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

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

Free Vibrations : Increase Rate of Decay

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

Onset of Vibration : Decreases Rate of Build - Up

Self - Excited Vibration : Limits Amplitude

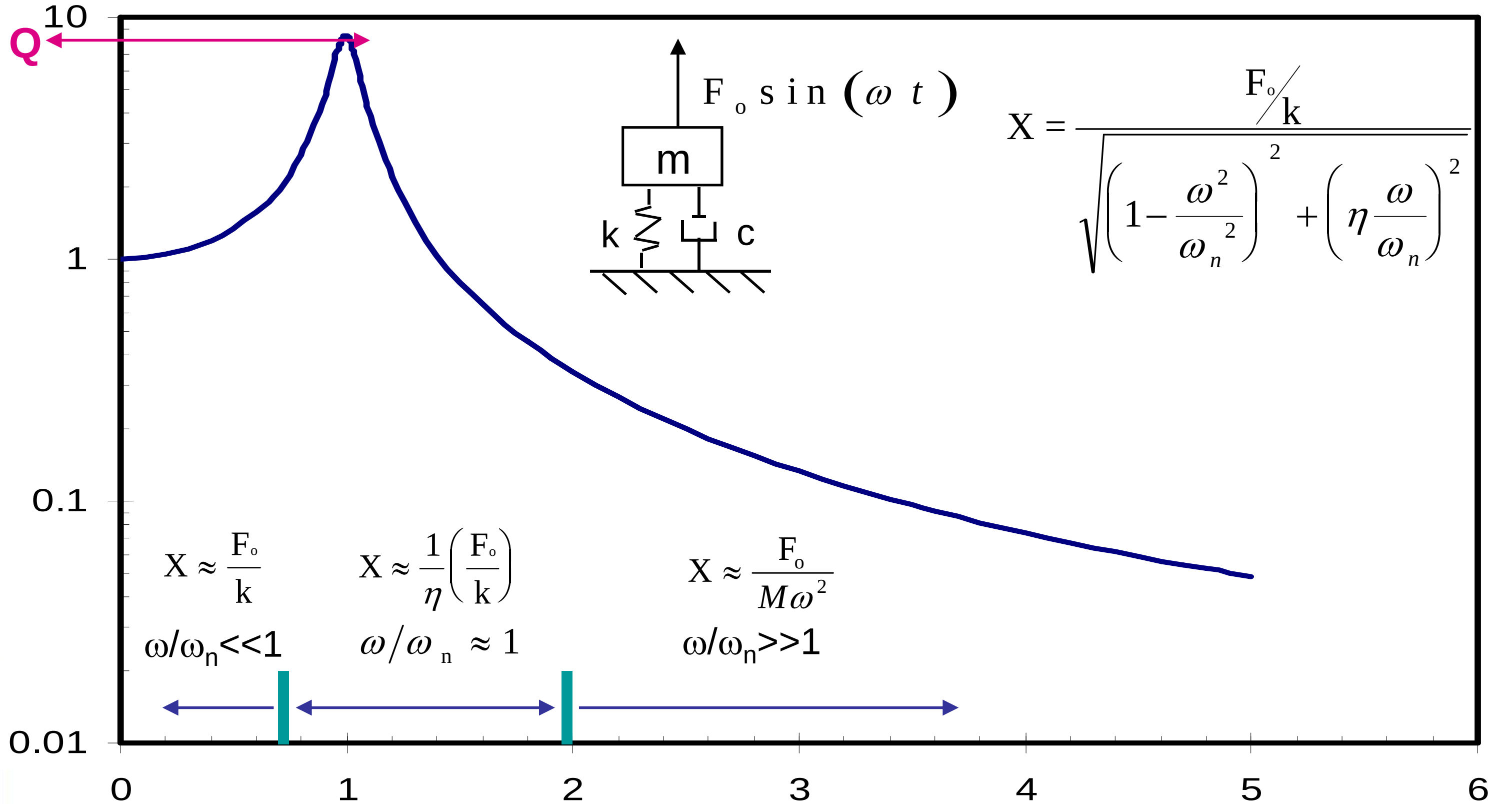
- **Flutter**
- **Stick Slip**

MATERION

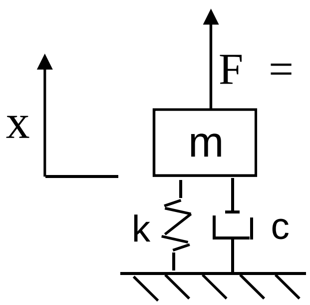
Practical Consequences of Damping

- **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



$$F = F_o \sin(\omega t)$$

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

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

$$D = \int_{\text{cycle}} c v . dx = \pi \; c \omega \; X^2$$

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

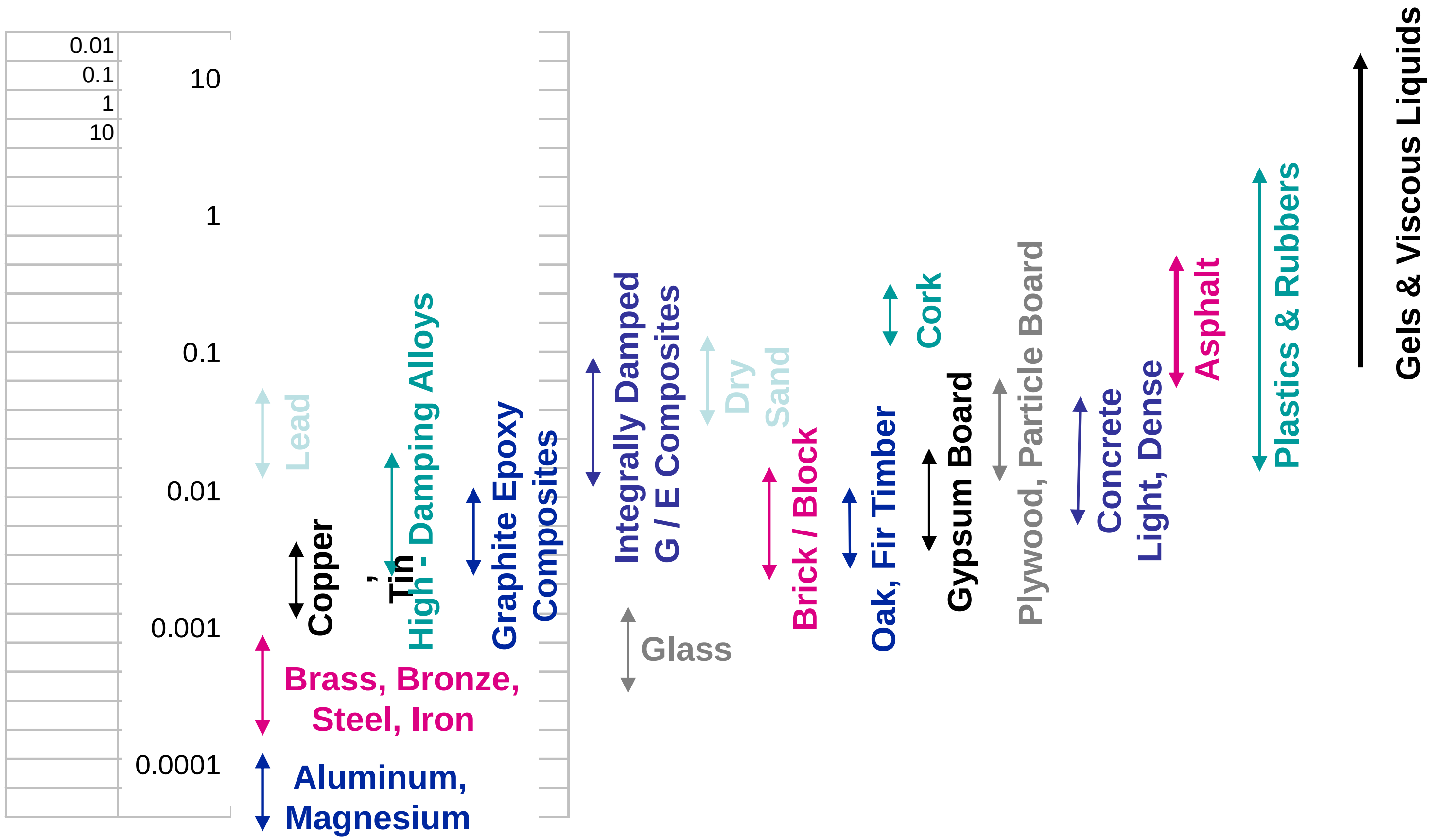
$$F_k = -kx$$

$$F_c = -cv$$

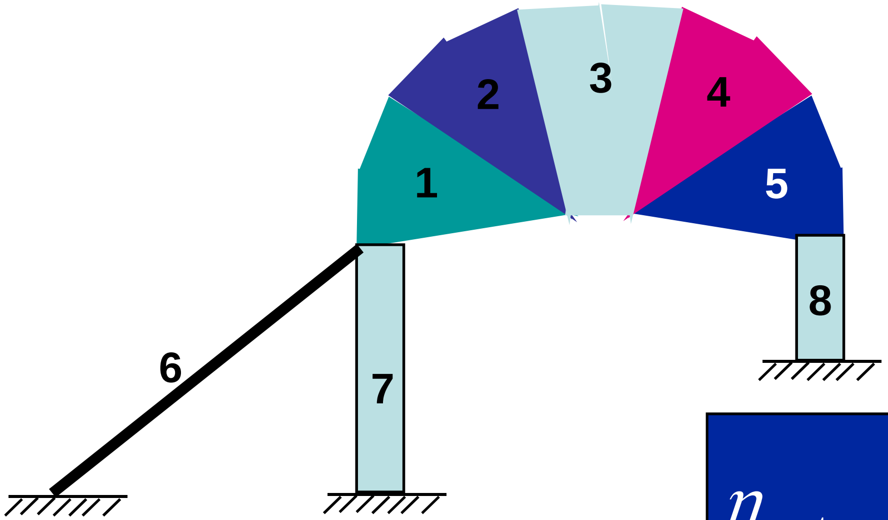
$$\omega_n^2 = \frac{k}{m}$$

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

Ranges of Material Loss Factor Near Room Temperature



System Damping



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

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

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

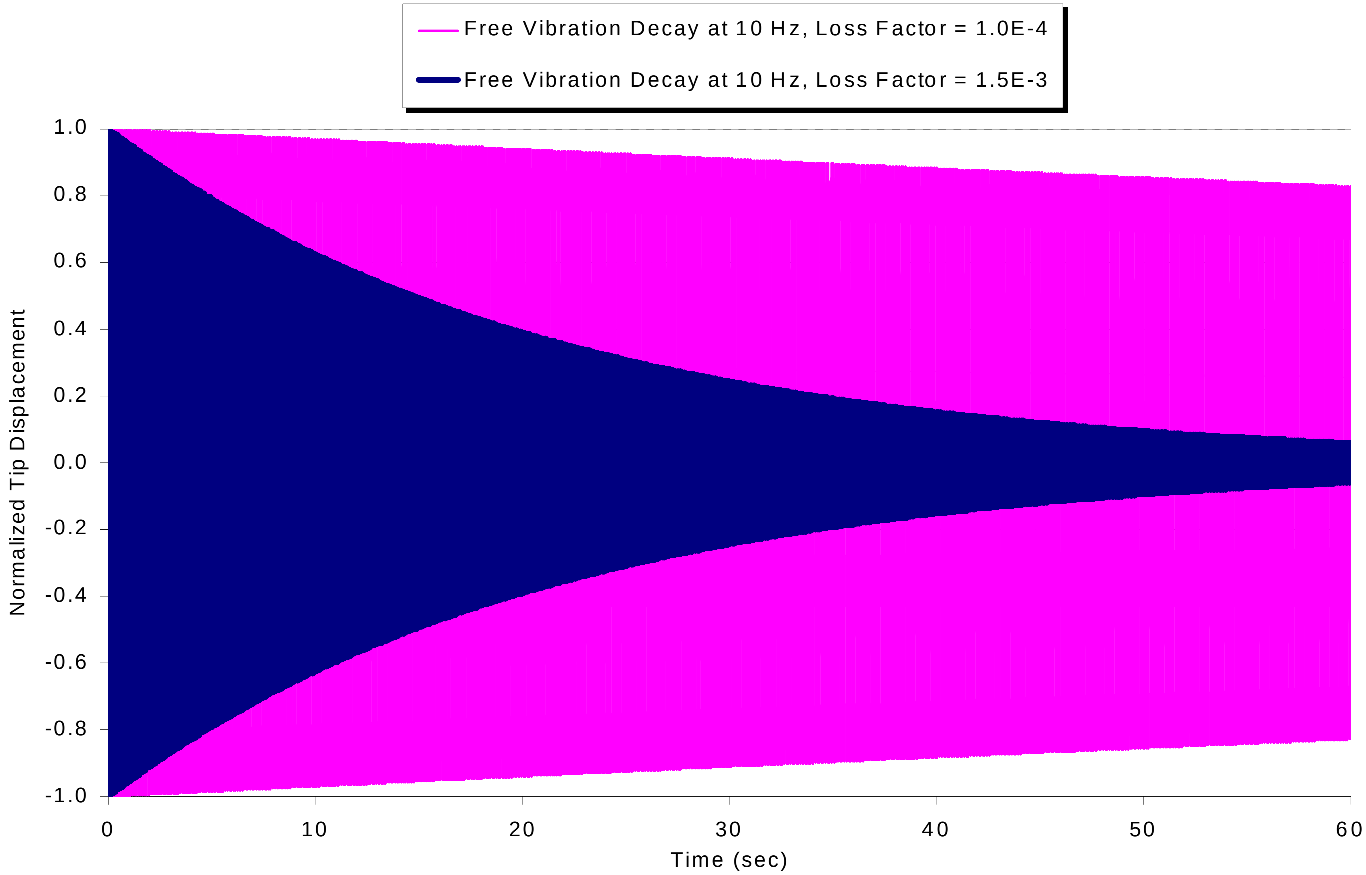
$$\eta_{system} = \frac{D_{TOT}}{2\pi W_{TOT}} = \frac{\sum \eta_i W_i}{\sum W_i}$$

If only $\eta_1 \neq 0$:

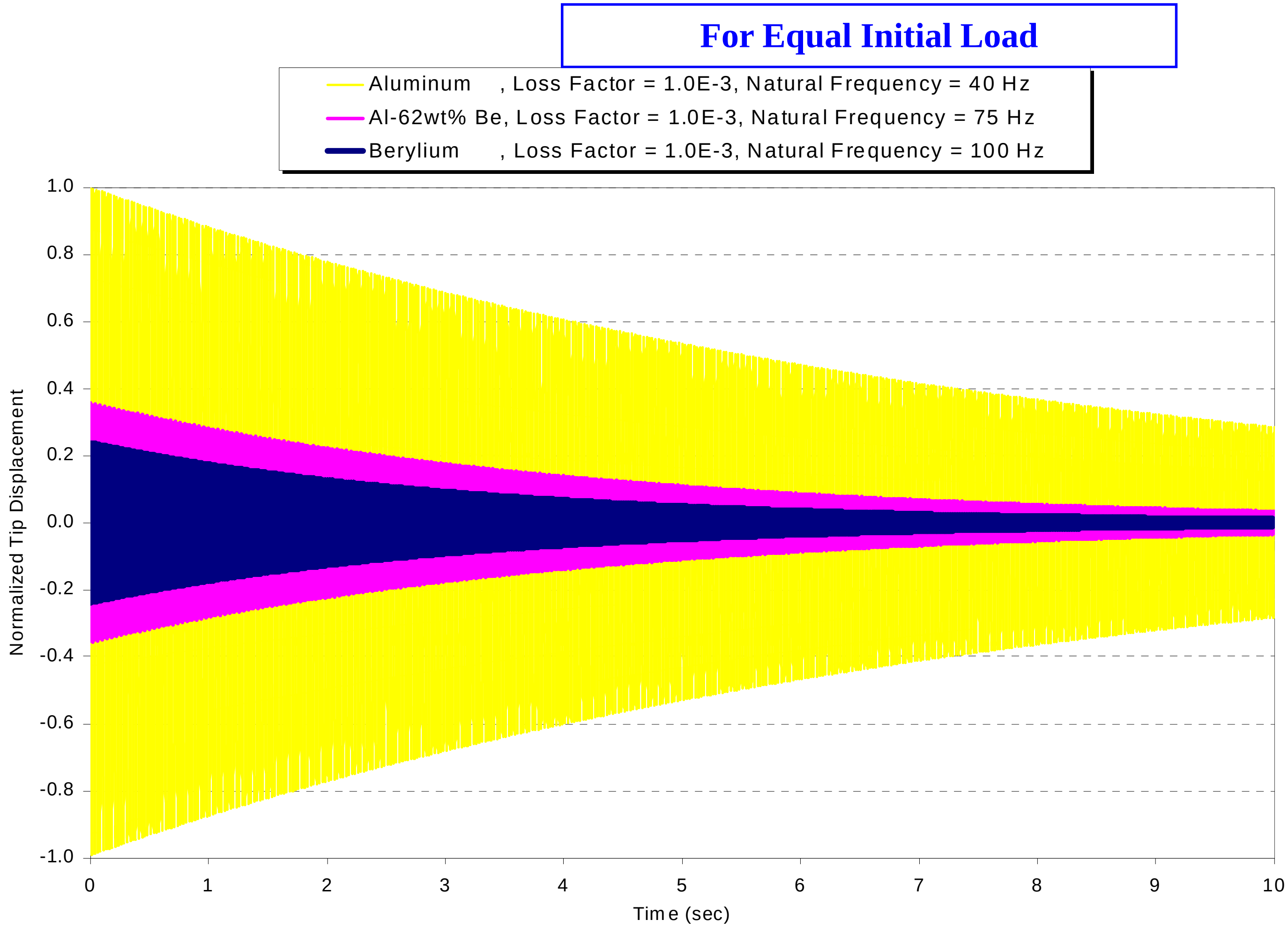
$$\eta_{system} = \eta_1 \frac{W_1}{W_{TOT}}$$

η_1 needs to be > 0 $\qquad$ $\frac{W_1}{W_{TOT}}$ needs to be > 0

How Different Levels of Damping Capacity Affect Vibration Decay



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



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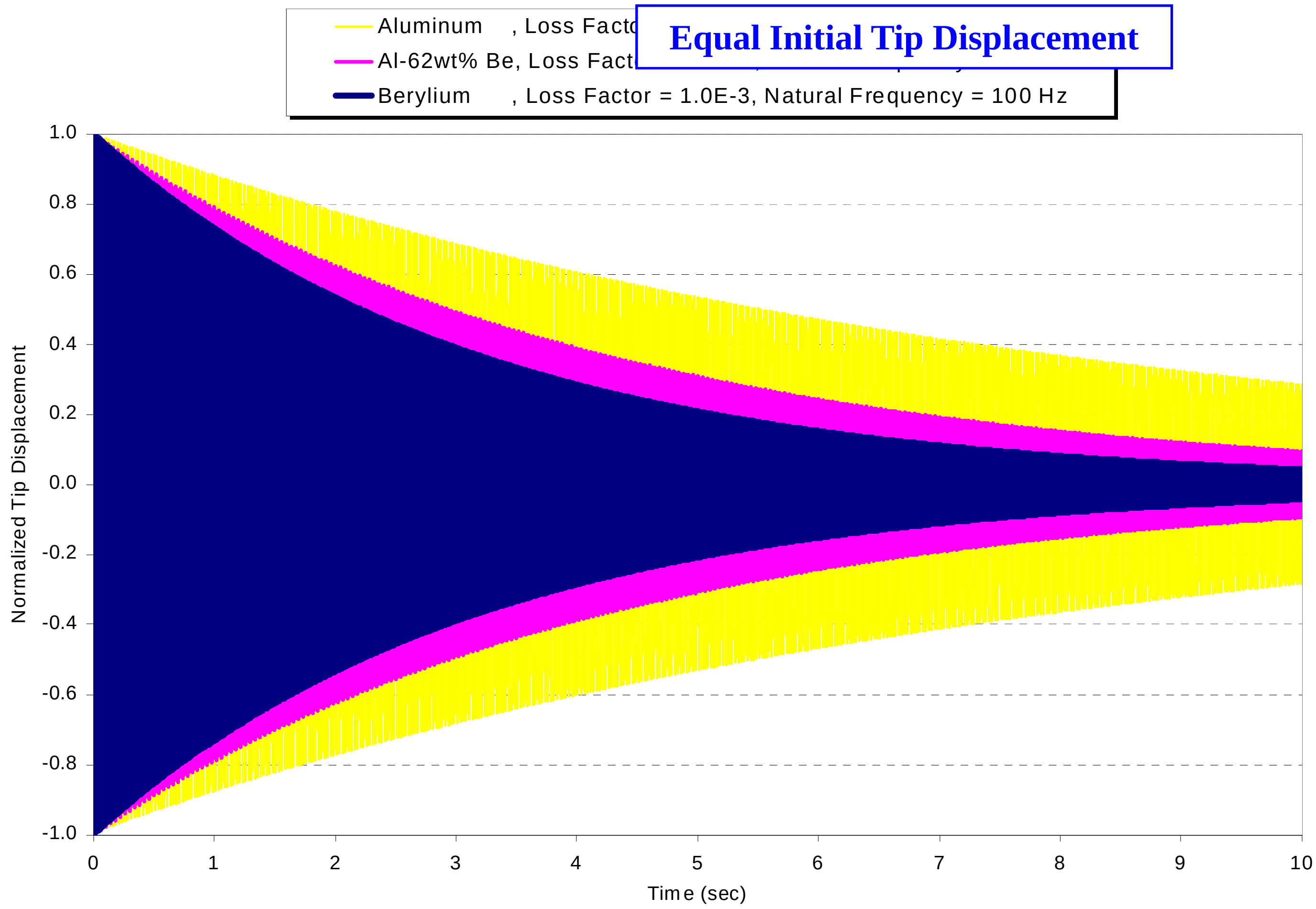
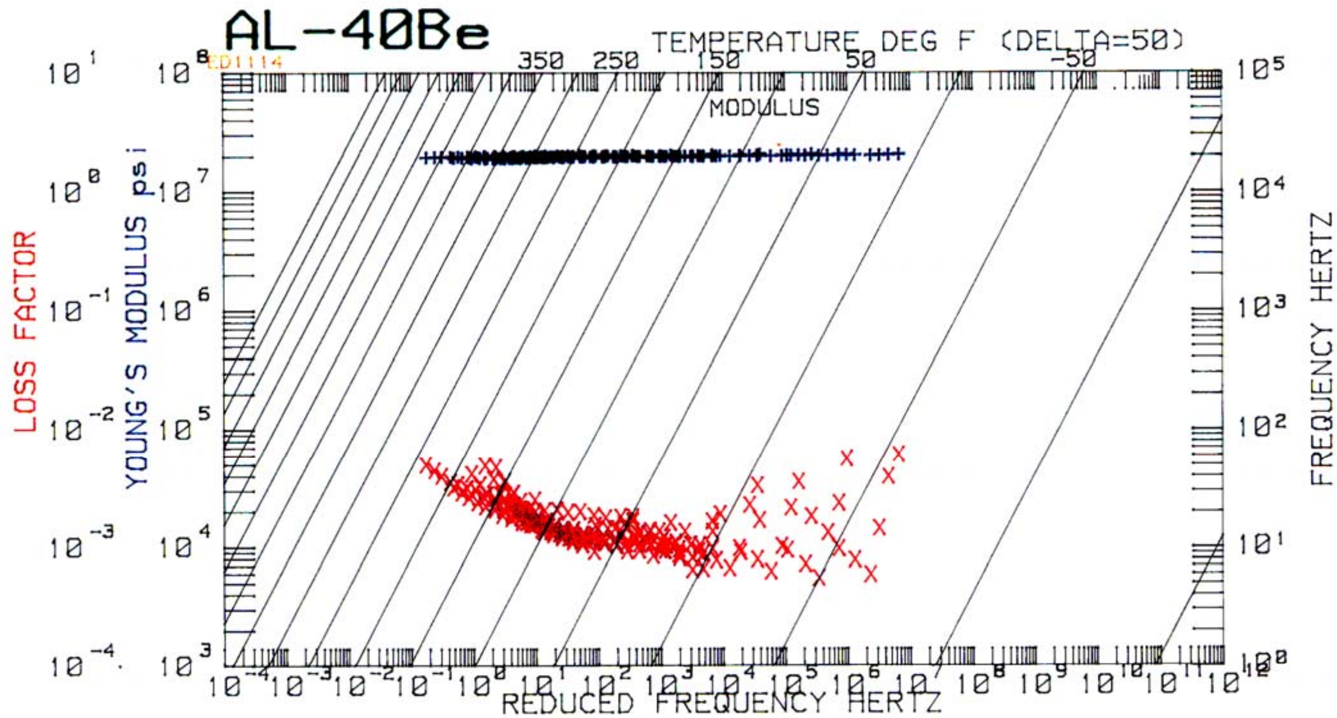
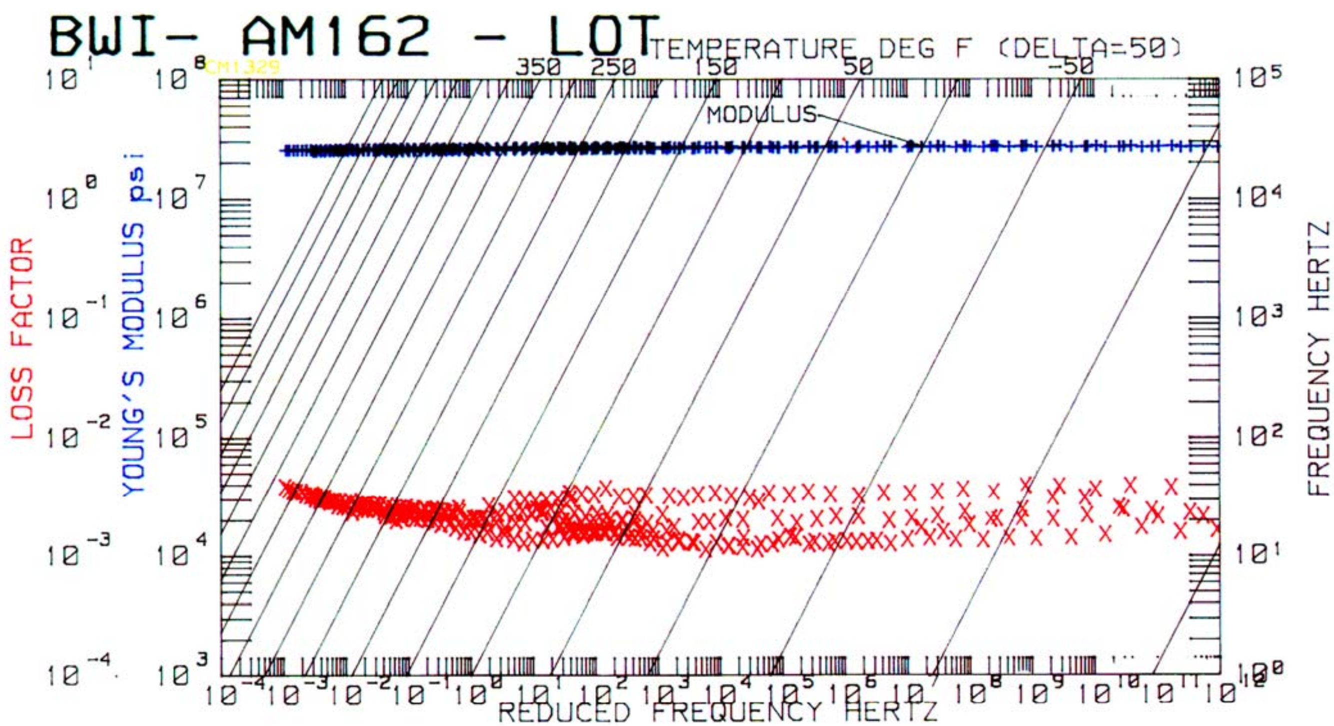



AL-40Be
TEMPERATURE DEG F (DELTA=50)
350
250
150
50
-50
MODULUS
LOSS FACTOR
YOUNG'S MODULUS psi
FREQUENCY HERTZ
REDUCED FREQUENCY HERTZ


BWI- AM162 - LOT
TEMPERATURE DEG F (DELTA=50)
350 250 150 50 -50
MODULUS
LOSS FACTOR
YOUNG'S MODULUS psi
FREQUENCY HERTZ
REDUCED FREQUENCY HERTZ