Vibration Isolation – Definitions and Terms

Acceleration "a" [m/s^2]: the rate of change of velocity with respect to time.

Amplitude: the magnitude of vibration expressed in terms of zero-to-peak displacement.

Axial: In the same direction as the bush or shaft centreline.

Critical Damping "C_{crit}" [N-s/m]: the minimum amount of damping required to return the system to equilibrium without any oscillation.

Dynamic Stiffness "K_d" [N/m]: When an oscillating load is applied to a material, it is the ratio between the applied force and the resultant maximum deflection. In rubber, the dynamic stiffness will increase as the frequency of vibration increases (see Figure 1 below).

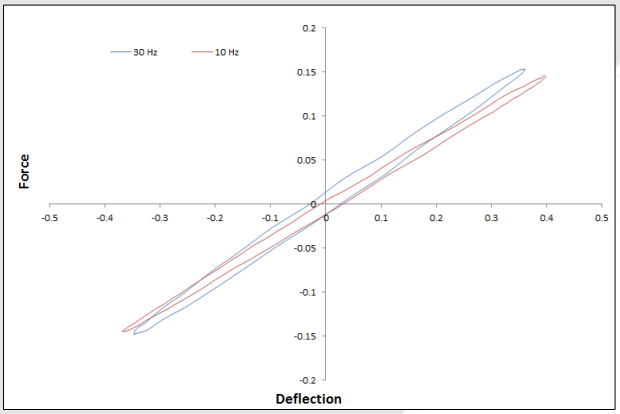


Figure 1: Load vs deflection curve of a rubber isolator under oscillating compression at 10 Hz & 30 Hz

Damping: the component in a mechanical system that dissipates energy (usually converting motion to heat) and results in a decay in the amplitude of motion with each successive cycle.

Damping Coefficient "C" [N-s/m]: characteristic of a material to attenuate (or damp) its oscillation. It is inversely proportional to the frequency of the oscillation.

Damping Factor "ζ": the ratio of damping coefficient to critical damping: $\zeta = \frac{C}{C_c}$. A value greater than or equal to 1 indicates that the system will not oscillate.

Degrees of Freedom: the number of coordinates or independent variables required to completely describe the state of a vibrating system. For example, a one-degree of freedom system vibrates in one axes only.

Durometer (hardness): defined as a material's resistance to permanent indentation. Rubber hardness is typical measured using a device called a durometer, which measures the depth of an indentation in the material created by a given force on a standardised indenter. There are a number of different methods and standards but the two main scales are Shore A and IRHD.

Frequency "f" [Hz]: the repetition rate of a periodic event, typically expressed in cycles per second or Hertz.

Hysteresis: the difference between the amount of energy absorbed when the rubber is loaded and the amount of energy released when the rubber is unloaded. High hysteresis rubbers are good for energy absorption, i.e., shock and vibration, while low hysteresis rubbers are more resilient.

Isolation: the protection of equipment from shock and vibration.

Isolation Efficiency "η": The amount of vibration absorbed by an isolator: η= 1-T.

Mechanical Vibration: A periodic or random oscillation about an equilibrium point. In industrial applications it is generally unwanted, since it represents a substantial increase in potential fatigue damage and equipment instability.

Natural Frequency "f_n" [Hz]: The frequency at which an structure or component will oscillate if disturbed by an external force. For a single degree of freedom system: $f_n = 15.76\sqrt{\frac{1}{\Delta x}}$; where "x" is the displacement in millimetres.

Period: the time (usually in seconds) of one complete oscillation of a single cycle. The inverse of frequency.

Phase: is expressed in degrees as the time between two events divided by the period and multiplied by 360 degrees.

Radial: movement or loading perpendicular to the bush/shaft centreline.

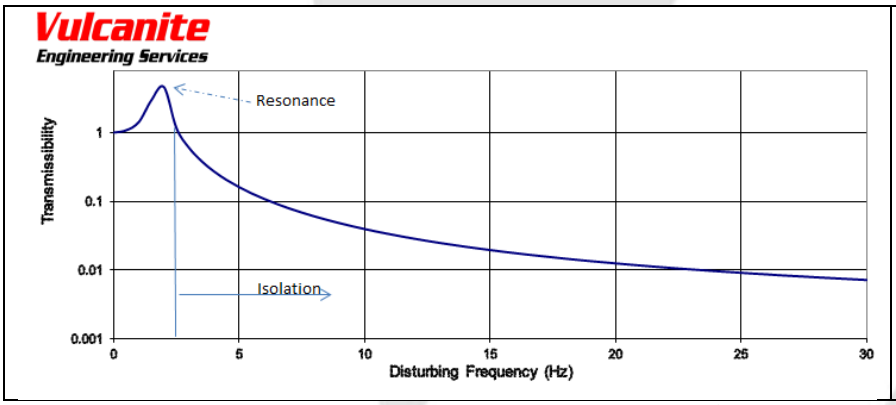
Random Vibration: irregular (non-sinusoidal) vibration characterised by excitation at a broad range of frequencies of random amplitude simultaneously.

Resonance: When a system is subjected to a periodic disturbance of the same frequency as its natural frequency. Resonance is typically identified by a substantial amplitude increase and related phase shift.

Shock: the transmission of kinetic energy to a system over a short period of time compared to the natural frequency of the system.

Static Stiffness "K" [N/m]: When a load is applied to an elastic material, it is the ratio between the applied force and the resultant deflection: $= \frac{F}{\Delta x}$. In rubber, this value is directly proportional to the hardness of the elastomer and is sometimes referred to as the spring rate.

Transmissibility "T": Ratio of the dynamic output to the dynamic input and can be measured with respect to motion, force, velocity or acceleration. Isolation or attenuation (T<1) of the input disturbance occurs when the input frequency $f_f > f_n\sqrt{2}$



$$T = \sqrt{\frac{1 + \left(2\zeta\frac{f_f}{f_n}\right)^2}{\left[1 - \left(\frac{f_f}{f_n}\right)^2\right]^2 + \left[2\zeta\frac{f_f}{f_n}\right]^2}}$$

Figure 2: Typical Transmissibility curve of a rubber isolator

Torsional: rotational movement or loading around the bush/shaft centreline.