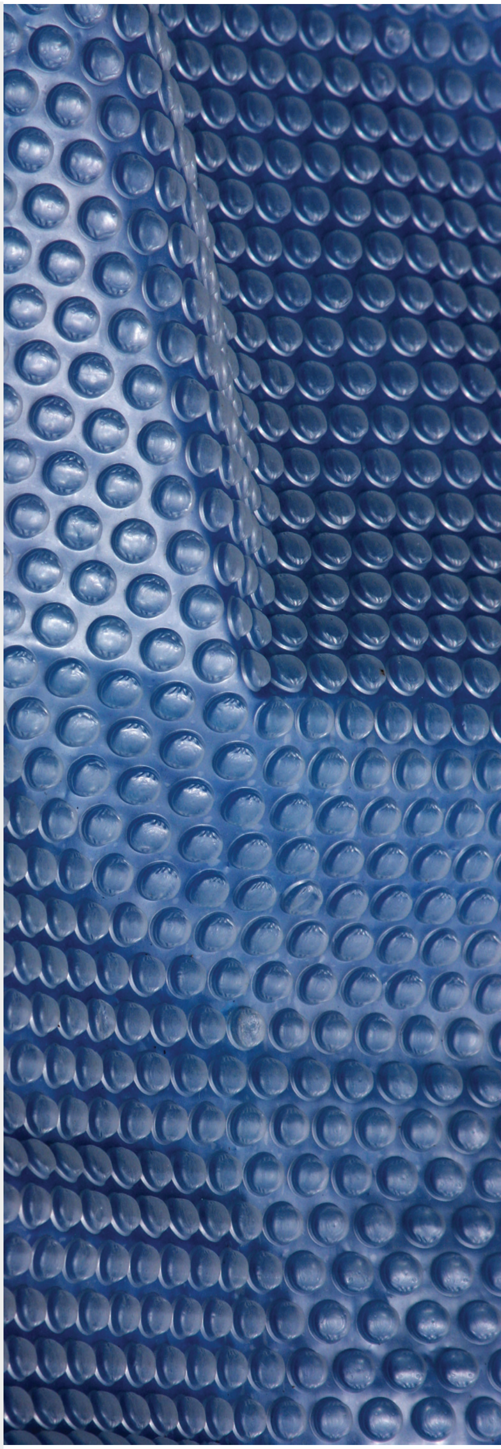
ROGERS CORPORATION

Materials Design:
Understanding Vibration Isolation Efficiency Curves



Understanding how to compare the overabundance of materials designed for vibration management in today's marketplace is challenging. There are several materials that can perform vibration isolation, but not all materials are high performance. Bubble wrap, for example, will do a great job at isolating vibrations if used correctly, but it is not a durable product and will ultimately fail. Bubble wrap is an extreme example, but engineers have identified that bubble wrap is an effective way to prevent damage from products in shipping but not necessarily applicable for vibration mounts.

To select the right material, engineers must understand the physical properties required in the application, including temperature resistance, expected service life, safety factors, and regulatory specifications. Material options then need to be compared with respect to vibration isolation.

Two curves are found in the majority of vibration data sheets and understanding how to read them and how they are generated enables engineers to design effective solutions.

The first, Load versus Natural frequency, helps engineers identify the material with the lowest natural frequency. The second, Vibration isolation efficiency, takes the design one step further by comparing materials to identify which product has a larger region of isolation. When designing for isolation, engineers tend to look for materials with a low natural frequency.

Both Load vs. Natural Frequency and Vibration Isolation Efficiency are derived from Material Characterization testing often referred to as Transmissibility Testing. To learn more on this subject, read MATERIALS DESIGN: Vibration Isolation and Damping, The Basics on the Rogers Website.

Vibration Isolation Efficiency Curve

This curve illustrates how the isolation of a material changes based on its natural frequency under various loadings. This graph aids engineers in determining what percent of the vibration is isolated or removed from the system.

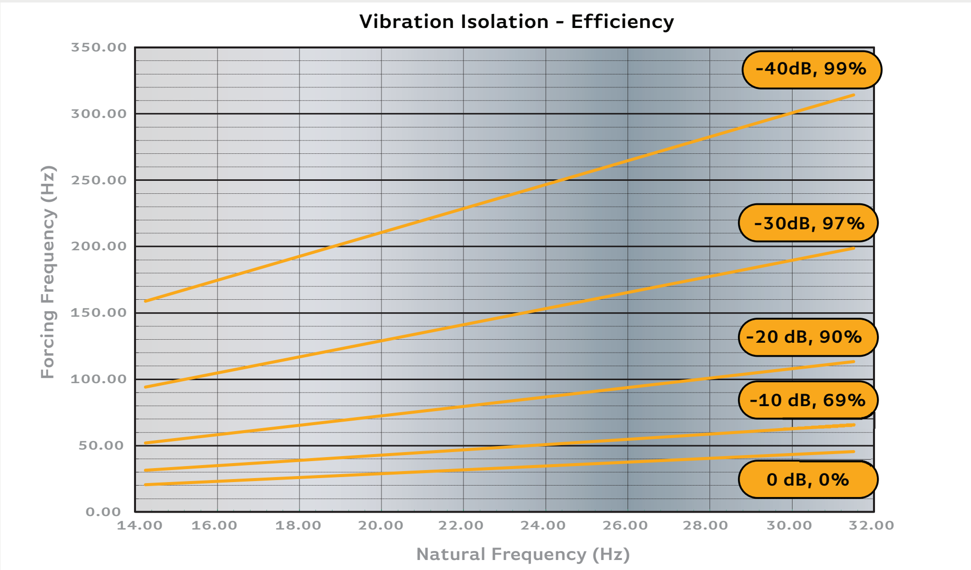


Figure 1.0
Rogers' PORON® 4701-30-15 material Vibration Isolation Efficiency curve for 12.7mm (0.500") thickness

The Vibration Isolation Efficiency Curve is generated from data captured during material characterization. Transmissibility curves are obtained for the same material by altering the mass (load) being applied to the system. Figure 2.0 below illustrates how this data typically appears.

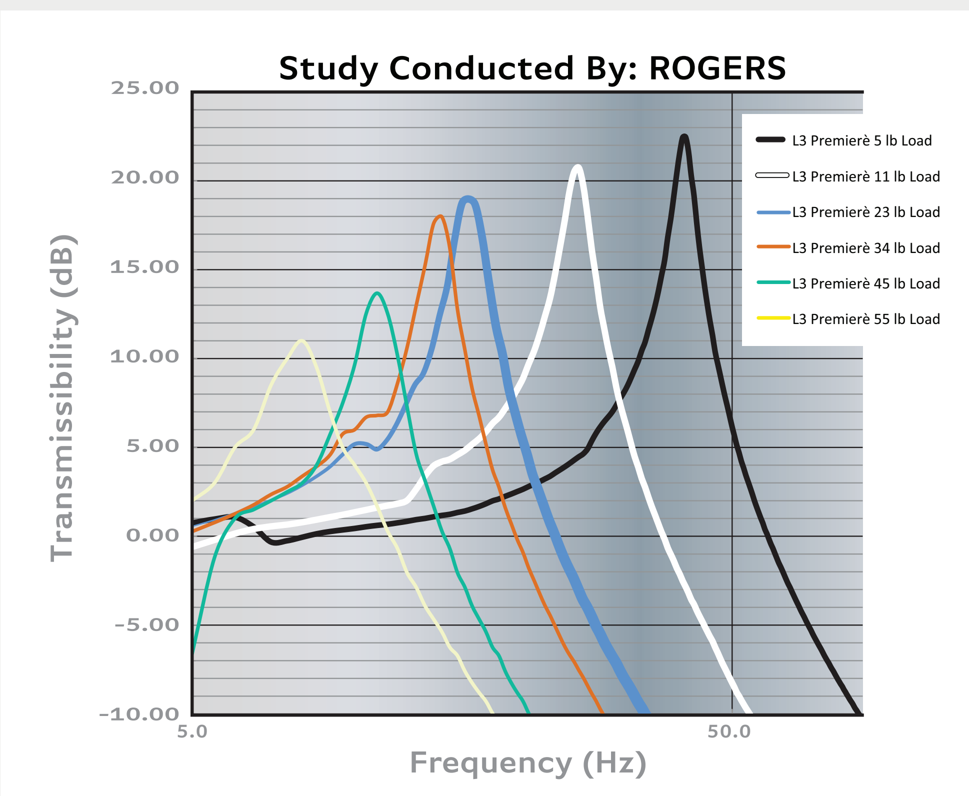


Figure 2.0
Rogers' BISCO® L3-Premierè Transmissibility Curve at various Loads

The natural frequency of the material decreases as additional load is applied to the system. The load is increased incrementally until the material has surpassed its limit of compressibility. As the material's natural frequency shifts lower, the region of isolation increases. This change in the region of isolation is then translated into the isolation efficiency curves shown on data sheets.

Using the curve in Figure 2.0, the diagonal lines on the efficiency curve are generated. Recall from MATERIALS DESIGN: Vibration Isolation and Damping, The Basics, the Equation for isolation and how we measure transmissibility.

Transmissibility is a measurement used in the classification of materials for vibration management characteristics. It is a ratio of the vibrational force in a system to the vibrational force entering a system. On the transmissibility curve itself it is often represented in decibels, using the Equation to the left.

$$dB = 20LOG(Ao/Ai)$$

Equation 1.0

$$\%\ Isolation = 1 - \%\ Transmissibility$$

Equation 2.0

In Equation 1.0 the ratio (Ao/Ai) is the measured percent of vibration being transmitted through the system. Isolation can then be calculated as shown below in Equation 2.0 as the remaining percentage.

The X-axis of the efficiency curve is natural frequency and the Y-axis is the forcing frequency that is subjecting the material to vibration. To graph the efficiency curves, a specific percent of isolation, 0% for example, is selected. This point is identified on each curve in Figure 3.0, noting the natural frequency of that curve and the forcing frequency at that point of isolation. These X, Y coordinates are then plotted on the efficiency curve in Figure 5.0 below and the efficiency curve is drawn. This procedure can be done for a wide variety of Isolation percentages, but 0%, 69%, 90%, 97% and 99% are used most often.

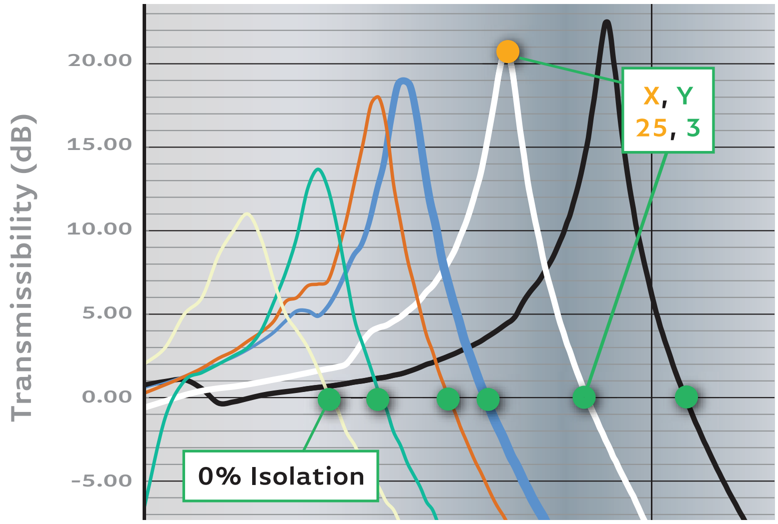


Figure 3.0

Enlarged section of Graph in Figure 2.0.

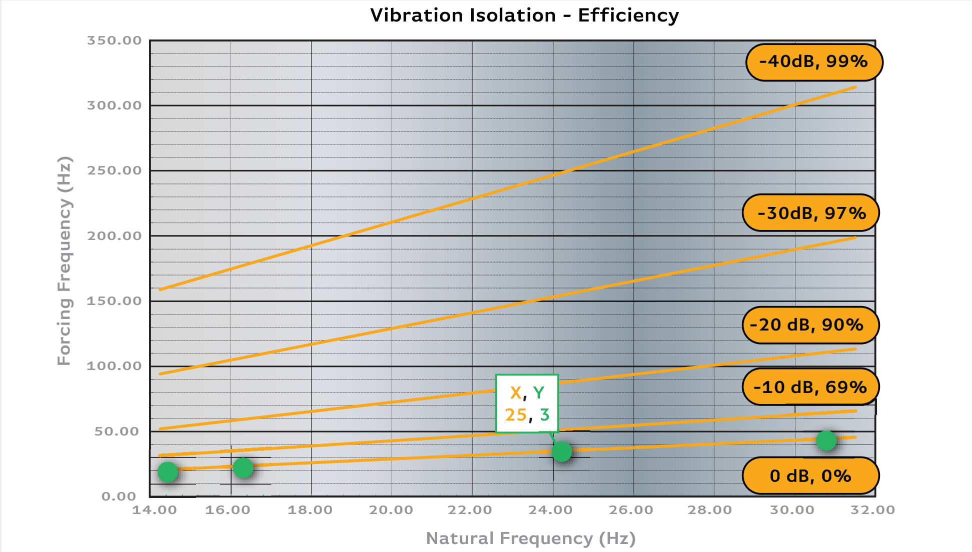


Figure 4.0
Data Points Translated into Load versus Natural Frequency Curve.

To use this curve effectively, it must be used in conjunction with the Load vs. Natural Frequency curve for the same material. These two curves are frequently represented together. Designers identify the natural frequency of the product based on the loading being applied to the material. This is accomplished by consulting the load versus natural frequency curve. Once loading is identified, the natural frequency is located on the X-axis of the vibration isolation efficiency curve and compared with various forcing frequencies of concern on the Y-axis. The curves in Figure 5 and Figure 6.0 demonstrate how this might be achieved.

For example, if a load of 25 kPa is applied to a 4.8mm pad of PORON® 4701-30-15 grade foam, the natural frequency of the foam will be 22.5 Hz. Using the efficiency curve in Figure 6.0. We draw a vertical line at 22.5 Hz. Now the engineer will need to assess the forcing frequency the application is being subjected to. At a 100Hz forcing frequency, the engineer can expect to see greater than 90% isolation. At a 145 Hz forcing frequency, the engineer can expect 97% isolation.

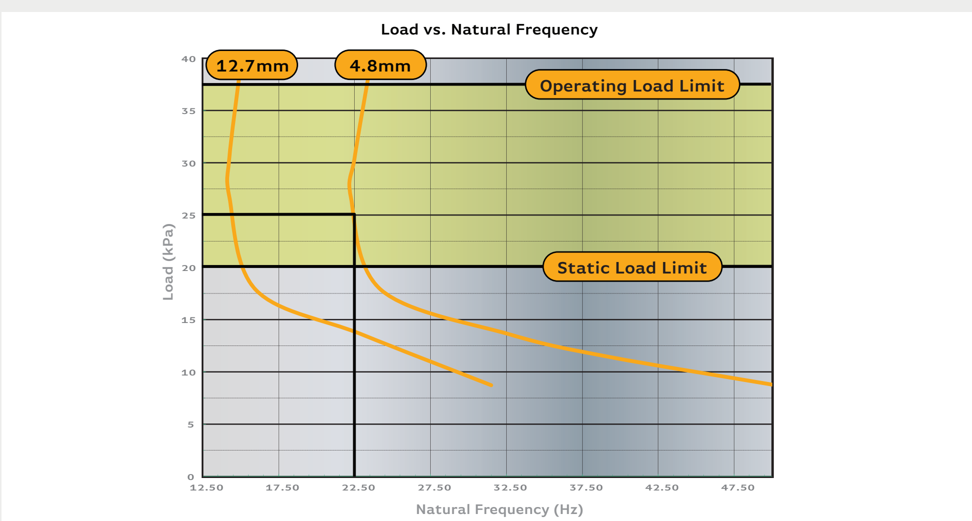


Figure 5.0
Load vs. Natural Frequency PORON® 4701-30-15 Grade of Foam

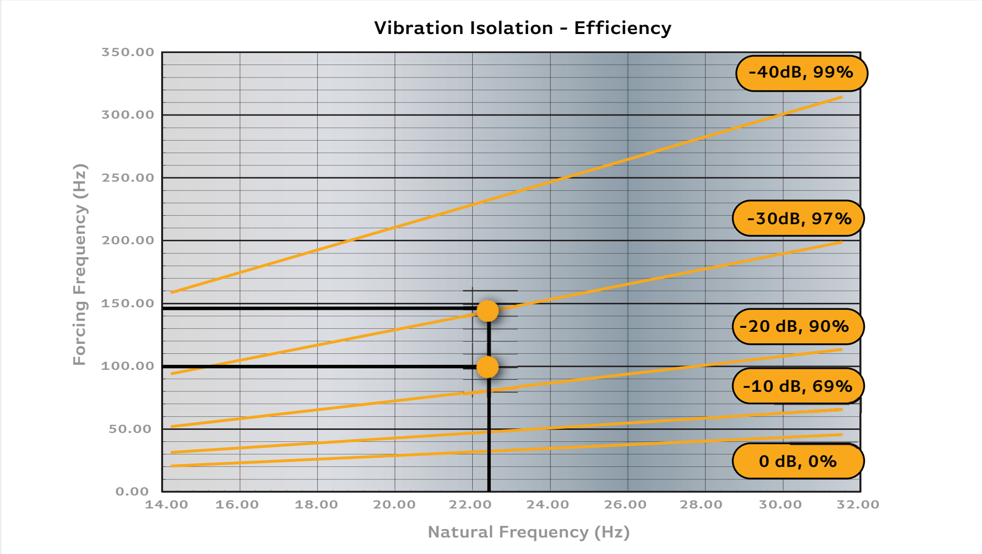


Figure 6.0 Vibration Isolation Efficiency PORON® 4701-30-15 Grade of Foam

Understanding and using the vibration isolation efficiency curves is the second step of the two step process to selecting an appropriate material. The first step is to understand and use the load versus natural frequency curve in MATERIALS DESIGN: Understanding Load versus Natural Frequency Curves and MATERIALS DESIGN: Vibration Isolation Application Examples.

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