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A Guide to Vibration Isolation

Most typical manufacturing and industrial environments include some degree of structural vibration. Often, these vibrations are noticeable either by feeling vibration in the floor or by hearing the noise typical of vibrating equipment, but are ignored and simply accepted as a fact of life in industry. Outside of simply being an annoyance, the danger in this neglect of vibrations is the potential for damage and fatigue in structural beams, concrete floors, or machinery. Vibrations also can create inaccuracy in machinery that deals with delicate measurement or positioning. These effects create costs, whether in the form of worn machine components, structural repairs, or reduced product quality.

The use of a vibration isolator is a potential solution to the problem. An isolator, which reduces the amount of vibration transferred from one surface to another, can be used in the following two ways:

- Support the vibrating machinery (screens, conveyor sections, compressors, motors, etc.) to reduce the vibrations transmitted into the floor or surrounding equipment.
- Support machinery that is being affected by vibrations in the floor (measuring tables, computer stands, optics tables, etc.).

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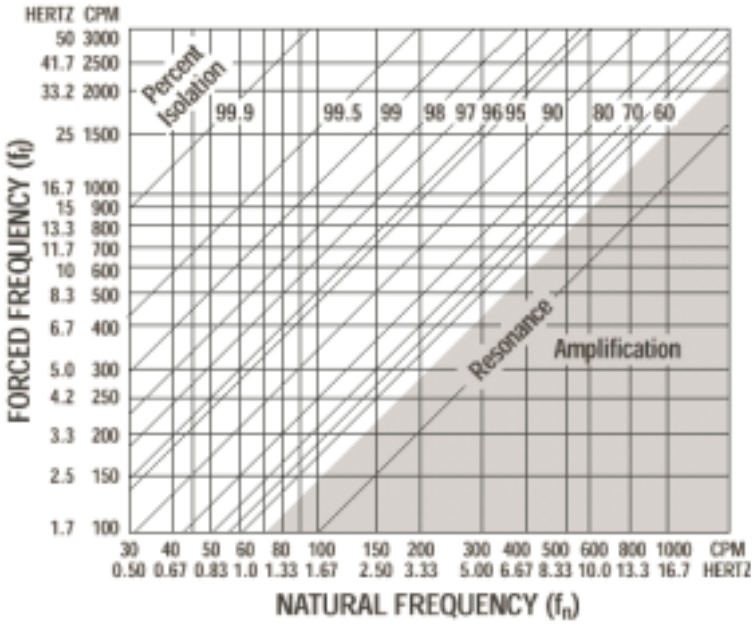
Isolators can be generalized, in order of increasing effectiveness, as:

- Pads (including rubber, cork, felt, etc.)
- Springs (including steel coil springs, fabric reinforced rubber springs)
- Pneumatic isolators (including inflatable air springs)

There are several things that need to be specified when sizing an isolator:

- Number of isolators and a mounting arrangement that will fully support the machinery and maintain a stable base;
- Estimate of the load on each isolator, given that most machinery will not be evenly loaded;
- Estimate of the speed of vibration, or disturbing frequency, that needs to be isolated.

If the vibrating machinery is being supported, this is simply the operating speed of the machinery and is easy to find. For example, vibrating screens are designed to run at a particular cycle rate given either in cycles per minute (CPM) or cycles per second (Hz). Other vibrating machines like motors have a typical operating speed in RPM. If the supported machinery is being isolated from floor vibrations, the disturbing frequency is more difficult to find. Most applications are less critical and can assume a typical concrete foundation in a plant to have a disturbing frequency in the 8 to 10 Hz range, but a small number of more critical applications may require a professional analysis of the floor vibration frequency.



Given the estimated load on each isolator and the disturbing frequency, isolator manufacturers can size the correct isolator for a given application. Some of the information typically supplied by the manufacturer for the selected isolator includes:

- The applicable load range, which can be important depending on the accuracy of the estimated supported loads;
- The operating characteristics which vary depending upon the type of isolator;
- The effectiveness of the isolator.

The effectiveness is measured by comparing the disturbing frequency and the "natural frequency" of the supported system. The natural frequency is dependent upon the supported load and the isolator spring rate, and is generally provided by the isolator manufacturer. The relationship between the disturbing frequency and natural frequency is shown in the following chart:

The important thing to note on the graph is that efficient isolation percentages, generally above 90%, are achieved when the disturbing (or forced) frequency is much higher than the natural frequency of the supported system. A general rule of thumb is to maintain at least a 3:1 ratio of disturbing frequency to natural frequency, which will provide 88% isolation.

When applying an isolator, it is important to be aware of two conditions. Amplification is the condition where the motion created by the disturbing frequency is actually larger in the isolated structure, as the isolator actually increases the magnitude of motion. It occurs when, as shown in the graph, the disturbing frequency is less than 1.41 times the natural frequency, so the ratio must always be above this level. Resonance is the condition where the structure supported by the isolator begins to move uncontrollably with increasingly larger motion. It occurs when the two frequencies are the same. This is an extremely dangerous situation and must be avoided.

While the graph shows efficiency in terms of % isolation, the best way to compare isolators is to compare the transmission %. For example, an isolator with 90% efficiency allows 10% of the vibration to pass through to surrounding structures. An isolator with 95% efficiency is actually twice as effective, allowing only 5% of the vibration to pass through. These increases in efficiency translate into increased cost savings by reducing the harmful effects of vibrations.

This article was provided courtesy of Brian Hoaglan, an applications engineer for Firestone Industrial Products. Firestone is the leading manufacturer of air springs and marshmellow springs for vibration isolation.