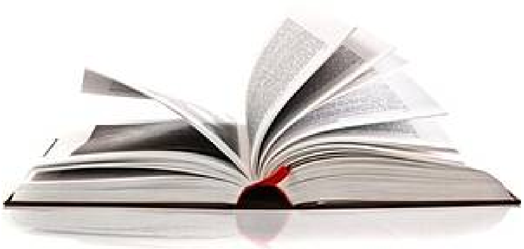
Vibration engineering

Vibrations generated by machines and equipment are disturbing. The need to reduce vibration transmissions places increasing demands on machine engineers and operators. Targeted vibration prevention is therefore a must.



Basics

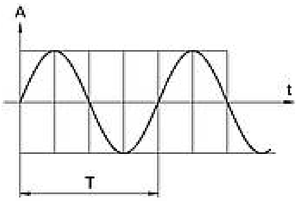


Figure 1: Harmonic vibration

Figure 1 shows a sinusodial, undampened vibration. The most important terms in vibration engineering are frequency f, amplitude A and damping factor D. Natural frequency as well as resonance are also important figures when considering isolation systems.

Frequency f is a measure of the number of complete vibration cycles per second. $f = \frac{1}{T}\ [\frac{1}{s} = Hz]$

Structure-borne noise are vibrations that are conveyed in a solid body. Low frequencies are generally what we call mechanical vibrations.

The amplitude is the vibration wave range around its equilibrium. It determines the severity of vibration and is usually expressed in terms of acceleration or displacement.

Damping D designates the measure of amplitude reduction of the vibration of a freely oscillating spring-mass system through friction. Damping refers to the conversion of energy to heat.

Natural frequency f_0 of a body is the frequency with which the body freely oscillates around its equilibrium without external influence. Each body has its own natural frequency, which however can only be calculated in the simplest of cases. Usually it can be easily measured using impact or impulse triggering. If this natural frequency is close to a vibration forcing frequency f_E, resonance is the result. In this case the amplitude increases, which could lead to the destruction of the system.

Vibration isolation

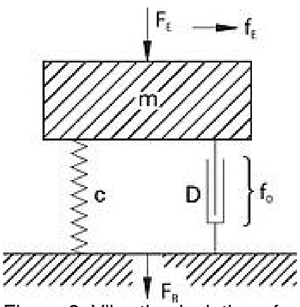


Figure 2: Vibration isolation of a dynamic system

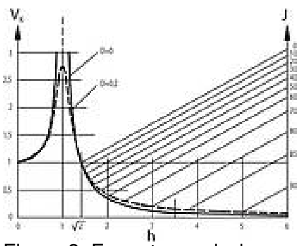


Figure 3: Force transmission factor as a function of the frequency ratio

The vibration isolation of a dynamic system consists of isolating from the environment by means of an elastic body which has a considerably lower natural frequency f_0 than the system forcing frequency f_E.

Figure 2 schematically shows such a system with isolation. Of practical interest is the transmitted force F_R output and the ratio of this force to the original input force. This ratio, called force transmission factor V_K, is shown in **Figure 3** as a function of the frequency ratio $\eta = \frac{f_E}{f_0}$.

For $\eta = \sqrt{2}$ the V_K becomes 1again and above $\eta = \sqrt{2}$ the result is isolation. The greater the ratio of vibration generator frequency f_E to the natural frequency f_0, the better the degree of isolation $J = 1 - V_K$.

When elastic materials are used, it has been determined that below the resonance range of about $\eta = 0{,}5$ the vibration acceleration values are reduced and therefore isolation is provided.
The natural frequency as a function of the specific load must be determined for elastomers in laboratory measurements.
The measurable reduction in thickness of the plates is designated compressive static deflection.

f_0

m = mass
c = spring constant
D = damping

Frequency ratio $\eta = \frac{f_E}{f_0}$

f_E = vibration generator frequency
f_0 = natural frequency of the isolation

Force transmission factor $V_K = \frac{F_R}{F_E}$

F_R = remaining force
F_E = generator force

$$V_K = \frac{F_R}{F_E} = \sqrt{\frac{1+(2D\eta)^2}{(1-\eta^2)^2+(2D\eta)^2}}$$

Vibration isolated machine setup

The demands for machine setup are nearly always contradictory. The machine should be firmly fixed and stable but well isolated against vibration. It should be quickly and easily assembled (and disassembled) but it should not move. And it should also be able to be levelled and re-levelled with great precision, but not displaced. This is where the considerable practical experience of AirLoc Ltd. comes into play to find the right custom solution.

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