Engineering Guide

INTRODUCTION

Forces and motions are the elements utilized by mechanical equipment to perform work. Unfortunately, these same elements can produce undesirable effects, even in the most carefully designed equipment. The adverse effects of vibration, shock and noise disturbances range from simple annoyances to shortened equipment life through failure of its components. They will affect comfort, safety or performance.

Vibration, shock and noise control components, properly applied, will improve your products. They will operate more smoothly and quietly, and they will be less disturbing to surrounding equipment and personnel, less susceptible to damage and less expensive to make. Bonded rubber mounts provide cost-effective solutions to problems involving vibration, shock and structural noise control.

The theory and concepts for bonded rubber mounts are relatively straightforward. A great many of the applications are uncomplicated, and the nonspecialist can handle them directly. However, some vibration and shock control problems are quite complex, making component selection and design complicated.

These applications require the involvement of specialists in order to arrive at suitable recommendations, and Lord has a technical staff available to assist you. In any event, the information presented in this catalog will prove useful in your independent application solutions, as well as at those times when technical assistance is necessary. See application selection guide (page 15).

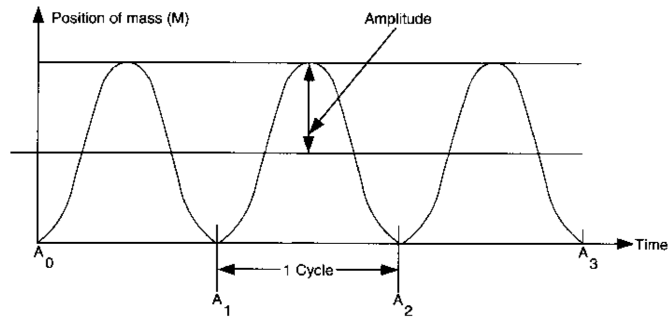
This catalog has been prepared to assist the individual who does not frequently deal with vibration and shock problems and to remind others of the versatility of bonded rubber mounts. It presents the important information needed to select and use bonded rubber mounts: terms and definitions, theory, sample problems and data on standard mounts.

TERMS AND DEFINITIONS

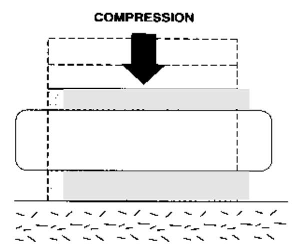
There are a number of terms which should be understood before entering into a discussion of vibration and shock theory. Some of these are quite basic and may be familiar to the users of this catalog. However, a common understanding should exist for maximum effectiveness.

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

Amplitude - the maximum displacement from its zero value position.



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.



Damping (c) - the mechanism in an isolation system which dissipates a significant amount of energy. This mechanism is important in controlling resonance in vibratory systems.

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

Durometer (hardness) - an arbitrary numerical value which measures the resistance to the penetration of the durometer meter indenter point; value may be taken immediately or after a very short specified time.

Fragility - is the highest vibration or shock level that can be withstood without equipment failure.

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

Isolation - the protection of equipment from vibration and/or shock. 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.

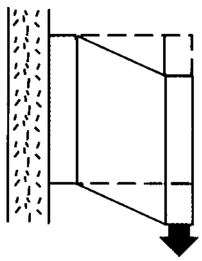
Natural frequency (f_n) - the number of cycles (expressed as Hertz or cycles per second) at which a structure will oscillate if disturbed by some force and allowed to come to rest without any further outside influence.

Random vibration - non-sinusoidal vibration characterized by the excitation of a broad band of frequencies at random levels simultaneously.

Resonance - A vibratory system is said to be operating at resonance when the frequency of the disturbance (vibration or shock) coincides with the system natural frequency.

Set - is 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 shock pulse is 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.

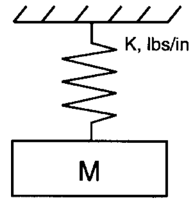
Spring rate - is the force required to induce a unit deflection of spring. A steel spring has a very linear relationship between force and deflection. Elastomeric springs may or may not be linear depending on the amount of deflection due to the load.

Static deflection (d_s) - the deflection of the isolator under the static or deadweight load of the mounted equipment.

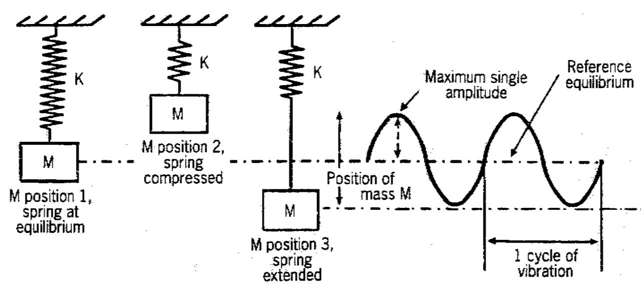
Transmissibility (T) - is a dimensionless unit expressing the ratio of the response vibration output to the input condition. It may be measured as motion, force, velocity or acceleration.

THEORY

Vibration is an oscillatory motion. Any body with mass and elasticity can vibrate. The simplest type of vibrating system is called a single-degree-of-freedom spring-mass system. The spring is characterized by its spring rate, K, and a mass, M.



This system is called a single-degree-of-freedom system because motion can occur in only one direction. Spring rate defines the force required to induce a unit deflection of a spring. A steel spring has a linear relationship between force and deflection. Elastomeric springs may or may not be linear depending on the amount and direction of the load. Nonlinearity can be designed into elastomeric springs to achieve certain results. Elastomeric springs also differ from steel springs in that their stiffness is sensitive to the rate or speed of deflection. If a rubber spring is deflected quickly, it appears stiffer than if it is deflected slowly.



When a mass is attached to a spring, the mass moves to its position of equilibrium, position 1. The difference between the spring's undeflected or free length and its position of equilibrium is called the system's static deflection, d_S. If a force is applied to the system, position 2, and then removed, the spring-mass system will vibrate, position 3. When plotted against time, the position of the mass relative to its equilibrium position is a sinusoidal curve. The maximum single amplitude is the deflection of the mass from its equilibrium position to its maximum displacement in one direction. Double amplitude displacement is the total deflection in both directions. The period of vibration is the time it takes for the mass to move from its equilibrium position to its peak in one direction, to its peak in the other and back to its equilibrium position.

If a load is applied to our spring mass system and then released, the mass will vibrate at a constant rate. We call this condition resonance, and the vibration rate is called the natural or resonant frequency. The natural frequency of a system can be considered a function of mass (M) and spring rate (K).