Common noise and vibration sources

Introduction:

Vibration appears in many situations and can be experienced it in the home, during transports of different types, and in professional life. In vibratory feeding systems, objects are induced to move forward along a vibrating path. Ultrasonic cleaners are used for sterilization. Vibrating boring machinery is used to bore in rock. In vibration testing, components and entire finished products are exposed to high vibration amplitudes to evaluate their ability to function in their service environment. Nevertheless, vibrations are usually unwanted and harmful. Vibrating production machinery degrades production tolerances and surface finish. An unbalanced turbine can bring about serious fatigue problems leading to breakdowns. Vibration exposure from prolonged and regular work with powered hand-held tools, equipment or processes can have adverse effects on the hands and arms of users. Without effective controls, workers using such equipment may suffer various forms of damage, collectively known as 'hand-arm vibration syndrome' (HAVS). This is a painful condition and the effects can include impaired blood circulation, damage to the nerves and muscles, and loss of ability to grip properly. The best known form of damage is 'vibration white finger' (VWF), which is a prescribed industrial disease. Vibrations of hand-held machines can cause blood circulation problems in the hands, also the so-called white finger syndrome. Low frequency vibrations in the earth's crust, earthquakes, can demolish entire cities.

Operation of machines and vehicles gives rise to forces. These forces, in turn, generate vibrations. In order to describe the vibrations, we need to know their amplitudes, frequencies, and sometimes even their mode shapes, i.e., the deformation pattern of the structure. In machines, the main sources of vibrations are often forces due to accelerations and retardations of masses. Examples are unbalanced shafts in rotating machinery, reciprocating motions in piston-based machines such as compressors and internal combustion engines, and reciprocating motions in sewing machines. In gears, the contact forces vary as the gear rotates, since the number of teeth in contact is not constant. Shocks and vibrations in gears are also caused by manufacturing variability (tolerances on the tooth geometry), surface roughness, and shaft misalignment. In electrical machines, such as motors and generators, the electromagnetic forces give rise to vibrations. In internal combustion engines, compressors, and other pneumatic and hydraulic machines, pressure variations in the medium are the significant vibration sources. How strong vibrations are acceptable? There are, of course, no definitive answers to that question. Many different factors could come into play, such as surface finish requirements in machining, requirements for assembly precision, or fatigue strength in the most extreme cases.

Noise and vibration and mainly vibration in industry come from the machines and appliances used for production. The sources of industrial noise and vibration and vibration therefore have a wide variety. In this chapter some common noise and vibration and vibration sources will be discussed along with possible noise and vibration and vibration control techniques. A systematic approach for analyzing industrial noise and vibration and vibration problems using the source-path-receiver model is presented. Noise and vibration and vibration control at the source is always the preferred option but is usually difficult. Noise and vibration and vibration control during the propagation path is the second choice and some commonly used techniques are discussed. Noise and vibration and vibration control at the receiver is the last resort and usually involves hearing protectors in the form of earplugs or earmuffs.

In a large number of practical situations, the vibration can be controlled by reducing the excitation level at the source. This reduction in excitation is possible only after the source has been identified and the nature of excitation clearly understood. In this chapter, examples of forced, self-, and parametric excitations where the level can be controlled at the source will be discussed.

2.1 Systematic Approach To Industrial Noise and vibration and vibration Control

The sources of industrial noise and vibration and vibration are many and varied which means that almost any imaginable noise and vibration control technique may have to be considered. A systematic approach should start with applying the source-path-receiver model. The noise and vibration sources can be considered to be of two main types: sources associated with structural vibrations and sources associated with gas fluctuations. An example of the first type is machine surface vibrations causing sound radiation and an example of the second type of noise and vibration source is the pulsating exhaust gases from an IC-engine. There are also sources associated with interaction of gas flows and structures and sources caused by a free gas flow, i.e., jet noise and vibration. When buying new machines or replacing an old machines noise and vibration should always be considered.

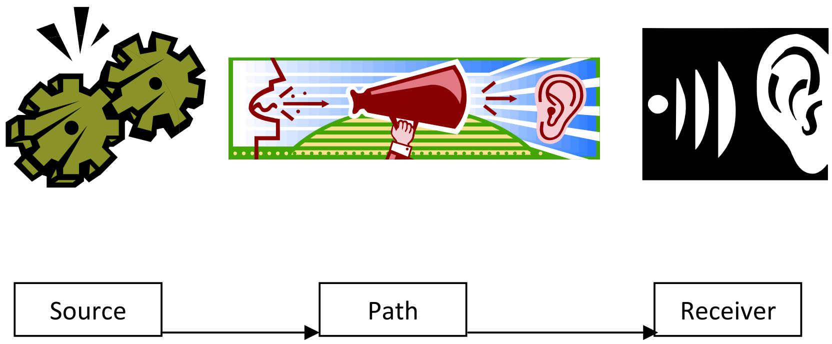

Fig. 0-1 Source-path-receiver model for analyzing noise and vibration problems [1]

Noise and vibration control at the source is always the preferred option but is usually difficult. It is however important to identify the main sources of noise and vibration. Noise and vibration control during the propagation path is the second choice and some commonly used techniques are discussed. Noise and vibration control at the receiver is the last resort and usually involves hearing protectors in the form of earplugs or earmuffs.

Noise and vibration control during the propagation path can involve measures such as enclosures, barriers and adding room absorption. Noise and vibration control at the receiver can involve protecting the worker using hearing protectors in the form of earplugs or earmuffs but can also involve enclosures.

2.2 Noise and vibration Control At The Source

In this section the different types of noise and vibration generating mechanisms will be discussed together with possible noise and vibration control techniques.

2.2.1 Noise and vibration generated by fluctuating forces in structures

The internal forces in a machine are transferred as structure-borne sound to the surface where it is radiated as sound. The forces can be either steady, for instance caused by reciprocating motion in an engine, or transient caused by impacts. The forces can also come from work performed on the work piece by a worker or a machine as exemplified in Figure 2-2. More noise and vibration is produced if a task is carried out with great force for a short time than with less force for a longer time.

Another example is a box machine where cardboard is cut with a knife blade, see Figure 2-2. The knife must cut very rapidly and with great force in order for the cut to be perpendicular to the strip and the result is high noise and vibration level. Using a blade which travels across the strip, the cardboard can be scored with minimal force for a longer time. Since the cardboard strip continues to move, the knife must travel at an angle in order for the cut to be perpendicular. The cutting is practically noise and vibration free.

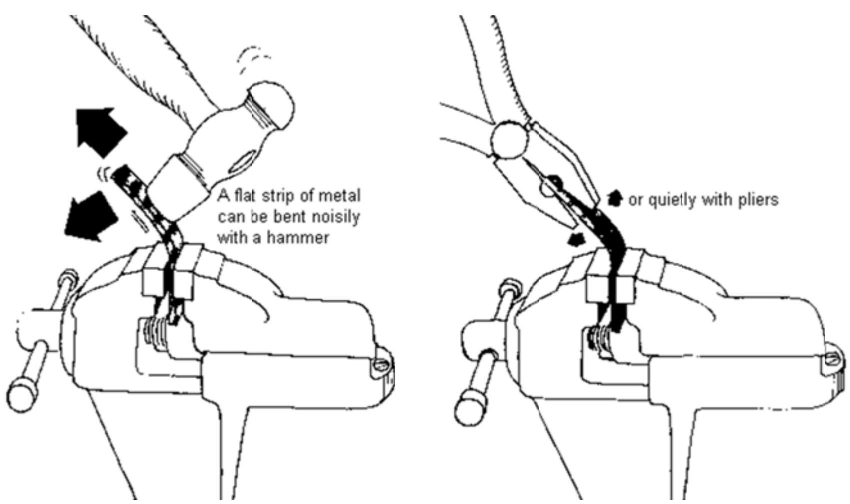

Figure 0-2 Noisy and quiet bending of a metal strip with high and less vibration (Picture: Asf, Bullerbekämpning, 1977, Illustrator: Claes Folkesson)

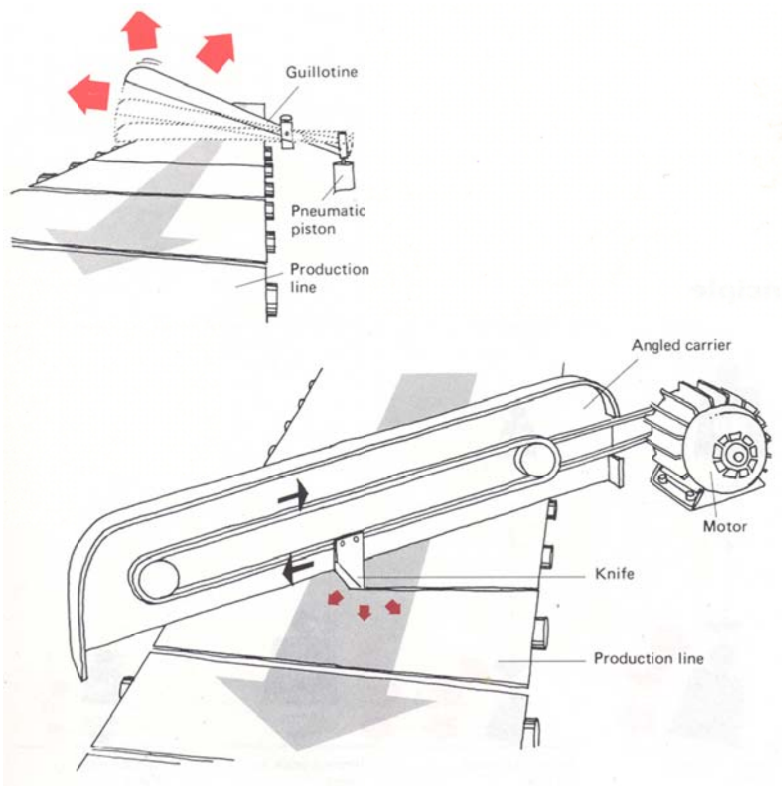

Figure 0-3 Noisy vs. low noise and vibration methods for cutting cardboard (Picture: Asf, Bullerbekämpning, 1977, Illustrator: Claes Folkesson)

Since, the structural vibration will have to radiate as sound from the machine surfaces reduction of the surface area or reduction of the radiation efficiency of he surface can be good noise and vibration control techniques. An object with a small surface area may vibrate intensely without a great deal of noise and vibration radiation. The higher the frequencies, the smaller the surface must be to prevent disturbance. Since machines always will vibrate to some extent, noise and vibration control will be aided if the machines are kept as small as possible.

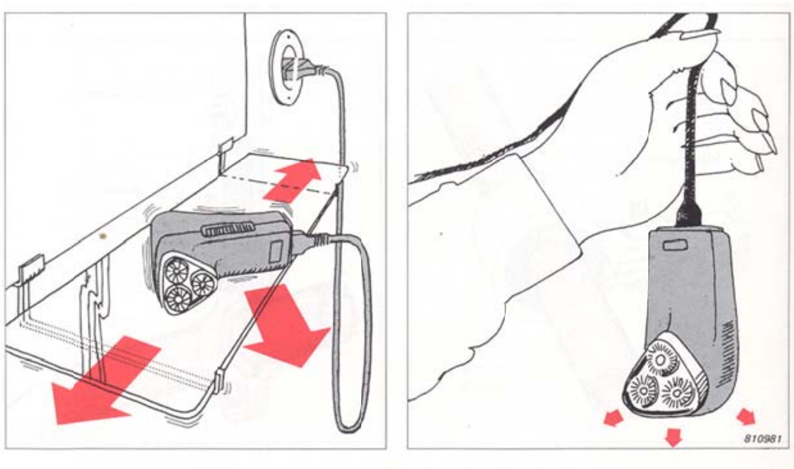

Figure 0-3 Example showing the importance of the size of the sound and vibration radiating surface on the resulting noise and vibration generation (Picture: Asf, Bullerbekämpning, 1977, Illustrator: Claes Folkesson)

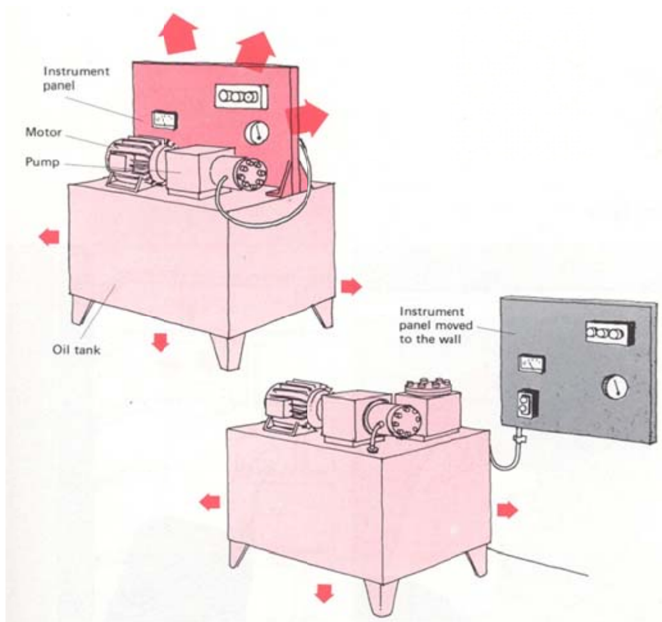

Figure 0-4 Example showing the importance of the size of the sound radiating surface on the resulting noise and vibration generation (Picture: Asf, Bullerbekämpning, 1977, Illustrator: Claes Folkesson)

Another example shows the noise and vibration generation from the control panel of a hydraulic system. If the panel is detached from the system itself, the vibrating surface is reduced, and therefore the noise and vibration level is decreased. Large vibrating surfaces cannot always be avoided. The surface vibration pumps air back and forth depending on the vibration patter, and it is this air pumping which causes the sound radiation. If the panel is perforated the air pumping is "short circuited" between the front and back of the plate, and the sound radiation is reduced.

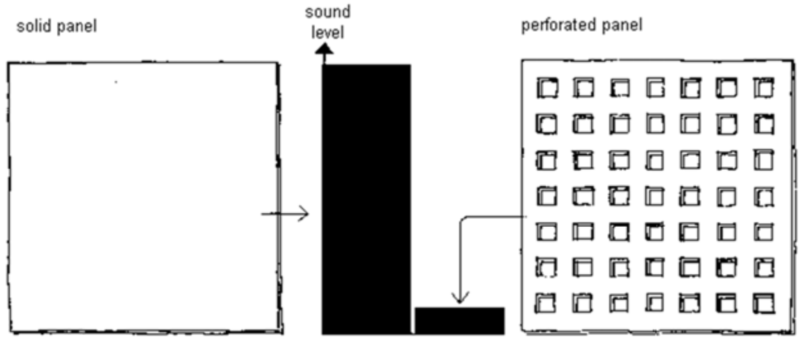

Figure 0-5 Principle for reduction of sound radiation by the use of a perforated plate (Picture: Asf, Bullerbekämpning, 1977, Illustrator: Claes Folkesson)

Another technique for causing this short circuiting between the front and back of a plate is to change the shape. If the plate has free edges short circuiting takes place at the edges therefore, a long, narrow plate radiates less sound.

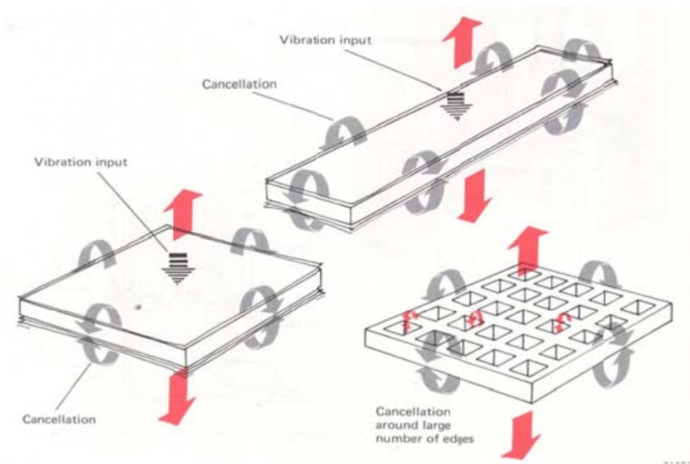

Figure 0-7 Principle for reduction of sound radiation by changing the shape of a radiating surface. (Picture: Asf, Bullerbekämpning, 1977, Illustrator: Claes Folkesson)

An example of the using of this principle is a belt drive which gives a large amount of low frequency noise and vibration because of the vibration of the broad belt. When the broad drive belt was replaced by narrower belts, separated by spacers the noise and vibration was reduced.

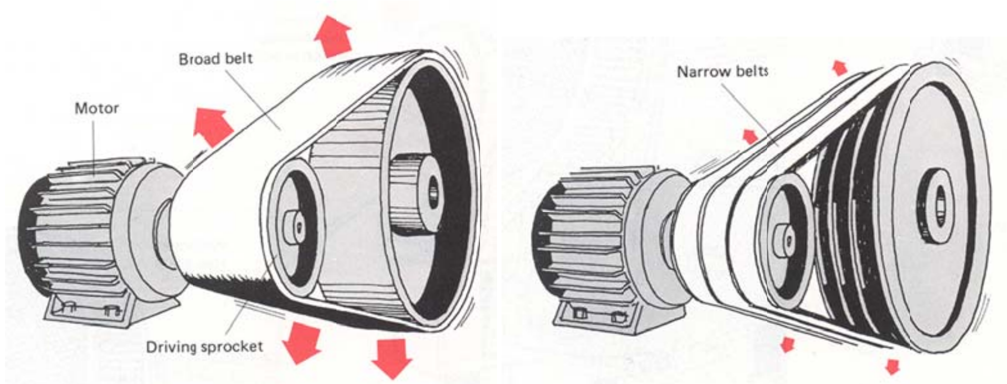

Figure 0-8 Example of reduction of sound radiation by changing the shape of a radiating surface. (Picture: Asf, Bullerbekämpning, 1977, Illustrator: Claes Folkesson.)

This principle can be used to reduce the noise and vibration from a cart which produces noise and vibration from the bottom and side plates when the cart is pushed. Sound is also emitted when material is slid down the cart walls. Pressure equalization only takes place at the top edges of the side plates. The walls were replaced by new ones, constructed with a pipe frame. Plates were fastened with a gap between the plates and the frame. Pressure equalization takes place along all the edges, and the low frequency noise and vibration is reduced.

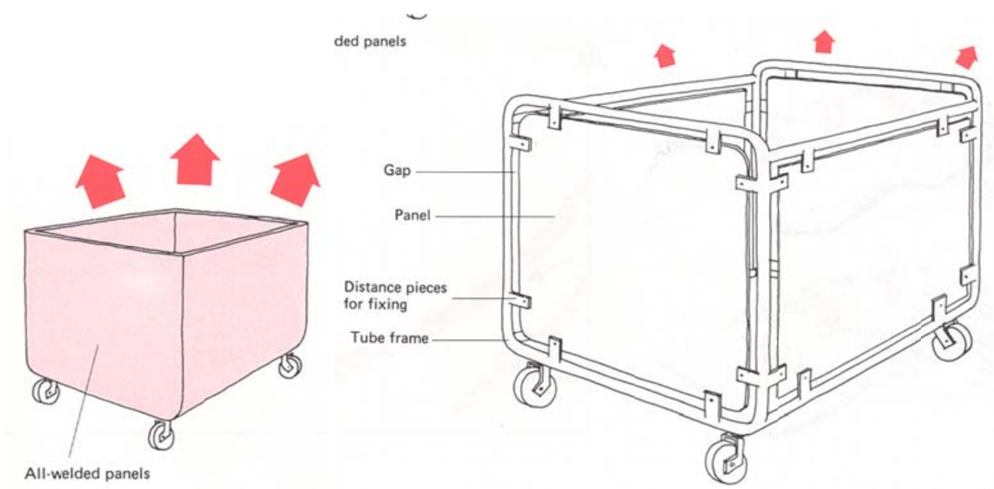

Figure 0-9 Example using the short circuiting of pressure at plate edges to reduce low frequency noise and vibration from a cart. (Picture: Asf, Bullerbekämpning, 1977, Illustrator: Claes Folkesson.)

Since, sound is generated by structural vibration measures to reduce surface vibration will also give noise and vibration reduction. One way is to increase the damping of the structure by adding coatings or intermediate layers with better internal damping.

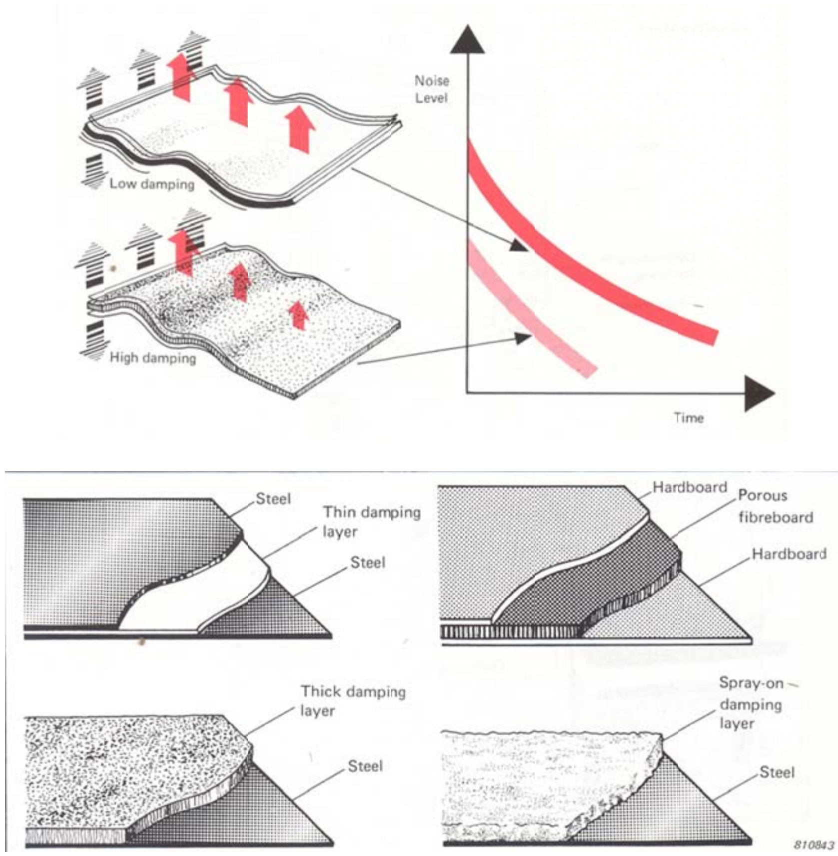

Figure 0-60 Principle for reduction of sound radiation by introduction of damping layers in a structure (Picture: Asf, Bullerbekämpning, 1977, Illustrator: Claes Folkesson)

An example of noise and vibration reduction using this technique is shown in Figure 2-11. The noise and vibration from a pump system comes to a large extent from the coupling guard which is made of sheet metal. The noise and vibration level was reduced by constructing it of damped metal.

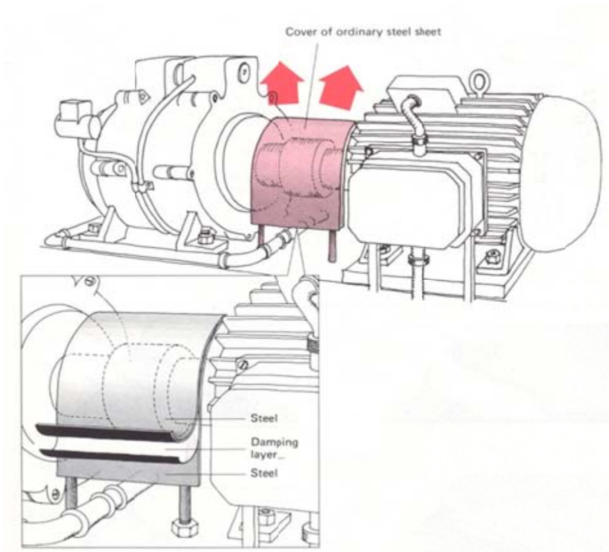

Figure 0-11 Example of reduction of sound/vibration radiation by introduction of damping layers in a pump coupling (Picture: Asf, Bullerbekämpning, 1977, Illustrator: Claes Folkesson)

Another reason for introducing damping is to reduce the effect of structural resonances. They increases noise and vibration from a vibrating plate, but can be suppressed by damping the plate. It may often be sufficient to damp only part of the surface, and, in some rare cases, damping of a single point is effective.

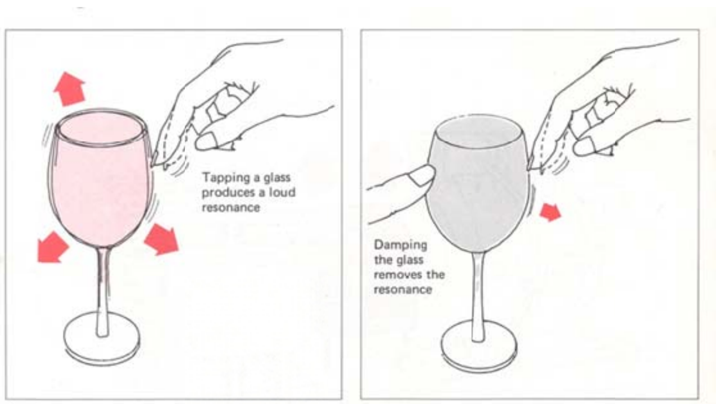

Figure 0-12 Principle for reduction of sound radiation due to structural resonances by introduction of damping. (Picture: Asf, Bullerbekämpning, 1977, Illustrator: Claes Folkesson)

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