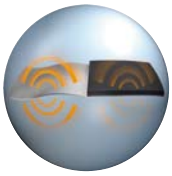

» Vibration Damping and Sound Deadening

Structure-Borne Noise (Vibration)

When sound travels through solid objects it does so in the form of vibration. This vibration is initiated by some form of mechanical excitation from a source that is in direct contact (coupled) with the structure. This sound is said to be "structure-borne". Often the vibration is able to pass into parts of the structure that are effective acoustic radiators and this generates airborne noise.

Vibration occurs to some degree in all industrial and service machinery and its control is key to effective noise management.

Reducing Vibration Noise

There are a number of different ways in which vibration noise can be minimised. The principle methods are:

1. Modification to the vibration generating mechanism (e.g. changing tool design, control of peak impact events etc);
2. Modification to the dynamic characteristics of the structure to reduce its ability to respond to the input energy. (e.g. by stiffness or mass changes or modification to the radiating surfaces, such as replacing it with a mesh instead of flat sheet)
3. Isolating the source from the body of the noise radiating structure by means of a flexible de-coupling material or resilient mounts.
4. Applying vibration damping materials that dissipates vibration energy in the structure and converts it to heat. This requires the use of a visco-elastic damping layer which has a mass close to that of the structure it is applied.
5. Applying active vibration control to modify the dynamic characteristics of a structure.

Vibration isolation and vibration damping (points 3 and 4 from the list above) are the two approaches that often involve the use of acoustic insulation materials.

The Principle of Damping

Damping introduces a retarding force that acts to oppose the motion of vibration. The introduction of a damping material onto a vibrating element will cause the oscillatory motions to decay more quickly than if it were left untreated.

In isolation systems damping is used to alter the natural resonance frequency of a surface. Damping materials can also be used to control vibration levels in structures and panels that are not adequately isolated from the excitation element. This is sometimes referred to as 'Sound Deadening'.

The Damping Ratio

The damping ratio, is of particular importance when looking to understand the impact a material will have with respect to damping. The damping ratio is defined by the following equation:

$$c = C / C_c$$

where C is the viscous damping coefficient and C_c is the critical damping coefficient defined as follows:

$$C_c = 2\sqrt{km}\ (\mathrm{kgs^{-1}})$$

where k relates to the spring constant or stiffness and m relates to the oscillator mass.

The importance of the damping ratio is that it defines how long the system will vibrate when excited.

Under-Damping

When the damping ratio is 0 an excited system will continue vibrating forever with no loss, as the ratio rises towards 1 the vibrations decay more quickly. This state is known as "under-damping".

In most vibration isolation applications it is rare to find systems where the damping ratio c, is greater than 0.1 unless high damping has been designed into a system on purpose.

Critical Damping

Systems which exhibit a damping ratio of 1 eliminate vibration as efficiently as possible and said to be "critically damped". Unlike under-damped systems, systems which are critically damped do not oscillate.

Over-Damping

Beyond critical damping are systems with damping ratios greater than 1 and said to be "over damped". These over-damped systems do not oscillate like under-damped systems but take longer than critically damped systems to settle after excitation.

Damping Of Sheet Metal

Damping of sheet metal structures can be accomplished by the application of a damping material to the metal sheet, such as is used in car bodies.

Many types of damping are available from various manufacturers for this purpose. Some may take the form of tapes, sheets or sprays that may be applied like paint though all make use of some non-hardening, visco-elastic material.

Loss Factor

The units of the Loss factor are dimensionless and represent the materials ability to dampen a structural element based on a hysteretic damping effect. It is based upon displacement, and for a solid material it is defined in terms of a complex modulus of elasticity $E' = E\,(1+j\mu)$ where E is the Young's modulus of elasticity.

Determining the loss factor for a chosen material is good way to determine its ability to control the vibration levels of a given system'. There are a number of methods that can be used to determine the loss factor for a given material. Perhaps the best is that described in ASTM 756-98, the 'cantilever beam' method. It should be noted that the Loss factor may change with frequency.

Armacell Solutions

Armacell manufactures the following products which provide effective damping control for sheet metal.

ArmaSound RD 240

ArmaSound RD 240 is a unique, high performance, dust and fibre free, elastomeric acoustic absorber. The comparatively high density and visco-elastic properties of the rubber based product also ensures ArmaSound RD 240 performs well as a vibration dampening material.

ArmaSound Barrier E

ArmaSound Barrier E is a high mass flexible vinyl mat loaded with naturally occurring minerals. In addition to offering excellent barrier performance, ArmaSound Barrier E also provides excellent acoustic damping when applied to a surface.

ArmaSound Barrier T

ArmaSound Barrier T is a high density bitumen based barrier with exceptional damping and barrier properties. It's high visco elasticity makes bitumen the most effective damping material available.

armacell engineered foams

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