Vibration Isolation Basics

Making the right choices can make all the difference when it comes to isolating vibrations. For more information about the options, please contact us directly.

For a more complete and in-depth presentation, please visit our website.

Introduction

This theory section on the vibration properties of optical tables, breadboards, and their support systems has been written for the scientist or engineer who is not familiar with vibration theory. It serves to introduce some of the key parameters and characteristics of optical tables. More importantly, it provides a basis on which products can be selected, ensuring that money is not wasted on over-specified product purchases or critical work time is not lost due to insufficient vibration isolation.

The wind can sway tall buildings at a horizontal frequency of 1 to 10 Hz. Vibrations due to equipment and machinery often have a somewhat higher frequency, but usually below 200 Hz. Vibrations, both natural and manmade, are always present and produce relative motions of objects that may be imperceptible to the casual observer but are often disastrous to a wide range of precision experiments.

Therefore, before choosing a vibration-isolation system it is important to determine the following:

1) The severity of the environment where the table is going to be placed (e.g., in a basement or on the upper floor of a steel frame building).

2) The sensitivity of the experimental setup.

When choosing a vibration-isolation system, consider the following:

- The severity of the environment determines the appropriate isolation support system.
- The sensitivity of the setup determines the appropriate table.

After both aspects have been considered separately, the overall requirements can be reviewed together to ensure that the tabletop is compatible with the mounting system.

Selecting a Tabletop

The absence of relative motion between any two (or more) components on the surface of an optical tabletop is the primary goal of optical table design.

An optical tabletop is an example of a common problem in engineering and physics, namely the deformation of a body or structure in response to external forces. These forces may be static, such as the sagging of a tabletop due to a large localized mass being placed on it. Alternatively, they may be dynamic, such as acoustic vibrations in the air, the vibrations of a small motor sitting on top of the table, or vibration induced from the building into the tabletop through its mounting points.

Compliance

The most widely used transfer function for the vibrational response of an optical table is compliance. In the case of a constant (static) force, this is defined as the ratio of the linear or angular displacement to the magnitude of the applied force. In the case of a dynamically varying force (vibration), the compliance is the ratio of the excited vibrational amplitude (angular or linear displacement) to the magnitude of the forcing vibration.

Any deflection of the tabletop is evident by the change in relative position of the components mounted on the table surface. Therefore, by definition, a lower compliance value is associated with a better table because deflection of the surface on which components are mounted is minimized.

Compliance is used to measure deflection at different frequencies and is measured in units of displacement/unit force (e.g., meters per Newton).

To understand compliance, consider a hypothetical structure with only one vibrational degree of freedom, (i.e., a structure with only one direction of deformation). This could be a steel bar that is firmly anchored at one end so that it can only vibrate in one direction.

The general expression for compliance of a system such as this is given by

$$compliance\frac{x}{F} = \frac{1}{\sqrt{(k - mf^2)^2 + (cf)^2}}$$

where k is the stiffness, c is the damping, f is the frequency, and m is the mass.