How to Interpret the ISO 15617 Impedance Tube Fabric Report

After more than 100 years, we still do not know the actual random incidence absorption coefficient for an absorber and current standards are inadequate and under intense review! The inconvenient truth is that the random incidence absorption coefficient measured in a reverberation chamber is neither accurate nor reproducible in different accredited laboratories.

In Figure 1 we illustrate the wide variation found in a round robin experiment by ISO 354 Working Group TC43/SC2/WG26 involving 13 laboratories of various sizes, geometry and volume. Since absorption coefficients are not reproducible among labs and the values can exceed unity, which is physically impossible, it is difficult to use these data to compare acoustical materials and fabrics.

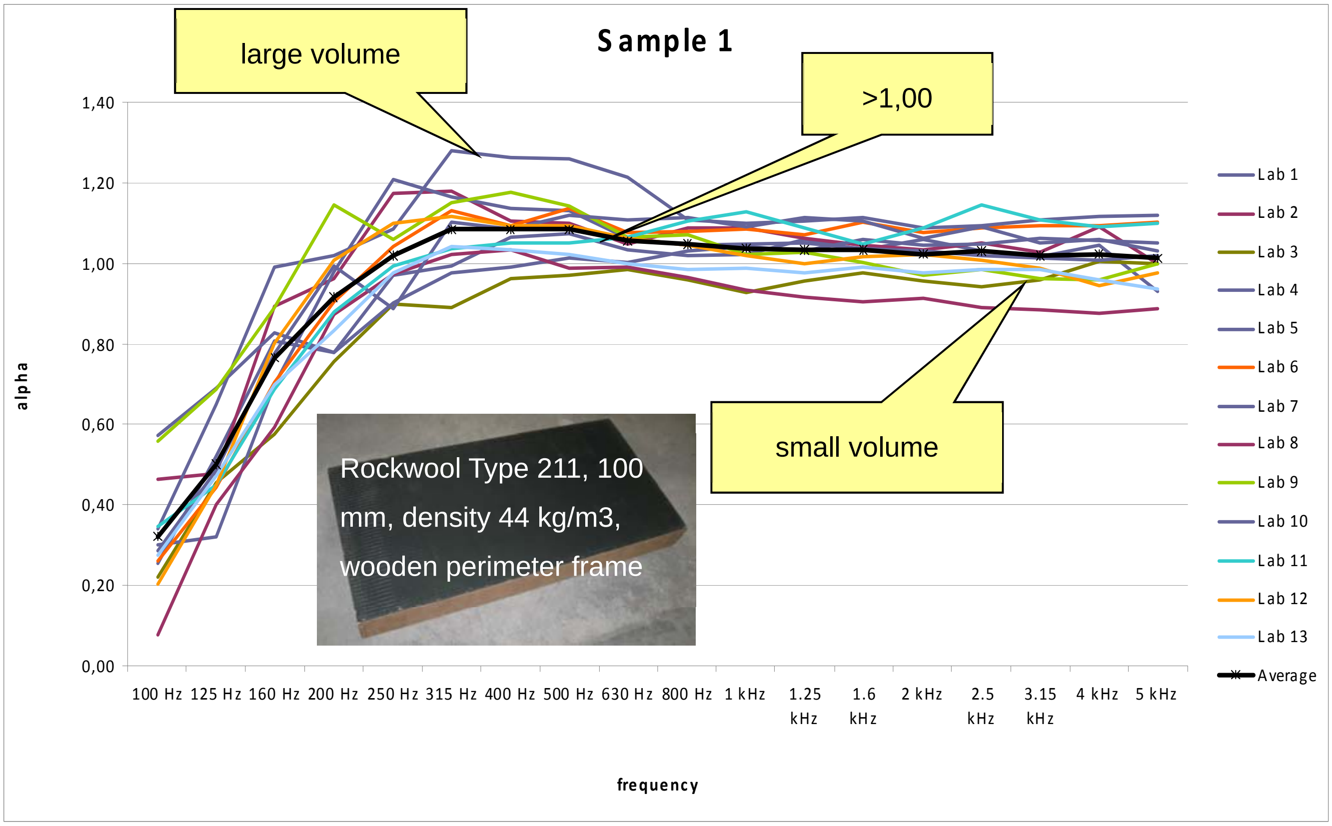

Figure 1. 13 laboratory round-robin. M.L.S Vercammen, ISRA Proceedings 2010, Melbourne, Australia.

The ISO 354 working group is actively studying approaches to create and verify the diffusivity of the sound field, which is necessary for measuring the Sabine absorption coefficient. The working group and D'Antonio have also proposed methods to calibrate the rev room, using a reference absorber, to improve the agreement among inter-laboratory measurements. In addition to an anticipated, improved, calibrated rev room standard, the author has proposed and developed an accurate and reproducible method to measure fabric transparency and its effect on the absorption of a fabric wrapped panel, using the normal incidence absorption coefficient.

Acousticians use the Sabine equation to calculate the effect of the random incidence absorption coefficient of the various surfaces in a room on the reverberation time. While it may not be obvious, there is a significant difference between the random incidence absorption coefficient, which refers to the arrival of sound from all directions, and the normal incidence absorption coefficient, which refers to sound impinging on a material perpendicular to its face. While we have discussed the problems with measuring the random incidence absorption coefficient, the normal incidence coefficient is very accurate and reproducible. In Figure 2, we illustrate the random incidence and normal incidence absorption coefficients of a 2” fiberglass panel mounted directly to a rigid boundary, using the Soundflow program.

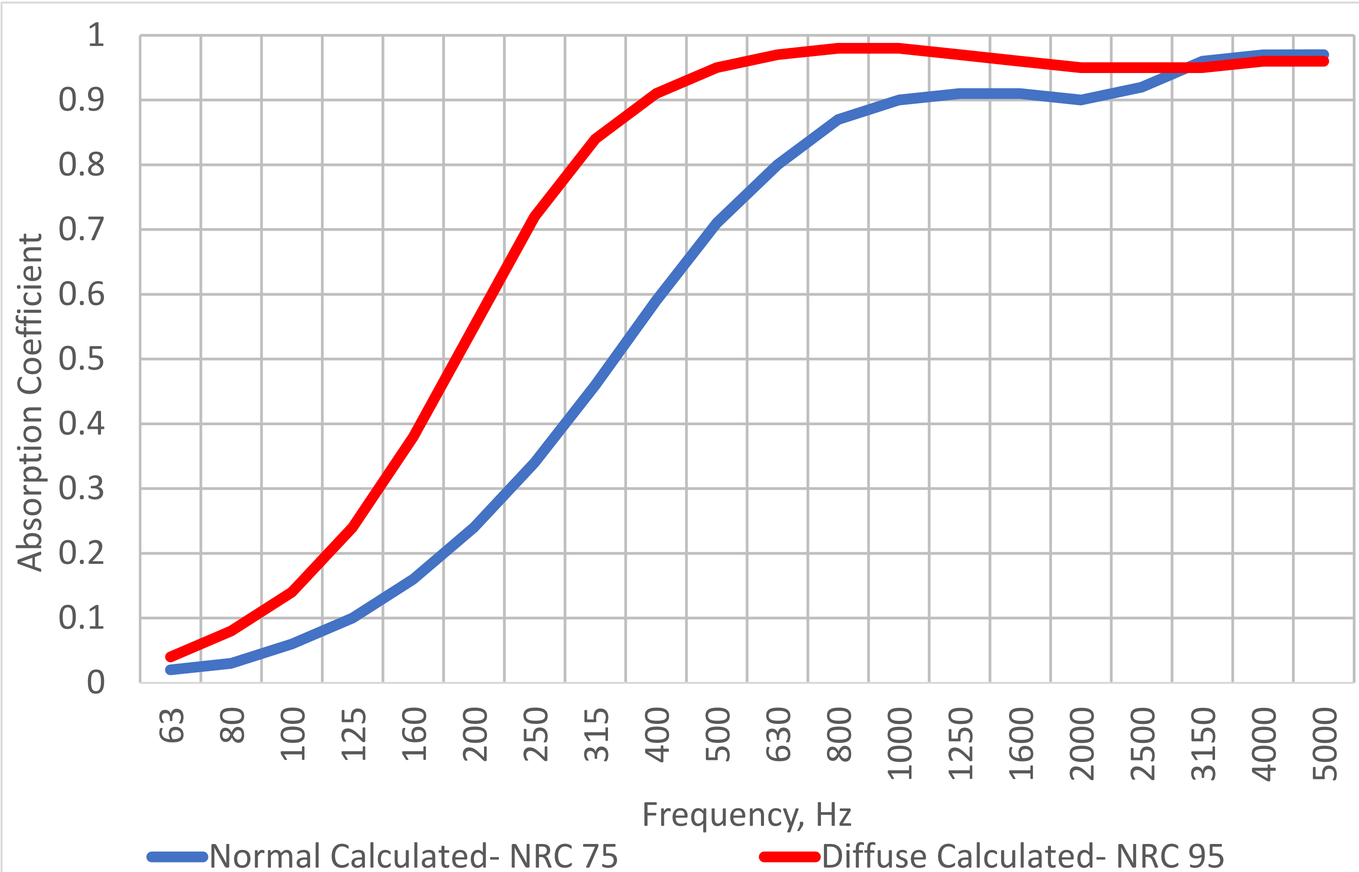

Figure 2. Calculated random incidence versus normal incidence absorption coefficients for a 2”, 6 pcf, fiberglass panel on a rigid boundary, using Soundflow.

You will notice the random incidence measurement in a rev room according to ISO 354 typically gives a broader spectrum. The NRC of the diffuse incidence measurement is roughly 1.27 times the normal incidence value.

Therefore, measurements of the two coefficients, should not be compared. However, this author has developed a simple and rapid measurement, using the normal incidence coefficient, determined in an impedance tube, to measure fabric transparency and evaluate the effect the fabric has on the absorption of the porous absorbing substrate in a fabric wrapped panel. Details of the measurement procedure can be found in the CARI brochure at www.carillc.com and summarized below.

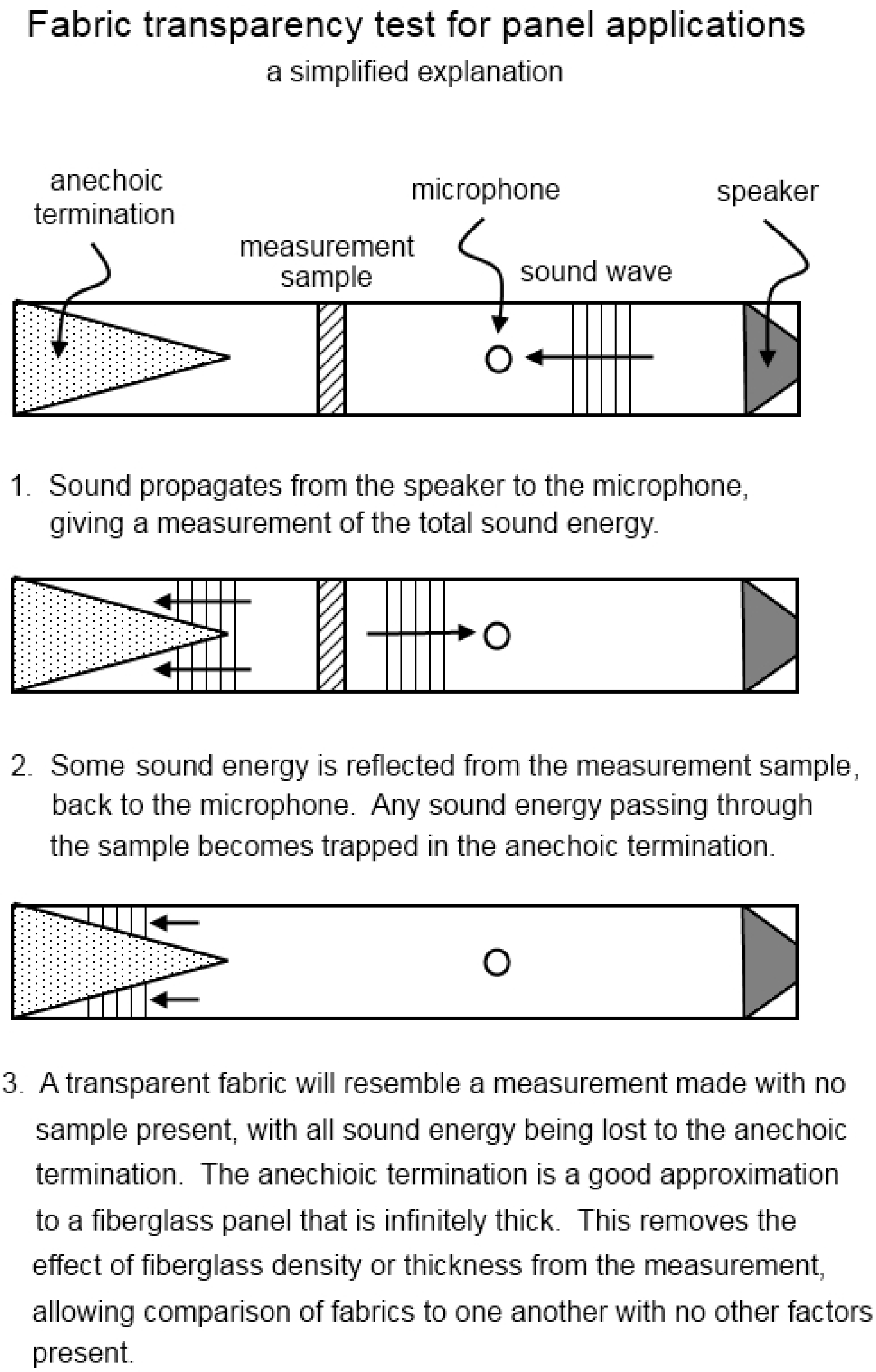

Figure 3. Fabric transparency and panel absorption test

The definition of <u>Transparency</u> used in this study is simply defined as the average percent absorption of a fabric measured in front of an anechoic termination from 250 to 4,000 Hz. In addition to fabric Transparency, this method compares the normal incidence absorption performance of a 2" 6 pcf fiberglass substrate with that of the substrate wrapped in the fabric under test. Therefore, we can now relate fabric Transparency with its effect on the absorption performance of the substrate. If the NRC of the fiberglass substrate and the fabric wrapped substrate are equal, the fabric is close to 100% transparent.

We can now describe how to interpret a Fabric transparency and panel absorption test report.

CHESAPEAKE ACOUSTIC RESEARCH INSTITUTE

Fabric transparency and panel absorption test

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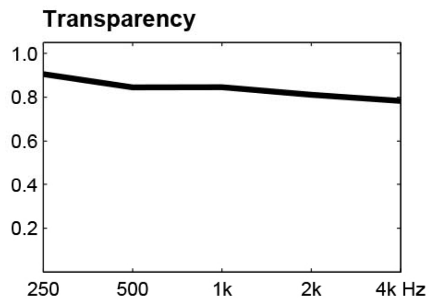
For: Client

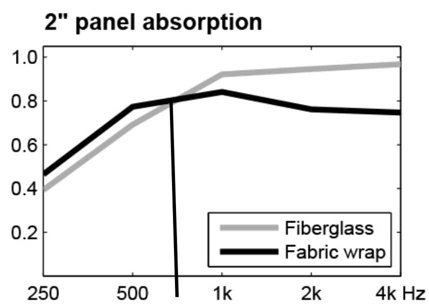
Test sample: Sample Under Test

Test method: The test method conforms to international standard ISO 10534−2 for determination of sound absorption coefficient and impedance in impedance tubes using the transfer−function method.

Transparency is expressed as absorption of fabric measured in front of an anechoic termination, and averaged from 250 to 2k Hz.



f [Hz]	%
250	91
500	85
1k	85
2k	81
4k	78
Ave	**85**



f [Hz]	%	%
250	39	47
500	69	77
1k	92	84
2k	95	76
4k	97	75
NRC	75	**70**

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Figure 4. Fabric transparency and panel absorption test report

The upper Transparency curve is a plot of the absorption of the fabric in front of an anechoic termination from 250 Hz to 4 kHz. The average value is reported at 85%. If this were between 95-100% the fabric would be considered completely transparent to incident sound.

In the lower 2” panel absorption chart, the absorption of the Fiberglass substrate (gray) and the Fabric wrapped panel (black) are compared. Notice that the Fiberglass has an NRC of 75, which we showed earlier equates to roughly a random incidence NRC of 95, and the fabric wrapped panel has an NRC of 70. What is revelatory about the comparison is the effect that the less than fully transparent fabric has on the frequency response of the absorption coefficient of the fabric wrapped panel. Roughly speaking,15 % (100 – 85) of the incident sound is not transmitted through the fabric. The test method does not allocate how much of this non-transmitted sound is reflected and absorbed. The two effects are combined. What the test reveals is how the fabric sonically equalizes the absorption spectrum of the fiberglass. It can be seen from the graph that the fabric decreases the high frequency absorption above about 750 Hz and increases the absorption below.

Why is this important? Well let's assume that the room in which these fabric-wrapped panels were to be installed already had sufficient high frequency absorption from the drapery, carpeting, acoustic ceiling tile and people and not enough low frequency absorption. Then this fabric would offer a useful sonic equalization and in fact be more useful than a fully transparent fabric which would only add more high frequency absorption. This is a fact often overlooked, because the focus is solely on the NRC.

This can be further illustrated by the results of a research study of fabrics of transparency ranging from 95% to 35%, shown in Figure 4. Many of the fabrics of interest to interior designers are backed with acrylics or polyesters and offer lower transparency than a typical fully transparent panel fabric. It is logical to ask if these backed fabrics, which offer a very desirable aesthetic design aspect, can be used as a panel fabric. In the past, panel fabrics were required to be fully transparent. The old test question was "Can I blow smoke through it?". This criterion is valid, if and only if the absorption performance of the substrate is desired. Since most porous substrates, like fiberglass, recycled cotton, polyester, etc. offer primarily high frequency absorption, this assumes the fabric wrapped panel is expected to offer primarily high frequency absorption. As we have mentioned, if a more balanced absorption spectrum is desired or if a spectrum preferentially absorbing lower frequencies is desired, then this test reveals that we can use the fabric as a sonic equalizer to modify the absorption of the substrate. In Figure 4, we illustrate this study. As you will notice the transparencies are listed at the top of each panel, ranging from 95% to 35%. The black line represents the 2" 6 pcf fiberglass substrate absorption and the gray composite line represents the absorption spectrum of the fabric wrapped panel. You can see that at high transparency the absorption of the fabric wrapped panel is similar to the substrate. Whereas, as the transparency decreases the high frequencies are attenuated and the lower frequencies accentuated.

The conclusion of this research is as follows:

If you desire the absorption performance of the substrate, then use a highly transparent fabric.

If you desire an absorption performance different from the substrate, you can use a backed, less than fully transparent fabric to modify the performance

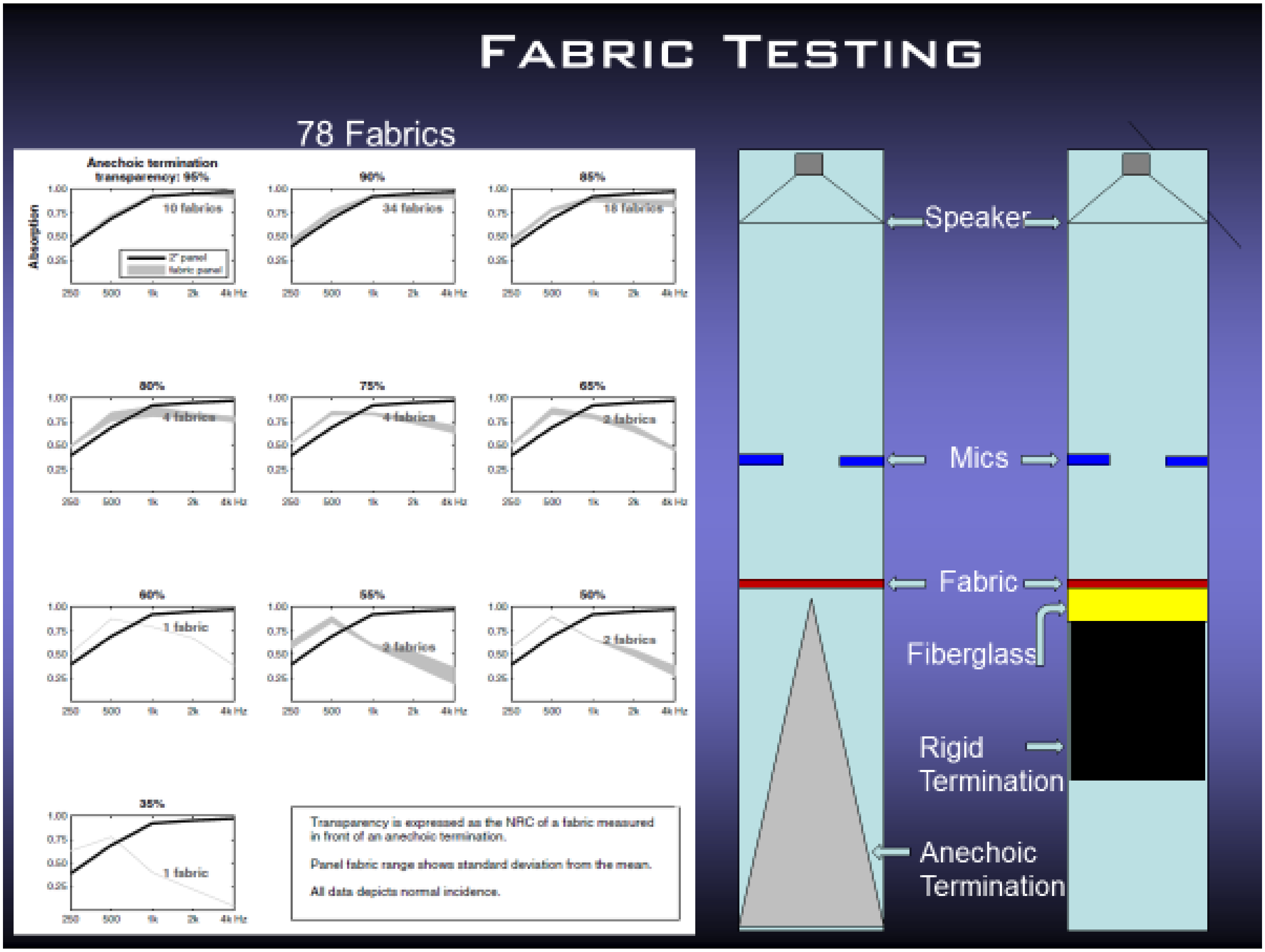

Figure 4. The above illustration relates the fabric transparency with the absorption of the fiberglass substrate and the fabric wrapped panel, for transparencies ranging from 95% to 35%. Three measurements are made in the impedance tube. 1. The fabric (red) absorption is measured in front of an anechoic termination (triangular wedge in the tube on the left). From this the average absorption between 250 and 4 kHz is called the Transparency. 2. The fiberglass substrate (yellow) is measured in front of a rigid termination (tube on the right) and 3. The fabric wrapped panel (red above yellow) is measured in front of the rigid termination. The graphs on the left illustrate that as the fabric transparency decreases the absorption spectra of the fabric wrapped panels migrates from being similar to the substrate to becoming more uniform to primarily absorbing low frequencies. Therefore, the fabric can be used as a sonic equalizer.