Measurement of Sound Absorption and Impedance

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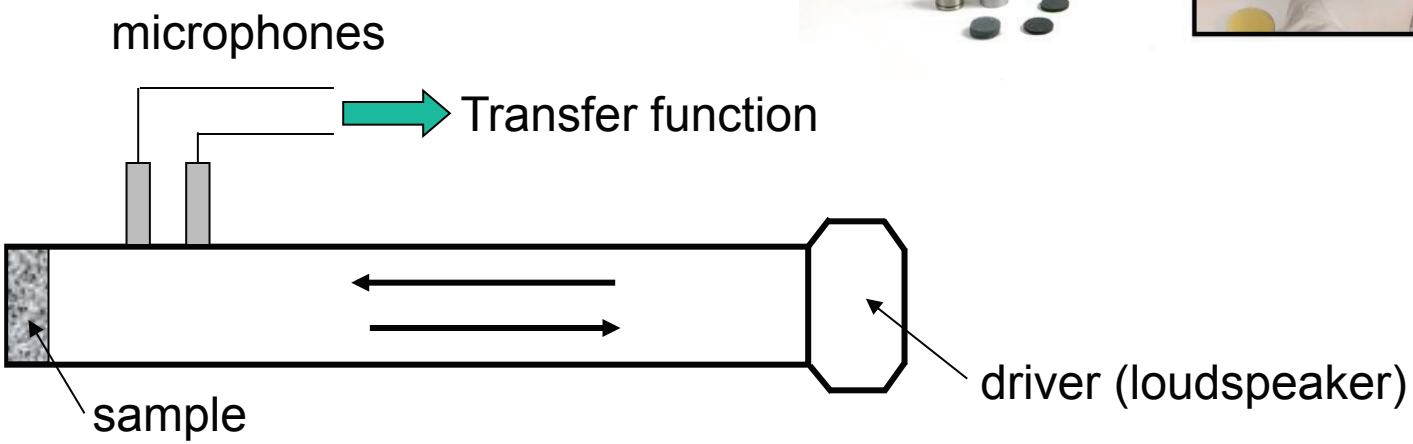
Measurement of Sound Impedance

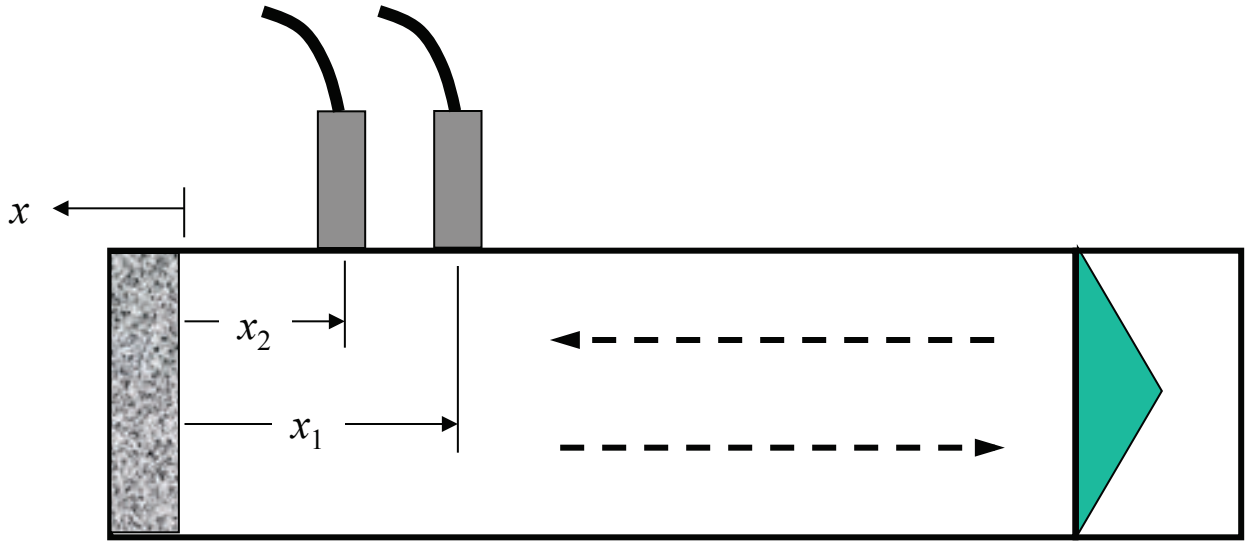
Impedance Tube Measurements

ASTM E1050-95 (ISO 10534-2) Test Method



Coordinate System and Microphone Locations

Impedance Tube Measurements



Material sample

Sound source

Plane Wave Theory

Impedance Tube Measurements

Total sound pressure at any point in the tube:

$$P(x) = Ae^{-jkx} + Be^{jkx}$$

$+x$ traveling wave

$-x$ traveling wave

The transfer function between points 1 and 2:

$$H_{12} = \frac{P(x_2)}{P(x_1)} = \frac{Ae^{-jkx_2} + Be^{jkx_2}}{Ae^{-jkx_1} + Be^{jkx_1}} = \frac{e^{-jkx_2} + Re^{jkx_2}}{e^{-jkx_1} + Re^{jkx_1}}$$

$R = \frac{B}{A}$ is the pressure reflection coefficient of the material

Solving for Material Properties

Impedance Tube Measurements

Solving for R:

$$R = \frac{e^{-jkx_2} - H_{12}e^{-jkx_1}}{H_{12}e^{jkx_1} - e^{jkx_2}}$$

Normalized specific boundary impedance:

$$\frac{z}{\rho_o c} = \frac{1+R}{1-R}$$

Sound absorption coefficient of the material for any angle of incidence :

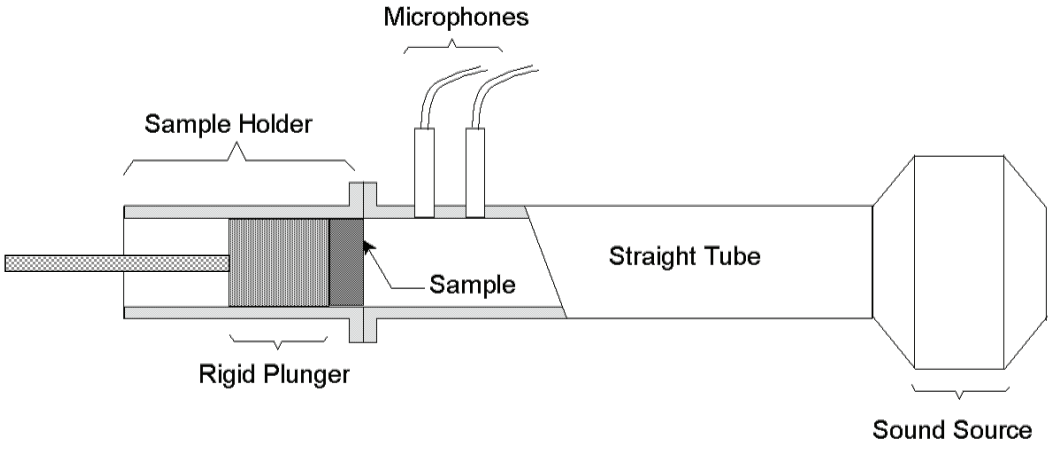
$$\alpha(\varphi) = \frac{4r'\cos\varphi}{\left(1+r'\cos\varphi\right)^2 + \left(x'\cos\varphi\right)^2} \quad \text{where} \quad r' = \frac{r}{\rho_o c} \quad x' = \frac{x}{\rho_o c}$$

Two-Microphone Standards

Impedance Tube Measurements

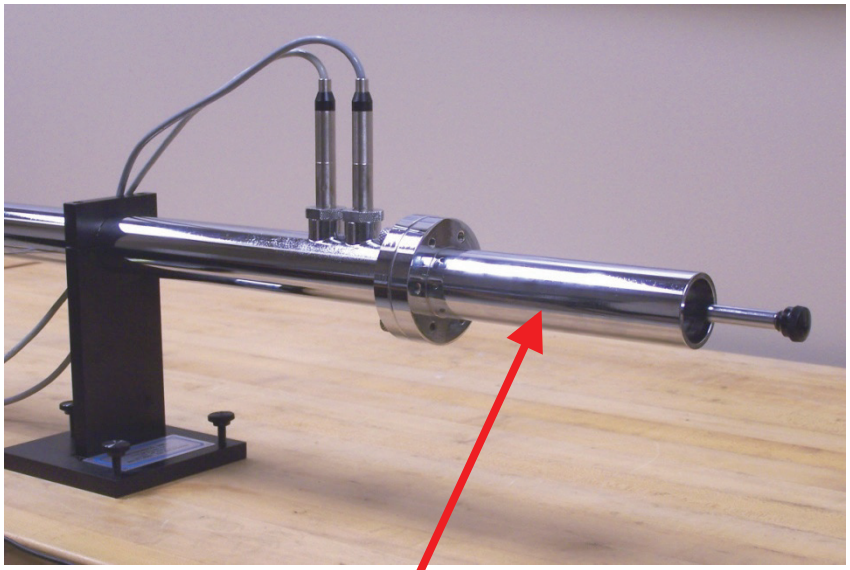
1. ISO 10534-2, *Acoustics-Determination of sound absorption coefficient and impedance in impedance tubes - Part 2: Transfer-function method*

2. ASTM E1050-10, *Standard Test Method for Impedance and Absorption of Acoustical Material Using a Tube, Two Microphones and a Digital Frequency Analysis System*

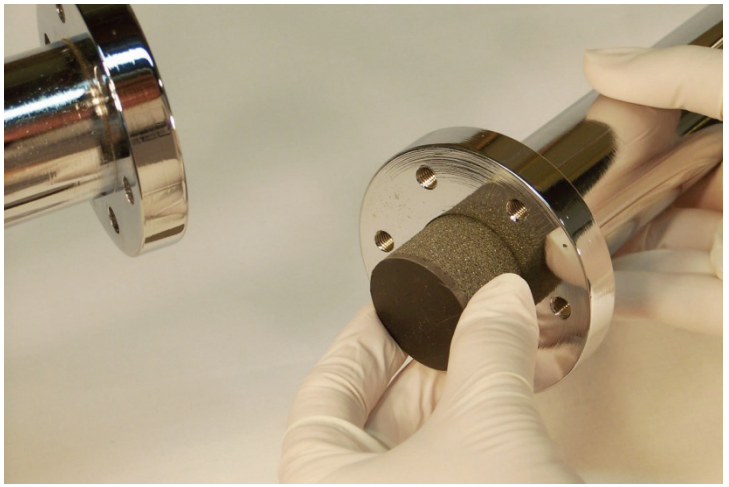


Sound Absorption Measurement

Impedance Tube Measurements



Sample holder
with rigid piston



Cutting with Rotating Blade

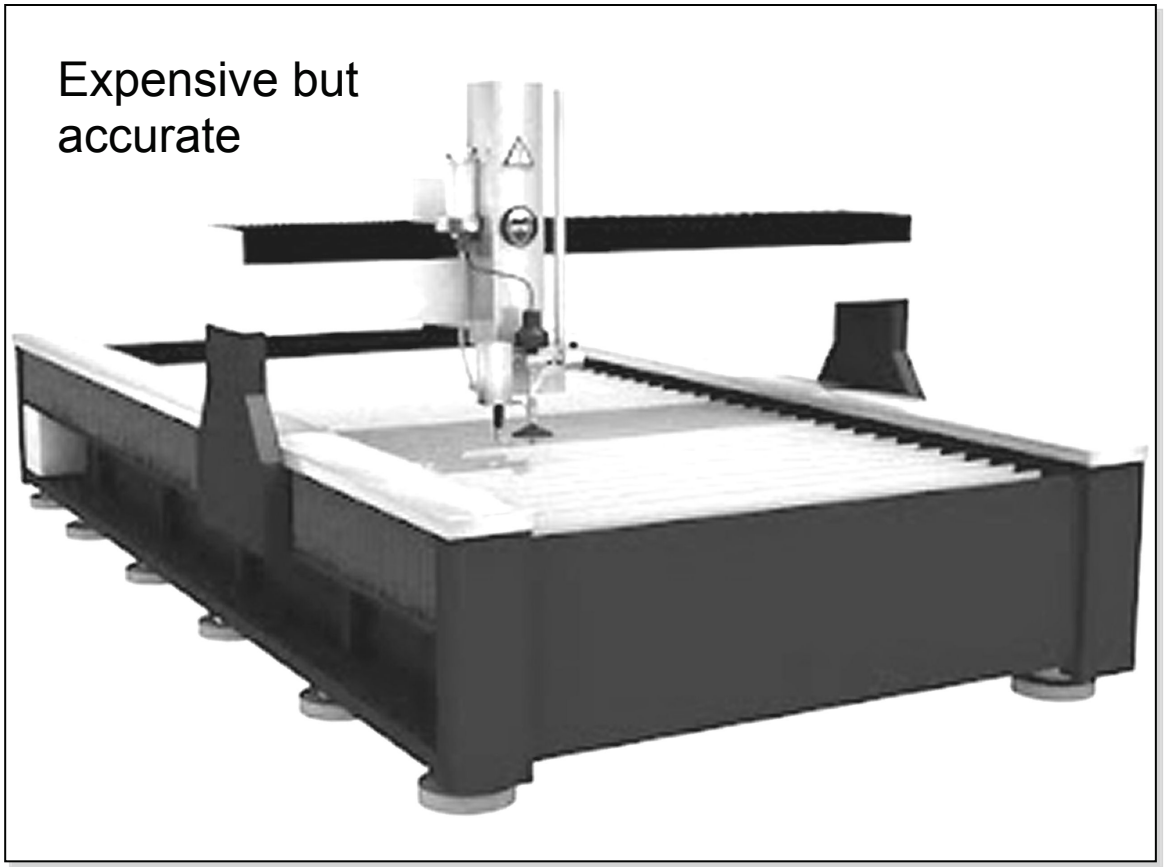
Impedance Tube Measurements

Inexpensive and accurate if kept sharpened

Stanley, Internoise 2012

Water Jet Cutting

Impedance Tube Measurements



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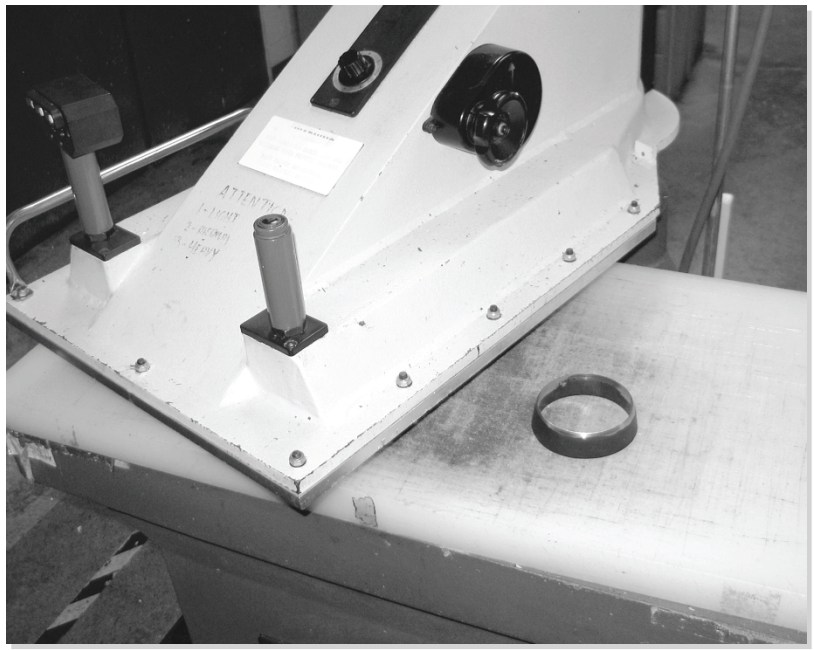
Stamping Press System

Impedance Tube Measurements



Used for low-density fibrous materials

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“Bad” and “Good” Specimens

Impedance Tube Measurements

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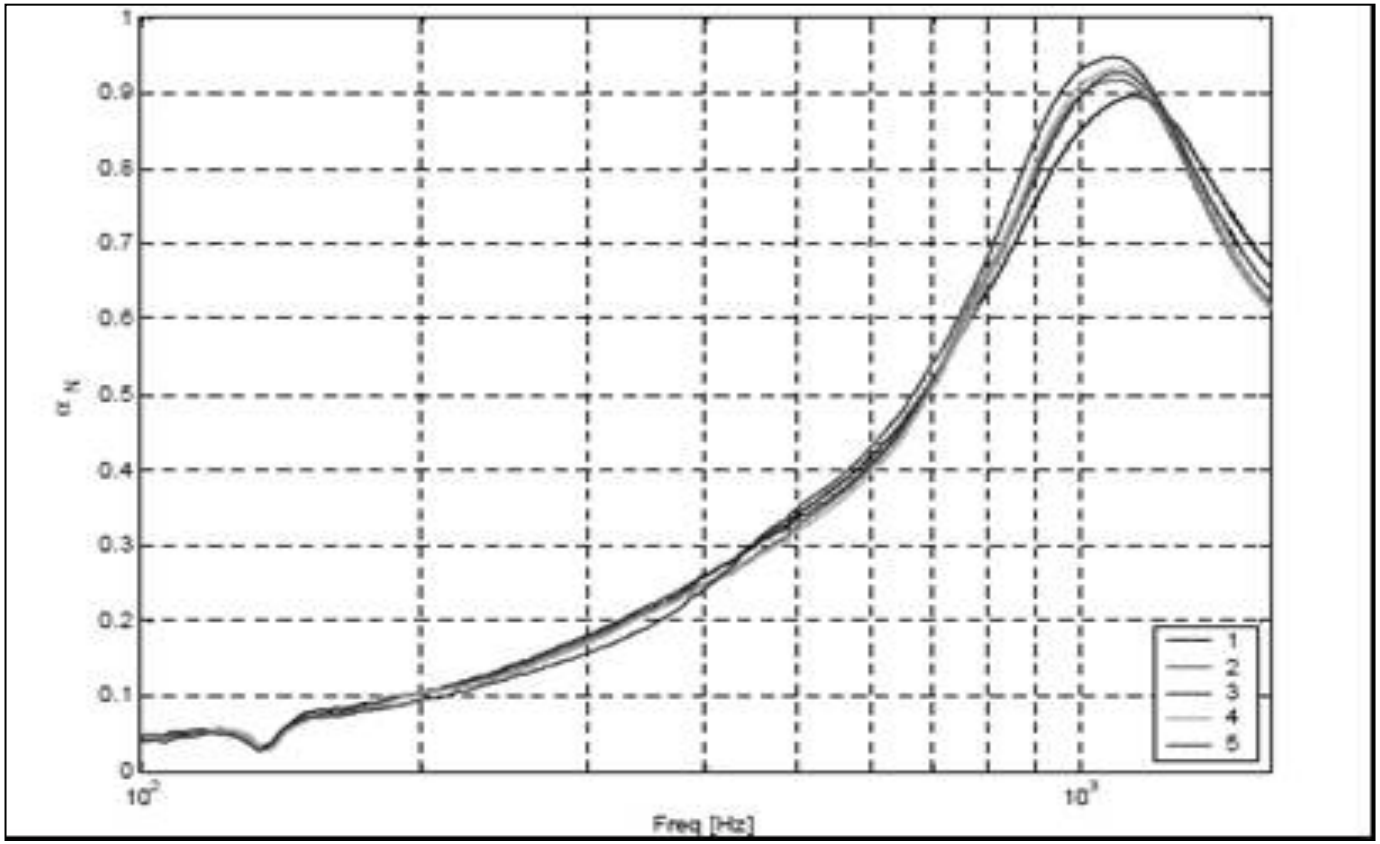
Stanley, 2012 Specimen Preparation

Impedance Tube Measurements

- Very important step for good results
- Gravity aided insertion and self centering
- Face uniformly flush with cell lip
- Front surface even across lip of test cell
- No facing protrusions or wrinkles interacting with cell wall
- Extremely small (at most) and consistent gap between specimen and cell wall
- No specimen compression in cell

Comparison of 5 Samples (Water Jet)

Impedance Tube Measurements



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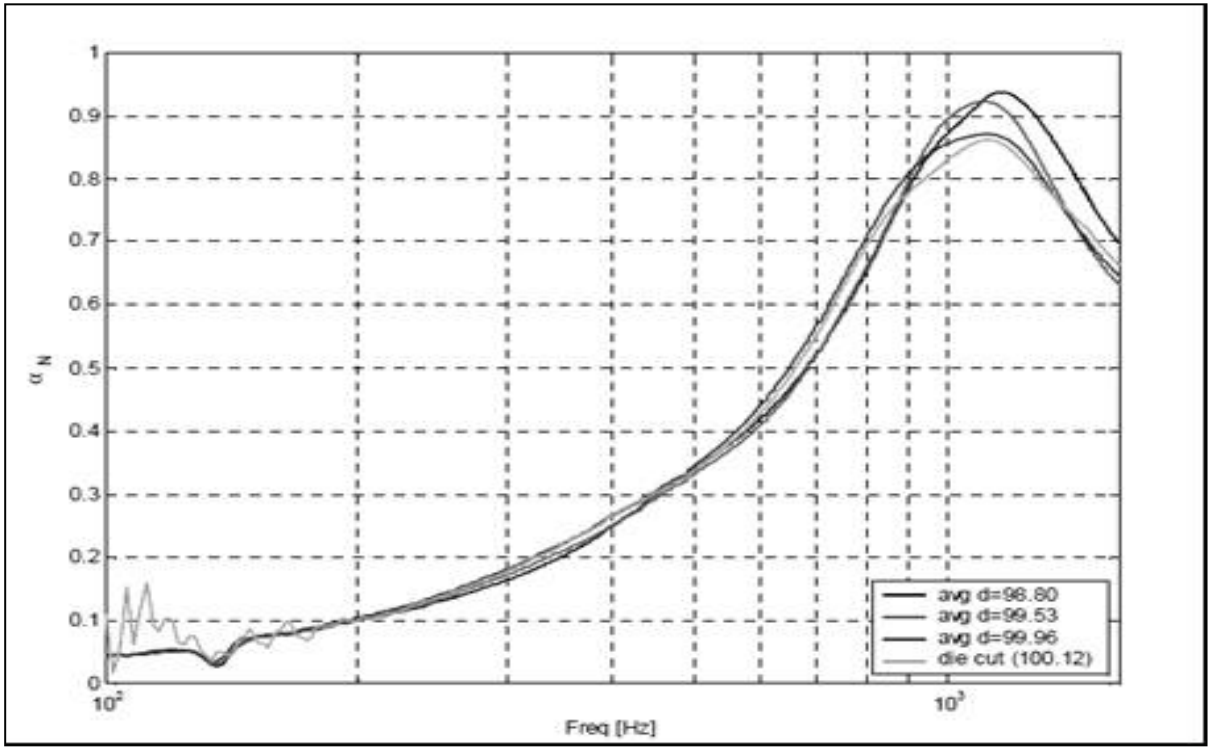
Comparison of 4 Samples

Impedance Tube Measurements

Absorption Response of One Die Cut, and Three 99 mm Water Jet Cut Foam Samples of Slightly Different Diameter.



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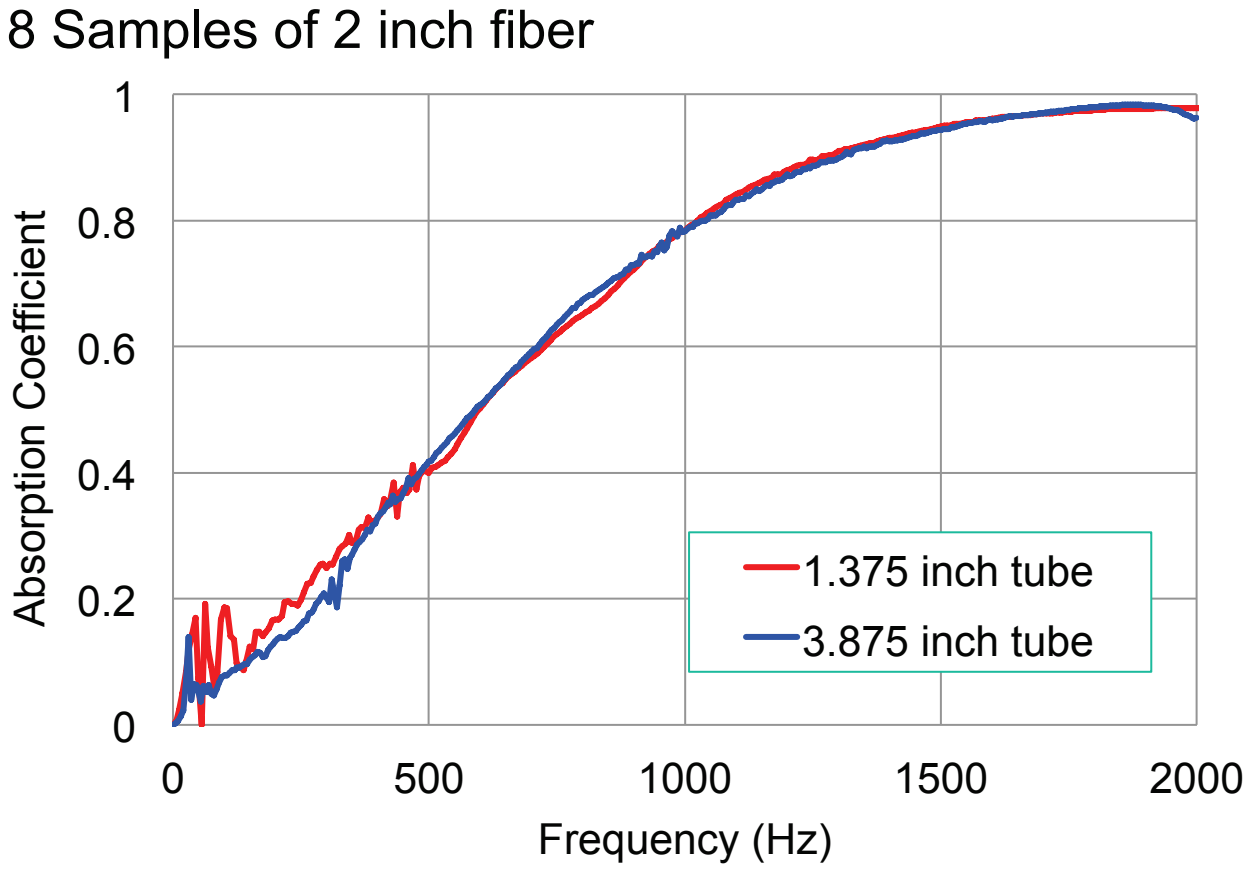
Effect of Impedance Tube Size

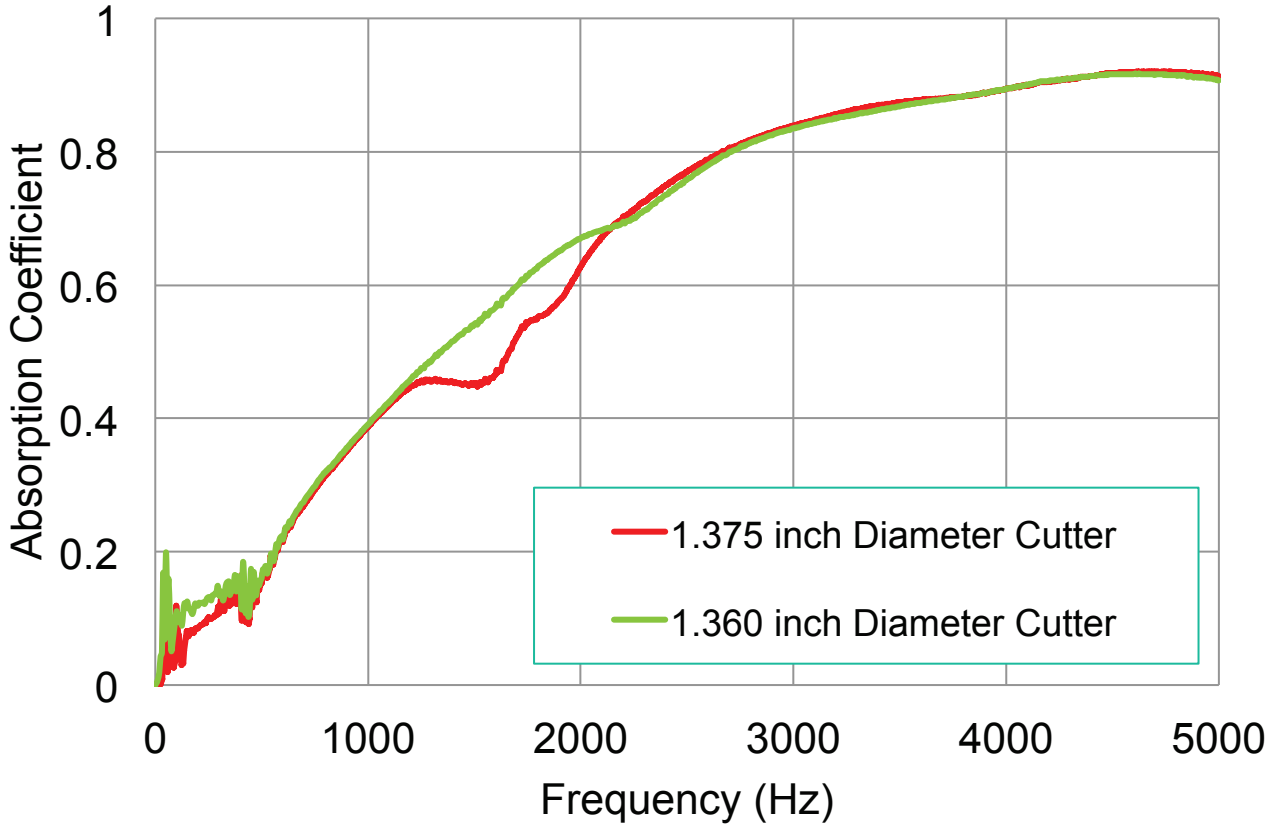
Impedance Tube Measurements



Effect of Cutter Size

Impedance Tube Measurements

8 Samples of 0.75 inch thick 0.6 lbs/ft³ Melamine



Summary

Impedance Tube Measurements

"While the use of an impedance tube system to measure acoustic absorption is not an extremely precise and repeatable process due to unavoidable variations of specimen cutting and cell fit, the disciplined use of the guidelines stated in this paper will help to insure that test results maintain a consistent level of accuracy and validity. The *experience gained with repeated preparation and testing* will also contribute to a better feel for more subtle aspects of preparation and specimen fitting for testing."

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