



# Spring Isolators

TECH NOTES



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## DESIGN & APPLICATION

The purpose of a resilient isolator system is to provide flexibility in the form of an isolation system that converts energy into a more manageable form. By providing deflection, the energy of the vibrating equipment is released over a longer period. Theory shows that as the operating speed of the equipment increases, the required deflection to absorb this energy decreases. For example, a heavy, sudden shock requires a higher deflection than a constant running engine.

The amount of energy that passes through an isolator is measured as a percentage of the vibration energy produced by the equipment. This factor is called transmissibility. It is also possible to increase the energy through the isolator system. For this increase, we use the term amplification. Though, for most systems where the energy is decreased, we use the term attenuation. A properly designed isolation system will attenuate the vibrations to a level necessary for the application.

To measure transmissibility, we need to know the deflection, or natural frequency, of the isolation system. To calculate the natural frequency of the isolation system, when given the operating deflection in inches, we use this equation:

$$\text{Natural Frequency, (Hz)} = \sqrt{\frac{9.8}{\text{Deflection}}}$$

Once we know the disturbing frequency ( $f_d$ ) and natural frequencies ( $f_n$ ), we can now calculate the transmissibility. For isolation systems without damping, the equation is:

$$\text{Transmissibility} = \left| \frac{1}{\left(\frac{f_d}{f_n}\right)^2 - 1} \right|$$

In practicality, transmissibility is not the term commonly used. We use the term isolation efficiency. This is the transmissibility subtracted from 100%. For example, if we have 20% transmissibility, we say we have 80% isolation efficiency.

$$\text{Isolation Efficiency (\%)} = 100\% - \text{Transmissibility (\%)}$$

Generally, in most non-critical applications, a minimum isolation efficiency of 80% is acceptable. As the application gets more critical, a computer chip manufacturing plant for example, isolation efficiencies in the high 90% range may be required. As the required isolation efficiency increases, so does the cost and complexity of the isolation system.

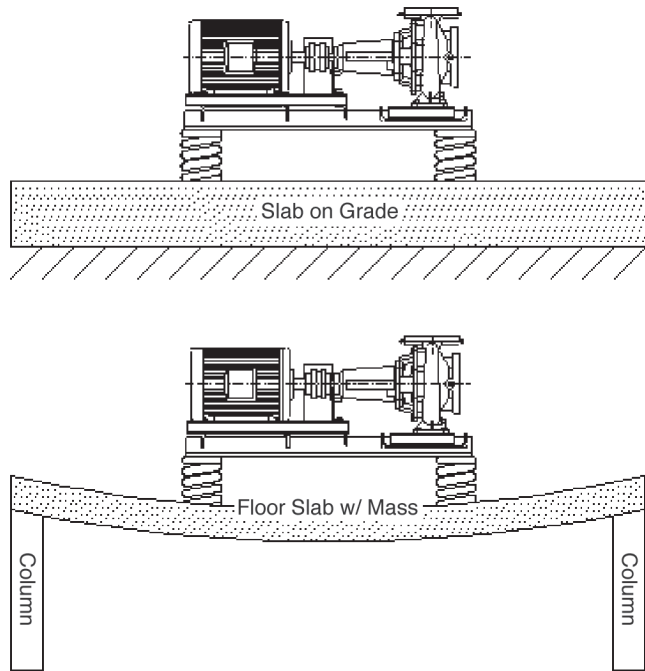
## FOR THE DESIGNER

It's important to know the operating speed of the equipment when selecting vibration isolation materials and isolators. However, more information is required to make the proper isolator selection when leafing through this catalog. Additional information required includes:

- Equipment weight and center of gravity
- Motor horsepower
- Number of isolation points and weight distribution at each point, if available
- Installation location within the building
- Is the equipment installed on grade or above, within the building?
- Is the equipment suspended?
- Is the equipment on the roof?

Generally, this is most of the information required. For specialty applications that fall outside the realm of these general categories, consult VMC Group's Engineering Services Division for additional support.

Installations above grade within a structure must be analyzed differently than those on a structural slab on grade. It is generally assumed that a slab on grade is infinitely rigid and cannot deflect. For the sake of vibration isolation, this is true. For installations above grade, the stiffness of the structure may play a significant role in selecting proper isolation. From the transmissibility equation, it is seen that the ratio between the disturbing frequency and the natural frequency of the isolation system is the driving factor. At the center of a mid-floor slab, natural frequencies may exist that are relatively close to theoretical natural frequency for an efficient isolation system based upon a rigid foundation. The concern is that placing a vibrating system on top of this slab at roughly the same frequency will create a two mass and spring system which may create resonance between the two systems.



As can be seen from the above sketch, the stiffness of the slab is a part of the total system. We can quantify its stiffness for illustration. Per current design guidelines, ASD & LRFD, a typical mid-point deflection in a beam is  $L/360$ , where  $L$  is the length of the beam. For a 20 foot beam span, the allowable deflection is 0.67 inches. By comparison, this is roughly the same deflection required for a 95% efficient system running at 1000 RPM on a rigid foundation. Therefore, it is very likely that amplification will occur if this system applies its vibratory force at the center of the span.

Solving this problem requires additional displacement in the selected isolation system. As we decrease the natural frequency of the isolation system, we decouple the natural frequency of the system from that of the slab. Typically, a good value for deflection of the isolation system is about five to six times that of the structure, assuming we are still in the range of isolation efficiency. And by decreasing the natural frequency of the isolation system, we increase the ratio of  $f_d/f_n$ , which will create a more efficient system.

Now that the correct spring deflection and load capacity are selected, the applications engineer can go through the various options in selecting the proper vibration isolator. VMC Group offers a wide variety of choices to aid the designer in this process. Typical choices are open spring, housed, snubbed or seismic isolators for base mounted equipment. For suspended equipment, the choice for the designer includes boxed spring hangers that are offered with or without elastomeric elements. These are also available with a pre-positioning pin option, which limits the travel in the system once it is filled.

## FLOOR MOUNTED EQUIPMENT

For equipment installed on a structural slab, four different application options exist. In each case, other information is necessary to properly select the isolation system.

### Open Spring Isolators

Use of an open spring in most applications needs to be looked at cautiously due to the lateral instability of the installation. If the equipment being isolated has lateral service loads, such as fan thrust, use of an open spring is not recommended. Also, equipment with high startup torque should not be isolated with open springs. When the equipment has other means of lateral support, say, a seismic snubber or two directional horizontal thrust restraints, an open spring will suffice. Use of an open spring in combination with an elastomeric break, will be the least intrusive to the acoustical designer.

### Housed Isolators

Housed isolators are primarily open spring isolators that are placed inside of a housing. The housing offers lateral stability and provides a flat upper surface for the equipment to rest on. Most isolators sold are of this variety. Housed isolators provide the safety needed for most non-critical installations that are subject to lateral operating loads and uplift. In addition, they are offered with base plates for anchoring to a structural slab.

### Snubbed Isolators

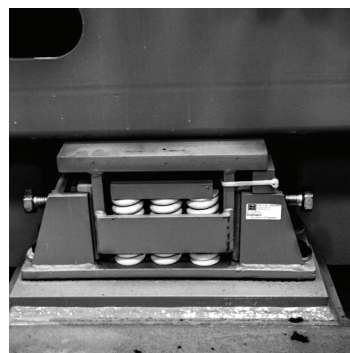
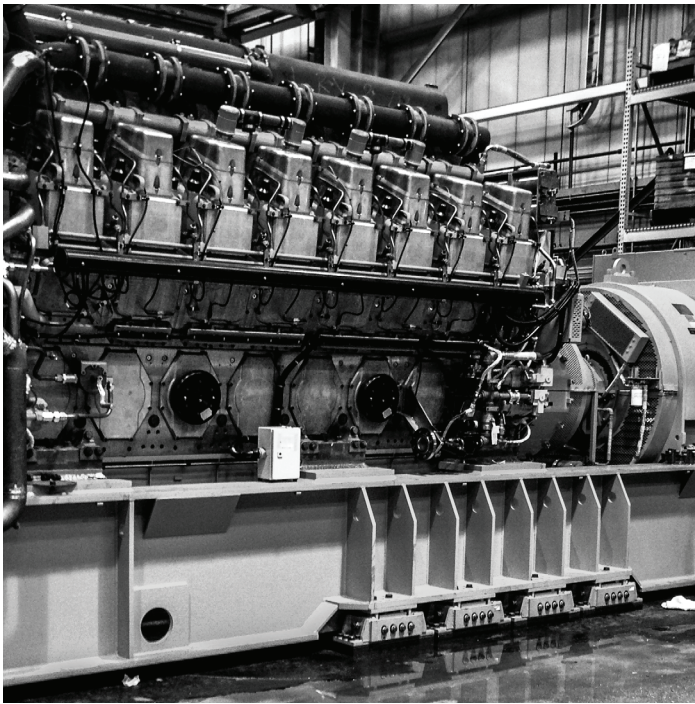
These are a special type of housed isolators that have internal snubbing that creates coulomb (or frictional) damping. Snubbing is generally required for installations that have a high degree of start-up torque and that frequently shut down and restart. During the start-up of some equipment, the motor will pass through a resonant frequency. Having a damping device will prevent amplification.

### Seismically Restrained Isolators

The last level of laterally restrained springs is seismic isolators. These isolators are designed to withstand the applied lateral load from a seismic event. These isolators are offered with provisions for positively fastening to the equipment and to the building structure. Their internal components have been designed and certified to carry prescribed seismic forces. When selecting a seismic isolator for a particular application, it is necessary to have a job specification or know exactly where the job installation is located. VMC Group's Engineering Services Division gladly offers all the assistance necessary to properly design, select and install seismic isolation systems. These isolators, along with housed and snubbed isolators, also offer the ability to use the isolator to block the equipment at a prescribed height prior to filling the system.

It is important to note that seismically restrained isolators are not intended to protect the equipment from a seismic event. Their purpose is to ensure the equipment stays positively attached to the building structure.

It should also be added that all seismically restrained isolators are housed, but not all housed isolators can be considered seismic rated.



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VMC Group offers a full line of spring isolators.



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