The Consequences of 'Leaky' Enclosures

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From an engineering perspective, an ideal industrial noise control solution focuses directly on the actual source of the noise. Eliminating the noise-generating mechanism altogether obviates the need for other noise control treatments or hearing protection devices. However, in cases where attenuating the source is not feasible, engineering controls must be oriented toward blocking the path that the sound waves travel toward employees. Acoustical enclosures are commonly used as sound path treatments to contain the noise from a machine; alternatively, a control room/booth or equipment operator's cab may be used to isolate the worker from the noise.

Anyone who has successfully used acoustical enclosures knows that the design, procurement, and installation process is deceptively simple. All too often first-time efforts fail to account for many of the constraints that can render the enclosure essentially useless. Things that cannot be overlooked include: providing convenient worker access (physical and visual); allowing for proper machine operation/product flow; and supplying fresh air or preventing undue heat or contaminate build-up inside the enclosure. All of these factors must be given careful consideration, otherwise the enclosure will not perform adequately.

Enclosures that come as "standard equipment" or are an integral part of the machine are usually accepted by workers and usually work quite well. On the other hand, employees may reject the addition of a retrofitted enclosure, and intentionally defeat its purpose if it hinders production or interferes with normal work processes in any way. Enclosures are commonly dismantled and inadvertently (or perhaps purposely) reassembled incorrectly, leading to a severe degradation in their acoustical properties. Interlock switches may be intentionally disabled to allow the equipment to operate without all doors and access hatches being securely closed. Sometimes maintenance personnel don't even make an attempt to put the enclosure panels back together at all.

Perhaps the most important consideration that is overlooked when considering a machine enclosure or operator booth/cab is the adverse effects of a 'leaky' enclosure, i.e., an enclosure with a large number of openings or unsealed penetrations. These openings are usually referred to as "flanking paths," which are defined as any route by which sound travels from one side of a barrier to another, other than the sound that goes directly through the wall or barrier itself. There is a very rapid deterioration in the amount of achievable noise reduction if even only small holes are present in an otherwise solid enclosure. This effect is not necessarily intuitively obvious and has the tendency to be overlooked; however, it will become readily apparent after installation when the actual attenuation doesn't come anywhere near what was expected. Unfortunately, there are numerous examples of "home-made" equipment cabs/enclosures that are essentially worthless, although some come close to being effective but could be much better if there weren't so many openings left in them.

Figure 1 illustrates the effect different sizes of openings have on the actual amount of attenuation provided by an enclosure. The straight line depicts the condition where all walls are solid and there are no openings. Obviously, in this case the potential transmission loss of the enclosure equals the actual transmission loss achieved. Four 'leaky' conditions are also shown, representing the effect of a very small (0.1%) opening to a 20% opening. The arrows on this graph point out an example where a mere 0.1% opening degrades the attenuation of an enclosure by 10 dB. This graph also illustrates the fact that an enclosure wall with a low transmission loss value to begin with will be less affected by unsealed openings than a barrier with a high transmission loss.

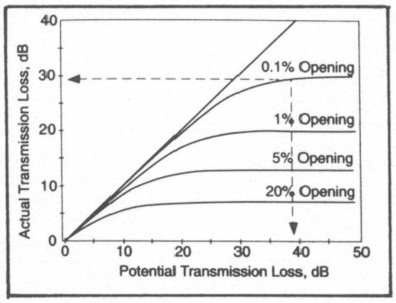


Figure 1. Effect of leaks in an acoustical enclosure. Example – the transmission loss of a wall with a potential TL of 39 dB will be reduced to 29 dB with a leak equal to only 0.1% of the total area of the enclosure.

Figure 2 shows an equipment operator cab that has many potential problems from an acoustical point of view. The door seals are either damaged or missing. Although it is difficult to observe from a photograph, there is a slight opening around each lever, gauge, and foot pedal whereby sound can leak in. Also, without any internal absorption in the cab the interior becomes a reverberant environment, which contributes to the noise problem.

Figure 2. Equipment operator cab with acoustical problems.

Figure 3 shows an example of a well-designed operator cab. The doors and windows close securely. Also, a flexible barrier material or caulking was used to seal around all controls, allowing adequate movement of levers while maintaining the overall integrity of the enclosure. In other situations, equipment manufacturers employ electrical controls rather than mechanical ones to minimize the number of moving parts that must pass through the enclosure wall into the cab.

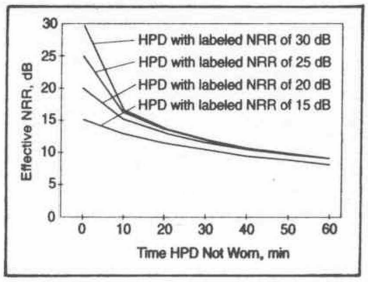
Whether purchasing an off-the-shelf enclosure or custom building one, it must

Figure 3. A well-designed operator cab.

seal absolutely air-tight to provide maximum effectiveness. One method to ensure that this will be achieved is to imagine that the enclosure will be used to hold water. Remember that any place where water can flow out represents a potential sound leak. If the enclosure passes this imaginary leak test, then it is more likely to deliver the amount of attenuation it was designed to provide. Also, a "light test" may be used where someone sits inside a darkened enclosure and looks for light entering around doors or other openings. Any glimmer of light indicates a gap that needs to be sealed. A dollar bill or other slip of paper is often used to check the effectiveness of a door or window seal. If the bill is inserted between the door and the seal as it is closed, it should not be able to be removed if the door gasket is adequate.

Of course, for production reasons it is not always practical to completely seal an equipment enclosure. When it is necessary to have openings for product flow or ventilation, a silencer, sound trap, or an acoustically treated chute should be used. A common mistake is to neglect items such as conveyors, which must be enclosed for at least a portion of their length immediately before entering and after exiting the enclosure. Therefore, some creative design work may be necessary to minimize any open areas and maintain acoustical integrity of the enclosure. This is a common situation encountered in industrial noise control; i.e., no single approach is applicable in all situations, and the most practical solution combines the exact science of acoustics with all production, maintenance, and economic constraints. SV

The Effect of Not Wearing Your Hearing Protector



Effective NRR when an HPD is not worn for the full 8-hour shift

It is important to be aware of the drastic reduction in the amount of protection afforded by an earplug/earmuff if it is removed for even just a few minutes during an 8-hour workshift. The accompanying graph illustrates this effect for Hearing Protection Devices (HPDs) with four different Noise Reduction Ratings (NRRs). Assuming workers are exposed to a constant level of hazardous noise throughout the workday, there is a surprising drop in the effective NRR provided by any particular HPD after only 10 minutes of non-use. Further, if the protector is not used for 60 minutes per shift (i.e., it is worn for seven of eight hours) then the effective NRR of nearly all HPDs is reduced to nine decibels or less, regardless of the labeled NRR. Therefore, it is not sufficient to wear your hearing protection most of the time – you must wear it all of the time to adequately protect yourself from noise-induced hearing loss.