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Q: Why do my elastomeric isolators exhibit different natural frequency vs. load characteristics from published values?

A: The published natural frequency vs. load values are provided as reference information to help in the isolator selection process. Since natural frequency is a function of the isolator stiffness and the static load applied to it, variation in either parameter will cause the resulting natural frequency to vary. While there are many factors which influence the stiffness characteristics of an isolator, this FAQ focuses on sensitivity to strain and strain rate.

Isolator stiffness is dependent on its geometry and elastomer modulus. While the geometry is relatively constant, elastomer modulus varies with strain and strain rate as a result of internal material damping, often referred to as hysteretic damping. It is this hysteretic damping which causes the dynamic stiffness of an isolator, or the effective stiffness measured when cycling the isolator with a sinusoidal input of given frequency and displacement amplitude, to be higher than the static stiffness measured with a slowly applied (quasi-static) force or displacement.

An example of the effect of strain and strain rate on the dynamic stiffness of an isolator is shown in Figure 1. These curves were generated by applying a sinusoidal displacement to an isolator, measuring the corresponding force and calculating the dynamic stiffness as the input frequency was increased from 1 Hz to 30 Hz. For a given displacement amplitude, increasing the frequency increases the strain rate and it can be seen that the dynamic stiffness increases accordingly. Conversely, for a given frequency input, increasing the displacement amplitude or strain causes the dynamic stiffness to drop.

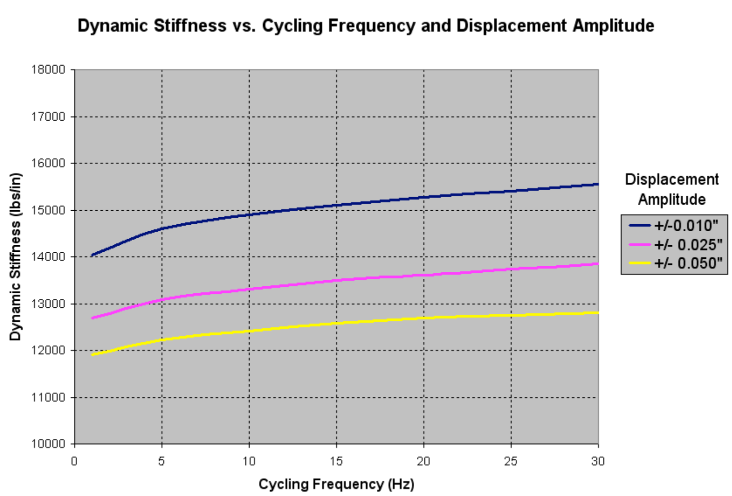

Figure 1 – Effect of strain (amplitude) and strain rate (frequency) on dynamic stiffness

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The degree of sensitivity to strain and strain rate is dependent on the base elastomer and the ingredients or fillers used to compound it. Strain sensitivity is also directly related to damping level. High damping results in high sensitivity. Low damping has less impact on strain sensitivity such that a part with no damping would exhibit constant stiffness, regardless of strain or strain rate. This is evident when testing metal coil springs with negligible or no damping.

When isolators are tested via frequency sweep on a shaker to determine their natural frequency vs. load characteristics, it is the dynamic stiffness that dictates the result. Due to the sensitivity of dynamic stiffness to strain and strain rate as shown in Figure 1, the natural frequency in turn is sensitive to the input amplitudes and response displacements of the isolator. If inputs are applied that are not similar to those used to generate the published natural frequency vs. load values, different results may occur.