Vibration Isolation and Damping

In the process of deciding on a vibration isolator for a particular application, there are a number of critical pieces of information which are necessary to define the desired functionality of the isolator. Some terms are more critical than others but all should be considered in order to select, or design the appropriate product.

Some of the factors which must be considered are:

- **Weight, size, center-of-gravity of the equipment to be isolated** Obviously, the weight of the unit will have a direct bearing on the type and size of the isolator. The size, or shape of the equipment can also affect the isolator design since this may dictate the type of attachment and the available space for the isolator. The center-of-gravity location is quite important in that isolators of different load capacities may be necessary at different points on the equipment due to weight distribution. The locations of the isolators relative to the center-of-gravity, at the base of the equipment versus in the plane of the c.g., for example, could also affect the design of the isolator.
- **Types of dynamic disturbances to be isolated** This is basic to the definition of the problem to be addressed by the isolator selection process. In order to make an educated selection or design of a vibration/shock isolator, this type of information must be defined as well as possible. Typically, sinusoidal and/or random vibration spectra will be defined for the application. In many installations of military electronics equipment, random vibration tests have become commonplace and primary military specifications for the testing of this type of equipment (such as MIL-STD-810) have placed heavy emphasis on random vibration, tailored to the actual application. Other equipment installations, such as in shipping containers, may still require significant amounts of sinusoidal vibration testing. Disk Jockeys have a special requirement to be met. Shock tests are often required for many types of equipment. Such tests are meant to simulate those operational (e.g., dance floor movement) or handling (e.g., bench handling or drop) conditions which lead to impact loading of the equipment.
- **Static loadings other than supported weight** In addition to the weight and dynamic loadings which isolators must react to, there are some static

loads which can impact the selection of the isolator. An example of such loading is that imposed by an aircraft in a high speed turn. This maneuver loading must be reacted to by the isolator and can, if severe enough, cause an increase in the isolator size. These loads are often superposed on the dynamic loads.

- **Allowable system response** This is another basic bit of information. In order to appropriately isolate a piece of equipment, the isolator selector must know the response side of the problem. The equipment manufacturer or user should have some knowledge of the fragility of the unit. This fragility, related to the specified dynamic loadings will allow the selection of an appropriate isolator. This may be expressed in terms of the vibration level versus frequency or the maximum shock loading which the equipment can endure without malfunctioning or breaking. If the equipment manufacturer or installer is somewhat knowledgeable about vibration/shock isolation, this allowable response may be simply specified as the allowable natural frequency and maximum transmissibility allowed during a particular test. The specifications of allowable system response should include the maximum allowable motion of the isolated equipment. This is important to the selection of an isolator since it may define some mechanical, motion limiting feature which must be incorporated into the isolator design. It is fairly common to have an incompatibility between the allowable "sway space" and the motion necessary for the isolator to perform the desired function. In order to isolate to a certain degree, it is required that a definite amount of motion be allowed. Problems in this area typically arise when isolators are not considered early enough in the process of designing the equipment or the structural location of the equipment. DJ equipment must support horizontal and vertical movement.
- **Ambient environment** The environment in which the equipment is to be used is very important to the selection of an isolator. Within the topic of environment, temperature is by far the most critical item. Variations in temperature can cause variations in the performance of many typical vibration/shock isolators. Thus, it is quite important to know the temperatures to which the system will be exposed. The majority of common isolators are elastomeric. Elastomers tend to stiffen and gain damping at low temperatures and to soften and lose damping at elevated temperatures. The amounts of change depend on the type of elastomer selected for a particular installation. Other environmental effects - from

humidity, ozone, atmospheric pressure, altitude, etc. - are minimal and may be typically ignored. Some external factors that may not be thought of as environmental may impact on the selection of an isolator. Such things as fluids (oils, fuels, coolants, etc.) which may be in the area of the isolators may cause a change in the material selection or the addition of some form for protection of the isolators.

- **Service life** The length of time for which an isolator is expected to function effectively is another strong determining factor in the selection or design process. Vibration isolators, like other engineering structures have finite lives. Those lives depend on the loads imposed on them. The prediction of the life of a vibration/shock isolator depends on the distribution of loads over the typical operating spectrum of the equipment being isolated. Typically, the longer the desired life of the isolator, the larger that isolator must be for a given set of operating parameters. The definition of the isolator operating conditions is important to any semi- reliable prediction of life.

What are we talking about?

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 (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 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 (fn)** – 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 (ds)** – 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

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