Winter 2000/2001

UPDATE

The Newsletter of the Council for Accreditation in Occupational Hearing Conservation

Considering an Engineered Noise Control Solution

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Part 1 in a series on engineeri approaches to reducing noise exposure.

As an OHC, your days may be filled with audiometric testing and employee training. You may also find it within your job description to solve problems associated with high noise levels in your workplace. Perhaps you are fortunate enough to work as part of a hearing conservation team that includes a noise control engineer who is able to recommend, develop and implement engineered controls that reduce employee noise exposure. But what if YOU are the hearing conservation program? Even if you have other professional resources at your disposal, you may be responsible for managing those resources and making overall program decisions. In any case, an understanding of fundamental noise control concepts and techniques will be helpful as you approach the following tasks:

- identify specific problems that would be realistic candidates for successful engineered noise control solutions;
- anticipate, understand and be able to evaluate the range of possible solution approaches recommended by a noise control professional;
- advocate for the funds necessary to implement the recommended changes;
- properly make use of and maintain the engineered noise controls; and
- avoid worsening the problem, either before or after the controls are implemented, by making changes to the process, equipment or work area that increase the noise level and/or employee noise exposure.

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Engineered Noise Control Solution

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Since noise control engineering *should* be a part of any effective corporate hearing conservation program, a basic familiarity with noise control concepts and techniques will be helpful to all OHCs who work in a corporate or plant setting. This article, which is the first in a series on engineering approaches to reducing occupational noise exposure, will discuss the benefits of engineered noise controls and present a process that OHCs may follow to assess any noise exposure problem prior to involving a noise control engineer. The remainder of the series will cover concepts that are the critical to the solution of every noise control problem: the three general approaches to engineered noise controls and the basic properties of acoustical materials. Specific examples of each type of approach will be discussed, including "do-it-yourself" noise control solutions that every OHC can easily implement to fix some very common noise exposure problems.

Within the context of the hearing conservation program, engineered noise controls should have a stature equal to that of audiometric testing, employee training and the wearing of personal protective equipment. Although engineered noise controls are often perceived as being a peripheral element of the hearing conservation program, in fact, well-designed engineered controls offer benefits beyond what can be achieved with even the most comprehensive and well-managed implementation of non-engineered approaches. The aggressive implementation of engineered noise control solutions can offer the following benefits, depending on whether the particular solution reduces only the employee's noise exposure or the actual sound level in the work area as well:

- reduced cost and administrative burden of the hearing conservation program;
- hearing loss prevention as well as regulatory compliance;
- reduced reliance on employee participation in other program elements (e.g., audiometric testing and use of personal hearing protection) as an essential factor in hearing loss prevention (or regulatory compliance);
- improved productivity, speech communication, concentration and safety; and
- removal of noise-related operational restrictions that limit the hours of operation and/or the total duration of operation, including those imposed for reasons other than hearing conservation (e.g., community noise issues).

When evaluating noise exposure problems as potential candidates for an engineered noise control solution, the above factors can serve as a checklist to help the OHC determine, for each problem, whether an engineered solution will be more cost effective than other alternatives. In particular, determining which of the above factors are relevant (and which are the most important) issues in each situation is an important first step in assessing and selecting the most effective noise control approach for that particular situation.

For instance, some approaches will reduce employee noise exposure but may not necessarily reduce the amount of noise that is generated by the equipment or process. Such an approach may be quite effective in one situation while not adequate in other cases. That assessment should take into account considerations such as:

- the number of employees who work in the (noisy) area;
- the specific tasks, locations, and movement within the work area that is required in order to perform the job;
- the amount of time in the noisy area that is associated with the above activity;
- whether employees are expected to communicate with each other or on radios or telephones while working in the noisy environment;
- the nature and frequency of other auditory signals that employees must be able to hear clearly (e.g., paging, alarms, etc.);
- existence and location of any nearby quiet spaces where employees may rest, perform other tasks and communicate with each other or use the telephone;
- the size and physical characteristics of the (noisy) building or room where the work activity takes place;
- whether the noise is adequately contained in the work area or also poses a hazard (or an annoyance) for passersby, adjacent work areas or the community;
- the nature of the equipment or process that is generating the noise; and
- the characteristics of the noise itself (e.g., sound level, time characteristics, frequency spectra).

The last item on the list is clearly the responsibility of the noise control engineer, who will undoubtedly acquire detailed noise measurements at the outset of the project. The recommendations he or she makes will depend as much on the information the OHC provides about the first nine items as on the characteristics of the noise. The OHC will be best prepared to discuss the range of solution options and the relative benefits of each option after spending some time researching and documenting all of the items on the above list.

An essential part of the OHC's preparation for initiating a noise control project is a productive liaison with the exposed employees and their management. The process of developing an engineered noise control solution is really a collaborative activity that relies heavily on the support and contribution of the employees who will be expected to work with or near the particular noise control equipment after it is installed. The installed controls will be most effective, and the process by which those effective controls are developed will be most valuable, if the input of the exposed employees is sought and given a high priority early on, *before* a solution approach is selected. Ideally, the exposed employees and their management should be brought into the planning activity prior to involving a noise control engineer. It is important that the noise generating equipment and the work process are well understood, along with any other factors that may constrain the selection, design or implementation of the noise control solution. If the expectations and limitations of the engineered controls are agreed to beforehand, it is more likely that the controls will be functional, compatible with the operation and accepted by the employees who must accommodate and maintain those controls.

(to be continued)

Selecting an Engineered Noise Control Approach: Controlling Noise at the Source, Path or Receiver

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(Part 2 in a series on engineering approaches to reducing noise exposure.)

Ideally, the selection of an engineered solution to a noise exposure problem is the product of a collaborative planning process that involves, at a minimum, the OHC, the exposed employees and their management, and a noise control engineer. The OHC plays a very important role in this process by bringing the members of the team together to develop a solution to the problem in a participative but very organized and systematic manner. Although the development of the technical specifics of the solution is clearly the responsibility of the noise control engineer, the *selection* of the *approach* should be based on a variety of factors that are best identified and documented by the OHC during field visits and employee interviews prior to bringing the noise control engineer into the discussions. The first installment in this series, "Considering an engineered noise control solution," (Winter 2000/2001 issue of *UPDATE*) presented two checklists that OHCs may use to identify and clarify the objectives as well as the relevant parameters and physical restrictions that will govern the operation of the installed solution. Only when that information is well documented and agreed to by the members of the in-house team, will the involvement of an outside noise control engineer be both helpful and cost effective.

Illustration provided courtesy of E•A•R Hearing Protection Products

Although not nearly as important as an understanding of the noise exposure problem itself, a familiarity with the basic approaches to engineered noise control will help the OHC and the other decision-making members of the team better understand the noise control engineer's recommendations. In turn, the OHC will be in a stronger position to advocate for funds to implement the recommended solution and to ensure that any equipment installed as part of the solution will be used and maintained by the exposed employees in a manner that preserves its intended (noise control) function. This article will discuss the basic approaches to engineered noise control and some of the factors that influence their selection and implementation.

Since noise exposure is a function of both the noise level *and* the duration of time over which employees are exposed, exposure may be controlled by reducing either, or both, of these elements. Reducing the duration of exposure is the basis of what is referred to as "administrative controls," which typically does not involve any engineered reduction in the noise level (although certain engineered solutions actually do accomplish their goals by reducing the duration of exposure). Since we are concerned here with *engineered* approaches to reducing noise exposure, let's concentrate on how we might control noise exposure by reducing the *level* of the noise to which employees are exposed. There are three general approaches, two of which are discussed below, along with examples of typical applications. The third approach will be the focus of the next installment in this series.

Source noise control. Noise control at the source is accomplished by changing the noise-generating equipment or process, which results in a reduction in the amount of noise that is produced by that particular source. Accordingly, the noise level associated with the treated source(s) is lowered in the entire surrounding area, and the noise exposure of all persons who happen to be in the area is reduced. If there are multiple noise sources that contribute substantially to employee noise exposure, each of these sources must be treated in order to realize a measurable reduction in the sound level in the work area. Examples of source noise control include, but are not limited to, the examples presented below.

- Changing or eliminating the basic mechanism of sound generation in a way that accomplishes the same task with less noise output. This is often the most ambitious type of noise control project and one that requires specialized expertise beyond a general understanding of noise control engineering. The potential benefits make it an option worth considering, however.
- Replacing noisy equipment by intentionally purchasing or designing newer, quieter equipment. Needless to say, implementation of a corporate "Buy Quiet" policy can prevent today's purchases from becoming tomorrow's noise control projects.
- Retrofitting the noise-generating machinery with parts that are expected to lower the noise emission, such as a different motor or fan.

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Noise Control Approaches

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- Performing maintenance and repairs to reduce noise generated by problems like worn parts (e.g., bearings), unbalanced rotating machinery and equipment that is being operated at an off-design condition. A good noise control engineer will be able to diagnose this type of problem by identifying characteristic symptoms in the noise signature of a particular piece of equipment.

Ideally, noise is best controlled at the source, since reducing the generation of noise usually has more widespread benefit than approaches that treat only specific locations in the work area or specific receivers (employees). But, source noise control solutions are typically expensive and may require modifications to the source that are not technically feasible. Additionally, in areas where there are multiple sources contributing to the noise level, treating all of the sources (which is required to achieve an appreciable reduction in noise level) is often simply impractical.

Illustration provided courtesy of E·A·RHearing Protection Products

Path noise control. This approach to reducing noise exposure acts along the path between the source and the intended receiver (the exposed employees) without interfering with the source itself. By inserting a noise control device in the path, the transmission of sound to the receiver is prevented or greatly reduced. This approach does not change the amount of noise that is produced, but it reduces the sound level due to the source(s) located upstream of the device and, thus, the exposure of employees who happen to be in the area *downstream of the noise control device*. Some examples of path noise control follow.

- Installing a noise control "device" such as a silencer (muffler) in the flow stream of gas or fluid flow systems to reduce the noise produced by venting, exhaust flow or turbomachinery located upstream of the silencer.
- Enclosing a noisy machine with a complete or partial enclosure to prevent or reduce the transmission of sound to the surrounding area. One example that might not come to mind immediately is acoustical pipe lagging, which prevents noise in the piping from radiating through the pipe wall to the surrounding environment.
- Repairing existing equipment enclosures and replacing missing parts. Noise "leaks" into or out of a structure that encloses either the source (or the receiver, for that matter) may be reduced by identifying and repairing gaps and openings in the enclosure. Often, these leaks can be easily identified and repaired without any specific knowledge of noise control engineering. Some guidance for "do it yourself" noise control will be the subject of a future installment in this series.
- Adding absorption to the surrounding space to reduce the buildup of reverberant sound in the work area. Although this will not reduce the noise level near the source (nor the noise exposure of employees in the vicinity of the source, such as at the "operator" position of a piece of machinery), it *will* prevent noise generated in one area of the plant from reverberating throughout the space and *causing* a problem in areas remote from the original noise source.

Receiver noise control. Control of noise at the receiver prevents or reduces the *reception* of noise by enclosing the affected employee(s) in a sound-attenuating structure. Receiver noise control treatments do not reduce the amount of noise produced by high-noise equipment, nor do they lower the sound level in any part of the work area (other than inside the sound-attenuating structure). This particular type of engineered solution works by reducing the *duration* of the affected employees' exposure to the noise produced by high-noise equipment in the work area. Protecting the receiver is typically the least elegant approach to retrofit engineered noise controls and one that may impose cumbersome operational restrictions. Receiver noise

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control has its place, however, and is often the easiest, most affordable and most accessible option, particularly in environments where multiple pieces of high-noise equipment contribute to the overall sound level. Here, source or path noise control approaches are likely to be unreasonably expensive, whereas enclosing noise-exposed employees in a sound-attenuating structure (when they are not specifically required to be working in the equipment area) effectively reduces the employees' exposure to *all* noise sources. Below are a few examples of this kind of approach.

- Constructing a "quiet" room (e.g., office, breakroom, control room, lunchroom) within the high-noise work area, where employees may spend time between operations, maintenance or monitoring tasks that require them to work on and around the high-noise equipment. Often, sound-attenuating structures are custom-designed by a noise control engineer and are constructed in the field from standard materials, much like any other building. There are also high-quality prefabricated units that may be purchased directly from a reputable vendor; these should be selected to provide the required amount of noise reduction. Although it sounds deceptively simple, the design of noise-attenuating structures is a fairly technical matter that requires the involvement of a noise control professional to ensure the acoustical integrity of the structure. A future installment in this series will explore the characteristics of properly designed noise-attenuating structures, both traditional and prefabricated.

- Smaller versions of the above "quiet" rooms, communication booths are prefabricated sound-attenuating structures placed strategically around high-noise work areas in locations where there are no other quiet spaces. These booths are sized to accommodate one or two employees, who may safely remove personal hearing protectors and communicate with each other or, via telephone or radio, with remote dispatch or control stations.

- Wearing personal hearing protectors, including communication headsets is a form of receiver noise control that is mentioned here for completeness.

The effectiveness of a receiver noise control approach depends on the willingness of the receiver to intentionally take advantage of the availability of the controls at every opportunity. An appreciation of the advantages and disadvantages of the three approaches will provide the OHC with a basis for evaluating the tradeoffs between the goals of the project and the potential effectiveness of each approach being considered. The next installment in this series will illustrate some examples of simple noise control techniques that may be easily implemented by the OHC to solve minor noise problems *without* the need for formal engineering. To assist the OHC with the solution of more complicated projects, the last installment of the series will describe resources and suggested procedures for obtaining and benefiting from professional noise control engineering support.

To be continued in the Summer 2001 Update.

Developing and Implementing an Engineered Noise Control Solution

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Part 3 in a series on engineering approaches to reducing noise exposure

The implementation of engineered noise control solutions is a responsibility that is shared by the entire hearing conservation team. The OHC is often the focal point of this effort, bringing the other members of the team together with the affected employees and their management to work with a noise control professional who will develop the detailed technical solution.

In the first article in this series, "Considering an Engineered Noise Control Solution," (Winter 2000/2001 issue of UPDATE), we discussed the role of the OHC in the identification and solution of noise exposure problems. Several checklists were provided to guide the OHC through the process of assessing noise exposure problems prior to involving a noise control professional. The second article, "Selecting an Engineered Noise Control Approach: Controlling Noise at the Source, Path or Receiver," (Summer 2001 issue of UPDATE) described the three basic approaches to controlling noise exposure and provided some typical examples.

This third and final installment will acquaint you with two basic noise control principles: *transmission loss* and *sound absorption.* Some suggestions for do-it-yourself solutions will be discussed, and, finally, resources will be provided to help you identify and engage a noise control professional for projects that require specialized skills.

Noise Control Principles and Materials: transmission loss and sound absorption

There are two basic principles that may be employed, either separately or together, to effect reduction in noise exposure: *transmission loss* and *sound absorption*. A general understanding of these principles, the differences between them, and the applicability of each to specific classes of problems is helpful in developing solutions to noise exposure problems and in understanding the recommendations of a noise control professional. It will also assist the OHC in facilitating discussions among employees, management, and the hearing conservation team as possible solutions are proposed. Misunderstandings regarding the concepts of transmission loss and sound absorption are undoubtedly the cause of many failed or less-than-successful engineered noise control attempts.

The most fundamental principle related to noise control materials is that of *transmission loss*, which may be thought of as "stopping" an unwanted sound from traveling between one space and another. Hazardous noise that exists in a plant area is "stopped" or prevented from entering a plant office or break room by the transmission loss properties of the room's structure. Likewise, noise generated by a machine housed in a sound-attenuating enclosure is "stopped" from entering the adjacent area by the transmission loss properties of the enclosure. As you might expect intuitively, transmission loss is typically provided by massive and continuous materials that completely enclose either the noise source or the receiver, depending on whether the objective of the solution (as discussed in the first article in this series) is to contain the noise inside a machine housing or to protect employees inside a quiet room. In general, as the frequency of the unwanted sound decreases, it takes more mass to "stop" the transmission of noise. Lead, loaded vinyl, concrete block, and drywall are examples of materials used for their transmission loss properties. Materials are rated for their performance using a metric called Sound Transmission Class or STC, expressed in units of decibels. An STC curve is a graph of transmission loss as a function of frequency, where each curve is named for its value at 500 Hz.

Sound absorption is the principle that complements transmission loss in most noise control constructions. Although sound that is contained within an enclosure is "stopped" from entering an adjacent space by the enclosure walls, if the inside surfaces of the enclosure are reflective, sound will reverberate inside the enclosure. This increases the sound level inside the enclosure such that its transmission loss properties may no longer be sufficient. For this reason, the interior surfaces of machinery enclosures are usually lined with absorptive material. These materials absorb incident sound and prevent it from reflecting back into the space but do not stop the absorbed sound from passing through into the adjacent space. Fiberglass, acoustical foam and standard architectural treatments like draperies and fabric office partitions are examples of absorptive materials. In the case of a "quiet" room or office where the unwanted sound is located in the adjacent space (outside the "quiet" room), absorptive material on the inside surfaces of the room is helpful, as in general building construction, for achieving a comfortable working environment with favorable conditions for speech communication. Materials that provide acoustical absorption are rated using an absorption coefficient, which may be interpreted as the percentage of incident energy that is absorbed by the material. Absorption coefficients are listed as dimensionless values of the parameter alpha (α) between 0 and 1 (sometimes slightly higher than 1 due to an artifact of the testing procedure).

Most noise control constructions will employ a combination of transmission loss and absorptive materials. Often, specialized materials or devices are also part of machine or personnel enclosures. For instance, pre-fabricated (acoustically-rated) wall and ceiling panels, doors, windows, ventilation or exhaust silencers and acoustically treated (wrapped) ventilation/exhaust ductwork are typical features of both employee and machine enclosures. Although an enclosure that is constructed for noise control purposes may not look much different than a typical office or room, the design and construction is quite specialized. It is important that construction personnel pay very close attention to the integrity of the structure during the construction process

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so that there are no weak spots, cracks or gaps that allow sound to inadvertently be transmitted between the enclosure and the adjacent space(s). Penetrations for electrical, ventilation and plumbing access should be minimized and properly sealed, and the structure should be vibration-isolated from the adjacent space to prevent noise from being transmitted through the floor or other structural members.

"Do-it-Yourself" Noise Control for the OHC

As an OHC, you are the first line of defense in protecting the acoustical integrity of the noise control enclosures that currently exist in your work environment. For instance, as you respond to employee inquiries about noise exposure, perform noise monitoring and begin to consider and prioritize noise exposure problems, you may be able to identify some problems that may be easily solved by your own personnel using the principles discussed here. Among these opportunities are the following, which may be implemented using materials available at a local hardware store:

- Caulk or re-cement cracks, gaps and leaks in walls, ceilings and floors where noise enters or leaves the space. A good rule of thumb is to look for places where light is visible coming from the opposite side of the wall or where an airflow path is evident. These are likely paths for sound transmission as well.
- Install acoustical seals to close gaps under doors.
- Install perimeter seals around doors.
- Replace abraded door seals.
- Replace lightweight doors in an otherwise intact structure with solid-core or acoustically rated doors.

Resources for Professional Noise Control Engineering Assistance

For the large majority of noise exposure problems for which an engineered solution is desired, the services of a noise control professional are appropriate and recommended. The following organizations are resources you may want to consider when shopping for professional assistance:

Institute of Noise Control Engineering (one of CAOHC's Component Professional Organizations - individual members may become Board Certified by passing an eight-hour exam). Members who are Board Certified and those who provide consulting services are listed on the INCE website: http://ince.org.

National Council of Acoustical Consultants (a trade organization of member firms - these are advertised by their specialties and geographic locations). A directory of firms is published for the use of potential customers on the NCAC website: http://www.ncac.com.

As an OHC, you are a key member of the hearing conservation team. Although you may not *develop* engineered solutions to noise exposure problems, you will no doubt be called on at some point to identify problems, suggest possible solutions, evaluate technical recommendations and possibly even prioritize projects. Your familiarity with the benefits, procedures, approaches and materials involved in engineered noise controls will be invaluable to the members of your team, and it will certainly make the experience more enjoyable. Most importantly, it will help ensure a properly designed solution that is well thought out and therefore effective, practical, maintainable and cost-effective for the employees whose noise exposure it is intended to reduce.

Example of a specially designed, well-sealed acoustical enclosure.