



Introduction to Damping

Impact, Mechanisms, and Measurements

Presented By
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Brush Beryllium & Composites



Structural Damping

= “Energy Dissipation”
= Removal of Energy from
Vibration of Interest



Effects of Damping on Systems Motions

Steady State : Limits Motions controlled by energy balance

- f Resonance**
- f Broad - Band**
- f Spatial Resonance (Trace Matching)**

Free Vibrations : Increase Rate of Decay

- f With Time**
- f With Distance**

Onset of Vibration : Decreases Rate of Build - Up

Self - Excited Vibration : Limits Amplitude

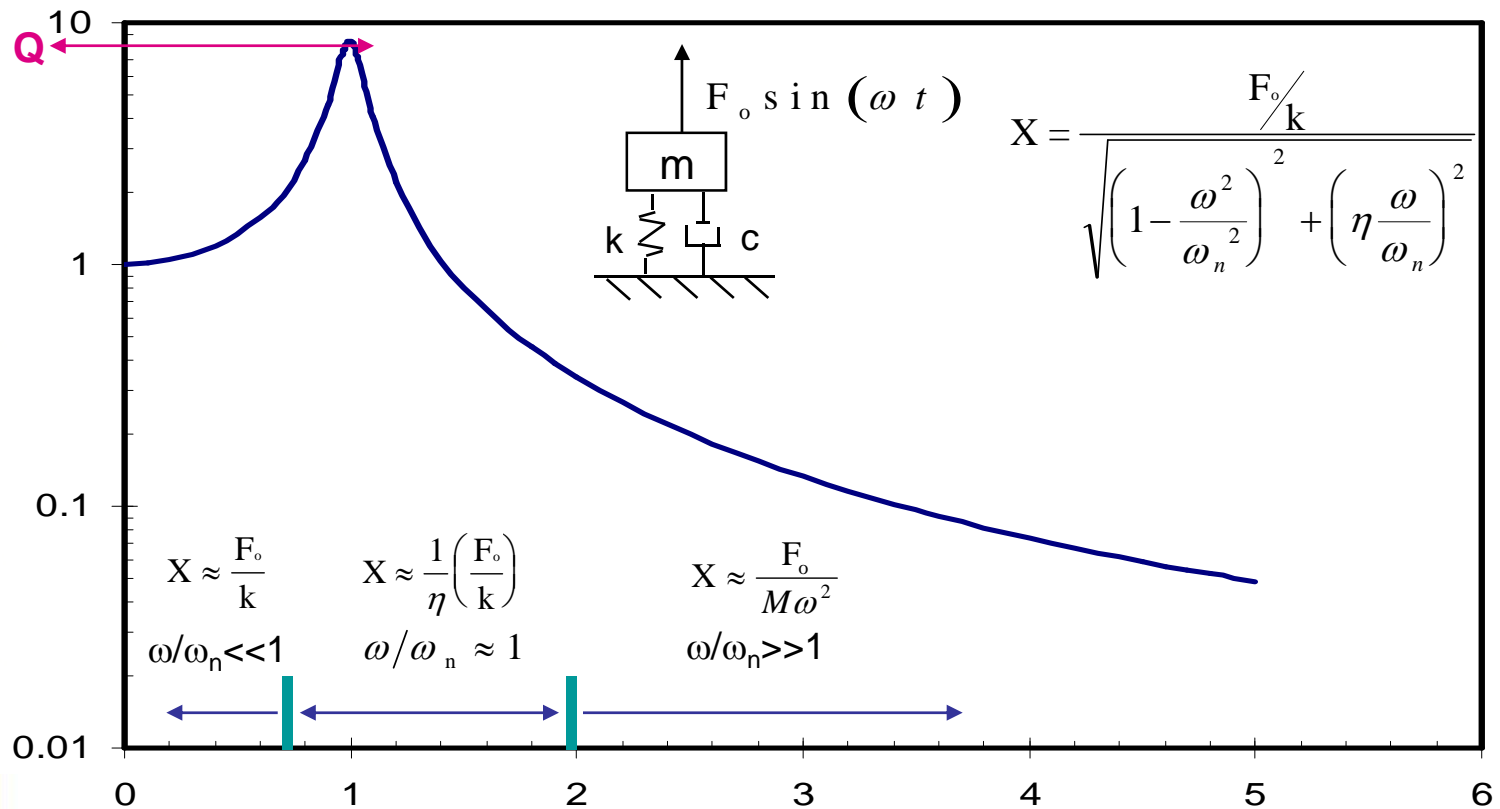
- f Flutter**
- f Stick Slip**



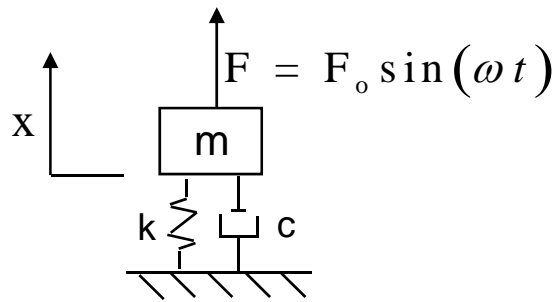
Practical Consequences of Damping

- **Increased Fatigue Life**
- **Increased Impedance (for Improved Vibration Isolation)**
- **Reduced Sound Transmission**
- **Reduced Noise from Repetitive Impacts**
- **Reduced Transmission of Vibrations and Structure - Borne Sound**

Single Degree of Freedom Example



Simple System: Steady State



$$F_k = -kx$$

$$F_c = -cv$$

$$\omega_n^2 = \frac{k}{m}$$

$$c_c = 2\sqrt{km} = \text{"Critical Damping Coefficient"}$$

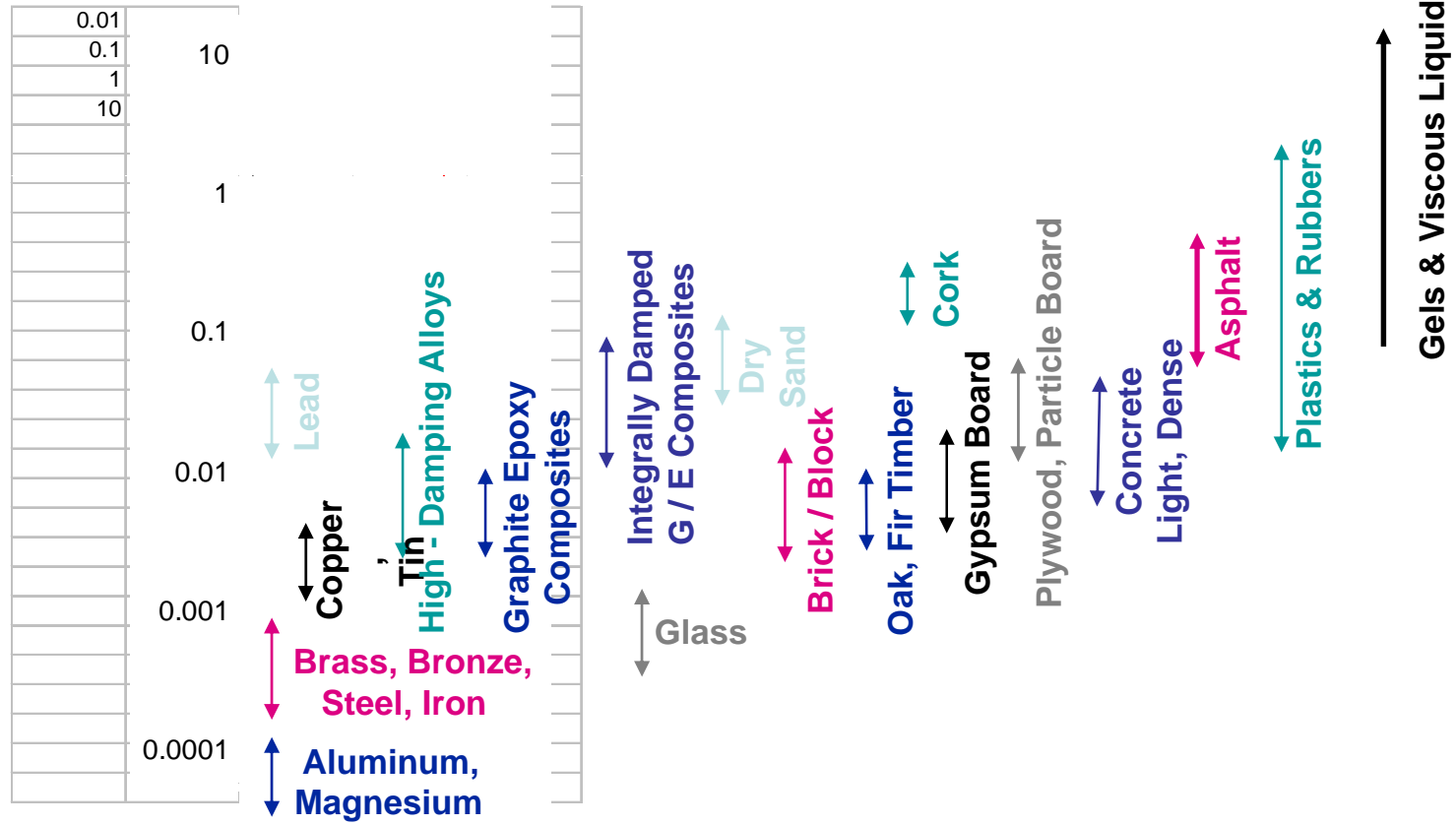
$$x = X \sin(\omega t - \phi)$$

$$W = (1/2)mv^2 + (1/2)kx^2 \xrightarrow[\text{Resonance}]{At} (1/2)m\omega_n^2 X^2$$

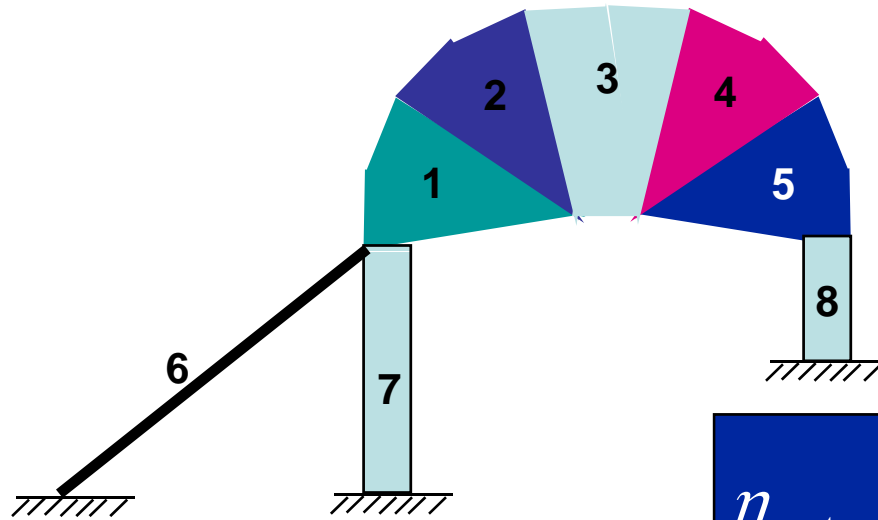
$$D = \int_{\text{cycle}} cv \cdot dx = \pi c \omega X^2$$

$$\eta = \frac{D/2\pi}{W} = \frac{c}{m\omega_n} = \frac{c}{\sqrt{km}} = 2 \frac{c}{c_c}$$

Ranges of Material Loss Factor Near Room Temperature



System Damping



$$D_i = 2\pi\eta_i W_i$$

$$D_{TOT} = \sum D_i$$

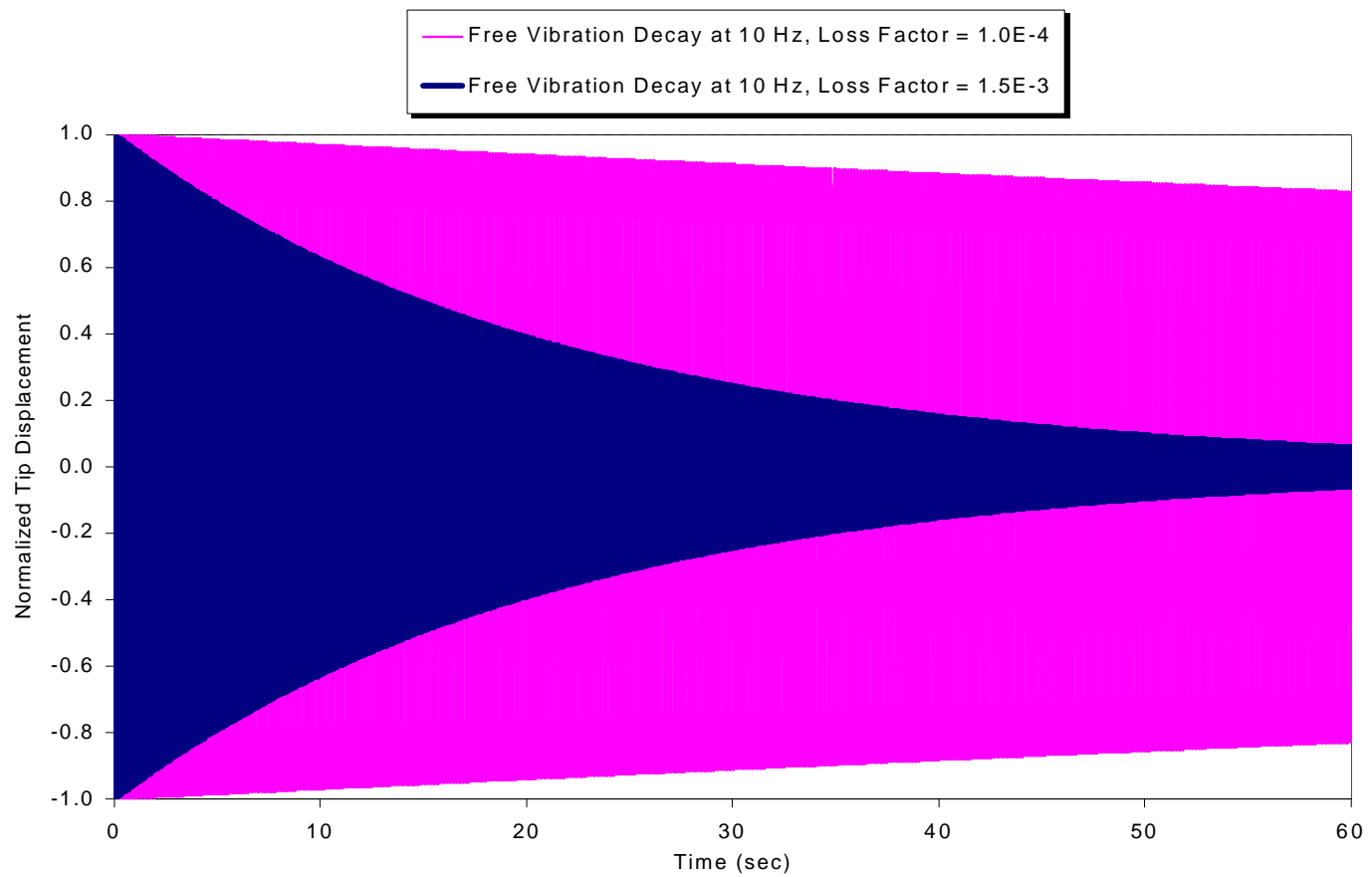
$$W_{TOT} = \sum W_i$$

$$\eta_{system} = \frac{D_{TOT}}{2\pi W_{TOT}} = \frac{\sum \eta_i W_i}{\sum W_i}$$

If only $\eta_1 \neq 0$:

$$\eta_{system} = \eta_1 \frac{W_1}{W_{TOT}} \quad \eta_1 \text{ needs to be } > 0 \quad \frac{W_1}{W_{TOT}} \text{ needs to be } > 0$$

How Different Levels of Damping Capacity Affect Vibration Decay

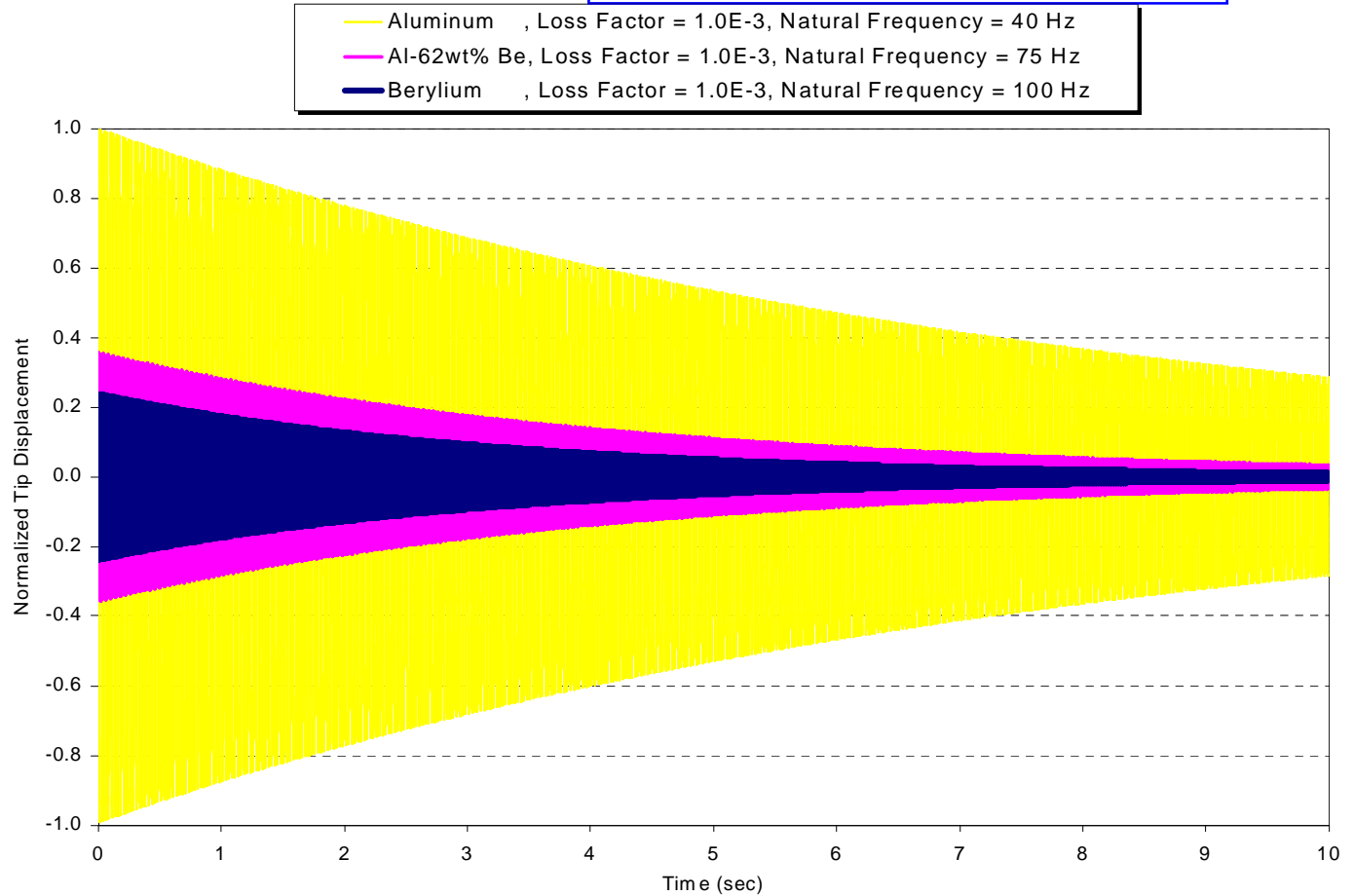




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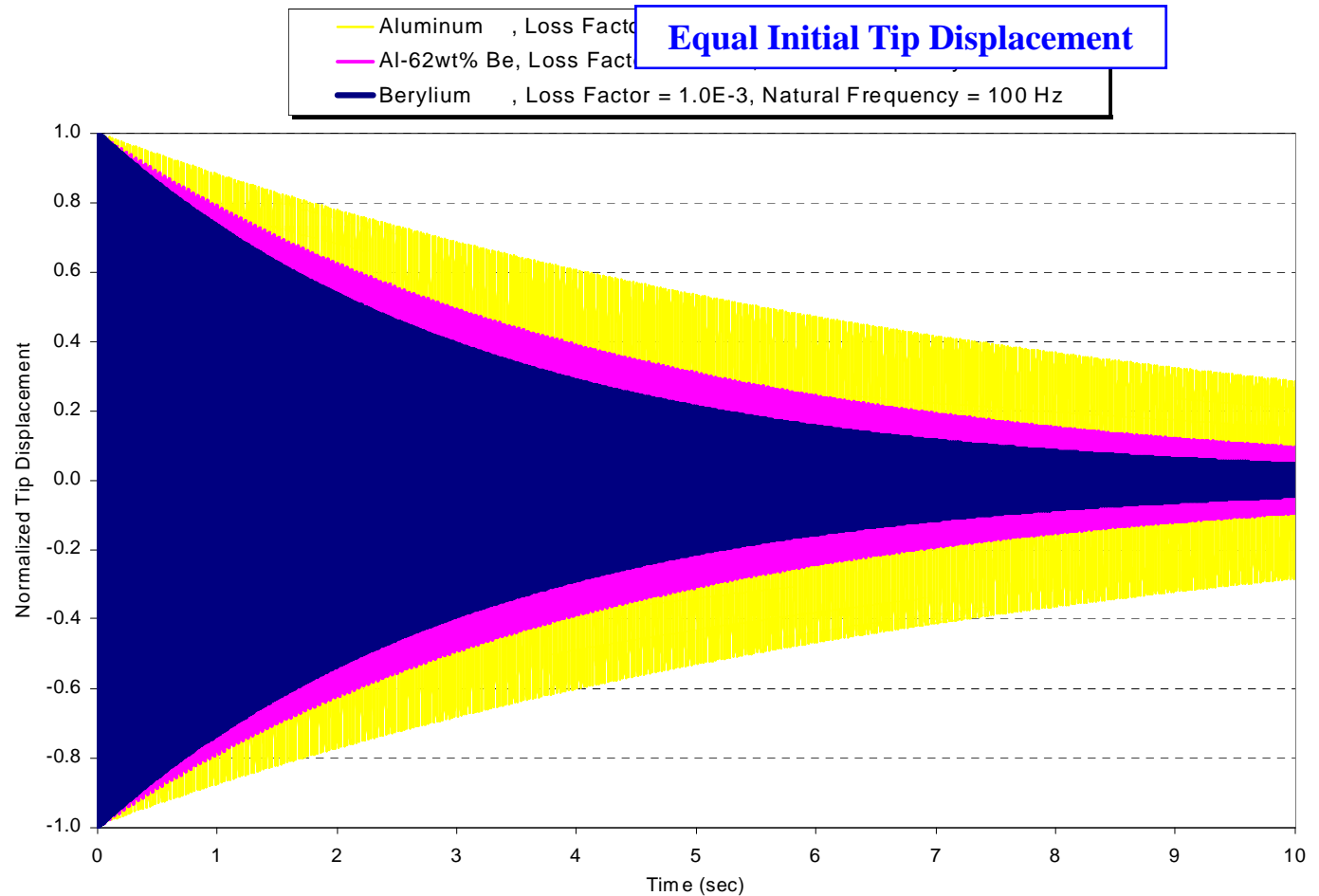
How Elastic Modulus Affects Vibration Decay if Materials Have Same Damping Capacity

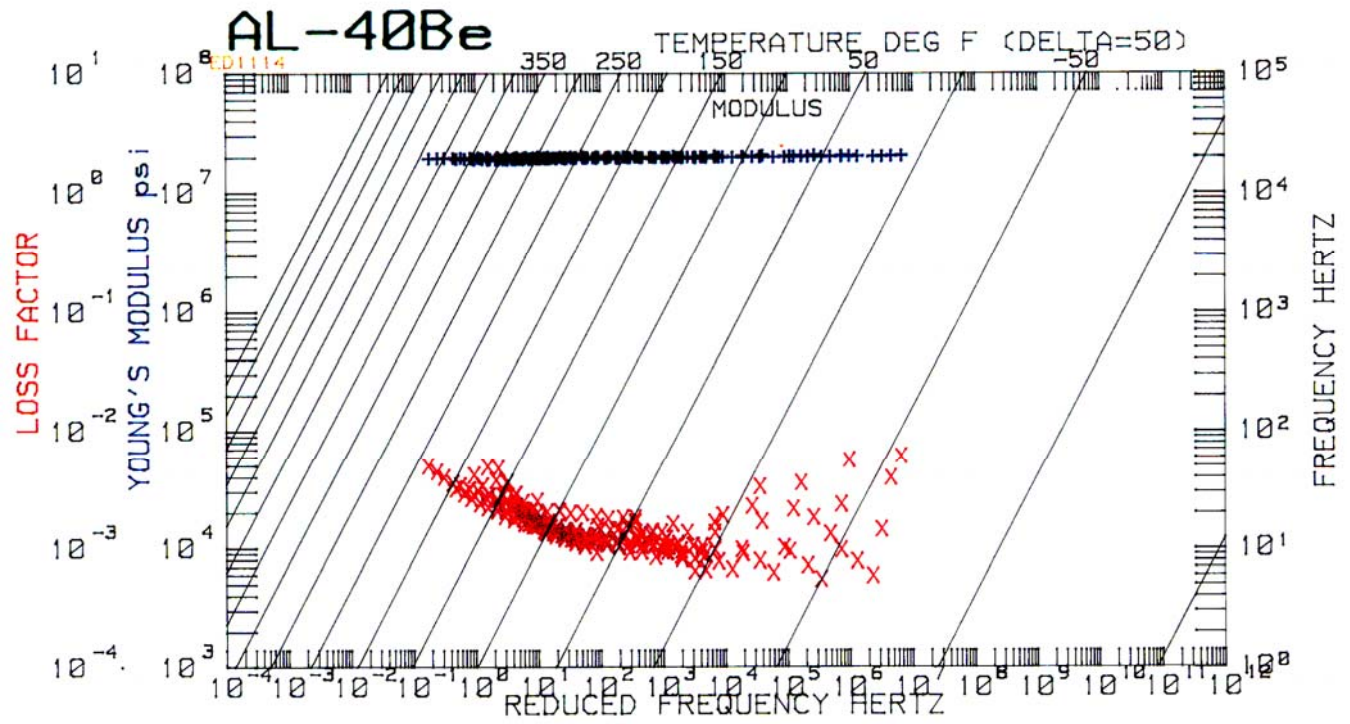
For Equal Initial Load





How Elastic Modulus Affects Vibration Decay if Materials Have Same Damping Capacity







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