DIGITALLY ANALYZING SIGNALS TO DETERMINE ACOUSTIC ATTENUATION

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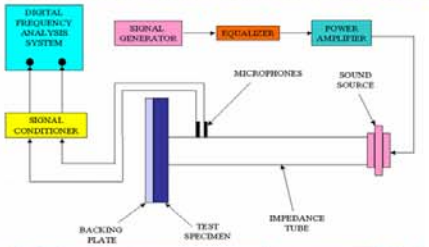
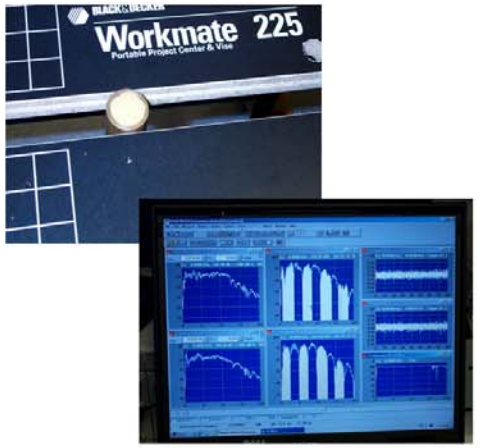
COMPARISON BETWEEN PULSE AND IMPEDANCE METHODS

PULSE METHODS	IMPEDANCE METHODS
Simplicity	Excellent accuracy
Low accuracy	Excellent frequency resolution
Low frequency resolution	Low spatial resolution

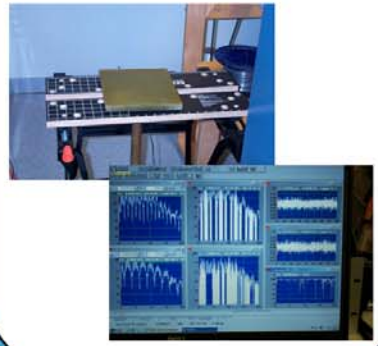
SCHEMATIC DIAGRAM OF THE SETUP



CALIBRATION



TEST SAMPLE



THEORY

$$Z = Z_C \coth(\Gamma l) \quad \text{Must Equal} \quad Z = \rho_{air} c_{air} \frac{1+R}{1-R}$$

Impedance at the surface of material from the material side — Impedance at the surface of material from the air side

where

Z – Normal Acoustic Impedance
Z_C – Characteristic Impedance
Γ – Propagation Constant
l – Thickness of the Sample
R – Complex Reflection Coefficient

$$R = \frac{H - e^{-jks}}{e^{jks} - H} e^{j2k(l+s)} \qquad H = \overline{H} / \overline{H}_c \qquad \overline{H} = \frac{G_{12}}{G_{11}}$$

where:

R – Complex Reflection Coefficient
H – Calibrated Complex Transfer Function
$k = \omega/c_{air}$
s – spacing between microphones
l – distance from sample to nearest microphone
G_{12} – Cross Power Spectrum
G_{11} – Auto Power Spectrum
– Complex Calibration Factor

THEORY

Absorption Coefficient

The Absorption Coefficient is the ratio of the sound energy absorbed by a material surface exposed to a sound field to the sound energy incident on the surface.

$$\alpha = 1 - |R|^2 = 1 - \left[\frac{1 + |H|^2 - 2|H|\cos(\phi + ks)}{1 + |H|^2 - 2|H|\cos(\phi - ks)} \right]$$

$|H|$ – Modulus of the Complex Transfer Function
φ – Phase of the Complex Transfer Function
$k = \omega/c_{air}$
s – spacing between microphones

CONCLUSIONS

1. Pulse methods cannot predetermine the frequency band of interest and are usually restricted to 2 kHz or less
2. Pulse methods cannot spatially resolve acoustic characteristics.
3. Two-Microphone Resonance Tube method can obtain acoustic characteristics of a sample over a predetermined frequency band.
4. Great spatial resolution for high frequencies due to the decreasing diameter of the resonance tube.

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