To help address the issues of vibration and noise control/dampening vibration in mechanical, refrigeration, HVAC and electrical installations, Eaton offers the following B-Line series vibration isolation products. It is our continuing effort to offer the industry quality support system products that meet the demands of today’s construction environment.

The following pages depict vibration isolation and noise control products that are commonly specified and required on piping, duct and equipment, but not limited to mechanical rooms. As an aid in choosing the proper vibration control device, the chart shown on the following page is a reference for obtaining Vibration Isolation Efficiency.

Considerations must be given to the desired deflection and the frequency (R.P.M.).

The Theory of Vibration Isolation

Background

Soils, floors, ceilings, walls, etc. deflect as the result of applied forces. Cyclical forces generated by machines result in work done on the floors, etc. Under steady state conditions, this work is stored as potential energy in the floor each cycle and returned as work in forcing the machine back to its equilibrium position. Disturbance is transmitted during this flexing.

Vibration Isolation is needed when disturbing force magnitudes are expected to be great enough to cause damage or annoyance.

<table>
<thead>
<tr>
<th>Assumption</th>
<th>Fact</th>
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<tbody>
<tr>
<td>1. We know the effects of vibration isolation (efficiency)</td>
<td>Formula for calculation shown below.</td>
</tr>
<tr>
<td>2. We know the magnitude of the disturbing forces created by the machines</td>
<td>Equipment manufacturers rarely provide these data. These forces are</td>
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<tr>
<td>3. We know the magnitude of disturbing forces beyond</td>
<td>seldom known except in generalities.</td>
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Consideration of items 1. and 2. is essential to determine acceptable isolation efficiency. Unfortunately manifold complexities prevent inclusion of steps for determination of these efficiencies in this document.
Proper Sizing

Once it is determined as to what type of vibration dampening device is needed, weight loading is the next crucial step. As a built in safety measure, take the actual weight of supported pipe or equipment (consider all accessories - i.e. valves, insulation, brackets, etc...) and multiply by 1.25. Then refer to the sizing chart for the selected product to determine part number.

Sizing: Divide weight of equipment by points of support to determine load requirement per support.

Example: 240 Lb. (90.7 kg) piece of equipment, 4 support points, take 240 x 1.25 = 300 Lbs. (136.1 kg) (safety measure), then take 300 ÷ 4 = 75 Lbs. (34.0 kg) Specify appropriate vibration device rated at 75 Lbs. (34.0 kg) for each of the support points.

If weight of equipment is unequally proportionate, select mounts to satisfy the weight distribution.

Vibration Isolation Data

Natural frequency of isolation system \(f_n\) (cycles per minute)

Visualize a machine suspended barely above 4 springs (one on each corner). Now release the suspension. The machine will deflect the springs and be pushed up and return a number of times with diminishing deflection until it comes to rest. The spring deflection at rest is called the static deflection. The number of cycles per unit time is the natural frequency of the isolation system. Unlike multi-degree of freedom floors with limitless natural frequencies, springs essentially have only one natural frequency.

\[
f_n = 188 \sqrt{\frac{1}{\text{static deflection (inches)}}}
\]

Vibration isolation efficiency % = 100% x \[1 - \left(\frac{1}{f_d} \cdot \frac{1}{f_n}\right)^2 - 1\]

Transmitted force \(f_t\) (pounds) \(f_t = f_d\) (100% - isolation efficiency)

Note that \(f_n\) must be compared to \(f_d\) for satisfactory isolation efficiency. Also note that the force transmitted can be greater than the disturbing force when \(f_n\) is close to or equals \(f_d\). This condition is called resonance and is avoided in vibration isolation.

Natural frequency of floor or soil

Visualize the effect of dropping a load on the floor. This floor will deflect and spring back diminishingly a number of cycles until it comes to rest. The number of these cycles per unit time is a natural frequency of the floor. It is essentially independent of the magnitude of deflection and hence is a characteristic of a given floor if given a light tap or a hard jolt at the same location.

The floor has many natural frequencies. The lowest natural frequency is called the fundamental. It is characterized by maximum deflection at mid span. The higher natural frequencies are generally less bothersome than the fundamental since they are less likely to be excited by machines in common use and are more quickly damped. The greater a floor deflects under a given load, the lower the fundamental frequency of that floor. Soft, springy floors have low fundamentals. Hard, solid floors have high fundamentals.

Disturbing frequency \(f_d\) (cycles per minute)

With few exceptions, the speed (RPM) of the machine will be most representative of the frequency of the disturbance. Disturbances are more readily transmitted when the disturbing frequency is close to a natural frequency of the floor or soil. For this reason, these characteristics are important considerations in designing a trouble-free installation.

Disturbing force \(f_d\) (pounds)

The disturbing force causes the problem. It is constantly changing from maximum positive through zero to maximum negative through zero to maximum positive each cycle. It results from unbalanced reciprocating and rotating masses. Its peak magnitude varies from ounces to tons. From less than 1% to over 60% of the weight of some types of machines. Generally this force will increase with time in a given machine as bearings wear, deposits form and moving parts get out of balance with each other.
Vibration Isolation

Critical Installations
96% to 99% Vibration Isolation Efficiency recommended (only 1% to 4% of disturbing vibration transmitted).

Standard Installations
90% to 95% Vibration Isolation Efficiency recommended (only 5% to 10% of disturbing vibration transmitted).

Non-Critical Installations
75% to 89% Vibration Isolation Efficiency recommended (only 11% to 24% of disturbing vibration transmitted).

For 1/4" (6.3mm) deflection: Specify B-Line series RM and RQ Neoprene Mountings or B-Line series RH Neoprene Hangers.

For 1/2" (12.7mm) deflection: Specify B-Line series RMD and RQD, (or JQTN for OSHPD pre-approved) Neoprene Mountings or B-Line series RHD Neoprene Hangers.

For 1"-2" (25.4mm-50.8mm) deflection: Specify B-Line series CHSCS, CH30SCS, HHSCS, and HH30SCS Housed Spring Mountings.

For larger deflection requirements, consult factory.

IE Computer Isolation Efficiency

$\sqrt{\frac{1}{\text{static deflection (inches)}}}$

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

$3 \times HX = 180 \quad \text{cpm} = 1.1" \text{ Deflection}$

$f_d \text{ Disturbing Frequency - (cycles per minute)}$

Eaton

B-Line series Pipe Hangers & Supports