

Damping Test Methodologies

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Damping – Not Dampening



Where is damping used?

Cars & Trucks

- ≡ Floor
- ≡ Dash panel



Where is damping used?

Cars & Trucks

- ≡ Floor
- ≡ Dash panel
- ≡ **Roof**



Where is damping used?

Cars & Trucks

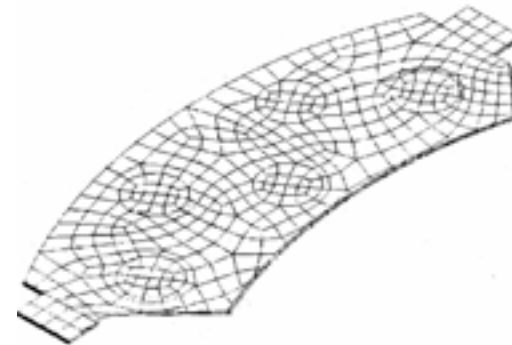
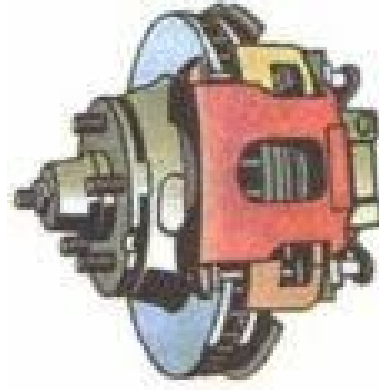
- ≡ Floor
- ≡ Dash panel
- ≡ Roof
- ≡ **Doors**



Where is damping used?

Cars & Trucks

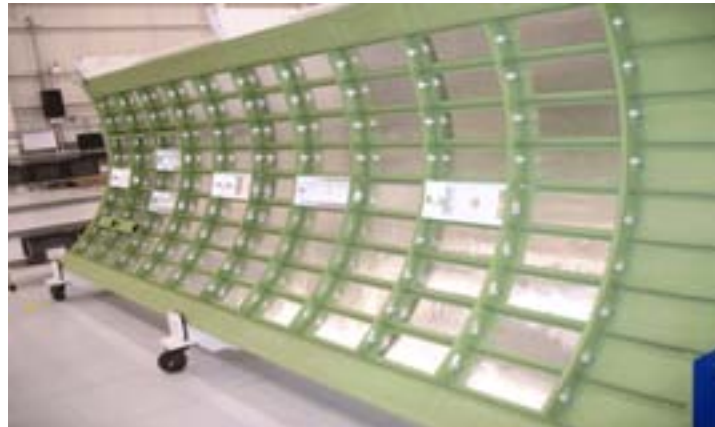
- ≡ Floor
- ≡ Dash panel
- ≡ Roof
- ≡ Doors
- ≡ **Brakes**



Where is damping used?

Cars & Trucks

- ≡ Floor
- ≡ Dash panel
- ≡ Roof
- ≡ Doors
- ≡ Brakes



Aircraft

- ≡ **Fuselage**



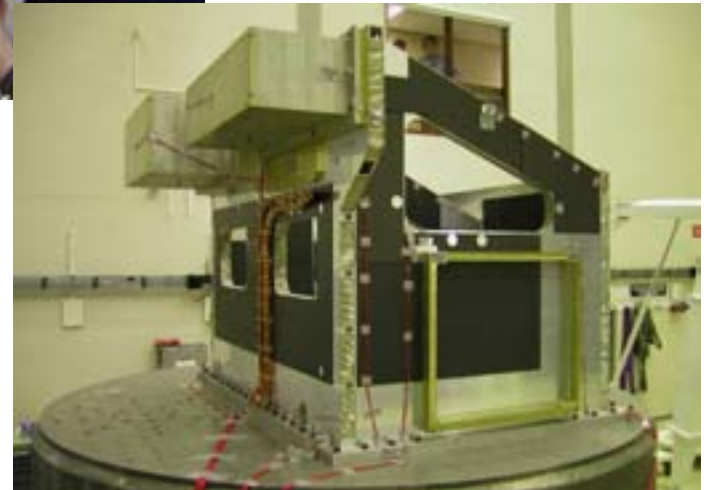
Where is damping used?

Cars & Trucks

- ≡ Floor
- ≡ Dash panel
- ≡ Roof
- ≡ Doors
- ≡ Brakes

Aerospace

- ≡ Fuselage
- ≡ **Engine Nacelle**
- ≡ **Spacecraft**



Where is damping used?

Marine

Absorption: 
Barrier: 
Damping: 

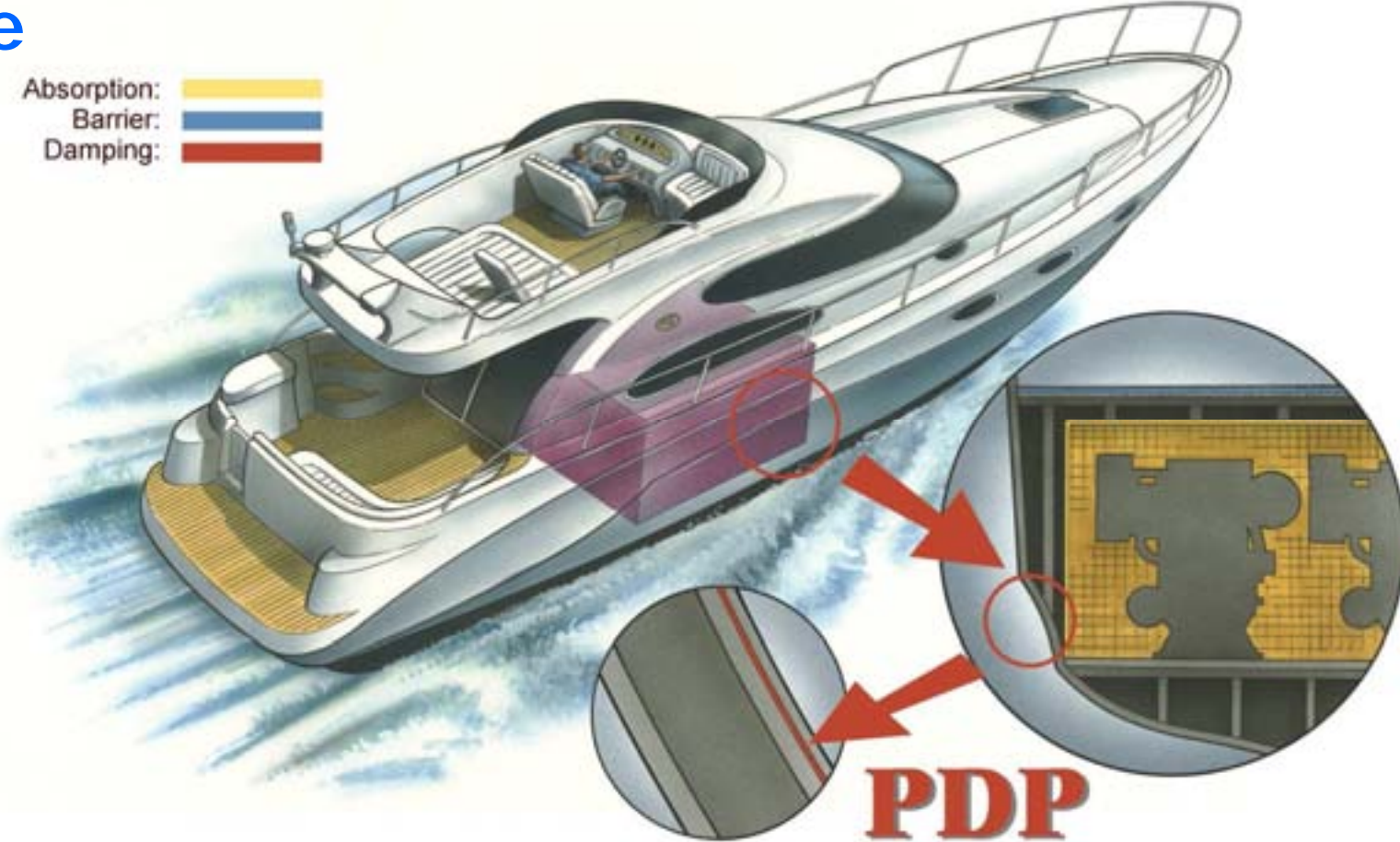


Photo courtesy American Acoustical Products

Where is damping used?

Appliances

Sinks

Etc.

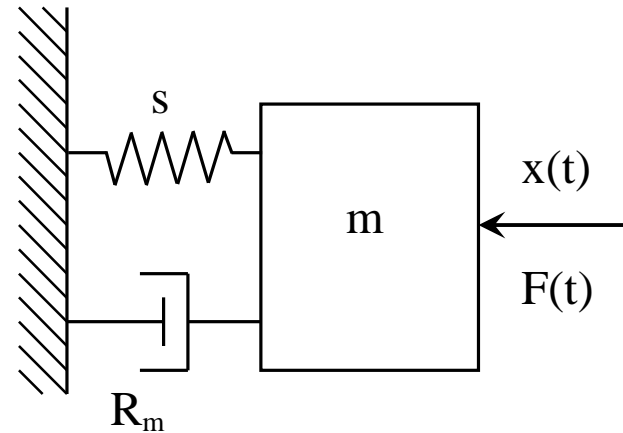


Damping Test Methodologies

It is important to have techniques to:

- ≡ Rank order the effectiveness of alternate damping materials
- ≡ Evaluate new materials
- ≡ Characterize damping materials for modeling
- ≡ Provide information for specifications

Equations of Motion – Spring mass damper system



$$m \frac{d^2 x}{dt^2} + R_m \frac{dx}{dt} + sx = F e^{j\omega t}$$

Steady State Solution

$$x = \frac{F e^{j\omega t}}{j\omega \left(R_m + j \left(\omega m - \frac{s}{\omega} \right) \right)}$$

Steady State Solution

$$x = \frac{F e^{j\omega t}}{j\omega \left(R_m + j\left(\omega m - \frac{s}{\omega}\right) \right)}$$

If you know the force input and response, you can measure the damping – but only at resonances

- ⌘ Measurement of the transfer function at resonance is the basis for many damping measurement techniques
 - Oberst Bar (SAE J1637, ASTM E-756)
 - Center Point (ISO 16940)
 - Modal Analysis

Transient Solution

$$x = A e^{-\frac{R_m}{2m}t} \cos(\omega_d t + \Phi)$$

A and Φ depend on the initial conditions

Systems with low damping take a long time to reach steady-state 

Damping can be determined from the transient solution by exciting a system at resonance and measuring the decay time

Geiger Plate – SAE J671

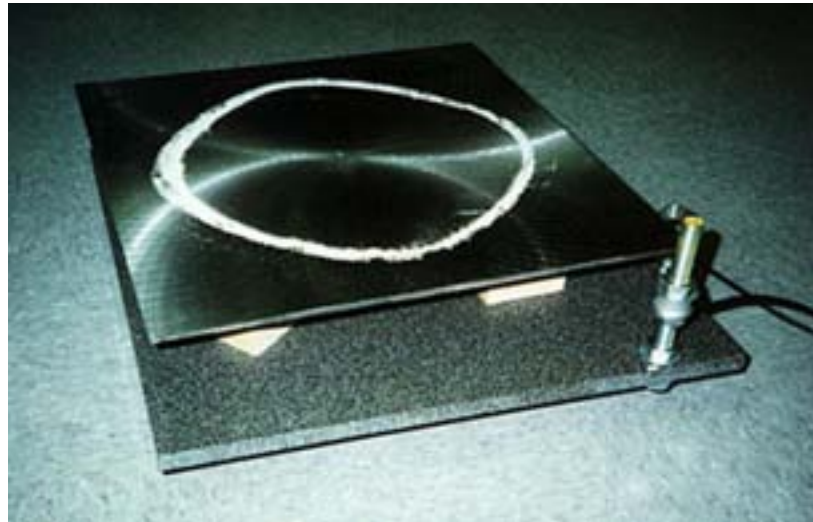


Photo courtesy Kolano and Saha Engineers

Excite a 20" x 20" x 1/4" thick steel plate at its resonance (100-200 Hz) and measure the decay time

Geiger Plate

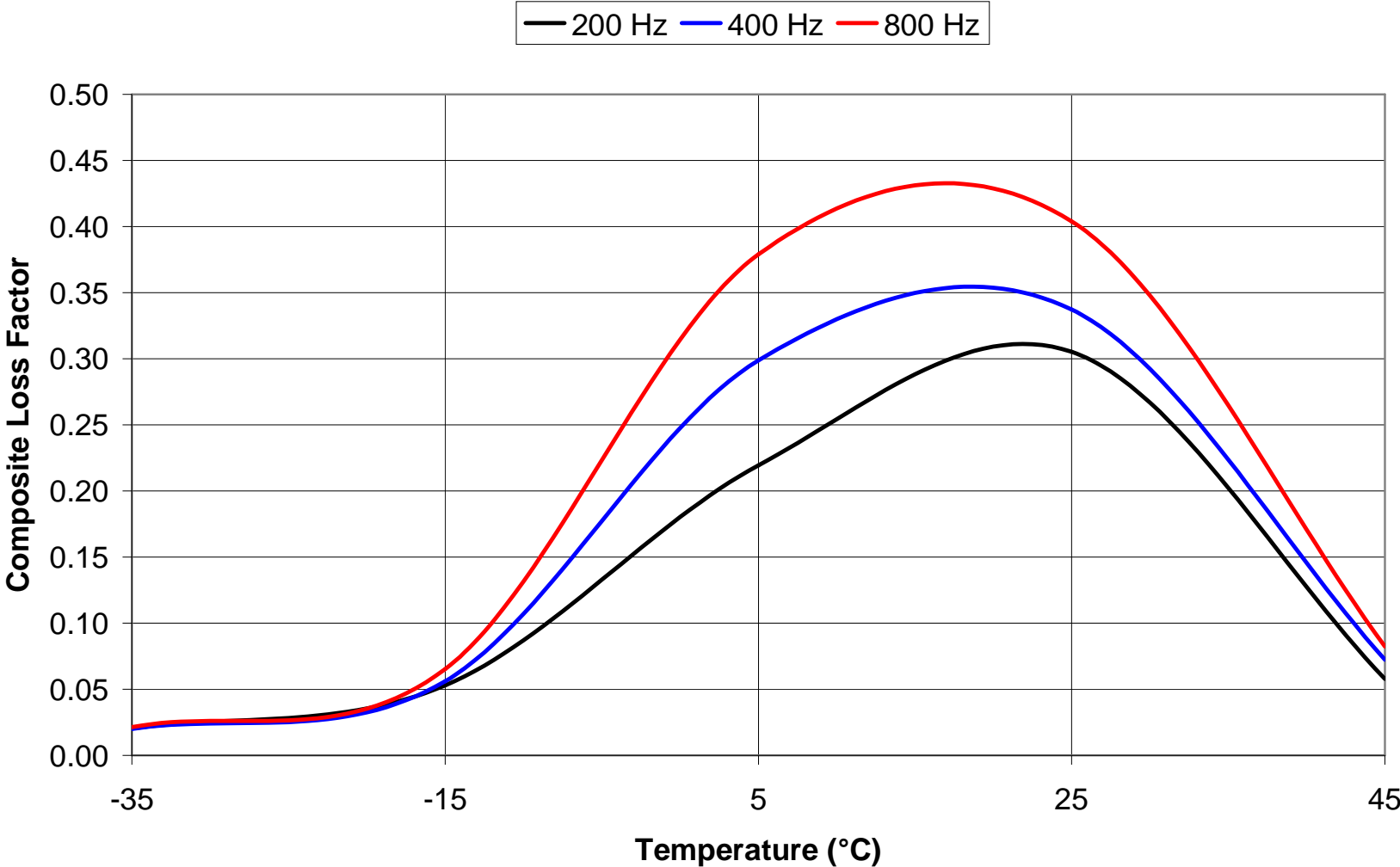
Can examine how various application strategies affect damping

Substrate is thicker than in many applications so the results may not compare well

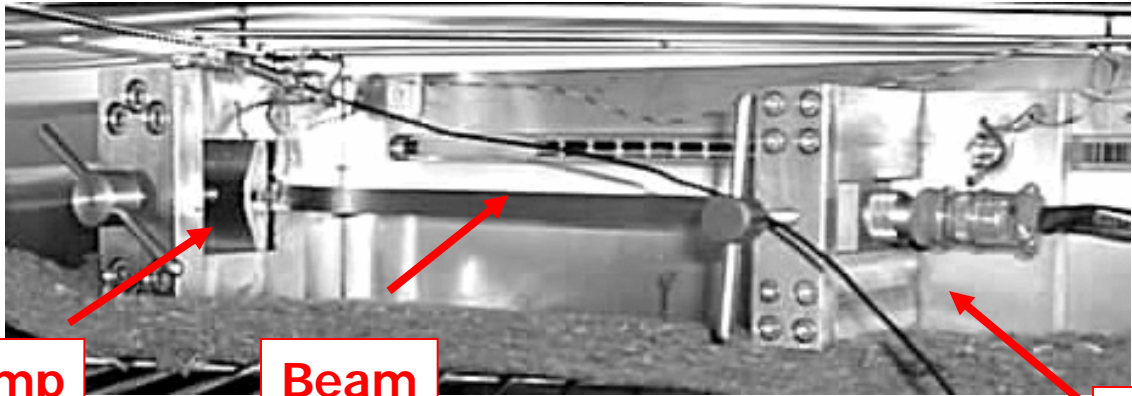
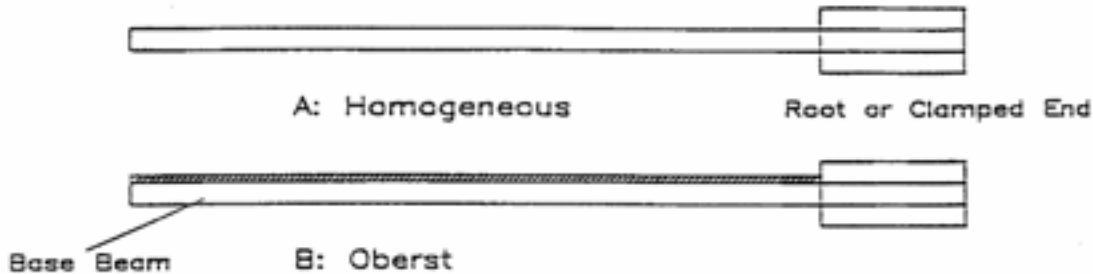
Damping is determined at one frequency and temperature based on the decay rate

Complex Modulus information is not obtained

Temperature/Frequency Dependence



Oberst Bar - SAE J1637/ASTM E-756

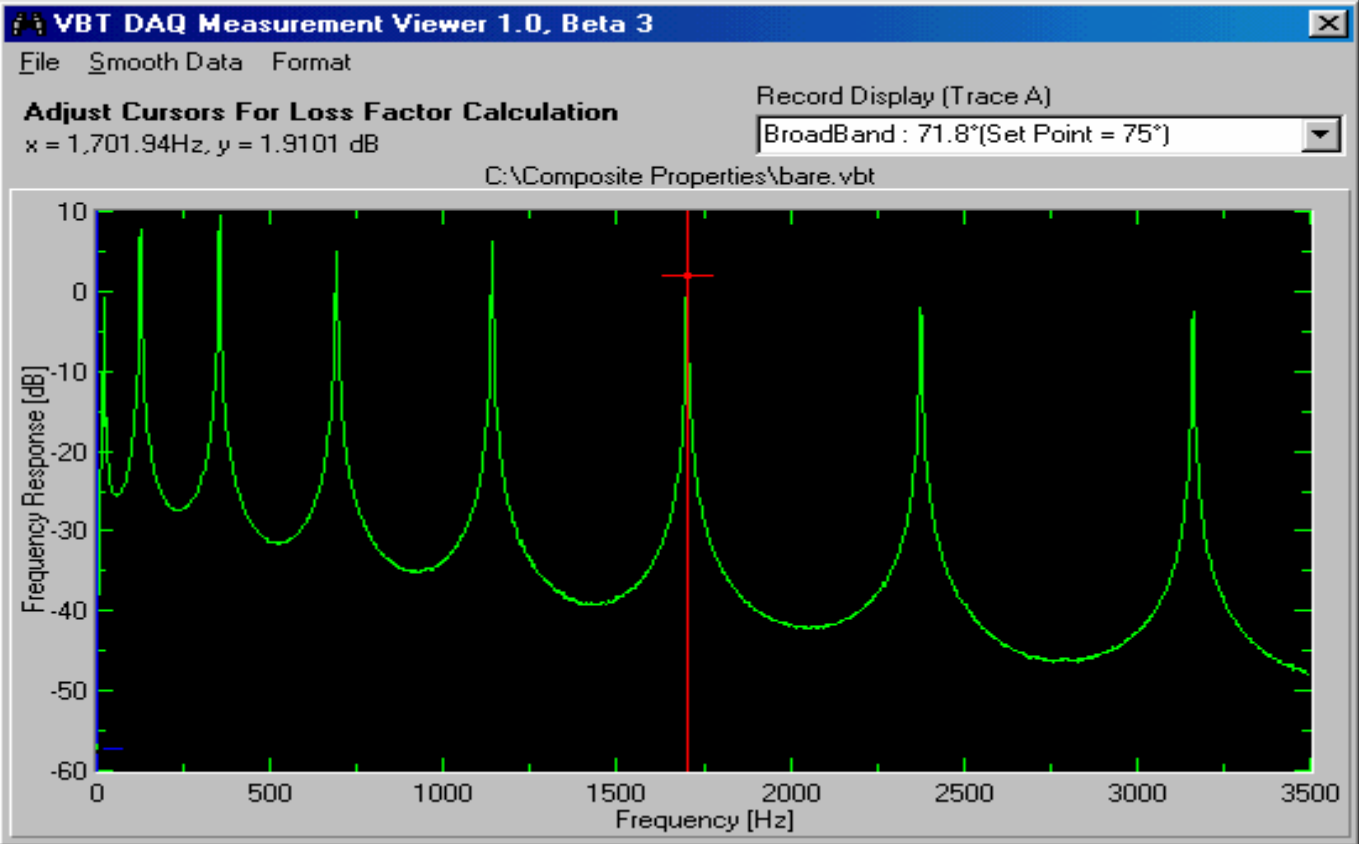


Clamp

Beam

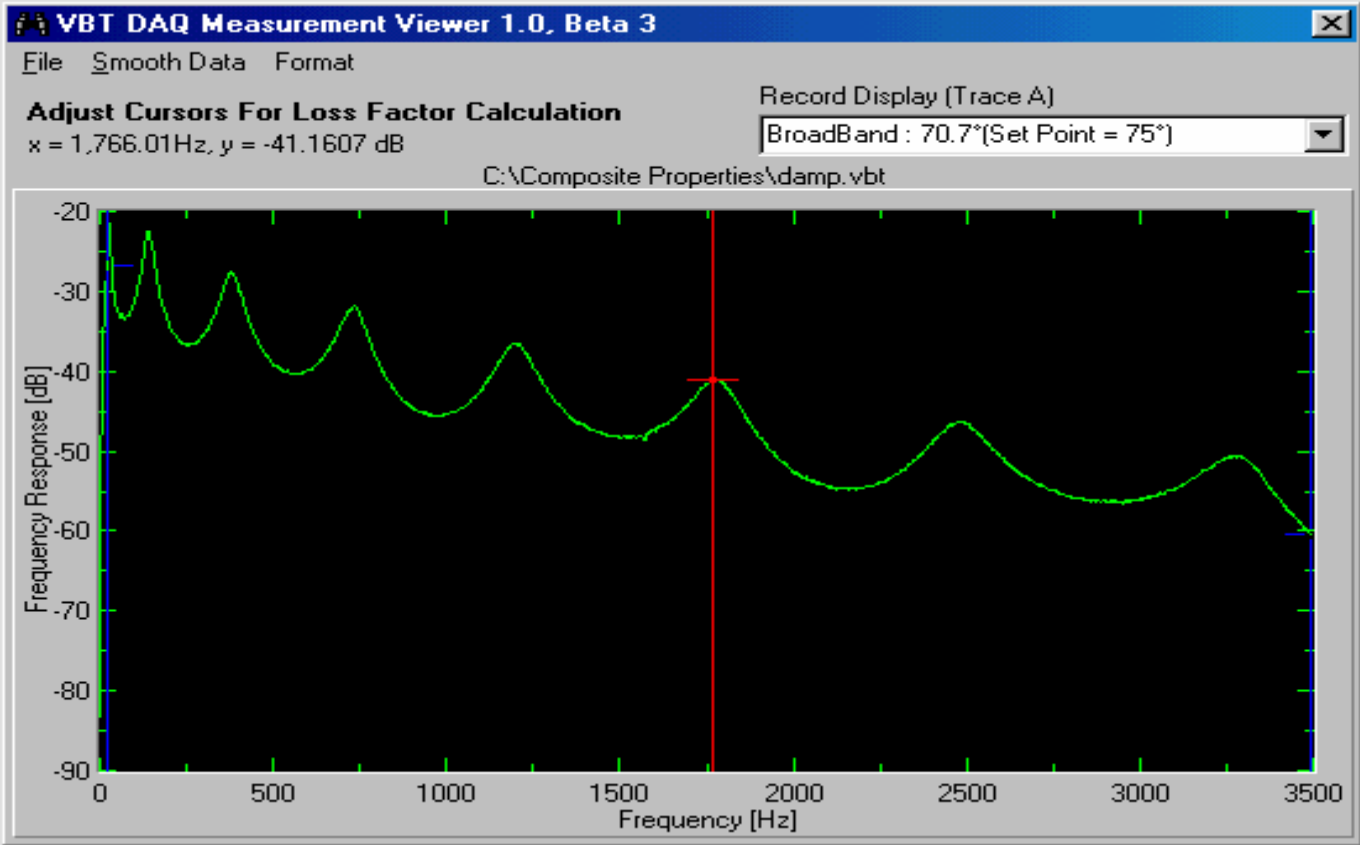
Exciter

Oberst Bar - SAE J1637/ASTM E-756



Sample FRF with Low-Level Damping

Oberst Bar - SAE J1637/ASTM E-756



Sample FRF with Increased Damping

Oberst Bar - SAE J1637/ASTM E-756

Calculations are more complex than Geiger Plate

Damping is determined at several frequencies

Test equipment can be placed in an environmental chamber for damping measurement at various temperatures

ASTM E-756: measure dynamic mechanical properties such as the material loss factor and complex modulus by measuring both bare and damped bars. Results can be used for making predictions

Center Point – ISO 16940

Developed to measure the damping in laminated glass

Technique is now utilized for many types of materials



Photo courtesy Kolano and Saha Engineers

Center Point – ISO 16940

Using an impedance transducer measure the force and response of the beam at resonance

Measure the damping based on the transfer function

Can determine the composite loss factor, bending, rigidity modulus, and flexural rigidity ratio

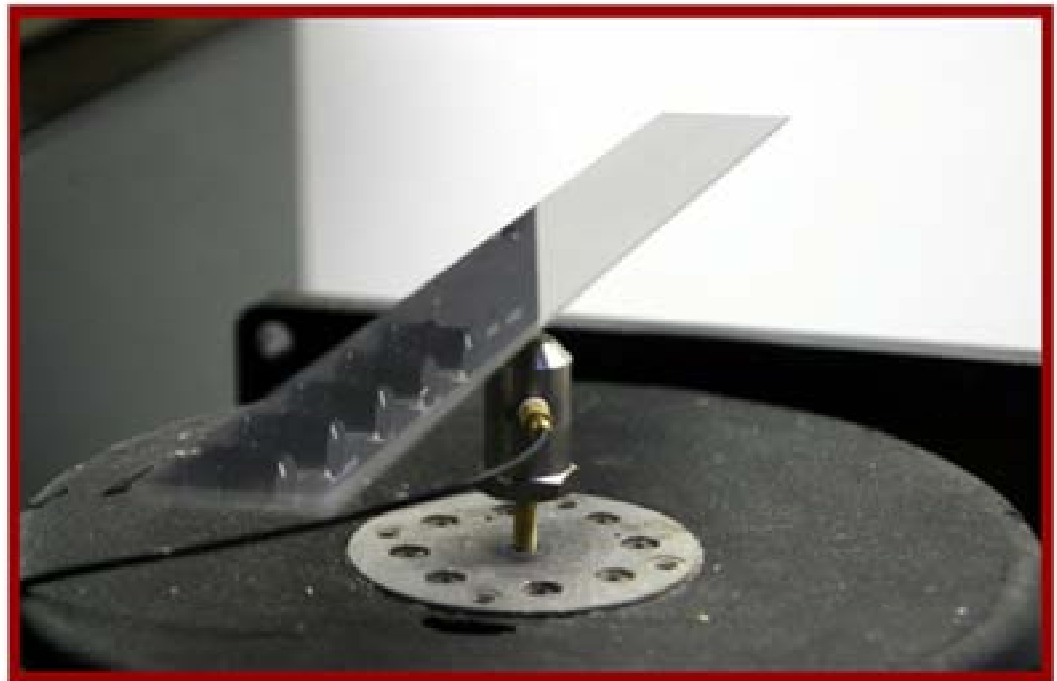


Photo courtesy Kolano and Saha Engineers

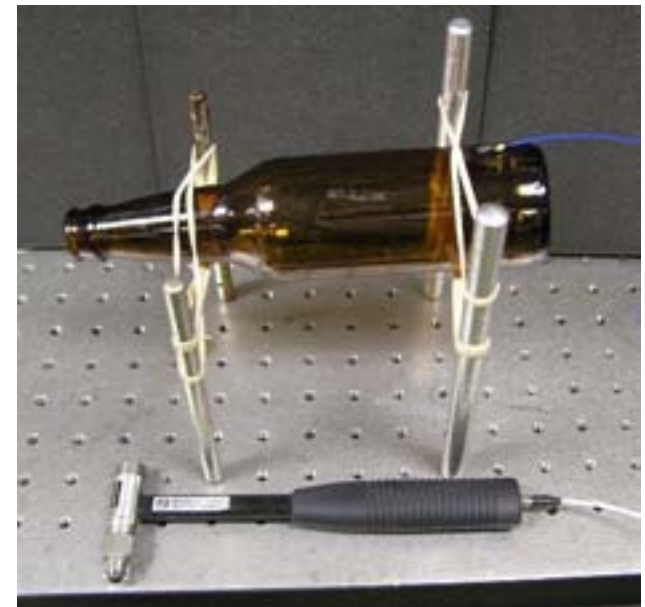
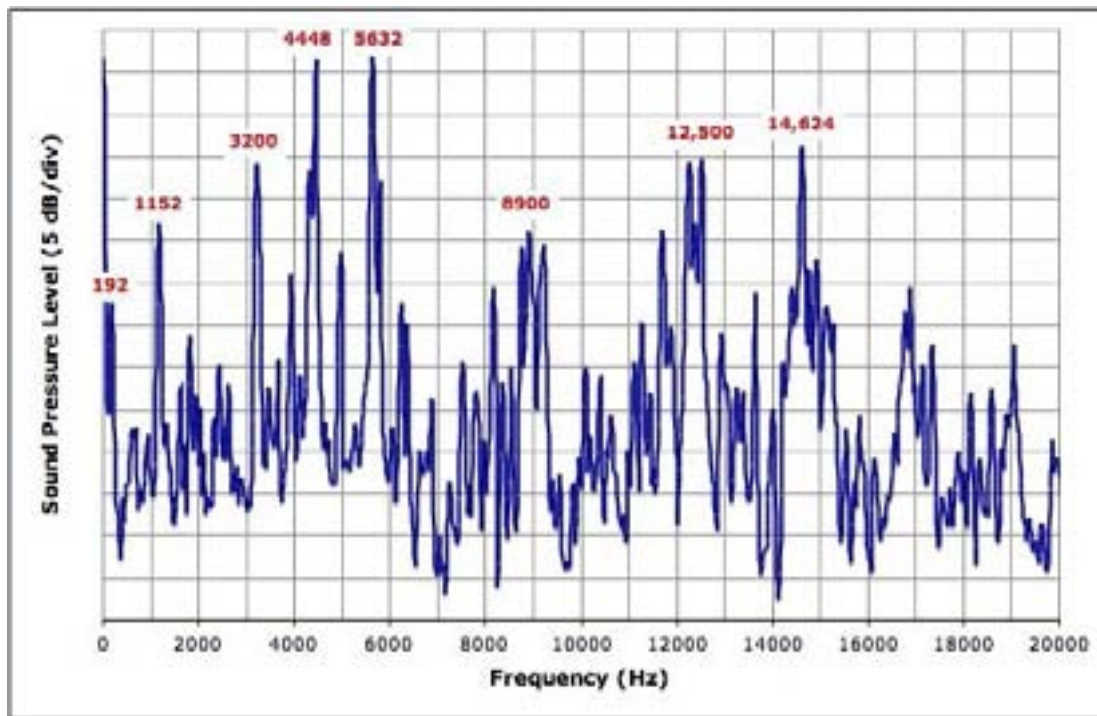
Center Point – ISO 16940

Can also be expanded to plates to measure the damping from “non-traditional” materials such as fibrous materials or floor systems



Modal Analysis

Used to measure the response of a structure to various inputs



Figures courtesy of Dr. Dan Russell, Kettering University

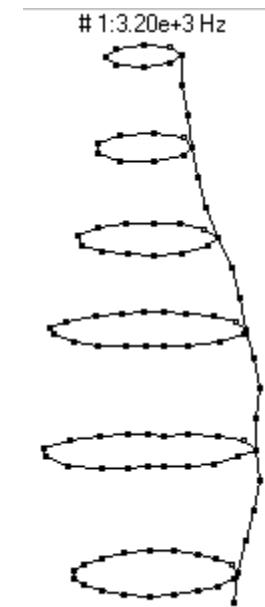
Modal Analysis

Need to make sure the response is due to a structural resonance

Measurement of the actual application

Analysis software may not be optimized for damping and user adjustments may be needed

Difficult to measure the response at different temperatures



Animation courtesy of Dr. Dan Russell
Kettering University

Summary

Damping is used in many applications

Current test methods provide for rank ordering, new material evaluation, material properties for modeling, etc.

Real-world damping materials add mass and stiffness as well as damping making it difficult to evaluate in-situ

Damping Characteristics vary by temperature and frequency

Trends due to difficulties in measuring actual applications indicate increased use of math modeling and greater demand for damping material properties