

CONTENTS

PREFACE.....	iii
EXECUTIVE SUMMARY.....	v
ACKNOWLEDGMENT.....	x
INTRODUCTION.....	1
VALUE OF A GOOD HEARING CONSERVATION PROGRAM.....	3
POLICY NEEDS.....	6
NOISE EXPOSURE MONITORING.....	8
ENGINEERING AND ADMINISTRATIVE CONTROLS.....	13
AUDIOMETRIC EVALUATION.....	20
HEARING PROTECTION DEVICES.....	27
EDUCATION AND MOTIVATION.....	30
RECORD KEEPING.....	33
PROGRAM EVALUATION.....	36
APPENDIX A: OSHA NOISE STANDARD COMPLIANCE CHECKLIST.....	38
APPENDIX B: PROGRAM EVALUATION CHECKLIST.....	43
APPENDIX C: AUDIO-VISUAL MATERIALS.....	48
APPENDIX D: SUGGESTED READING.....	52
APPENDIX E: RESOURCES.....	54

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INTRODUCTION

Noise is one of the most pervasive problems in today's occupational environment, affecting workers in manufacturing, construction, transportation, agriculture, and the military. Approximately nine million American workers are exposed to noise levels that are potentially hazardous to their hearing. 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. 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 conservation programs. A good hearing conservation program (HCP) has at least seven identifiable elements: noise exposure surveys, engineering controls, audiometric evaluations, worker education and training, the use of hearing protection devices, record keeping, and evaluation of overall program effectiveness. 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 noise-exposed employees. 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, and acoustical engineer.

This document summarizes the procedures involved in implementing these seven elements. They will be examined from the perspective of management, program implementors, and affected employees; and 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 HCP work, and the employees' category includes all persons who are exposed to hazardous levels of occupational noise.

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 conservation program. A strong commitment to a hearing conservation program can be shown by following these policies:

- 0 Strive for excellence in the program rather than just meeting minimal requirements.
- 0 Integrate the program into the overall company safety and health program.
- 0 Educate and motivate employees, so that hearing conservation practices become an integral part of their behavior on and off the job.
- 0 Designate a key person to serve as implementor/coordinator of the program.
- 0 Strive for simplification and continuity of the program's operating procedures.

- o Review the program's effectiveness regularly and make modifications when needed.

The nature and scope of the HCPs 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 good HCPs 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 HCPs 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 those responsible for protecting employees' hearing to develop and maintain hearing conservation programs that actually work, and are not just perfunctory measures. This guide is not meant to be technical in nature. The reader will find no 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, but we believe that citations are not necessary in a practical guide such as this. The interested reader may pursue these concepts further in the suggested readings.

VALUE OF A GOOD HEARING CONSERVATION PROGRAM

When a company has an effective hearing conservation program (HCP), 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, but is concerned with programs that are effective as well as efficient: those that succeed in preventing hearing loss in a practical and cost-effective manner.

Employer Benefits

HCPs 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 HCPs, 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 HCP 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. In addition, the conservation of hearing leads to the conservation of valuable employee resources. Studies of noisy companies that have implemented HCPs 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. Like other effective health and safety measures, HCPs 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 conservation in recreational settings.

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

Employee Benefits

The HCP's most obvious benefit to employees is that it saves their hearing and

ability to communicate. Because noise-induced hearing loss creeps up slowly, many individuals are unaware of their impairment until it is too late. Moreover, noise-induced hearing loss represents permanent damage, i.e., it cannot be restored through medical/surgical treatment. A good HCP, however, can identify hearing impairments before they become handicapping, and put an end to further deterioration. 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. Conserving hearing 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 HCP will enable employees to sustain their hearing ability and thus qualify for jobs (perhaps higher level) that have such requirements.

A side benefit of an occupational HCP is that it can detect hearing loss that may be due to causes other than workplace noise exposure. Some individuals may suffer hearing loss as a result of impacted ear-wax, 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.

Another benefit reported by employees in companies with effective HCPs is that they feel generally 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 reduced.

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

In summary, a good hearing conservation program is consistent with good health and good business. At a minimum, employees benefit from hearing saved. Reductions in noise exposure may also result in less fatigue and irritation, and possibly less stress-related health complaints. The company benefits from reduced worker compensation payments and medical expenses. Reduced noise exposures can be associated with improved employee morale, and, in some cases, higher production efficiency.

Further Reading

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POLICY NEEDS

Company policies relating to the HCP should be carefully planned and executed to benefit the affected employee and the employer. Experience with successful HCPs shows certain policy areas that management needs to address at the beginning:

1. Program policies should be based on effective practices rather than on minimum compliance with government regulations.
2. The HCP must be a functional part of the overall company safety and health program. It should not be a stand-alone, separately-budgeted operation.
3. A key individual (program implementor) should have ultimate responsibility for the program. This person may not necessarily perform all of the functions of the HCP, but is in charge of the overall program. Experience with successful HCPs 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 or a supervisor. This key individual acts as the "conscience" and "champion" of the HCP. He or she focuses the attention of both management and employees on the HCP's policies and ensures that they take the necessary steps to implement them. They should also have stature in the HCP's organizational chart, with authority to make decisions, correct deficiencies, and enforce necessary actions.
4. The key individual should develop and implement HCP plans and policies for an effective program. Authority to establish hearing conservation provisions beyond those required by OSHA should be assured.
5. Employee compliance with the company's HCP policies and procedures should be mandatory.
6. HCP policies should clearly describe standard operating procedures for each phase of the program.
7. 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 the in-house program elements. Vendors must understand and agree to abide by the company's HCP policies and standards of operation. On-site personnel must supervise contractors to make sure that they carry out their obligations.
8. 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 are only passing through these areas. These requirements should be conditions of employment. Other important policy statements should be written to cover:

- a. Monitoring of employee noise exposure levels on a regular schedule.
- b. Counseling of employees at the completion of each audiometric test, whether it is the initial, annual, retest, or termination examination.
- c. Determining the correct use of hearing protection devices by on-site equipment checks.
- d. Educating, training, and motivating employees to comply with the company's HCP provisions.
- e. Reviewing audiometric data to verify the effectiveness of the HCP.
- f. Encouraging employees to use company-provided hearing protectors for off-the-job exposure.
- g. Purchasing hearing protectors, audiometers, noise measuring equipment, and quieter machinery. This policy should address the reasons why the individual responsible for the HCP, not the purchasing department, should have final decisions about anticipated purchases.

Companies that issue clearly defined hearing conservation policies, and then adhere to these policies consistently, will have smoothly running HCPs. Employees will be fully informed 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

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NOISE EXPOSURE MONITORING

As with any health hazard, it is of utmost importance to determine the nature of the hazard accurately, 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 re-evaluations are conducted when changes in equipment or operations significantly alter the noise exposure. Readers are encouraged to consult items no. 1-11, 49, and 55 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.

Noise 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 HCP.
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 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, one measures environmental noise levels, 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.

Engineering surveys employ more sophisticated acoustical equipment in addition to sound level meters. These can 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

Measuring noise with a sound level meter (courtesy of Brüel and Kjaer Instruments).



A noise dosimeter measures and stores sound energy over time. It can be worn in the pocket, as shown, or on the belt with the microphone positioned on the shoulder.

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.

Management should also ensure that operating procedures for conducting and evaluating noise measurements are available, well defined, 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.

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

Program Implementor Responsibilities

Implementors of the HCP are responsible for making sure that the noise measurement program answers relevant questions. To obtain useful results, each sound survey must address the reason for obtaining the measurements, such as the identification of employees to be included in the HCP, or the evaluation of specific machinery for noise control purposes.

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.

Sound surveyors should 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 HCP 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 HCP. 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. 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.

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 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 sound surveyors or the program implementors 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.
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Further Reading

Earshen, J.J. Sound measurement: Instrumentation and noise descriptors. Chapter 3 in E.H. Berger, W.D. Ward, J.C. Morrill, and L.H. Royster (Eds.), Noise and Hearing Conservation Manual (4th Ed.). Akron, OH: American Industrial Hygiene Assoc., 1986.

Royster, L.H., Berger, E.H., and Royster, J.D. Noise surveys and data analysis. Chapter 4 in E.H. Berger, W.D. Ward, J.C. Morrill, and L.H. Royster (Eds.), Noise and Hearing Conservation Manual (4th Ed.). Akron, OH: American Industrial Hygiene Assoc., 1986.

See checklist in Appendix B of this guidebook, section entitled "Noise Measurement."

ENGINEERING AND ADMINISTRATIVE CONTROLS

Engineering and administrative controls may be essential to achieve an effective HCP. The use of these controls should reduce noise exposure to the point where the hazard 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 cases 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 conservation 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:

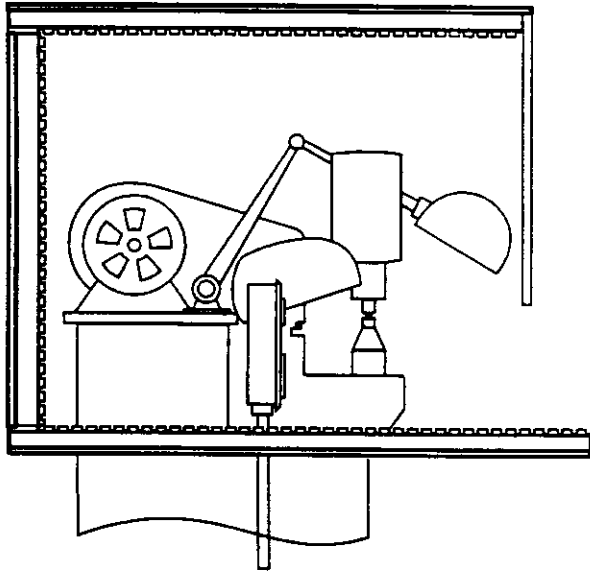
1. Reducing noise at the source.
2. Interrupting the noise path.
3. Reducing reverberation.
4. Reducing structure-borne vibration.

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.

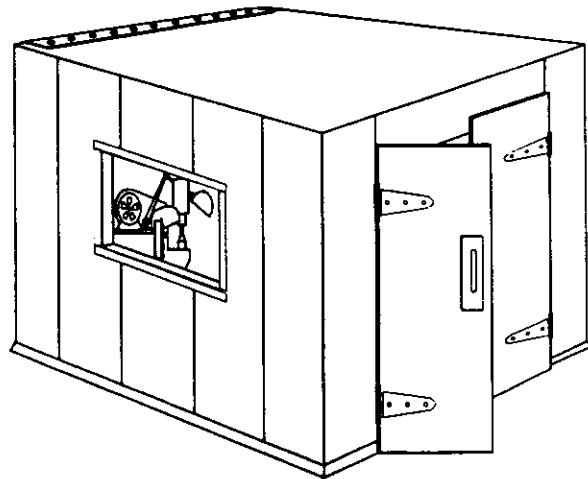
Assessing the applicability of engineering controls is a sophisticated process. First, the noise problem must be thoroughly defined. This necessitates measuring the noise levels and developing complete information on employee noise exposure and the need for noise reduction. Next, an approach to engineering 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

Partial Enclosure

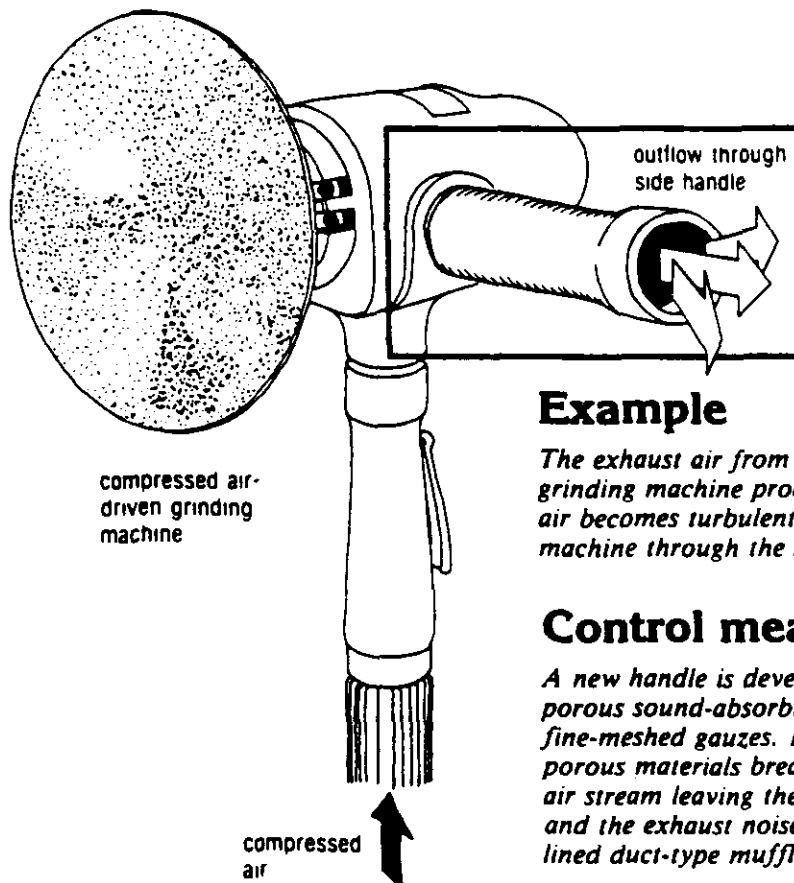


Interrupting the noise path with a partial machine enclosure (from Noise Control: A Guide for Workers and Employers, U.S. Dept. of Labor, OSHA).

Complete Enclosure



Interrupting the noise path using a complete enclosure.



compressed air-driven grinding machine

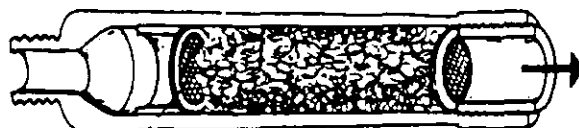
Example

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 developed, filled with a porous sound-absorbing material between two fine-meshed gauzes. Passage through the porous materials breaks up the turbulence. The air stream leaving the handle is less disturbed, and the exhaust noise is weaker. A straight lined duct-type muffler may also be used.

sound-damping handle



fine-meshed wire gauze

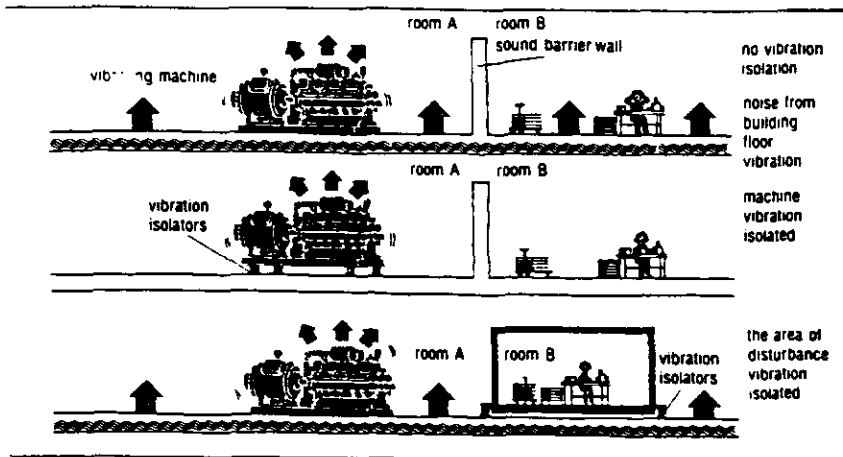
a porous sound-absorbing material

meshed wire gauze

Reducing noise at the source: Installing a muffler (from Noise Control: A Guide for Workers and Employers, U.S. Dept. of Labor, OSHA).

Example

Vibration isolation of machines can reduce the area of excessive noise as shown below. Either the machine or the working area can be isolated.

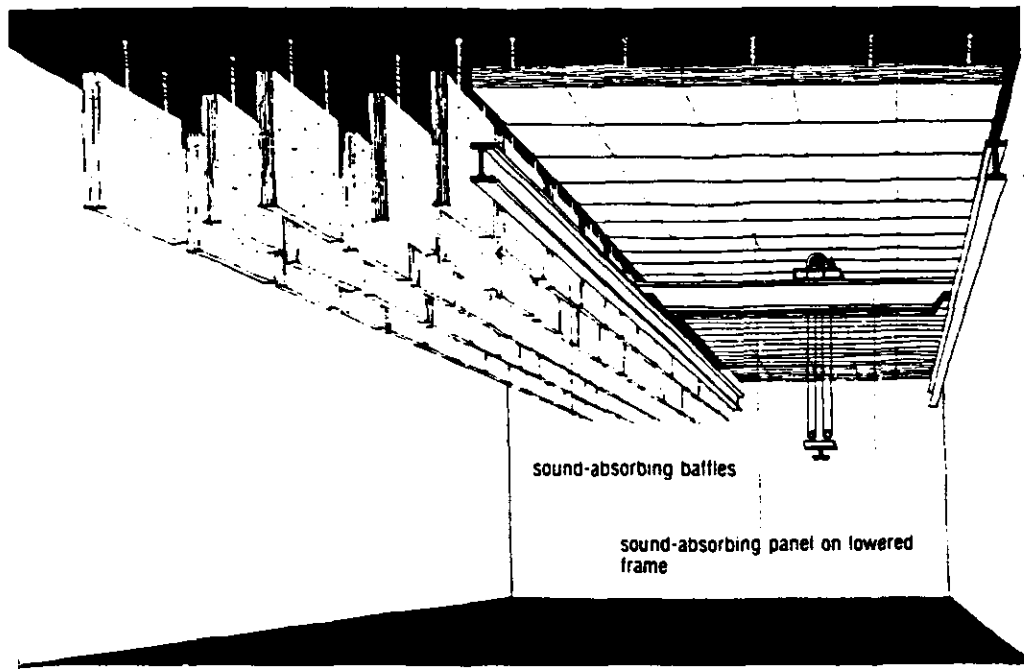


Reducing structure-borne vibration and reverberation (from *Noise Control: A Guide for Workers and Employers*, U.S. Dept. of Labor, OSHA).

Example

A workshop with intense low frequency noise is provided with absorbants that are effective for low tones. One part of the shop contains space for hanging absorption baffles, which provide good low frequency absorption and are easily in-

stalled. A traverse leaves no room for baffles in the other part of the shop. Instead, horizontal absorbant panels are installed above the traverse, 8 inches from the ceiling, to improve the low frequency absorption.



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.

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.

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

Program Implementor Responsibilities

One of the most important responsibilities of the HCP 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 HCP will probably not actually execute the noise 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 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.

Further Reading

Beranek, L.L. (Ed.). Noise and Vibration Control (Revised). New York: McGraw Hill, 1988.

Bruce, R.D. and Toothman, E.H. Engineering controls. Chapter 12 in E.H. Berger, W.D. Ward, J.C. Morrill, and L.H. Royster (Eds.), Noise and Hearing Conservation Manual (4th Ed.). Akron, OH: American Industrial Hygiene Assoc., 1986.

Harris, C.M. (Ed.). Handbook of Noise Control (2nd Ed.). New York: McGraw Hill, 1979. Chapters 19-31.

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

See checklist in Appendix B of this guidebook, section entitled "Engineering and Administrative Controls."