Analysis of Melamine
(ISS Foam Absorber)

POCs:

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Normal incidence impedance measurements, using the two-thickness method (TTM), were conducted in the NASA LaRC Flow Impedance Test Laboratory (FITL) to assess the acoustic characteristics (characteristic impedance and propagation constant) of "melamine." The TTM requires measurements on two test samples from the same bulk material, one of which is twice the thickness of the other. A single piece of melamine foam, with the following designations, was provided to the Liner Physics Group for analysis.

Material Code: 89324

Use Type: Insulation

Designation: Sonexone (Sonexone is a registered trademark of Illbruck Incorporated)

Composition: Melamine

The geometry of this piece of foam was such that the largest sample that could be constructed for use in the FITL normal incidence tube (see fig. 1) was 2"-wide by 1.942"-long by 2.4"-deep. The fixtures for testing in the FITL normal incidence tube requires samples to be 2"-wide by 2"-long. Thus, two 0.029" thick shims were used to build the sample up to 2"-wide by 2"-long by 2.4"-deep. Acoustic tests were then conducted with this sample. The foam was then shaved down to the next desired depth, and was re-tested. This process was repeated until the sample depth was 1.1 inches (see figs. 2 & 3). In total, seven 2" by 2" test samples were constructed from the available material. The depths of these samples were 1.1, 1.4, 1.6, 1.8, 2.0, 2.2 and 2.4 inches. All seven samples were tested in the normal incidence tube with an OASPL of 140 dB over the frequency range of interest (500 to 3000 Hz). From these tests, the specific acoustic impedance (acoustic pressure divided by particle velocity normal to the surface of the test material) of each material was determined. The results for the 1.1 and 2.2-inch samples (z1 and z2) were used with the TTM to determine the characteristic impedance and propagation constant for melamine.

The following equations are used to calculate the bulk material characteristic impedance (zc) and propagation constant (g) from z1 and z2. Note that z1 and z2 are normalized to rc, as will be the case for zc. The real part of the g is in nepers/meter and the imaginary part is in radians/meter.

$$zc = \sqrt{z1\,(2 * z2 - z1)}$$

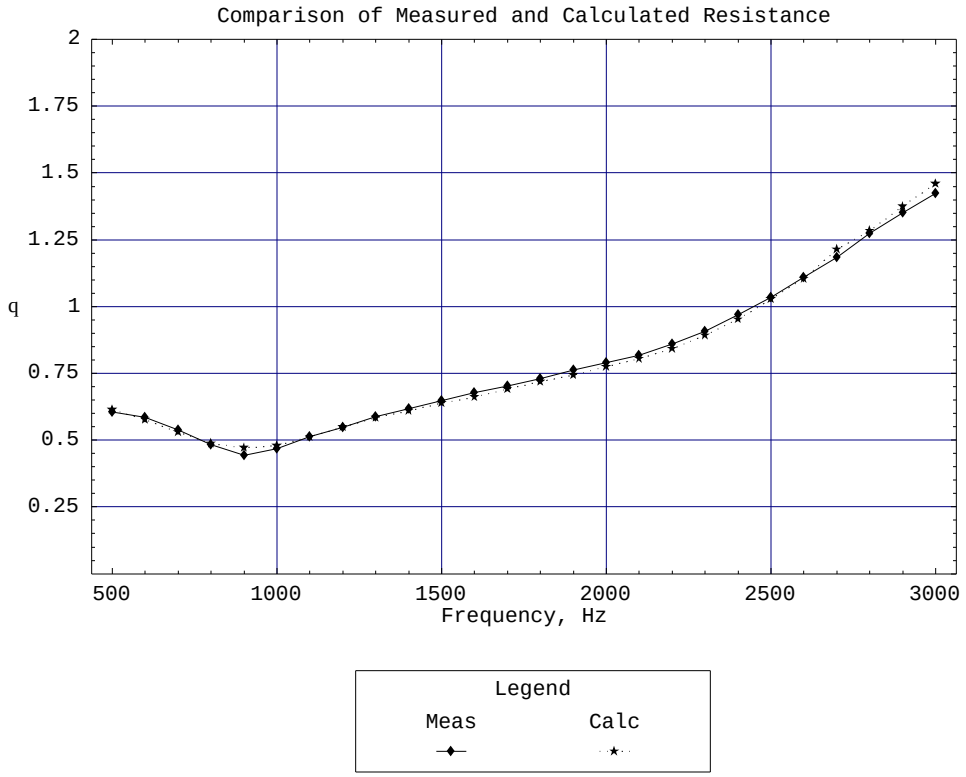
$$a = \sqrt{\frac{2 * z2 - z1}{z1}}$$

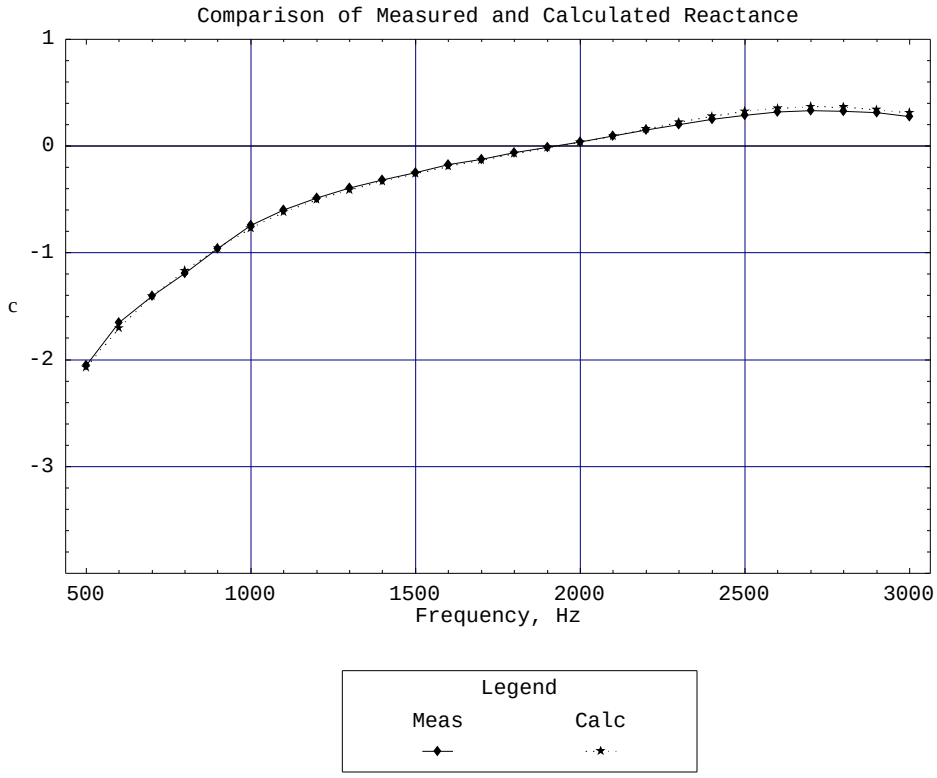
$$la = \mathrm{Log}\left[\frac{1 + a}{1 - a}\right]$$

$$g = \frac{la}{2\,d}$$

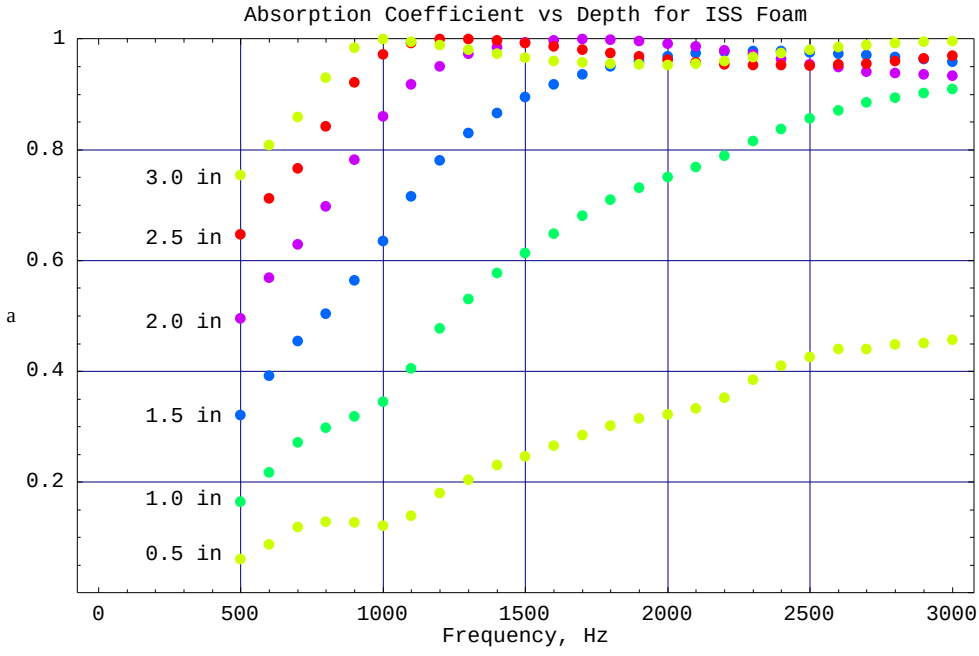
where *d* is the depth of the shorter sample (1.1" for our test).

To demonstrate that the TTM is properly working, we use the characteristic impedance and propagation constant derived above to predict the acoustic impedance for one of the other depths. The following charts show the measured and predicted impedances (resistance and reactance) for the 1.6-inch sample. Clearly, the method is working well.





Finally, the predicted absorption coefficient results for foam depths of 0.5 to 3.0 inches, in steps of 0.5 inches, are provided for comparison purposes.



Concluding Remarks:

Melamine foam has been analyzed in the NASA Langley Research Center Flow Impedance Test Laboratory. This analysis was conducted using the Two-Thickness Method together with normal incidence acoustic impedance tests. The normal incidence acoustic absorption of melamine foam can now be predicted with confidence for depths between 1.1 and 2.4 inches. Within reason, the predictions will also be good for depths outside of this range.

References:

1) "Comparison of three methods for measuring acoustic properties of bulk materials" C. D. Smith and T. L. Parrott; JASA 74(5), November 1983

2) "A unique wide-band liner for high temperature applications" K. K. Ahuja and R. J. Gaeta, Jr.; NASA CR 201677, March 1997

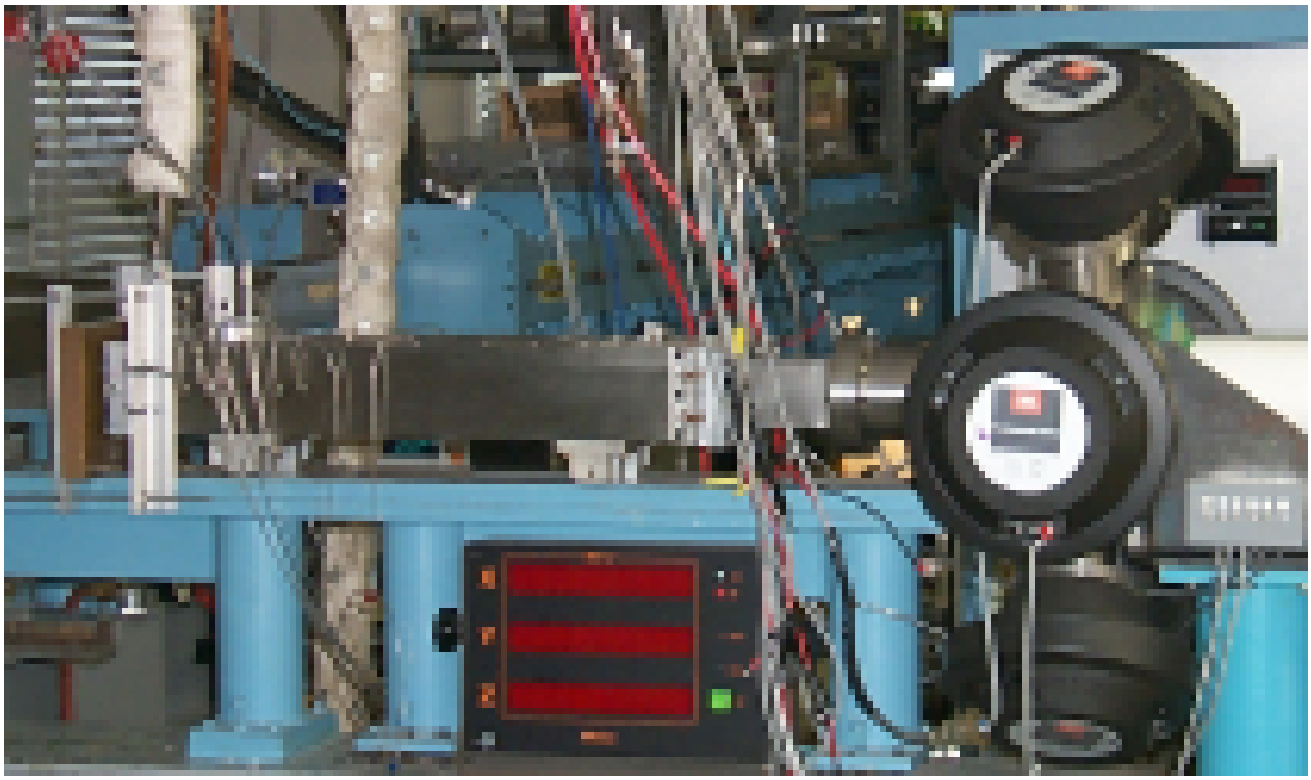


Figure 1. Photograph of NASA LaRC Normal Incidence Tube

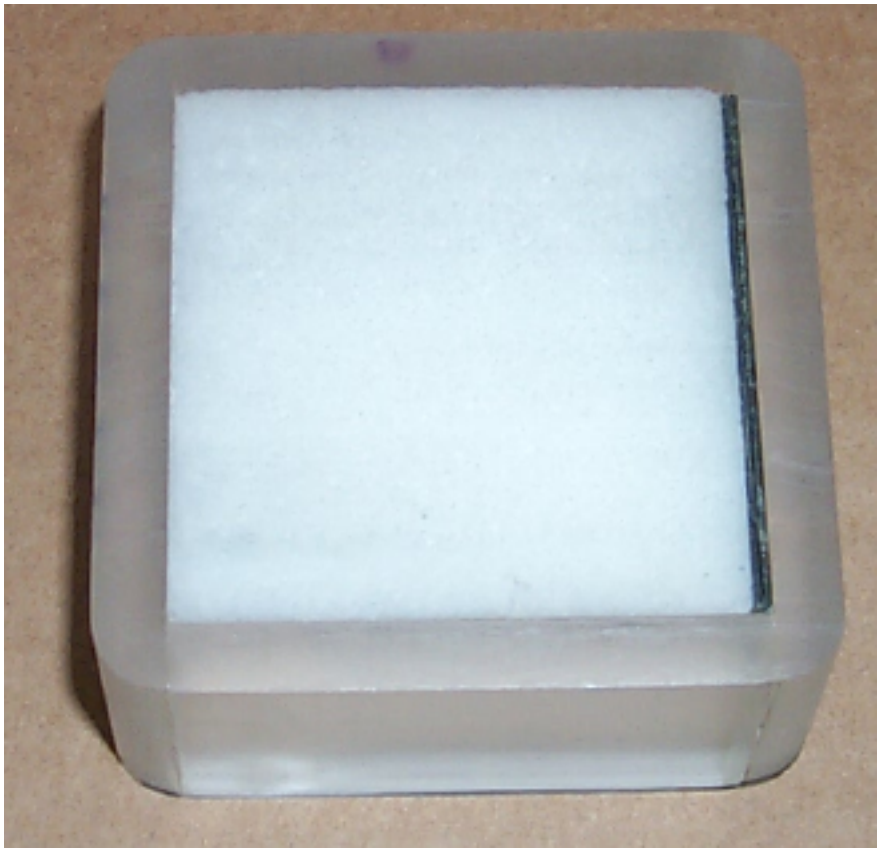


Figure 2. Photograph of 2"-wide by 2"-long by 1.1"-deep sample (includes 2 0.059"-thick shims)

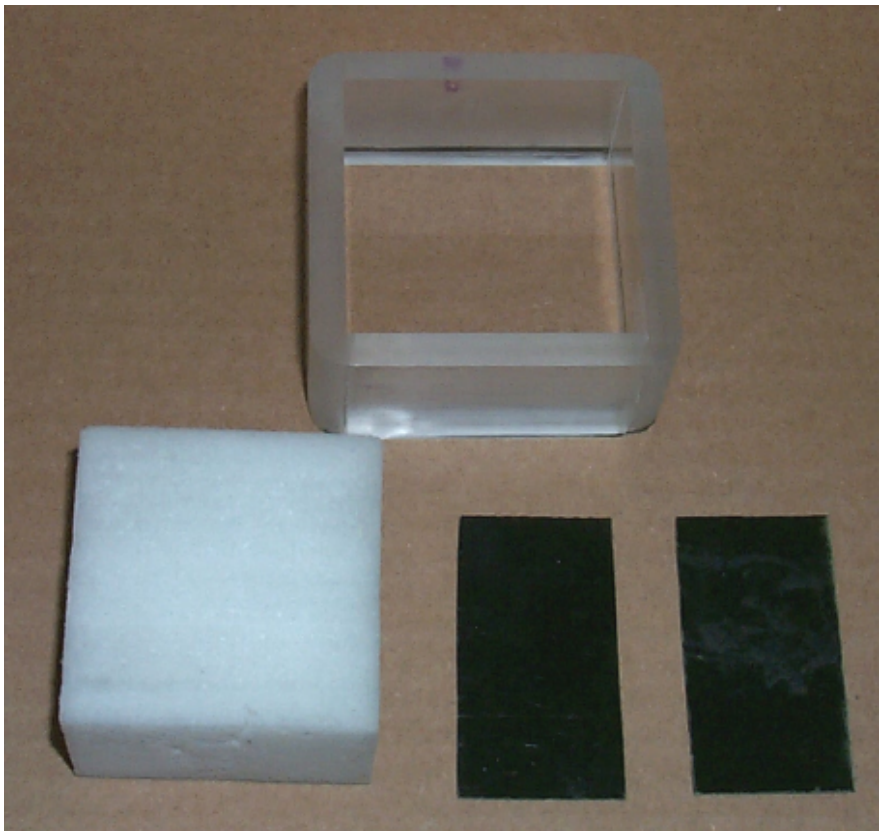


Figure 3. Photograph of sample holder, melamine material and two shims.