VIBRACHOC RANGE

1 - METAL MOUNTING SYSTEMS

VIBRACHOC have a range of all steel mountings whose essential element is the **"steel cushion"** made from compressed woven or knitted stainless steel wire mesh.

Metal mounts have considerable mechanical strength as well as high damping characteristics in the order of 10 to 20%, depending on the application.

Advantages

Stability. Steel mounts provide stable characteristics and the height under load remains constant with time.

Unaffected by corrosion. Steel dampers are unaffected by oil, grease, solvents, adverse weather and corrosive products.

Unaffected by temperature. Steel dampers withstand temperatures from - 70°C to + 300°C without changing characteristics.

Low natural frequency. Steel mounts with springs can have natural frequencies as low as 3 Hz, which can provide up to 98% attenuation for low speed rotating machinery.

2 - GENERAL INFORMATION ON VIBRATION AND SHOCK

2.1 Purpose of an elastic suspension

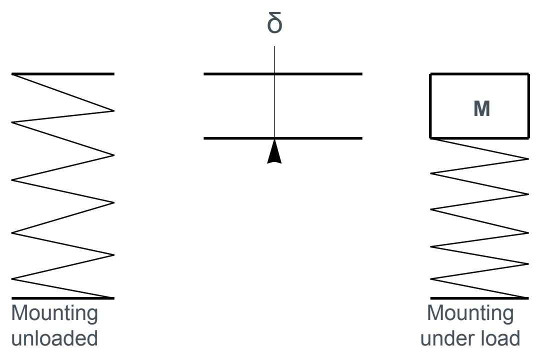
An appropriate elastic mount placed between the support and the equipment usually fulfils two functions :

- it has an important static role: it provides better load distribution by absorbing certain manufacturing tolerances, thus allowing more reliable, cheaper installation;
- it has a dynamic role : it provides protection against vibration and shock, considerably reducing the surrounding vibration and increasing the life time of the equipment isolated.

2.2 Theory

2.2.1 Natural frequency

An elastic mount characterised by its load-deflection curve. The load produced by a mass M causes a static deflection δ (difference between the unloaded height and the height under load) and a subtangent Δ.



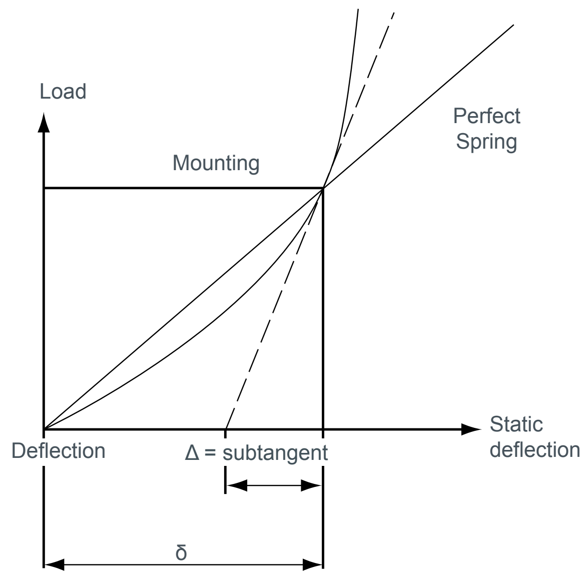
The Natural frequency of the suspended mass is given by the formulae

f in Hz $f = \frac{1}{2\pi}\sqrt{\frac{K}{M}}$

K = stifness of the mounting in N/m

M in kg $f = \frac{15,8}{\sqrt{\delta}}$

Δ = dynamic deflection in mm



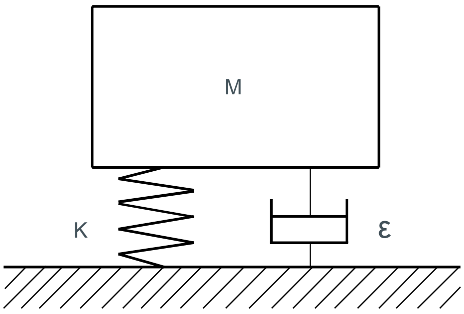
The load-deflection curve is linear for a theoretical spring but is not necessarily linear for a mounting. The form of the curve is highly variable and depends on the design and materials of the mountings.

2.2.2 Natural frequency

The purpose of a mount is to reduce the transmission of excitation forces between the suspended mass and the foundation. The degree of attenuation obtained depends firstly on the natural frequency of the mount or, more exactly, on the ratio of fe (excitation frequency) to f_0 (natural frequency).

In the simplest case, that of a single degree of freedom (vertical translation), the natural frequency of the mass + isolator without damping and is written

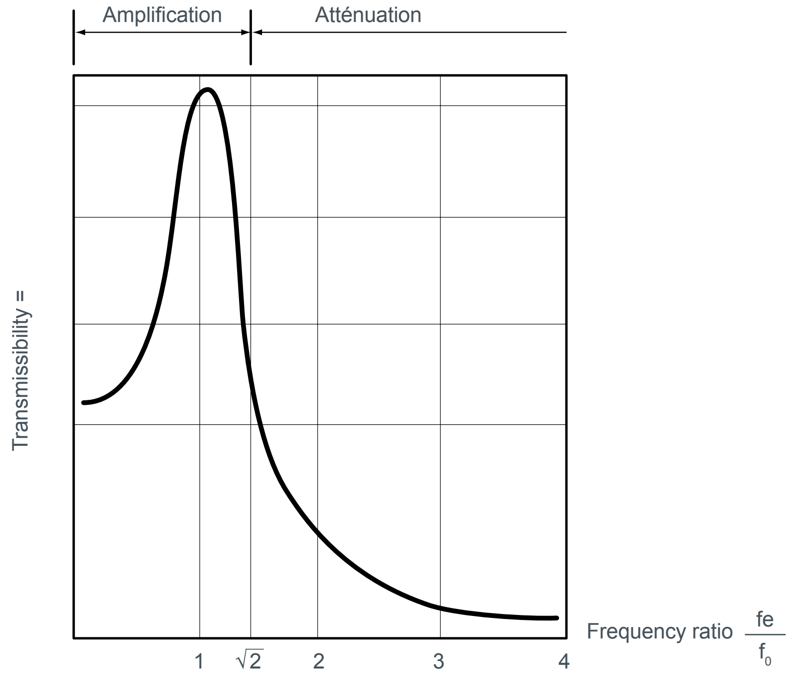
$$f_0 = \frac{1}{2\pi} \sqrt{\frac{K}{M}}$$



f_0 = Hz
K = Stiffness of isolator in N.m
M = Kg
Model of an elastic mount
K = stiffness
e = damping

Transmissibility is the ratio of the transmitted force fp to the excitation force fe. Examination of the curve opposite shows that :

- for $fe/f_0 < \sqrt{2}$ and in particular when the natural frequency of the mount is greater than the excitation frequency, there is amplification of vibration rather than attenuation.
This illustrates the fact that the selection of unsuitable resilient mount makes the problem worse rather than solving it.
- for $fe/f_0 > \sqrt{2}$, the excitation is attenuated. This shows the advantages of using a mount with a natural frequency (f_0) as low as possible in relation to the excitation frequency (fe). The greater the difference, the higher the degree of attenuation.



2.2.3 Damping

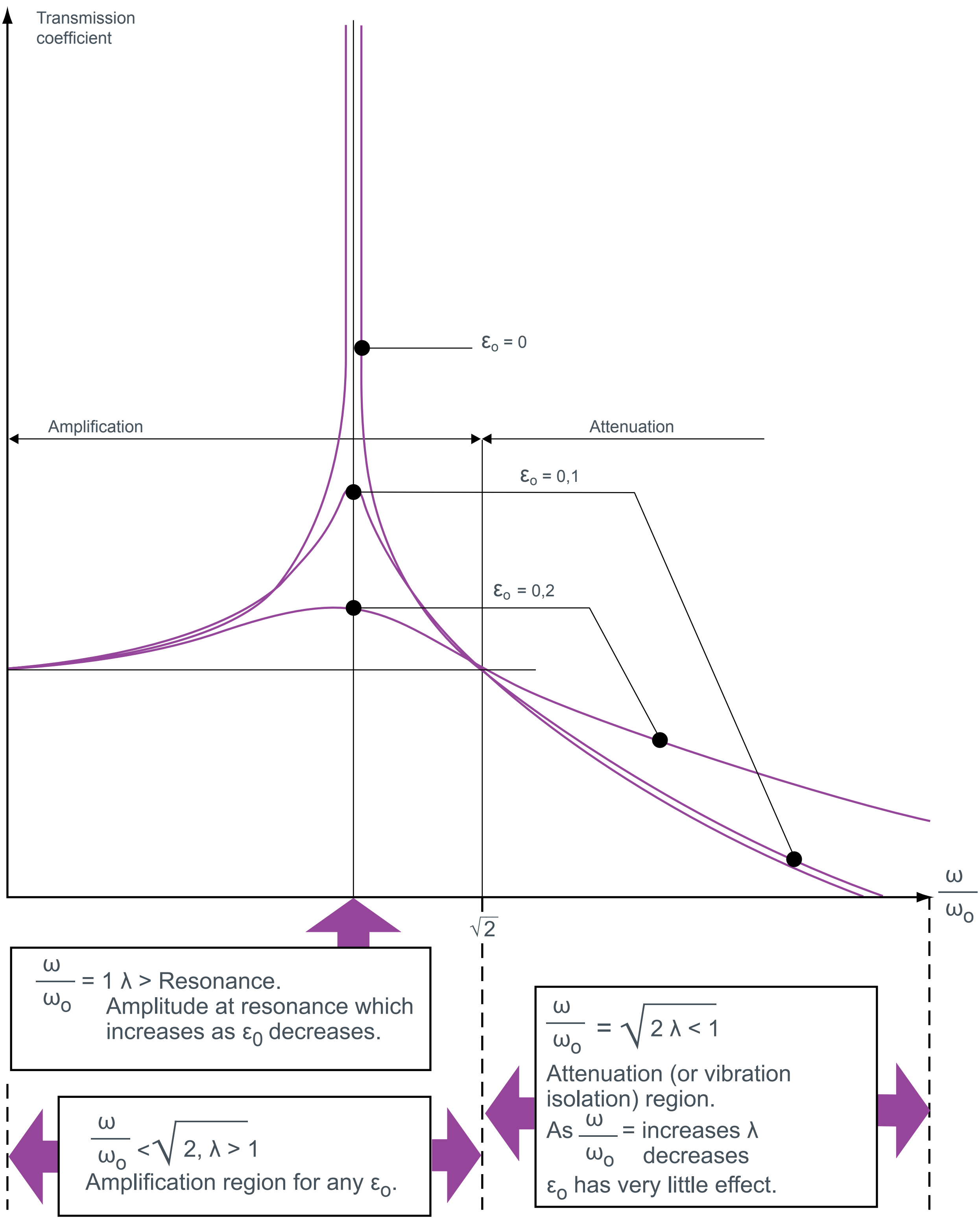
Damping dissipates vibrational energy by dry or viscous friction and acts as a brake, preventing displacement of the suspended assembly.

It can be seen that :

- for $fe/f_0 < \sqrt{2}$, the amplification decreases with higher damping, particulary when close to resonance;

- for $fe/f_0 > \sqrt{2}$, attenuation improves with lower damping.

To limit amplification at resonance while achieving good attenuation, it is necessary to find a good compromise when choosing a damper.



For an efficient mounting system use :

a high value of $\frac{\omega}{\omega_o}$ ⟶ low value of ω_0 ⟶ low value of λ

a high value of ε_0 ⟶ - limited amplification in the resonant region;
- minor effect in the attenuation region.

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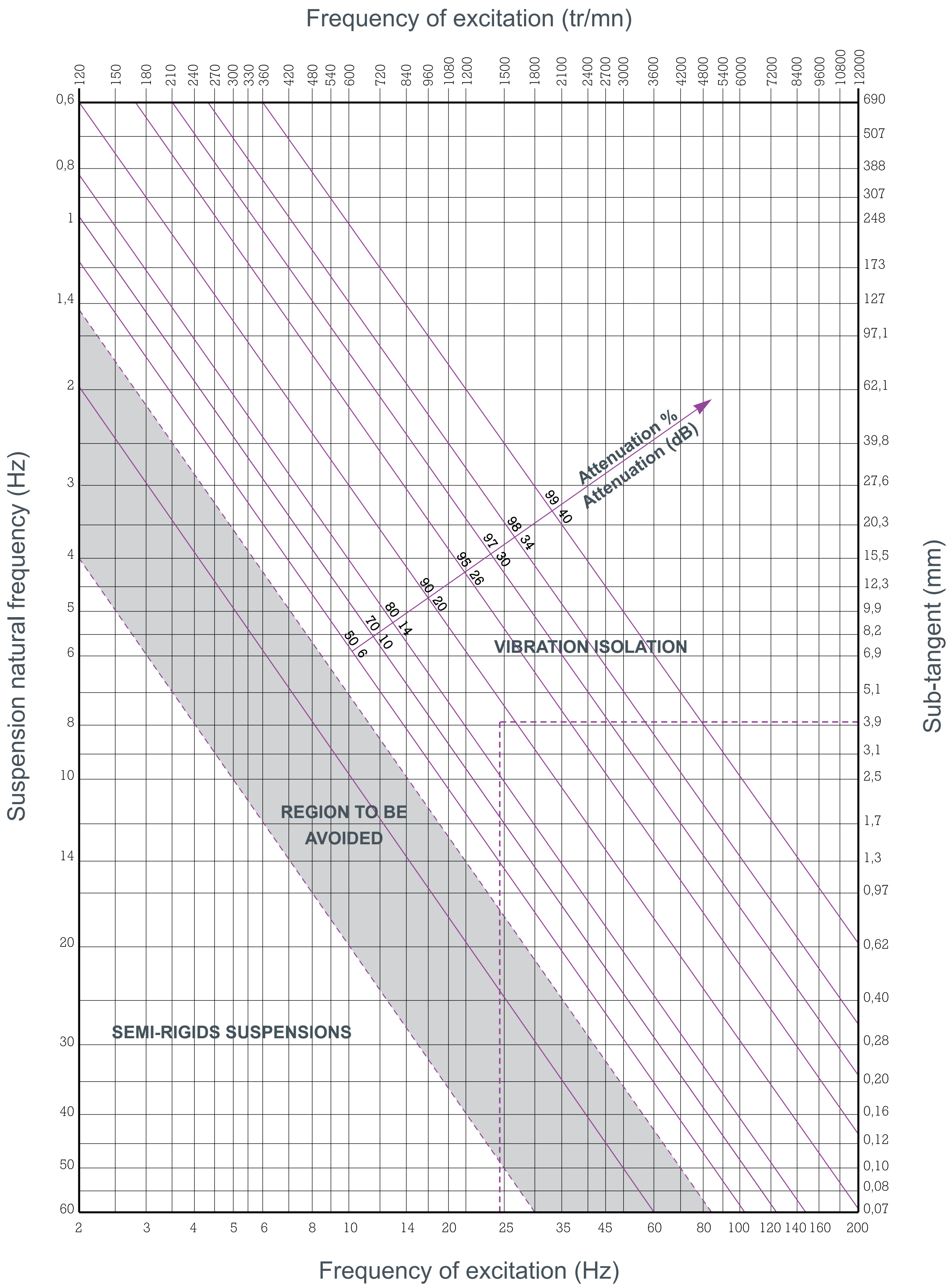
Attenuation as a function of natural frequency and frequency of excitation
(A theoretical graph for a mounting system without damping)



- Select the running speed (rpm) or frequency of excitation (Hz) of the equipment to be mounted, on the horizontal axis.
- Project a vertical line to intersect with a horizontal line which passes through the natural frequency of the mounting system selected.
- Where the two lines intersect, follow a diagonal line to find the level of isolation for the mounting system chosen.

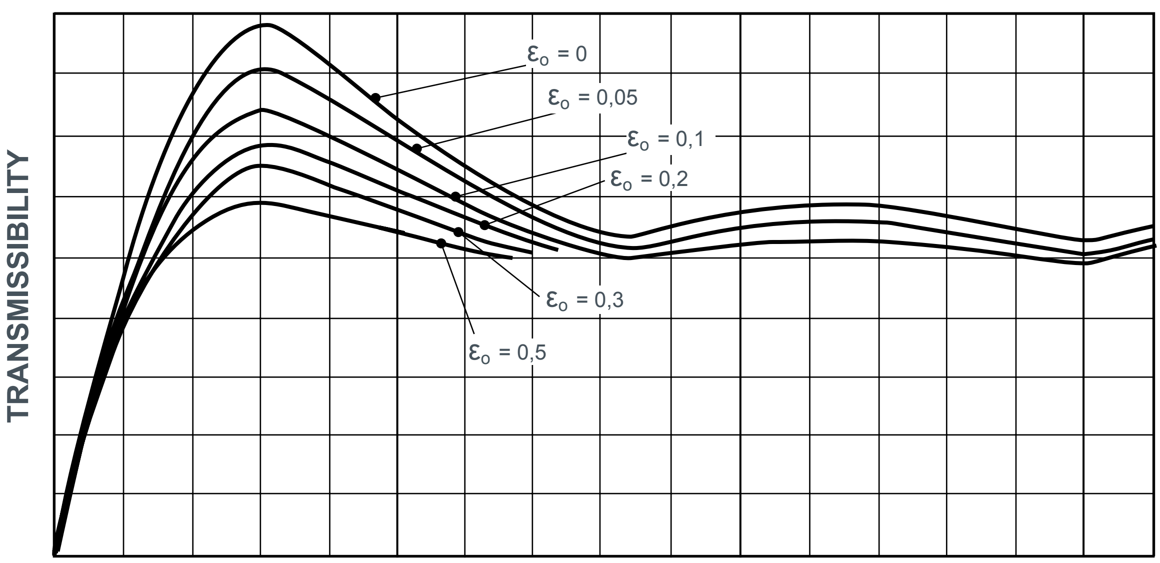
2.2.4 Shock

For impact machines like presses, forging hammers, etc, excitation is generated in the form of individual very short-time based shocks. In the same way as for vibration, where the importance of the relationship of fe to fn is paramount in determining the attenuation provided, here it is the fn/fs relationship (f_0 : natural frequency of the mounting - fs : shock frequency) which as to be considered.

We can deduce from these curves that :

- to obtain attenuation of a ½ sine shock (T < 1) the fn/fs ratio must be approximately less than 0.30. Beyond this limit the excitation force is amplified. Thus for a shock lasting 0.02 second, the resonant frequency of the isolators chosen must be as low as possible and in any case must be lower than 7.5 Hz;
- the presence of damping between 0 and 0.5 of critical contributes to the attenuation of a shock, but this improvement is slight for f_0/fs < 0.3.

The influence of the damping effect will be all the greater in the case of multi-frequency excitation where it is not always possible to select a natural frequency well away from the excitation frequencies. This is also true when searching for a compromise between shock attenuation (force transmission) and the limitation of displacement.



NATURAL FREQUENCY, fn X DURATION OF SHOCK T (secs) - FOR ½SINE SHOCK

Polígono Industrial O Rebullón s/n. 36416 - Mos - España - rodavigo@rodavigo.com

3 - VIBRACHOC RANGE APPLICATIONS

Industry

- Isolation of rotating machinery
- Isolation of machine tools
- Protection of works of art

Defence

- Protection of vehicle mounted electronics (tanks,shelters, off-road vehicles)
- Protection of inertial platforms, guidance systems, fire control and command and control electronics
- Protection of missiles, their associated equipment and components

Marine and naval

- Suspension of motors, engines, sructures, and exhaust systems
- Protection of electronic cabinets
- Discrete acoustics

Aerospace

- Protection of electronics
- Helicopter lead lag dampers and laminated bearings
- Mounting for onboard avionics
- Engine and APU Mounting Systems

Rail

- Protection of train mounted electronics
- Suspension of train mounted equipment (forms, air conditioners, transformers)
- Improved acoustics (suspension of bay front panel, floors ...)

Civil engineering

- Suspension of fans and air conditioning systems
- Suspension of floors
- Suspension of pipes and ducting

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4 - INDUSTRIAL APPLICATIONS OF THE VIBRACHOC RANGE

4.1 Machine tools and impact machinery

- Lathes, horizontal and vertical mills, tapping machines, drills, etc.
- Hydraulic and mechanical presses, shears, etc.
- High speed presses, power hammers, etc.
- Printing machinery, textile machinery, etc.

Suspension of machine tools
For example, lathes, drills, mills, planes, mortise cutters, saws, grinders, nibblers, gear cutter, borers, tapping machines, etc. The machinery is isolated actively (attenuation of the vibration generated by the machine) and passively (the machine is protected from floor vibrations).

- Vertical natural frequency between 20 and 25 Hz, provides excellent attenuation of the vibration spectrum, very effective for this type of machinery.
- Various assembly possibilities : integral levelling, non-slip base, fitting under machinery that does not have any mounting holes, etc.

Suspension of machinery for forming materials
For example : shears, folding machines, presses for punching, stamping, pressing and embos-sing, machinery for making nuts, hydraulic and mechanical presses, etc.
This type of machinery operates mainly by delivering blows and the shocks generated, which are sometimes significant, have to be absorbed by dampers with both a considerable capacity and high mechanical strength. The noise propagated to the structure is also noticeably reduced.

Suspension of high speed presses
The suspension has to avoid transmitting shock to the floor while maintening the stability of the machine, particulary for automatic feed.

The dampers must be selected to avoid resonance with the machine speed :

- the machine speed may vary from 0 to 600 cycles/min;
- if the speed is greater than 250 cycles/min, highly efficient isolation is obtained by using very low frequency mountings. An integrated damping system is usually necessary (metal pad, fluid dampers, etc.).

4.2 Rotating and vibrating machinery

- Engines, generators sets, compressors, fans, crushers, centrifuges, dryers, pumps, etc.
- Sieves, riddles, engine test benches, pipework, etc.

Suspension of well balanced rotating machines
This category includes most rotating machines, which develop free forces during operation which are quite low in comparison with their mass, such as : generator sets, air conditioning plants, most engines, fans (in clean air), compressors, pumps, etc.

The choice of mounting depends mainly on the speed of rotation of the machine and the degree of attenuation required. The natural frequency of the mounting must be low for slow rotational speed and high attenuation.

The antivibration mounting protect the machine without using an inertia mass. However, the engine should be mounted on the same chassis as the driven equipment if they are not already mounted in this way, to avoid excessive stress on the couplings.

Suspension of rotating machines with high dynamic forces
Grinders, centrifuges, dryers, certain types of reciprocating compressors, pumps, engines (with 2 or 3 cylinders), etc. may generate very high forces (such as eccentric loads, unbalanced forces or torque, start-up and short-circuit torque, etc.) during operation which may affect their stability and the various connectors and hoses. It is essential to limit the displacement of the suspended equipment by ensuring that the anti-vibration system is properly designed:

- the mountings should include dampers such as metal pads, damping fluids, etc.;
- an inertial mass may be incorporated, but only if the damping obtained is insufficient to stabilise the equipment.

The design of the mounting system must cover all aspects and be carried out from the start of the equipment installation design to define the supporting structures accurately at a sufficiently early stage.

Consult us for particular solutions.

Passive suspension of rotating machines
Certain types of compressors are perfectly balanced and do not generate any significant vibration. However, their operation and setting are so sensitive to vibration or shock (nearby workshops, handling, etc.) that they need passive protection.

The machine should be mounted on an inertial mass suspended on mountings with springs and metal pads.

Suspension of on-board rotating machines
On board lorries, trailers, trains, road and rail vehicles, boats, etc.

In addition to active protection, the machine needs to be protected against shocks and vibrations generated by the vehicle.

“Captive” mountings are usually used. They have travel limiting stops in all directions to ensure absolute safety while the vehicle is moving.

Suspension of vibrating machinery
Suspending sieves, vibrating riddles, etc... is more complex because these machines already have elastic couplings (e.g. springs) which assist operation.

If the machine is suspended on vibration mountings, it becomes a two-stage vibration system. When designing these systems the natural frequency of the elastic couplings within the machines as well as any flexibility in the chassis have to be taken into account.

Suspending engine test benches
This type of equipment poses a special vibration problem:
- the forces generated may be very high and sudden;
- the equipment must be able to be used with engines that vary considerable in size, weight and power.

An effective solution is to use an inertia mass suspended on very low frequency mountings with adequate integral damping.

4.3 Vehicles

- Civil engineering plants
- Handling equipment
- Trucks
- Trailers
- Road vehicles
- Railway engines

Particular attention must be paid to elastic mountings for equipment on civil engineering plant and vehicles in general. **The relative elasticity of the structures must often be taken into account as they can generate low or very low frequency vibration as a result of shocks arising from the work or movement.**

To be effective, the elastic mounting, must, therefore, be carefully designed.

The following examples, in particular for cabs, seats and equipment, are given for illustration only. The right solution may vary considerably from one machine to another.

Suspension of propulsion systems
The problem here is to minimise the vibration and noise generated by the engine through the structure of the vehicle (structure borne).

The disturbing frequencies vary from 10 to 100 Hz (and harmonics) for engines and 120 to 400 Hz for gear boxes.

The damping system should usually have :
- a low (isometric) resonant frequency (if possible 6-8 Hz);
- a limited displacement under extreme forces (system with very progressive siffness);
- considerable low frequency damping and as low as possible above 100 Hz.

4.4 Marine - offshore

The vibration and noise on board ships is generated by :

- the system of propulsion: the alternating hydro-dynamic forces generated by the propellors pass through the hull, usually creating low frequency vibration;
- the main engines and auxiliary engines which transmit vibrations to the hull via the structure : the spectrum is usually in the 15-50 Hz region;
- the exhausts : spectrum 16-8000 Hz;
- the effects of the sea : swell, heavy seas, wind;
- accidental shocks against the quays.

Regulations have been drawn up to protect the crews, passengers and equipment from discomfort caused by shocks and noise.

The VIBRACHOC range provides a comprehensive selection of means for complying with the standards and regulations for vibration and noise on ships (ask us for details).

Suspension of main engines and auxiliary engines

The main engines and auxiliary engines transmit vibrations to the structure of the ship. They also emit noise :

- directly into the air;
- indirectly, as the structures linked rigidly to the engine themselves become sources of transmitted noise.

Mountings (dampers) at strategic places between the engine and the structure significantly reduce the structure borne vibration and noise.
Many parameters are required for calculating the suspension required for marine engines : the rotation speed of the engine, the number of cylinders, the number of blades on the propeller, the natural frequency of the hull, the elastic coupling characteristics, the roll, the pitch and the maximum permitted forces. The technical service of Paulstra has several computer calculation programmes to define the most suitable suspension.

An extensive range of all metal or elastomer based dampers is available for mounting all kinds of engines :

- **diesel engines** of all sizes for merchant ships, war ships or pleasure boats;
- **auxiliary engines**, generators, pumps, compressors, windlasses, etc.

Suspending exhaust pipes

The turbulent gases circulating in exhaust pipes are a source of vibration and noise.
Using elastic mountings to anchor exhaust pipes from diesel engines has the advantages of :

- reducing the vibrations transmitted to the structure of the ship;
- attenuating the global noise in areas near the funnels, by between 5 and 20 dB (A);
- eliminating expansion compensators, as the mounting allows free expansion of the ducts;
- eliminating the deformation of the pipes caused by rigid mountings. The suspension of an exhaust pipe usually requires supports and stabilisers.

Suspension of on board equipment

Elastic suspension of sensitive on-board equipment (radio, navigation, electric or electronic enclosures, control panels, etc) provides protection against vibration coming from the structure. On board warships, high deflection mountings also provide protection against shocks from mines, etc. Stabilisers have to be added to supporting dampers for tall enclosures or racks.

4.5 Buildings

The problem of preventing vibration caused by air conditioning, ventilation, compressor or pumping systems, etc, in housing (flats, hotels, etc) offices or factories is now becoming more common for two reasons :
1) there is a general tendency to reduce the vibration and noise levels to comply with new noise regulations;
2) there is also a general tendency to build lighter constructions with greater spans, implying greater floor flexibility.

Active damping of machinery by preventing vibration being transmitted through the structure of buildings is often a way of complying with these regulations. The mechanical vibration filtered by VIBRACHOC mountings is transmitted at a level that is too low to excite structures that could create noise.

Suspension of foundations of lifts, hoists, etc.
The vibration generated by the winch while operating a lift has to be damped but it is especially important to absorb the shock generated when the machine starts or brakes. This often requires the use of elastic systems with good damping.

Suspension of fans, air conditioning, compressors, pumps, etc.
An elastic suspension provides good protection against vibration, **while, in most cases, avoiding the need for concrete masses, a costly solution** which prevents the equipment being moved easily.

The vibration and noise generated by a machine are more of a nuisance to the environment if they are positioned at a structurally weak point (roofs, terraces, floors, etc) and near offices or flats.

The rigidity of the floor is a factor that has to be taken into consideration when deciding which type of suspension to use.

Suspension of floating slabs
An economical solution is not to mount each machine separately but to group all the equipment likely to cause vibration on one slab, said to be floating because it is linked to the structure of the building by very low frequency mountings.

This system considerably increases the inertia of the suspended part and thus significantly reduces the displacement of the slab.

Suspension of pipework and conduits
Pipes and conduits generate two types of vibration :
- low frequency vibration due to turbulent flow (8-15 Hz);
- high frequency vibration due to the vibration of the pipes themselves (above 25 Hz).

The suspension usually also has to withstand quite high temperatures and allow the pipes to expand freely, which means that elastic all metal and/or telescopic systems have to be used.