BARRY CONTROLS

DEFENSE & INDUSTRY
Antivibration

DEFINITIONS

There are a number of terms which should be understood before entering into a discussion of vibration and shock theory. Some of these are quite basic and may be familiar to many. However, a common understanding should exist for maximum effectiveness.

Acceleration - Rate of change of velocity with time - usually along a specified axis, usually expressed in "g" or gravitational units. It may refer to linear or angular motion.

Amplification - The magnification of an input condition, resulting in a higher output amplitude.

Amplitude - The displacement from a zero value position.

Center-of-Gravity System - An equipment installation wherein the center of gravity of the equipment coincides with the elastic center of the isolation system.

Compression - When specified as a direction for loading - a deformation caused by squeezing the layers of an object in a direction perpendicular to the layers.

Critical Damping (Cc) – The return of a displaced object to its equilibrium position through dissipation of energy without over oscillating in the shortest possible time.

Critical Damping Factor (C/Cc) – The ratio of a system's actual damping (C) to its theoretical critical damping (Cc). Typical values for commercially viable elastomers are .05 to .33.

Damping (C) - The "mechanism" in an isolation system which dissipates energy. This mechanism controls resonant amplification (transmissibility) and roll-off in isolation in vibratory systems. **NOT THE SAME AS ISOLATION.**

Decibel (db) - A dimensionless expression of the ratio of two values of some variable in a vibratory system.

Decoupling – The process of forcing modes of vibration to be independent of each other via strategic positioning and orientation of isolators and selection of their stiffness characteristics. Decoupling is achieved by positioning the elastic center of the isolators coincident with the CG location of the isolated mass. In a decoupled mounting system, excitation in one direction (degree-of-freedom) results in response only in that direction. Mounting systems can be designed to be fully decoupled, i.e. all modes independent of each other, or partially decoupled where only some of the system modes are independent of each other.

Deflection - The movement of some component due to the application of a force. In vibratory systems, deflection may be due to static or dynamic forces or to the combination of static and dynamic forces.

Degree-of-Freedom - The expression of the amount of freedom a system has to move within the constraints of its application. Typical vibratory systems may move in six degrees of freedom - three translational and three rotational modes (motion along three mutually perpendicular axes and about those three axes).

Disturbing frequency (fd) - The number of oscillations per unit time of an external force or displacement applied to a vibrating system. fd = disturbing frequency.

Durometer (hardness) – An industry standard hardness measurement for elastomers. It is an indirect indicator of material stiffness or modulus. A durometer gauge measures the resistance to the penetration of an indenter point into the surface of a molded elastomer specimen. The value may be taken immediately or after a very short specified time. Elastomers used in vibration and shock isolators generally fall in the range of 35-75 durometer on the Shore A scale.

Dynamic Matching - The selection of isolators whose dynamic characteristics (stiffness and damping) are very close to each other for use as a set on a given piece of equipment. Such a selection process is recommended for isolators which are to be used on rotational motion sensitive equipment such as guidance systems, radars and optical units.

Dynamic deflection (Δd) - Deflection of the isolator under the dynamic loads of the mounted equipment.

Dynamic Disturbance - The dynamic forces acting on the body in a system. These forces may be the results of sinusoidal vibration, random vibration or shock, for example.

Elastic Center - A theoretical point in space at which a system of two or more non-coincident isolators can be represented by a single isolator of equivalent system stiffness. The elastic center of a system of isolators is analogous to the center-of-gravity of a system of masses, however it is not necessarily located at the geometric center of the system of isolators. Isolators which have different stiffness characteristics in different axes can be inclined or "focused" in order to project their elastic center to a point away from their geometric center. The position of the elastic center is a function of isolator locations, orientations and stiffness ratio(s).

Elastomer - A generic term used to include all types of "rubber" - natural or synthetic. Many vibration isolators are manufactured using some type of elastomer. The type depends on the environment in which the isolator is to be used.

Fragility - The amount of vibration or shock which a piece of equipment can take without malfunctioning or breaking. In isolation systems, this is a statement of the amount of dynamic excitation which the isolator can transmit to the isolated equipment. It is the highest vibration or shock level that can be withstood without equipment failure.

Free Deflection - The amount of space an isolated unit has in which it can move without interfering with surrounding equipment or structure. This is sometimes called "sway space."

"G" level - An expression of the vibration or shock acceleration level being imposed on a piece of equipment as a dimensionless factor times the acceleration due to gravity

Iso-elastic - A word meaning that an isolator, or isolation system, exhibits the same stiffness characteristics in all directions.

Isolation - The protection of equipment from vibration and/or shock through the reduction of the input. The degree (or percentage) of isolation necessary is a function of the fragility of the equipment.

Load deflection curve - The measured and recorded displacement of a mounting plotted versus an applied load.

Linear (properties) - A description of the characteristics of an isolation system which assumes that behavior varies linearly with deflection, temperature, vibration level, etc. This is a simplifying assumption which is useful for first approximations but which must be treated carefully when dealing with critical isolation systems.

Loss Factor - A property of an elastomer which is a measure of the amount of damping in the elastomer. The higher the loss factor, the higher the damping. Loss factor is equal to the inverse of the resonant transmissibility of a vibratory system. The loss factor of an elastomer is sensitive to the loading and ambient conditions being imposed on the system.

Modulus - A property of elastomers (analogous to the same property of metals) which is the ratio of stress to strain in the elastomer at some loading condition. Unlike the modulus of metals, the modulus of elastomers is non-linear over a range of loading and ambient conditions. This fact makes the understanding of elastomers and their properties important in the understanding of the performance of elastomeric vibration and shock isolators.

Natural Frequency (fn) - That frequency (expressed as "Hertz (Hz)" or "cycles per second") at which a structure, or combination of structures, will oscillate if disturbed by some force (usually dynamic) and allowed to come to rest without any further outside influence. Vibratory systems have a number of natural frequencies depending on the physical characteristics of the isolated equipment. The relationship of the system natural frequency to the frequency of the vibration or shock determines, in part, the amount of isolation (protection) which may be attained.

Octave - A doubling (or halving) of frequency. This word is used in various expressions dealing with vibration isolation.

Power Spectral Density (PSD) - An expression of the level of random vibration being experienced by the equipment to be isolated. The units of PSD are g^2/Hz, and the typical symbol is "Sf.".

Random Vibration - Non-cyclic, non-sinusoidal vibration characterized by the excitation of a broad band of frequencies at random levels simultaneously. Typically, many applications of equipment in the field of Military Electronics are exposed to random vibration.

Resilience - The ability of a system to return to its initial position after being exposed to some external loading. More specifically, it is the ability of an isolator to completely return the energy imposed on it during vibration or shock. Typically, highly damped elastomers have low resilience while low-damped elastomers have high resilience.

Resonance - A vibratory system is said to be operating in resonance when the frequency of the disturbance (vibration or shock) is coincident with a system's natural frequency.

Resonant Dwell - A test in which the equipment is exposed to a long term sinusoidal vibration at its resonant frequency. This type of test can be used as an accelerated fatigue test for sinusoidal vibration conditions. In recent times, sinusoidal testing is being replaced by random vibration testing, and resonant dwell tests are becoming less common.

Returnability - The ability of a system, or isolator, to resume its original position after removal of all outside forces. This term is sometimes used interchangeably with resilience.

Roll-off Rate - The steepness of the transmissibility curve being recorded during a vibration test, after the system natural frequency has been passed. This term is also used to describe the slope of a random vibration curve.

Set - The amount of deformation never recovered after removal of a load. It may be in shear or compression.

Shear - When specified as a direction for loading - a deformation caused by sliding layers of an object past each other in a direction parallel to the layers.

Shock Pulse - A transmission of kinetic energy to a system, which takes place in a relatively short length of time compared to the natural period of this system. It is followed by a natural decay of the oscillatory motion. Shock pulses are usually displayed as plots of acceleration vs. period of time.

Spring Rate - Force required to induce a unit deflection of a spring. A steel spring has a very linear relationship between force and deflection. Elastomeric springs may or may not be linear depending on the amount of deflection due to the load and the direction of loading. Usually expressed in pounds per inch of deflection (lbs/in) under load, or Newtons per millimeter (N/mm) in metric units. Spring rate is also known as stiffness.

Static deflection (Δs) - Deflection of the isolator under the static or deadweight load of the mounted equipment. It can also be the deflection under other static conditions, like inertia loads.

Stiffness – See Spring Rate.

Sway Space – See Free Deflection.

Tension - When specified as a direction for loading - a deformation caused by pulling or separating the layers of an object in a direction perpendicular to the layers.

Transmissibility (T) - A dimensionless unit expressing the ratio of the vibration response compared to the input. It may be measured as motion, force, velocity or acceleration. When transmissibility is greater than 1, amplification occurs; when less than 1, isolation is achieved.