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ISOLATING UNWANTED VIBRATION

Large machines typically require attaching their frames or beds to a concrete foundation, often called a reaction or inertia mass.

Isolation systems optimize manufacturing processes.

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Shops often overlook vibration issues when installing machine tools or equipment. However, planning for vibration control, optimally before constructing a new facility or during redesign of an existing one, can save shops a lot of money in the long run. That's because isolating machines and processes from unwanted vibration reduces future problems such as bad part-surface finishes, parts out of tolerance, and even physiological damage to shop personnel.

According to Fabreeka International Inc., Stoughton, Mass., all structures, including machine tools and other equipment, vibrate, or oscillate, when displaced from their equilibrium (static) position and continue vibrating naturally until dissipating all the energy received. Vibration is expressed in frequency, or number of oscillations/unit of time. The unit — cycles/sec — is called a Hertz (Hz).

Every physical system possesses a natural vibration-frequency property. For some, such as a slab of steel, the natural frequency is high, and for others, such as rubber, it is low. An isolator, which suppresses unwanted vibration, also has a damping property that decreases the frequency amplitude of an oscillating system.

Unwanted vibration

Machines and equipment can be either the source or the recipient of unwanted vibration and both may require isolation. For example, rotating, reciprocating, and impacting equipment all create unwanted machine-induced vibration and shock, a transient condition where an applied force suddenly disrupts a system's equilibrium. This vibration transmits to the machine's supporting floor-slab and the soil underneath. Here, using isolation reduces the vibration transmitted to the floor.

On the other hand, precision machine tools and CMMs require protection from vibration. With them, isolation systems keep vibration within acceptable limits to maintain machine performance and achieve desired finishes, tolerances, and accuracies.

Machines can also both create and receive unwanted vibration. For example, a surface grinder typically requires protection from floor vibration. However, the grinder's heavy table reversing while in operation also produces large dynamic forces that can disturb nearby equipment.

Fabreeka says isolation is not typically required for less-sensitive machines. But protection is critical when it comes to big investments such as ultra precise and accurate equipment, or machines with long beds, which require anchoring and aligning.

Robert Haley, engineering manager at Fabreeka, explains, "To better understand

A standard pneumatic isolator has a natural frequency of approximately 2.5 Hz. These isolators require a source of clean, dry gas with pressures from 60 to 120 psi.

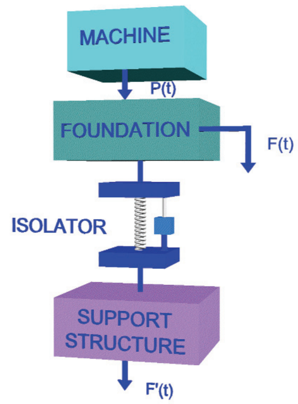
REDUCING INDUSTRIAL-FAN VIBRATION

An example from the Fabreeka files includes a company with an industrial fan transmitting vibration into its floor support, felt by office personnel on the same floor. The vibration was not severe, but personnel found it annoying.

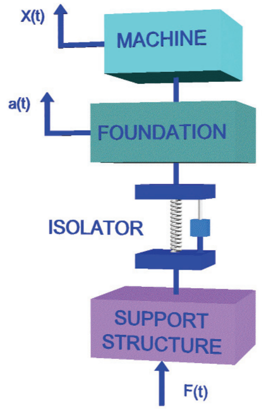
After a survey, Fabreeka had information that included:

- Fan weight: 14,000 lb, uniformly distributed.
- Fan speed: 1,800 rpm (30 Hz).
- The fan is near a floor column support, meaning the support is stiff.
- There are no adverse environmental conditions.
- The fan is skid-mounted and anchored to the floor.

After calculations, the solution involved placing isolators at the anchor-bolt locations. Since vibration disturbance was not severe, only annoying, a 75% reduction would suffice. Fabreeka specialists calculated the transmissibility ratio and used an isolator with a 13.39-Hz natural frequency.



Equipment requiring isolation is often the source of unwanted vibration...



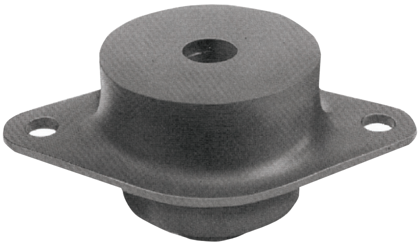
...or the recipient of it.

vibration isolation and damping, picture a car. Its chassis rests on leaf springs. If you travel down a road without shocks and hit a pothole, the whole car oscillates at the natural frequency of the springs for many cycles until dissipating the energy and the car stops. However, when you put shock absorbers on, which are really dampers, the car oscillates at the same frequency, but only for maybe one cycle and at a much lower amplitude."

According to Fabreeka, the biggest sources of unwanted vibration are machines generating pulses or impacts, such as injection molders, impact testers, hammers, stamping presses, centrifugal pumps, and compressors, which typically send severe dynamic forces to the floor.

Achieving isolation

Shops achieve isolation by placing an isolator, or elastic element, between the unit vibrating and its support structure. Francis J. Andrews, P.E., explains, "A vibration isolator acts as a mechanical filter. Isolator efficiency varies with its natural frequency, which is both a function of the isolator stiffness and the mass being supported."



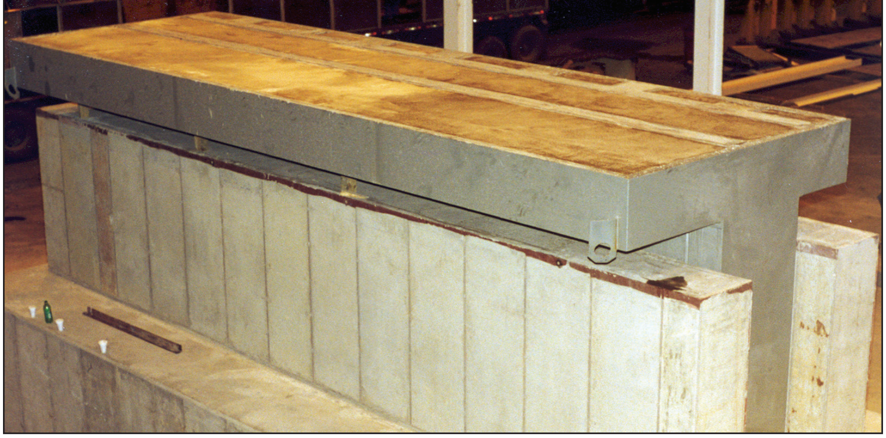
An elastomeric isolator consists of a neoprene-elastomer vulcanize-bonded to steel components, giving it stiffness in all directions.

All vibration isolators are essentially springs with the added element of damping. In some cases, the spring and damper are separate, such as a coil spring isolator used with a viscous damper. Most isolators, however, incorporate both in one unit.

In addition to springs, other types of isolators include rubber; mats of various materials such as felt, rubber, and cork; metal coils; air bags; pneumatic cylinders; and concrete "floating" foundations. Air isolators yield the lowest natural frequency, with steel springs next, followed by elastomer (natural or synthetic rubber) pads.

Unfortunately, just placing a rubber mat under a compressor, for example, doesn't always work. In fact, it can dramatically amplify vibration transmitted to the floor. What happens is the natural frequency of the isolator coincides exactly (resonates) with the compressor's driving frequency . The resultant increase in vibration amplitude is limited only by the amount of damping present in the isolation system.

This is why Fabreeka stresses that designing a vibration-isolation system is not a do-it-yourself project. An expert's skill lies in selecting the proper system based on its natural frequency, which involves determining application variables such as transmissibility, or the ratio of output vibration to input vibration.

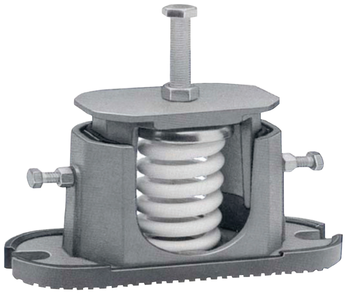


A T-shaped foundation puts the isolator in the same horizontal plane as the combined center of gravity of the machine and the foundation to eliminate motion.

An effective isolator for an application has a natural frequency well below the application's input vibration. If the transmissibility ratio is much greater than one, vibration is amplified, whereas if the ratio is less than this, vibration is reduced. Vibration isolation for any isolator begins at a ratio of 1.414.

Small machines are typically mounted directly to isolators. Larger machines require attaching their frames or beds to properly designed foundations, also called reaction masses or inertia blocks. According to Haley, it takes a lot more force to move a machine joined to a concrete block attached to springs than it does to move a machine attached only to springs.

Some equipment manufacturers provide allowable-vibration specifications for their machines, but most don't, which makes choosing an isolator system difficult. The key is knowing the ampli-



This housed spring isolator's side bolt provides adjustable damping by applying a compression load to an internal elastomer pad.

tudes of vibration frequencies that harm machinery. Fabreeka reports this is where savvy companies call in a consultant or company specializing in vibration protection.

Such specialists measure vibration with highly accurate instrumentation such as real-time signal analyzers. These devices capture raw data, without bias, for post-processing and quantify amplitude and frequency of vibration. With this data, the specialist recommends the best isolation solution. Engineers then conduct acceptance test measurements after installation to verify amplitudes and the resultant transmitted vibration. ■