University of SALFORD MANCHESTER

LABORATORY TEST REPORT

BS EN ISO 10534-2: 2001. DETERMINATION OF SOUND ABSORPTION COEFFICIENT IN IMPEDANCE TUBES. TRANSFER-FUNCTION METHOD.

CLIENT:	Camira Fabrics
	The Watermill
	WF14 8HE
PRODUCT(S):	Fiji
TEST DATE:	21/09/2018

TEST REPORT No.: ACOUS/03797-2   **DATE OF ISSUE:** 27/09/2018

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Approved: _[signature]_

Andy Moorhouse
Director of Acoustics Laboratories

1.   TEST SAMPLES AND CONDITIONS

1.1.   Description of Test Samples

Details on the material tested for the determination of a normal incidence sound absorption coefficient with the impedance tube are provided below. For the material tested, three samples of 100mm diameter and three samples of 29mm diameter were supplied by the Client and submitted for testing.

Product Identification: Fiji.

Manufacturer: Camira Fabrics.

Description: Single-layer polyester fabric.
Layers: 1.

100mm Samples Condition: Satisfactory.
29mm Samples Condition: Satisfactory.

The purpose of this laboratory test was to measure the normal incidence sound absorption of the product above, when applied to the surface of an acoustic absorptive material. For this purpose, the absorptive material selected was a generic melamine foam, provided by the University of Salford. The fabric material was laid on top of the melamine foam with no adhesives or bonds between the two materials.
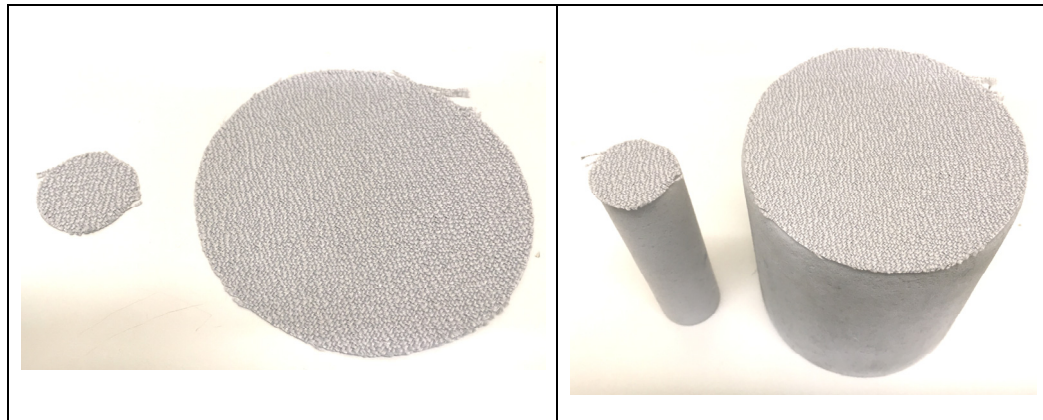

Figure 1: Test Sample (left). Test samples over melamine foam (right).

Table 1 below provides further details on each one of the tested samples and the melamine foams used for the test. All the parameters in Table 1 have been measured in the Acoustics Laboratory of the University of Salford. The mass per unit area was determined by measuring the mass of each sample and the sample surface area.

Unit	Diameter (mm)	Thickness (mm)	Mass per Unit Area (kg.m^{-2})
Melamine Foam 1	100	100	0.879
Melamine Foam 2	29	100	0.833
Sample 1	100	0.8	0.267
Sample 2	100	0.8	0.255
Sample 3	100	0.7	0.267
Sample 4	29	0.8	0.227
Sample 5	29	0.8	0.227
Sample 6	29	0.6	0.227

Table 1: Physical characteristics of each test sample and melamine foam.

1.2. Test Conditions

All tests were conducted under the following conditions:

Temperature: 17 °C
Relative Humidity: 50 %
Static Pressure: 1028 hPa.

2.   SOUND ABSORPTION COEFFICIENT IN IMPEDANCE TUBE

2.1.   Test Details

The aim of these impedance tube tests is to determine the sound absorption coefficient at normal incidence (α) of the test sample, which is defined as the ratio of sound power entering the surface of the test object, and not returning, to the incident sound power of a plane wave reflected by the same surface at normal incidence.

The test methodology followed was the one detailed in BS EN ISO 10534-2, using an impedance tube with a sound source generating plane waves connected to one end and the test sample mounted in the tube at the other end. The decomposition of the interference field is achieved by measuring acoustic pressures at two fixed locations, using wall-mounted microphones, and calculating the complex acoustic transfer function and the normal incidence absorption ratios of the material.

2.2.   Equipment

For this particular test, a **B&K Type 4206** Impedance Tube was used (Figure 2). This impedance tube is in accordance with BS EN ISO 10534-2 and consists of an adjustable signal filter, a loudspeaker, a sound propagation tube, microphone holders, a large sample tube (100 mm diameter), and a small sample tube (29 mm diameter). Each sample tube contains an adjustable plunger for positioning the test sample and creating air gaps behind it if desired.
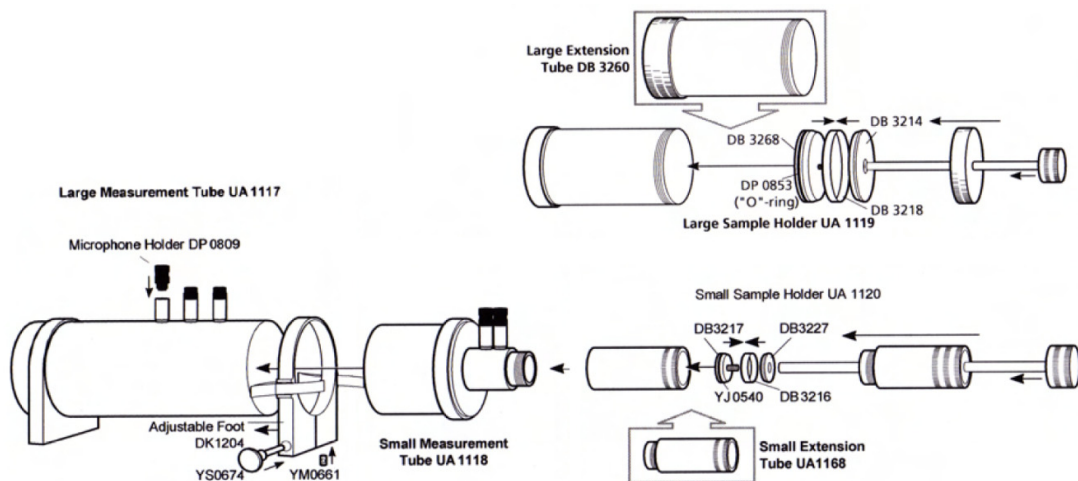

Figure 2: Breakdown of Impedance Tube components[1]

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[1] Brüel & Kjær – Technical Documentation, Impedance/Transmission Loss Measurement Tubes Type 4206, (EXTRACT)

Loudspeaker Characteristics – The diameter of the loudspeaker is 80mm with a maximum rated input signal equal to 10W at 20°C (max average power). Because it has an impedance of 4Ω, the voltage input to the loudspeaker was set to be between 1.0 – 1.414V during measurements, in order to avoid signal distortion, with the adjustable filter connected to the loudspeaker set to 'linear'.

Large Sample Tube Characteristics – The large sample tube has an inner diameter of 100mm. The two microphones positioned within the large tube were separated by 100mm, with the closest microphone to the sample located 100mm away from its surface. The configuration described above allows for testing in a frequency range between 50Hz and 1.6kHz, in one-third octave-bands centre frequencies.

Small Sample Tube Characteristics – The small sample tube has an inner diameter of 29mm. The two microphones positioned within the small tube were separated by 20 mm, with the closest microphone to the sample located 35 mm away from its surface. The configuration described above allows for testing in a frequency range between 500Hz and 5kHz, in one-third octave-band centre frequencies.

Real-Time Analyser – A 5-Channel B&K PULSE Fast Fourier Transform (FFT) analysing system and signal generator, with a pre-installed "Normal Incidence Absorption" software package, was used to perform measurements, calculations and result analysis.

Additionally, a temperature and barometer transducer was used to measure the temperature and atmospheric pressure. A full list of the equipment used during the tests is presented in Table 2 below.

Equipment	Serial/Ref No.
B&K Pulse Analyser	2477213 / PULSE N.2
Impedance Tube Type 4206	2681869
Desktop PC with Software and Peripheral Equipment	21329
Two ¼" Condenser Microphones Type 4187	2677390 & 2677391
Power Amplifier	129003364

Table2: List of equipment.

2.2. Procedure

The test sample, consisting of the fabric surface laid over the melamine foam, was mounted at the end of the impedance tube by means of the sample holder, which is assumed to behave as a rigid termination, with no gaps between the sample and the termination. The sample holder was then mounted to the end of the tube and the microphones placed at measurement positions following the characteristics described in Section 2.1 for samples with 29mm and 100mm diameter. The impedance tube was mounted vertically on the wall, to allow the thin fabric to be placed on top of the melamine foam surface. Finally, a broadband stationary random signal was generated from B&K Pulse through a power amplifier and into the loudspeaker mounted in the impedance tube.

For each one of the test samples, the normal incidence sound absorption coefficient was then determined by decomposing the incident and reflected components of the sound field within the tube, which were measured by the two separated microphones along the tube length. The incident and reflected components of the sound pressure level, at the two microphone positions, were then used to calculate three frequency response functions, from which the reflection and absorption coefficients can be calculated.

2.3. Calculations

The complex reflection coefficient (R) of the sample is calculated using the following equation:

$$R = \left(\frac{H_{12} - H_i}{H_r - H_{12}} \right) e^{j2k(s+l)} \tag{1}$$

Where,

H_{12} is the transfer function between the two microphone signals, given by:

$$H_{12} = H_r + jH_i \tag{2}$$

j is the complex integer equal to $\sqrt{-1}$;

H_i the frequency response function associated with the incident component;

H_r the frequency response function associated with the reflected component;

k the wave number (in rad.m^{-1});

l the distance (in m) between the sample surface and the closest microphone;

s the distance between the two microphone positions (m).

The normal incidence sound absorption coefficient (α) is then calculated from the complex reflection coefficient as follows:

$$\alpha = 1 - \left| R \right|^2 \tag{3}$$

The two-microphone method assumes plane wave propagation within the tube with no mean flow and no losses due to absorption at the tube wall. Specifications of the impedance tube, as supplied by the manufacturer, are available on request.

4.　　RESULTS

The measured normal incidence sound absorption coefficient for each one of the test samples submitted for testing are detailed in the following pages of this report, along with the standard deviations which have been calculated using the results obtained for the small and large samples. Additionally, Figure 3 below presents the measured normal incidence sound absorption coefficient for the melamine foam utilised in the tests on its own.

The results here presented relate only to the items tested and described in this report.

Freq. (Hz)	α_S Mean
50	0.080
63	0.126
80	0.139
100	0.218
125	0.274
160	0.420
200	0.528
250	0.642
315	0.747
400	0.834
500	0.891
630	0.924
800	0.935
1000	0.973
1250	0.944
1600	0.940
2000	0.987
2500	0.994
3150	0.985
4000	0.996
5000	0.995
6300	0.994
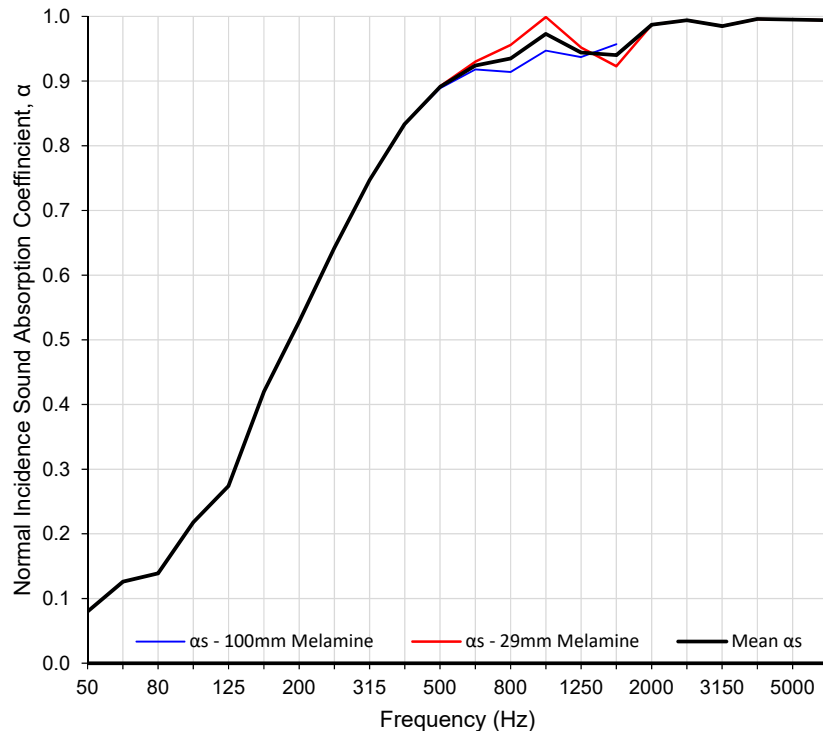
Figure 3: Normal incidence sound absorption coefficient α_S of the melamine foam.

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BS EN ISO 10534-2:2001. Acoustics - Determination of Sound Absorption Coefficient in Impedance Tubes. Transfer Function Method.

Test Date: 21/09/2018   Ref.: ACOUS/03797-2

Client: Camira Fabrics. The Watermill, WF14 8HE.

Sample Description: **Fiji** - Single-layer polyester fabric on 100mm Melamine Foam (M.F.).

Manufacturer: Camira Fabrics.

Large Sample (50-1600Hz)
Diameter: 100mm
Average Thickness: 0.8mm + 100mm M.F.

Small Sample (500-5000Hz)
Diameter: 29mm
Average Thickness: 0.7mm + 100mm M.F.

Normal incidence sound absorption coefficient, α_S

Freq. (Hz)	Mean α_S 100mm Samples	Standard Deviation	Mean α_S 29mm Samples	Standard Deviation
50	0.099	0.004	-.-	-.-
63	0.144	0.027	-.-	-.-
80	0.234	0.058	-.-	-.-
100	0.266	0.003	-.-	-.-
125	0.361	0.017	-.-	-.-
160	0.506	0.005	-.-	-.-
200	0.642	0.006	-.-	-.-
250	0.76	0.002	-.-	-.-
315	0.848	0.004	-.-	-.-
400	0.905	0.002	-.-	-.-
500	0.937	0.002	0.929	0.014
630	0.977	0.001	0.964	0.005
800	0.898	0.003	0.983	0.003
1000	0.884	0.002	0.989	0.007
1250	0.911	0.002	0.925	0.021
1600	0.957	0.002	0.935	0.01
2000	-.-	-.-	0.984	0.012
2500	-.-	-.-	0.962	0.018
3150	-.-	-.-	0.969	0.017
4000	-.-	-.-	0.956	0.024
5000	-.-	-.-	0.958	0.024
6300	-.-	-.-	0.952	0.028

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Large Sample (50-1600Hz)   _Small Sample (500-5000Hz)_

Diameter: 100mm   Diameter: 29mm

Average Thickness: 0.8mm + 100mm M.F.   Average Thickness: 0.7mm + 100mm M.F.

Normal incidence sound absorption coefficient, α_S

Freq. (Hz)	α_S Mean
50	0.099
63	0.144
80	0.234
100	0.266
125	0.361
160	0.506
200	0.642
250	0.76
315	0.848
400	0.905
500	0.933
630	0.971
800	0.941
1000	0.936
1250	0.918
1600	0.946
2000	0.984
2500	0.962
3150	0.969
4000	0.956
5000	0.958
6300	0.952