Quieter By Design

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A paper on noise control for occupational health originally written for Safeguard magazine.

Abstract

In industry, noise can cause damage to hearing. However, it can also cause a range of non-auditory effects. In industrial environments noise can be reduced by purchasing quiet equipment, locating noisy equipment away from workers, ensuring appropriate vibration isolation is used, enclosing noisy equipment where necessary, attenuating noise through ducts and louvres, and by providing adequate shelter from noisy environments. Although noise in office environments does not generally pose a risk of hearing damage, there are a range of factors to consider that may reduce the non-auditory effects of noise on health. This article gives some guidance on how to set and achieve appropriate noise criteria.

Introduction

Acoustic design is a specialised field. However, there are many quite straightforward steps that can be taken to achieve an appropriate noise environment. This article demonstrates how to set and achieve appropriate noise criteria.

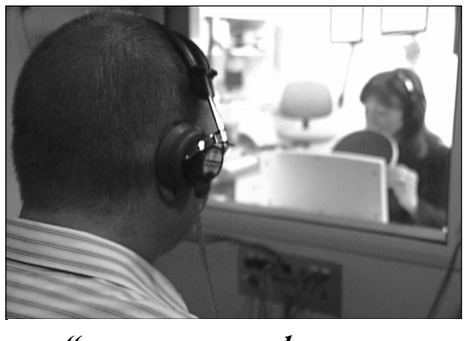
Industry & other "noisy" workplaces

In industry we seek to control noise because excessive noise causes irreversible damage to hearing. The majority of workers suffer only an 'acceptable' level of damage provided that they are not exposed to any more than 85 dBA L_{eq} over an 8-hour period, or more than 140 dB L_{peak}. It is really important to realise two things at this point:

1. Even below this level of noise, permanent damage to hearing can occur to some people over time (remember this damage cannot be reversed); and
2. Damage to hearing is not the only negative effect of excessive noise exposure.

From the first of these points we immediately see that providing hearing protection, and even getting workplace noise levels to 85 dBA $L_{eq\ (8\ hour)}$ or less, does not ensure a healthy workforce, or indeed compliance with the Health & Safety Act. The second point is a bit more subtle. People exposed to excessive noise will:

- Fatigue faster;
- Become irritable;
- Be more prone to lapses in concentration; and,
- When exercising considered judgement, be more prone to making poor choices and doing so with inadequate information.



"...permanent damage to hearing can occur to some people over time..."

Add to this mistakes and misunderstanding due to poor communication in noisy environments and suddenly we see that even "legal" noise levels in the workplace may act as a handbrake to your business and expose staff to unacceptable conditions. To cap it all off, at the end of a long working day, we send these fatigued, irritable and judgement impaired people out onto the road and home to their families. One wonders at the true social costs of excessive noise.

These effects are all collectively described as the non-auditory effects of noise.

In my experience many workers face noise levels at work ranging from 83 to 95 dBA $L_{eq\ (8\ hour)}$. This is typical of many light manufacturing, construction, roading, agriculture and aviation jobs. A significant number of workers are exposed to 95 to 100 dBA $L_{eq\ (8\ hour)}$ — typical in heavy manufacturing or other specific tasks.

Relatively few people work in jobs with exposure to greater than 100 dBA $L_{eq\ (8\ hour)}$. The consequences of not wearing hearing protection correctly, or at all, in these environments are potentially severe.

So what is an appropriate level for noise in an industrial or traditionally noisy workplace? The wording of the HSE Act and Regulation 11 of the HSE Regulations is actually quite explicit about this point. Providing workers with hearing protection when the noise level is above 85 dBA $L_{eq\ (8\ hour),}$ and doing nothing else, is not good enough. An employer must take all practicable steps to firstly eliminate, then if this is not practicable, isolate, and finally to

minimise the hazard (in this case noise). We've all heard this mantra repeated over and over but how do we apply this to noise?

Buy Quiet

The first thing to do is make noise one of your key purchase criteria. Where possible buy quieter machines. If a supplier does not state how much noise equipment produces, be sure to ask. The answer will often be expressed as a Sound Power Level (L_w of SWL) although a Sound Pressure Level (Lp of SPL) may also be given. Lower numbers are better, but in order to compare the numbers they will all need to be expressed as either L_p at a standard distance, or L_w.

Good Maintenance

Where you have existing plant, maintain it to a high standard. Clean and well-lubricated machinery can make significantly less noise than old slogged out equipment. We have measured reductions of up to 20 dB simply by lubricating and servicing equipment.

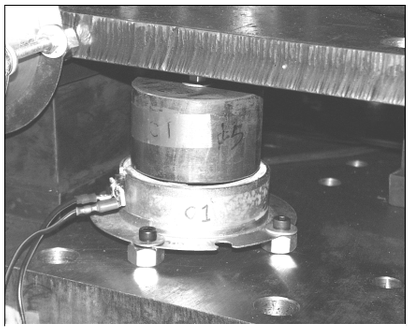
Distance

Noise drops off rapidly with distance, but only outdoors. Where possible place noisy items of equipment or activities as far away as possible from workers and neighbours. Where complete separation cannot be achieved, consider a location that affects the fewest people adversely. In many cases an appropriate response may be to use one building, room, or area of a plant for noisy activities, and to design this appropriately.

Vibration Isolation

Where machinery generates vibration, proper isolation can dramatically reduce the noise level present in other parts of the plant. Vibration isolation is especially important where machines are mounted to floors, mezzanines, support frames and walls.

The lack of proper vibration isolation can render enclosures useless. In general isolation can be achieved by using a suitable mount – usually made

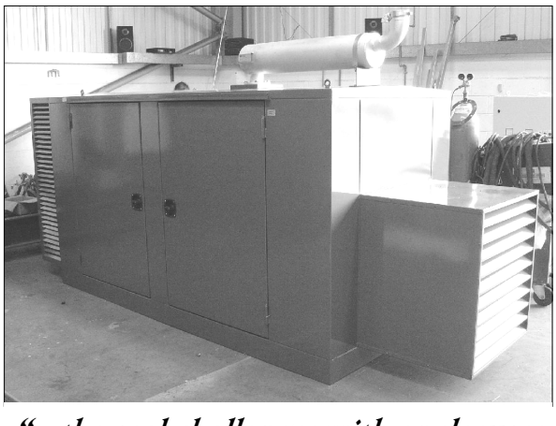


"...proper isolation can dramatically reduce the noise level present in other parts of the plant..."

from rubber or a spring — or by isolating a whole slab or frame from its surrounds by a break in the material.

The most common mistakes in mount selection are underloading the mounts or short circuiting the mount by having a part of the mount or equipment touching something that is not isolated. Always aim for as close to the maximum rated static deflection of the mount as you can get without exceeding this at the actual loading you will be subjecting each mount to.

For rubber pads and strips use the minimum amount of material possible. Bigger pads or strips mean less loading.



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Modifications

Sometimes quite simple modifications make a big difference. For example where rocks or timber smash against metal surfaces, the use of a tough polymer such as Linatex or similar can achieve great reductions with good wearing properties. Pneumatic equipment can be fitted with discharge silencers or attenuators. Many modifications are possible and could be considered, taking a wide range of factors into account.

Enclosures & Barriers

Enclosures or barriers designed to protect against noise are usually built around equipment, although these have been built around the operator instead in some circumstances. The key points with enclosures are:

- They should have an internal volume around three times as large as the equipment they will hold;
- The material they are built from must have the right combination of mass and stiffness, and be thick enough to achieve the desired noise reduction;
- There can be no rigid connections between the equipment inside the enclosure and plant or buildings outside the enclosure (these will transmit the noise and vibration);
- The inside of the enclosure should be lined with a suitable noise absorber;
- The enclosure must be completely airtight except for carefully designed ventilation.

The real challenges with enclosures are usually getting air into and out of the enclosure to carry away waste heat or for processing; and getting enclosure joints etc made to the required degree of tolerance.

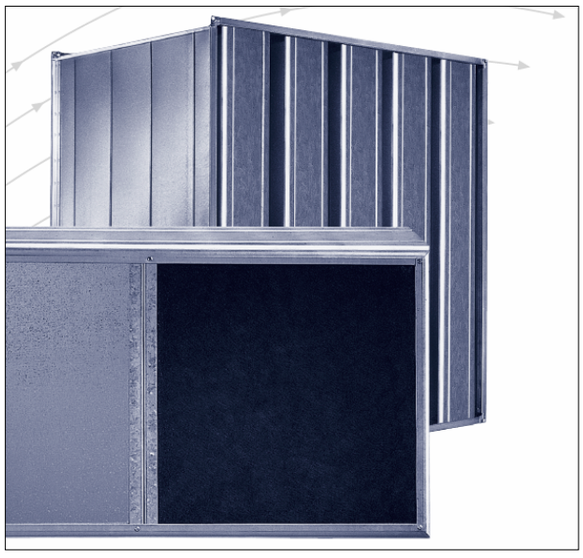
The mass of the material chosen for an enclosure is critical because at lower frequencies it is the mass of the enclosure material that will determine how well it works.

Below a critical frequency, the stiffness and damping properties of the material come into play. An awareness of the properties of the proposed enclosure materials and the acoustic spectrum of the noise source are important to ensure sufficient attenuation is achieved. Where an

enclosure is to be made from two or more layers of material, an important consideration is the "coincidence dip" (controlled by bending of the material). This is a drop in attenuation performance over a narrow range in frequency. The position of this dip varies by material and stiffness. It is important to design enclosures and barriers so that the coincidence dips of two layers overlap as little as possible.

Barriers work by reducing the amount of noise energy that passes through the barrier and also by increasing the distance that noise has to travel to get from the source to the receiver. Key points of barrier design are:

- Sufficient mass;
- No gaps, cracks or holes under or through the barrier;
- Sufficient height;
- Sufficient width; and
- Barriers only have limited effectiveness indoors.



"...an attenuator intended for use on a cooling tower or kitchen extract discharge has very different requirements to one for an air-conditioning system..."

While design and construction of modifications or enclosures and barriers can be a costly exercise, often significant reductions can be achieved by good attention to detail. In fact attention to detail is critical in achieving any significant reduction at all. However, in principle any equipment can be enclosed or treated in some way.

Attenuators, Louvres and Ducts

Attenuators and acoustic louvres are specialist devices designed to allow air to flow, while at the same time reducing the transmission of noise from one place to another. Often one or more fans are present, with varying ability to push against pressure.

Ductwork, attenuators and louvres all generate pressure for the fans to work against, and it is important that this is carefully considered. If the fan is made to work to maximum capacity it will generally make a lot more noise and will certainly cost more to run. The attenuator or louvre chosen may no longer

achieve the desired outcome.

Attenuators, especially if they need to be large, are a significant investment, so it is critical that these are properly specified.

The specification should include not just size, shape and pressure drop, but also installation orientation, and the specification of the absorbent, frame and panel materials. For example an attenuator intended for use on a cooling tower or kitchen extract discharge has very different requirements to one for an air-conditioning system.

Shelters & Refuges

Where significant reductions cannot be achieved then obviously hearing protection of the correct type and fit becomes critical. So does a noise refuge or shelter.

This may take the form of a quiet control room or a smoko room within a noisy factory area. Such rooms must provide adequate ventilation, while also remaining below 65 dBA $L_{eq\ (8\ hour)}$.

"...Clean and well-lubricated machinery can make significantly less noise than old slogged out equipment..."

Offices & other "quiet" workplaces

Generally there is acceptance that there is no risk of damage to hearing below 75 dBA $L_{eq\ (8\ hour)}$. Most office and retail staff, as well as certain types of factory workers are exposed to noise at or below these levels. It is often in these relatively quiet environments that the non-auditory effects of excessive noise exposure are most apparent to workers.

Common concerns are that the noise from air-conditioning systems, computer fans, and office equipment etc is annoying or distracting. Sometimes the concern is noise from colleagues sharing an open space or in the room next door. Occasionally the problem is noise from traffic on the road outside or an activity such as a gym in the building next door.

Finally, we are all exposed to noise both at home and during many of our recreational pursuits.

Depending on the level and duration of this noise exposure the result may be damage to hearing or the irritation and fatigue etc described above.

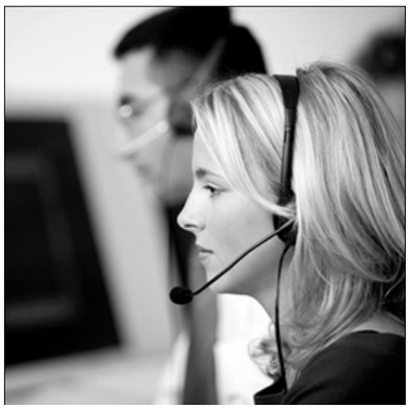
Workers who are exposed to noise during both work and rest periods are especially susceptible to adverse effects. Where insufficient rest is achieved these workers may also be more error and accident prone at work.

So, since noise can cause all these negative fatigue and irritation effects we want to make all workplaces as quite as possible – right? Well, no. It's certainly true to say that no one working in an office should be exposed to a background noise level of 50-65 dBA just from air-conditioning and fans. However, the cost of getting all offices, especially open plan offices down to a noise level of say 30-35 dBA or less would be very high.

In addition many workers would find that the environment lacked sufficient stimulation. Another issue is privacy. A certain amount of background noise assists with privacy by masking some of the sound made by colleagues speaking and thus rendering the conversation unintelligible to others. In a private office we recommend around 33 to 38 PNC, while in a general office area 38 to 43 PNC is more appropriate. In toilets, kitchens and arcades etc 50 to 55 PNC is perfectly acceptable.

The office walls, doors, partitions and ceilings all play a part in ensuring that the level and character of the noise in the building is acceptable – while at the same time achieving appropriate privacy. Privacy is important because of the nature of the conversation and the ability to concentrate on a specific task or conversation without outside distraction. Many variables affect acoustics of rooms, but here are some points to consider:

- Avoid excessive vibration from air-conditioning plant, servers and adjacent workplaces etc entering the building structure. We regularly see examples of unpleasant work environments created by these issues;
- Air-conditioning systems need regular maintenance of moving parts such as fans and motors;
- Glass, tiles, plasterboard and metal look great but are all acoustically reflective. Consider whether you need to make sound carry or would like it to be reduced. Decorate accordingly adding acoustic adsorption to walls and ceilings where necessary. Even certain types of furniture make a difference;
- Carpet, acoustic ceiling tiles, heavy curtains, and soft furnishings all help absorb noise;
- Avoid hard surfaces parallel to each other – these can generate flutter echoes;
- Consider flanking paths that may carry unwanted noise – such as ceiling voids where walls stop at a suspended ceiling;
- Place equipment such as photocopiers in areas where a bit of extra noise will be less noticed and possibly even welcome, but not where privacy or intense concentration is required.



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Concluding remarks

Many regard excessive noise in the workplace as inevitable. It's not. Neither is the same noise environment correct or desirable throughout a workplace. Dealing with noise issues is not straight forward and detailed knowledge can go a long way. Don't be afraid to ask for help.

The right advice will give a better quality result at less cost than a standard solution. Knowing what can actually be achieved in a given situation can prevent the waste of time and money to no additional gain.

When planning the management of noise in your workplace decide first on the appropriate noise level for each area. Take protection of hearing, the level of concentration, detail and judgment required of workers into account.

How much opportunity does the worker have to get away from the noise completely? What is the total exposure to noise throughout the day? Is there any requirement for greater privacy in certain areas of a workplace?

Once you have answered these questions it is possible to work out the design solutions and compare these to your budget. Prioritise your response according to the most significant hazards first, down to "nice to do's" last as you would with any other decision.

Additional Information:

AS/NZS 1269.2:2005 Occupational noise management - Noise control management. (http://www.standards.co.nz)

AS/NZS 1269.3:2005 Occupational noise management - Hearing protector program. (http://www.standards.co.nz)

Management of Noise at Work – Control Guide (http://www.osh.dol.govt.nz/order/catalogue/738.shtml)

Woods Practical Guide to Noise Control. Ian Sharland. Woods Acoustics, Colchester. 1972.

About the Author

Rob Hay joined Marshall Day Acoustics in 2006. Prior to this he was the manager of the environment division of the occupational health and safety consultancy, Triex.

Aside from his interest in making things quieter, Rob is also a keen glider pilot. ❑