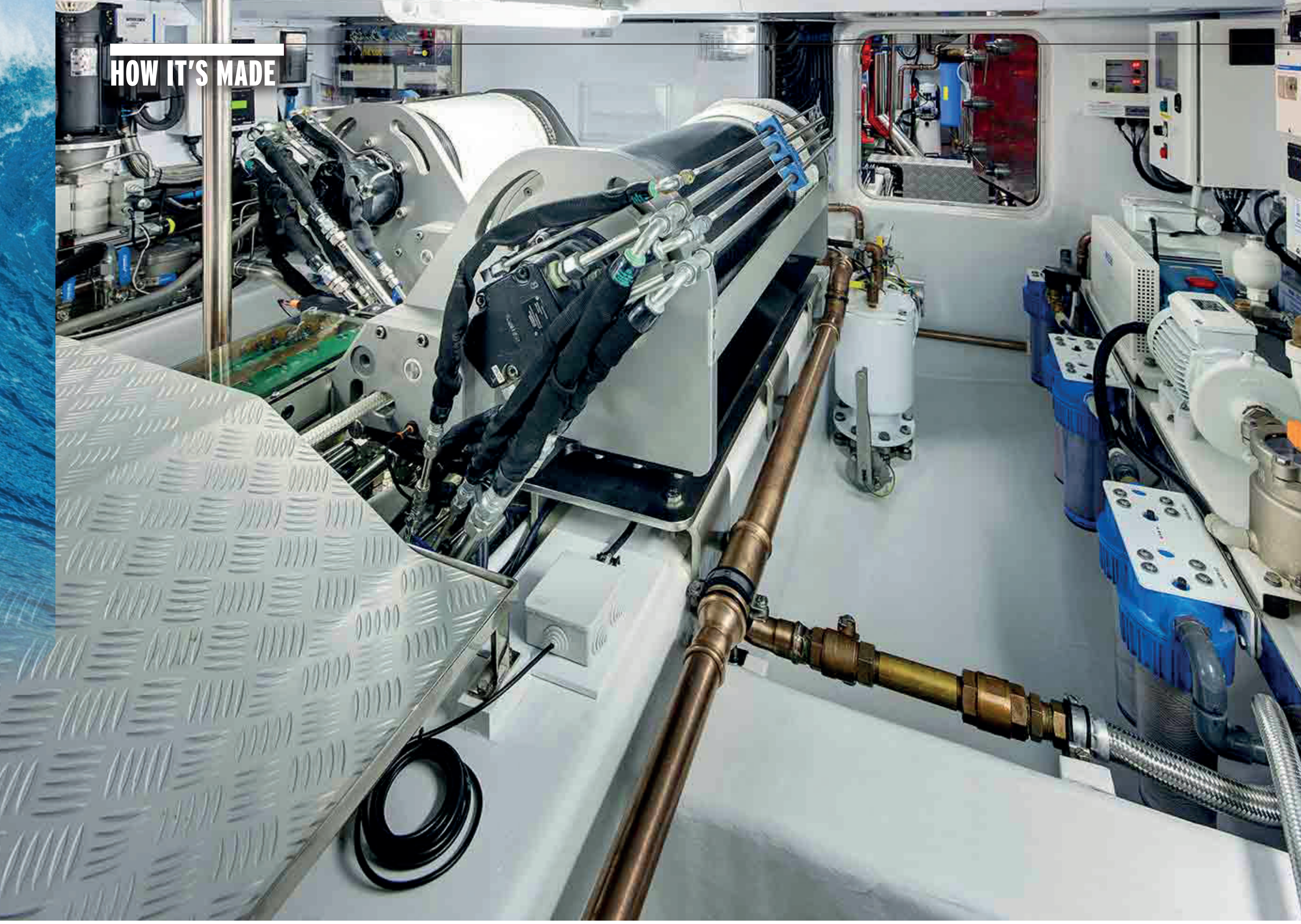


Choosing antivibration methods requires a knowledge of the vibrations

by our staff

VIBRATION, SHOCKS AND NOISE MUST BE CONSIDERED POLLUTING FACTORS ALSO FOR HUMAN HEALTH; OBVIOUSLY WE NEED TO INTERVENE TO ELIMINATE THEM OR BRING THEM DOWN TO ACCEPTABLE LEVELS FOR SOCIAL AND ECONOMIC REASONS.

Any activity in which machinery or operating equipment with moving masses are present produces vibrations, shocks and noise. Natural phenomena such as earthquakes are also a source of oscillation and vibration. Paying serious attention in daily life highlights this reality, which only habit and indifference can reduce to being dangers we can ignore. Vibrations, shocks and noise or structural frequencies with particular characteristics combined in a determining way to cause poor functioning of the machinery that generates them, poor functioning of machines and apparatus operating in the surrounding areas, the deterioration of

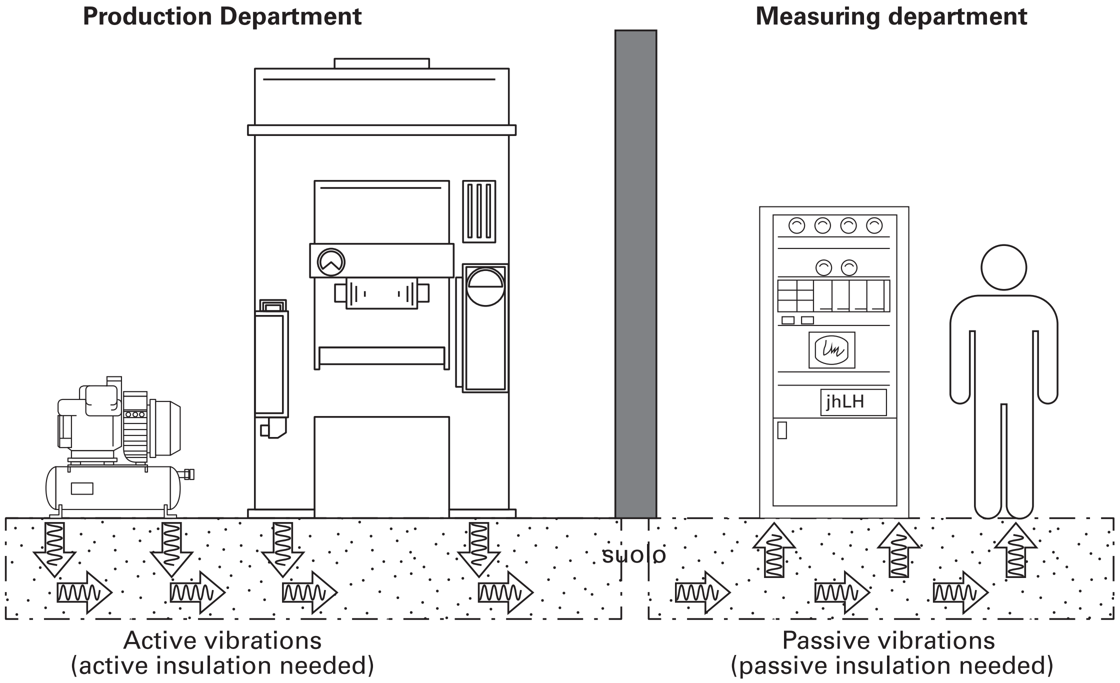


Fig. 1 – Active and passive vibrations.

structures and negative effects on human health.
These negative effects can be reduced to acceptable levels or completely eliminated by applying elements and/or devices that can insulated and/or dampen the vibration, be it “active” or “passive” (see figure 1), shocks and noises or structural frequencies transmitted through solids.

Negative effects on humans

Our knowledge of illnesses caused by vibrations, noise and structural frequencies transmitted through solids is continually evolving.Vibration and noise are held responsible for several kinds of professional disturbances and illnesses, for example: widespread physical complaints, nervousness and irritation with consequent neurovegetative dysfunction; tiredness, nausea, poor concentration, generally low performance, insomnia, digestive and cardiovascular disturbances.
Arthritic problems with joints are among the well-known consequences for operators of pneumatic drills. Hearing problems are the most immediate and direct consequence of noise of various kinds and frequencies. Professional deafness produced by environmental vibration was the subject of studies at the beginning of the past century.

Effects on machinery and apparatus

Vibration definitely causes wear and poor functioning in a perverse chain of cause and effect without limit, with certain damage for the productive economy.
The structures of buildings, especially if subjected to vibration or shocks of significant amplitude, also suffer significant effects on their conservation and life.

Vibration

Mechanical vibration can be defined as a force generated by alternate and compressed cyclical movements that oscillates around

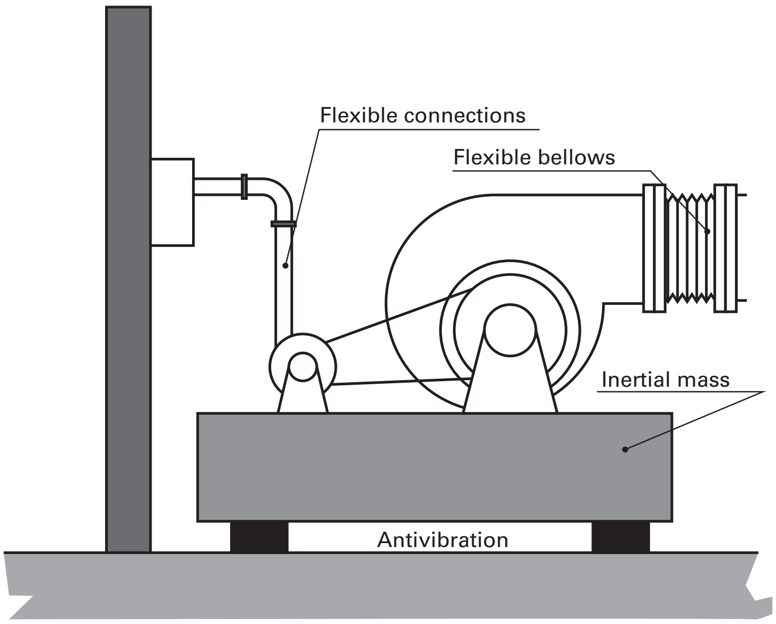


Fig. 2 – Close connection of the excited mass with the inertial mass.

a static equilibrium reference value. There are two important characteristics that characterised vibration: the frequency, expressed in cycles per minute or in revolutions per minute or cycles per second (in Hz), the number of cycles that the oscillating mass completes in a given time; amplitude expresses the shift of the oscillating mass with respect to the reference axis; its value depends on the intensity of the force causing the oscillation and diminishes as the frequency increases. Mechanical vibration is one of the most common disturbance phenomena in industrial installations with machinery operating with masses that are not perfectly balanced and have cyclical/alternating movements. In these situations particular reference is made in the design, choice and use of antivibration devices.

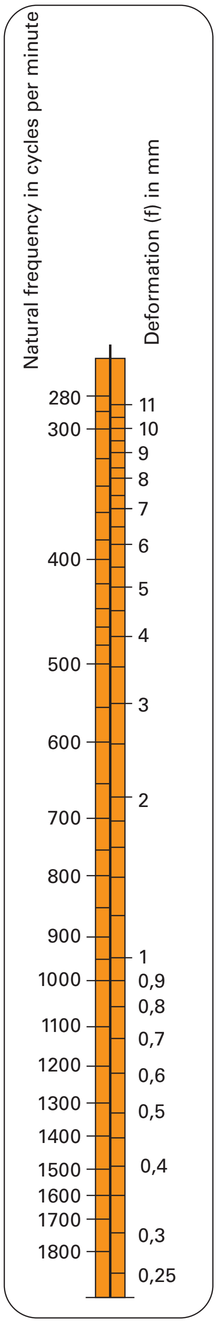


Fig. 3 – Natural frequency as a function of defamation.

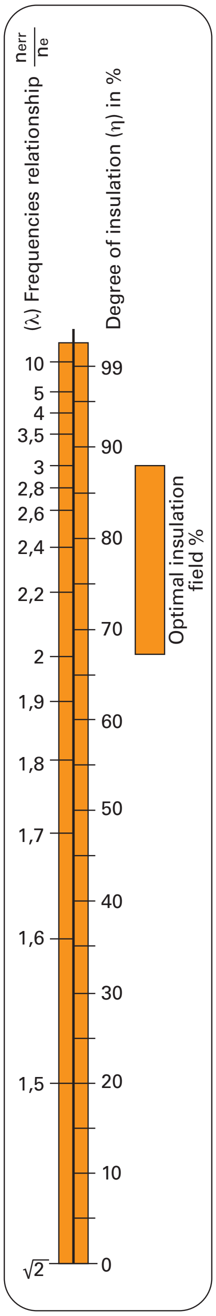


Fig. 4 – (λ) relationship between the nerr / ne frequencies and degree of insulation (η in %).

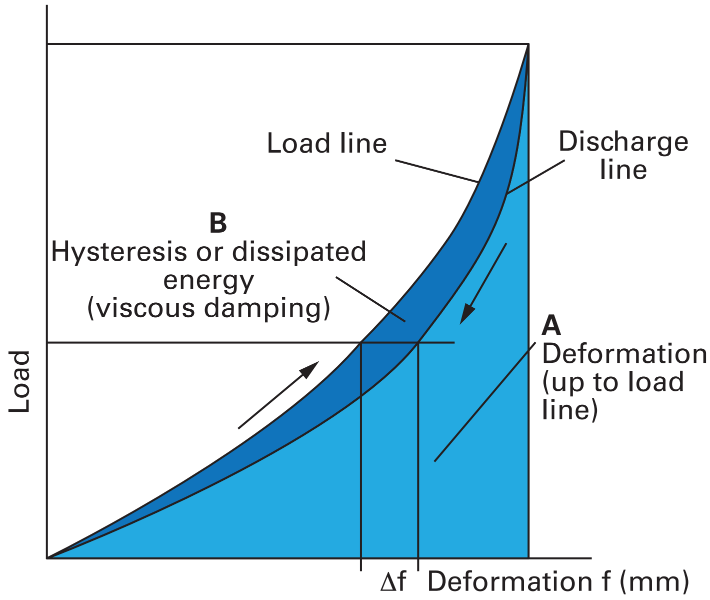


Fig. 5 – Hysteresis in an oscillation cycle of a viscoelastic antivibration device.

Shock

Shock is a sudden impact caused by a moving mass that is suddenly blocked. This is characterised by the fact that the acceleration of the mass is developed and decays in a very short time, generating vibration.

Noise or structural frequencies

These disturbances are caused by vehicles, construction work, earthquakes, movement over floors or platforms etc. While the insulation of mechanical vibration, produced by compressed cyclical disturbance forces, can be calculated using vibration theory, the insulation of noise and structural frequencies obeys the laws of wave mechanics and depends on different factors. Their intensity is measured in decibels (dB) and they are damped by the acoustic rigidity of the viscoelastic materials available and applicable. Change in the acoustic rigidity of viscoelastic materials through which they pass causes reflection of the waves and attenuates them. In steel spring antivibration systems, the interposition of viscoelastic elements not only improves vibration insulation but intercepts the propagation of the frequencies in question transmitted through solids.

Elastic deformation and elastic characteristic

The elastic element supporting the weight of a mass undergoes deformation (f) or deflection or elastic deformation. This deformation is closely related to the elastic characteristic (C) of the insulating element and with the weight of the suspended mass (P), in the following way:

$$f = \frac{P}{C}\,(\text{cmomm}) \qquad \frac{\text{P(indaN)}}{\text{CindaN/cmo(daN/mm)}}$$

The equation below shows that in a system in which the note of the suspended mass (P) and the deformation (f) of the antivibration elastic element are known, we can find the relative elastic characteristic (C):

$$C = \frac{P}{f}\,(\text{daN/cmodaN/mm})$$

Excitation frequency (n_{err})

The excitation frequency (n_{err}) is a characteristic of the machine that creates it. It is also a function of the angular velocity of the rotating masses without appropriate balance and assumes characteristics corresponding to the periodicity of the movements. The excitation frequency is generally sinusoidal and coincides with the

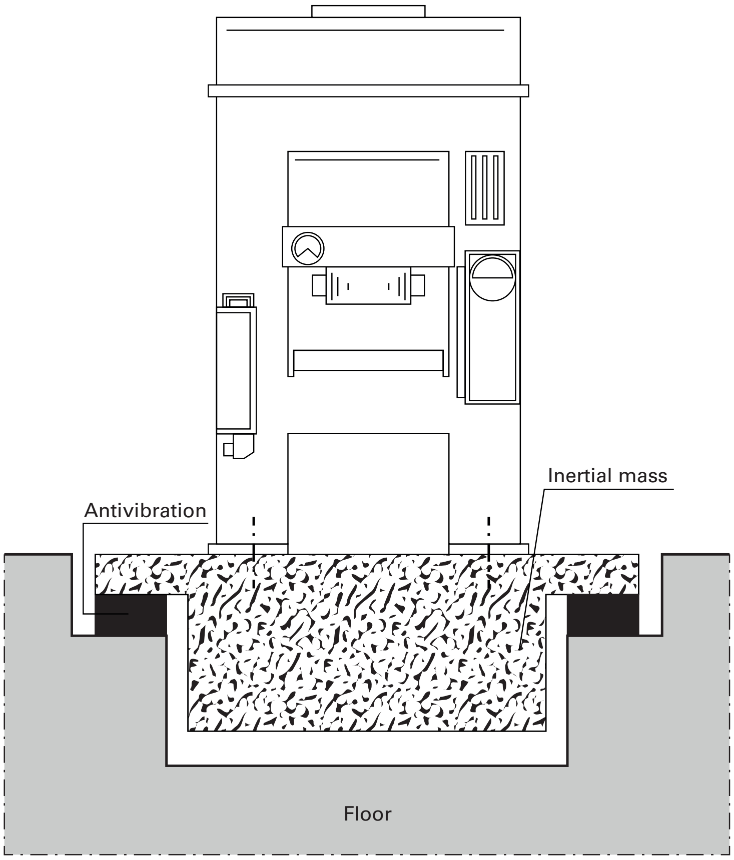


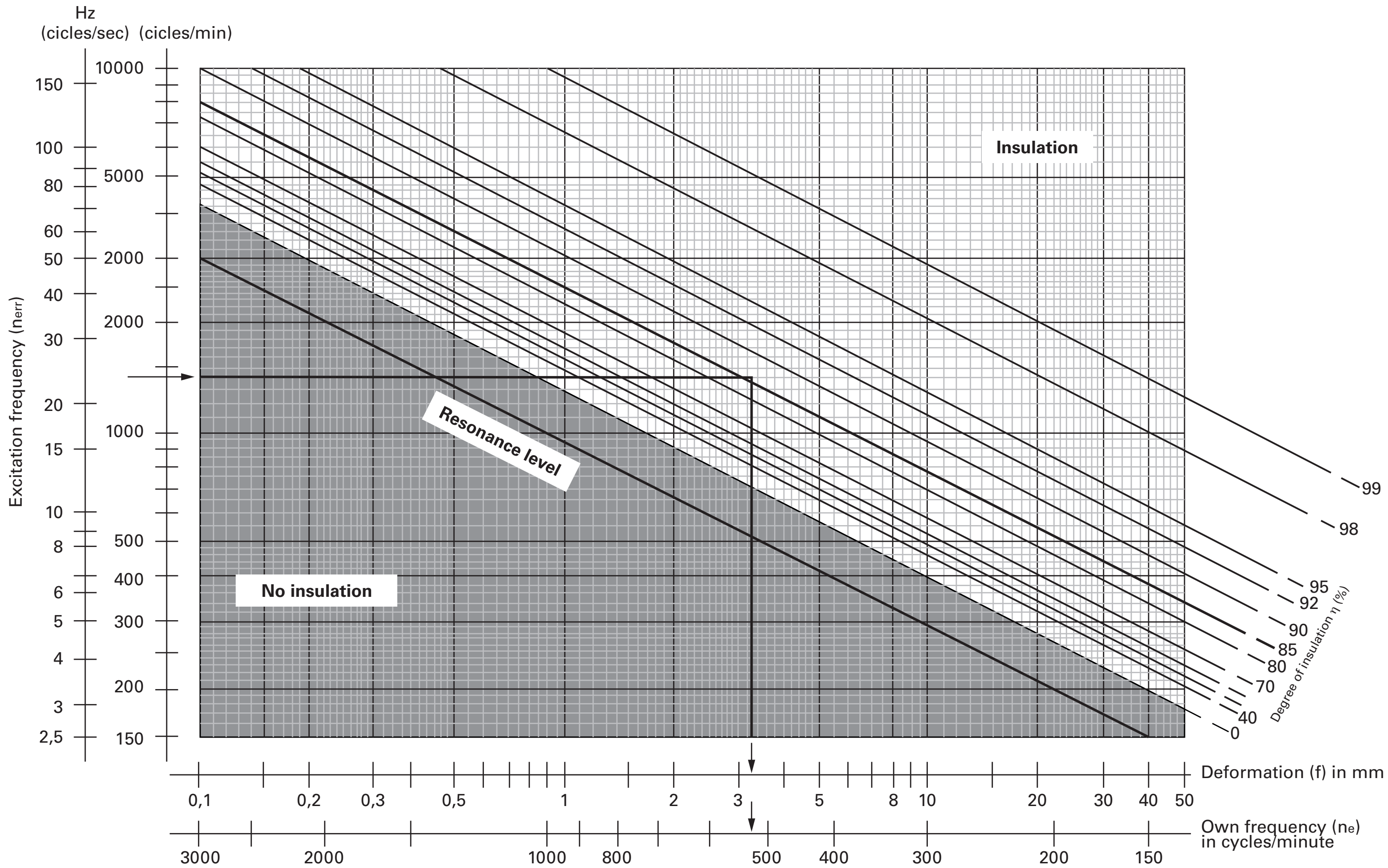
Fig. 6 – Positioning the antivibration elements between the flooring and the inertial mass.

number of revolutions or the cyclical rotational movement of the masses. To avoid the forces acting upon it amplifying the oscillation, the forces must be in a certain relationship with the mass; the greater the entity of the force creating the vibration the greater must be the mass in question (see paragraph "Inertial masses"). This relationship leads to the need to increase the masses with "inertial masses". In these cases the excited mass must be rigidly connected to the inertial mass to constitute a single system to rest on the elastic antivibration elements (figure 2 and figure 6).

"Natural" frequency

The natural frequency (n_e) of a machine or system is that at which the machine vibrates when it is placed on elastic antivibration elements without being influenced by external forces. This frequency drops when the sum of the mass creating the vibration and the inertial mass increases, as described in the paragraph "Degree of insulation".

The "inertial mass" must be of a piece with the mass of the sus-



pended system and with the antivibration mounts (figure 2 and figure 6). If we know the deformation (f), the natural frequency (n_e) can be obtained from the histogram in figure 3 and vice versa.

Insulators

The phenomena we are speaking of can be insulated in two ways: active or passive (see figure 1).
Active insulation avoids the vibration produced by a machine or system being propagated to the surrounding areas or two parts of the system itself (control panels, computers etc.).
Passive insulation avoids machines or apparatus being influenced by non-insulated vibrations.
Passive insulation is also that used to protect human health from vibrational disturbances of various kinds and sources.
It is not always possible to intervene at the source of vibration to carry out active insulation; in these cases passive insulation has to be used. It must be noted that vibrations, shocks and structural frequencies are easily propagated through structures, land, flooring etc.

Inertial or seismic masses

The natural frequency (n_e) of a system mounted on antivibration elements is inversely proportional to the mass of the system; this means that its natural frequency diminishes of the weight of the insulated system increases with the addition of the so-called "inertial" or "seismic" mass. The reduction of the natural frequency (n_e) increases the degree of insulation; in fact increasing the relationship (λ) between the frequencies the degree of isolation (η in %) increases (see figure 4).
A block of concrete, suitably reinforced and rigidly connected to the machine to be insulated, forming with it a single element, is often enough to obtain a valid degree of insulation. In fact, increasing the total mass of the system, the "natural" frequency (n_e) is reduced and the degree of insulation (η in %) increased. Antivibration elements will be applied between the "inertial mass" and the floor it rests on (figure 2 and figure 6).

Degree of insulation

With particular reference to mechanical vibration, vibration can be effectively insulated by making the natural frequency (n_e) lower than the excitation frequency (n_{err}): coefficient (λ) (see fig. 4).

$$\lambda = \frac{n_{err}}{n_e}$$

The degree of insulation (η) increases as a function of the coefficient (λ) and can also be verified as follows:

η (%)=

$$\eta(\%) = \frac{\lambda^2 - 2}{\lambda^2 - 1}$$

The (η) parameter expresses the percentage of vibration insulated by the antivibration device and can be obtained from figure 4 where it is in a graphic relationship with the relation between the frequencies (parameter λ).
For optimal insulation the (λ) value should be between 2 ÷ 3, corresponding to insulation of between 67% and 87% (see fig. 4).
When the frequency ratio is equal to 1, the frequencies are added together in resonance with dramatic results for the system.

Damping

Damping of vibration must not be confused with insulation.
As we have shown, insulation can only be obtained with a suitable relationship (λ) between the frequencies. Steel spring antivibration devices, thanks to their considerable deflection under load, are excellent for insulating but not for damping vibration; combining steel springs with viscoelastic material we obtain insulation and damping of vibration as well as insulation of the frequencies transmitted through solids.
Vibration is damped because the viscoelastic material dissipates the vibration energy into heat. In a viscoelastic insulating system the relation between the load on the antivibration device and the deflection (f) in an oscillation cycle evolves as shown in the graph in figure 5.
As the load settles down the deflection (f) increases and the surface (A) below the load line as far as the abscissa represents the elastic deformation work of the antivibration device. When the load the creases there is a discharge curve out of phase with the load curve because of a (Δf).
The surface (B) between the two lines is defined as hysteresis and corresponds to the quantity of energy dissipated, or viscous damping of the element in consideration; the dissipated energy or viscous damping is transformed into heat and is the consequence of internal friction in the elastic material.
This phenomenon is repeated for each cycle of the vibration wave; if the elastically suspended system is free and there are no further disturbing impulses, the oscillation falls off and is cancelled out, unlike what happens in a non-viscous system with a mass in harmonic oscillation.
A high level of damping is advisable where resonance is possible, avoiding the formation of oscillations in the mass supported by the antivibration device.
The weight of the inertial mass must be between one and three times that of the mass to be insulated. Inertial masses are usefully used in the active insulation of bumps, ventilators, compressors, presses, printing presses, power hammers and any machinery that produces shocks that need to be damped with antivibration elements. It is worth underlining that all kinds of antivibration devices have positive characteristics and performance if they are correctly installed and correctly chosen.
Any antivibration system must be mounted as an independent element, with no tension with respect to surrounding parts. It should be noted that viscoelastic materials, which may be used to improve insulation and dissipate structural frequencies transmitted through solids, are electric isolators; in using them we must consider the need to apply an electrical earth to the machine or system mounted on the viscoelastic antivibration systems.