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# 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):**           Era
**TEST DATE:**            31/05/2018

**TEST REPORT No.:**  ACOUS/03797-4               **DATE OF ISSUE:**  15/08/2018

Signed: _Leonardo Weber_                          Approved: _Andy Moorhouse_

Leonardo Weber                                    Andy Moorhouse
Acoustics Research Consultant                     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:**     Era.

**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.
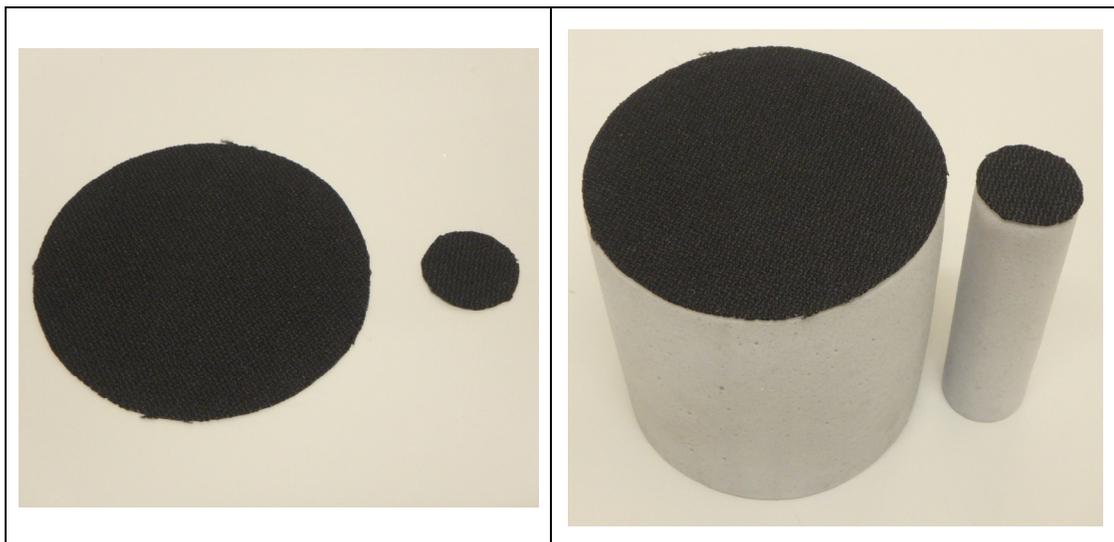


**Figure 1: Test Sample (left). Test samples over melamine foam (right).**

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 | 0.908 |
| Sample 1 | 100 | 0.8 | 0.331 |
| Sample 2 | 100 | 0.8 | 0.331 |
| Sample 3 | 100 | 0.9 | 0.318 |
| Sample 4 | 29 | 0.7 | 0.303 |
| Sample 5 | 29 | 0.8 | 0.303 |
| Sample 6 | 29 | 0.9 | 0.303 |

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

## 1.2.  Test Conditions

All tests were conducted under the following conditions:

**Temperature:**          23 °C
**Relative Humidity:**    49.2 %
**Static Pressure:**      1010.8 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.
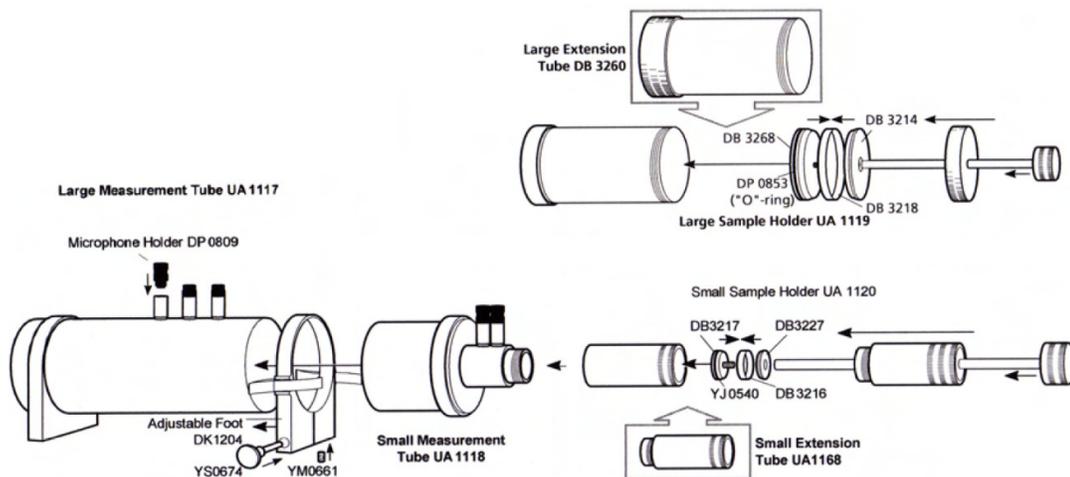


**Figure 2: Breakdown of Impedance Tube components[1]**

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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:

$$\alpha = 1 - \left| R \right|^2 \qquad (3)$$

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) | $\alpha_S$ Mean |
|------------|-----------------|
| 50 | 0.072 |
| 63 | 0.139 |
| 80 | 0.190 |
| 100 | 0.217 |
| 125 | 0.286 |
| 160 | 0.404 |
| 200 | 0.530 |
| 250 | 0.638 |
| 315 | 0.740 |
| 400 | 0.828 |
| 500 | 0.897 |
| 630 | 0.930 |
| 800 | 0.933 |
| 1000 | 0.957 |
| 1250 | 0.957 |
| 1600 | 0.942 |
| 2000 | 0.992 |
| 2500 | 0.996 |
| 3150 | 0.984 |
| 4000 | 0.996 |
| 5000 | 0.994 |
| 6300 | 0.994 |
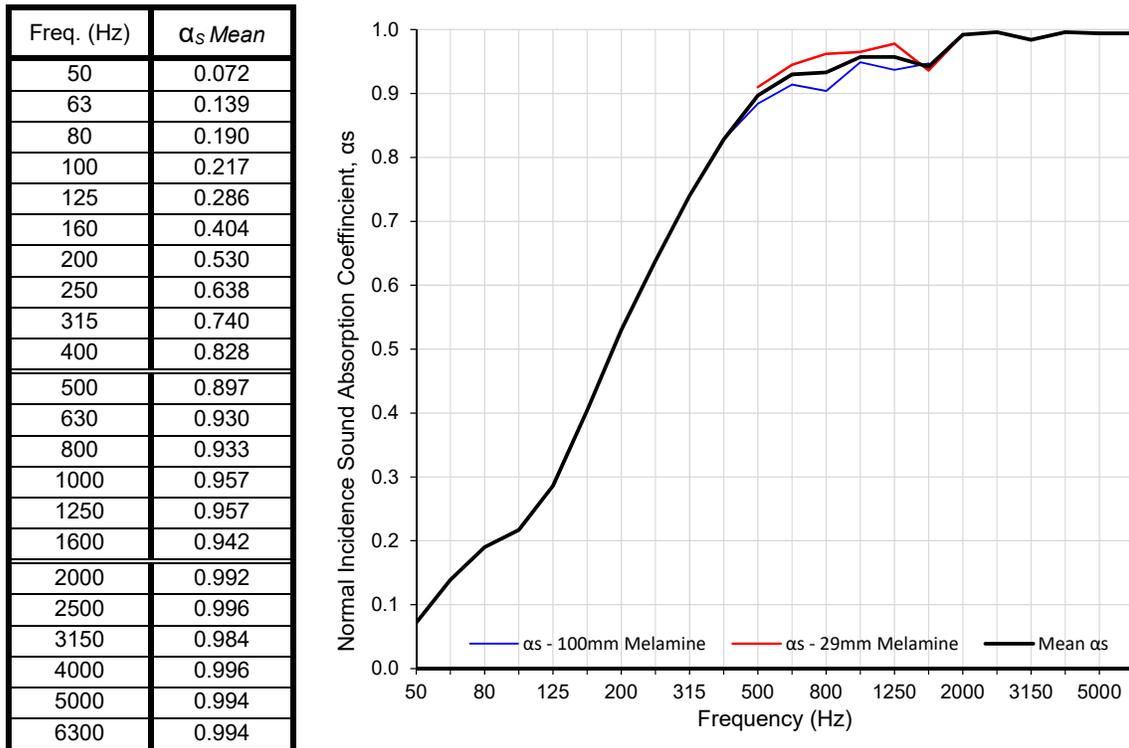


**Figure 3: Normal incidence sound absorption coefficient $\alpha_S$ of the melamine foam.**

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

Test Date: 31/05/2018                    Ref.: ACOUS/03797-4

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

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

Manufacturer: Camira Fabrics.

| *Large Sample (50-1600Hz)* | *Small Sample (500-5000Hz)* |
|---|---|
| Diameter: 100mm | Diameter: 29mm |
| Average Thickness: 0.8mm + 100mm M.F. | Average Thickness: 0.8mm + 100mm M.F. |

### Normal incidence sound absorption coefficient, $\alpha_S$

| Freq. (Hz) | Mean $\alpha_S$ *100mm Samples* | Standard Deviation | Mean $\alpha_S$ *29mm Samples* | Standard Deviation |
|---|---|---|---|---|
| 50 | 0.093 | 0.026 | -.- | -.- |
| 63 | 0.089 | 0.01 | -.- | -.- |
| 80 | 0.205 | 0.002 | -.- | -.- |
| 100 | 0.254 | 0.008 | -.- | -.- |
| 125 | 0.346 | 0.007 | -.- | -.- |
| 160 | 0.536 | 0.021 | -.- | -.- |
| 200 | 0.7 | 0.014 | -.- | -.- |
| 250 | 0.845 | 0.004 | -.- | -.- |
| 315 | 0.928 | 0.002 | -.- | -.- |
| 400 | 0.946 | 0.001 | -.- | -.- |
| 500 | 0.926 | 0.002 | 0.952 | 0.01 |
| 630 | 0.893 | 0.002 | 0.943 | 0.017 |
| 800 | 0.875 | 0.004 | 0.928 | 0.011 |
| 1000 | 0.693 | 0.003 | 0.905 | 0.017 |
| 1250 | 0.744 | 0.004 | 0.891 | 0.015 |
| 1600 | 0.792 | 0.002 | 0.886 | 0.016 |
| 2000 | -.- | -.- | 0.837 | 0.008 |
| 2500 | -.- | -.- | 0.802 | 0.006 |
| 3150 | -.- | -.- | 0.806 | 0.005 |
| 4000 | -.- | -.- | 0.775 | 0.001 |
| 5000 | -.- | -.- | 0.772 | 0.001 |
| 6300 | -.- | -.- | 0.751 | 0.008 |

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Test Date: 31/05/2018                                                   Ref.: ACOUS/03797-4

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

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

Manufacturer: Camira Fabrics.

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

Diameter: 100mm                                                     Diameter: 29mm

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

### Normal incidence sound absorption coefficient, α$_S$

| Freq. (Hz) | α$_S$ Mean |
|---|---|
| 50 | 0.093 |
| 63 | 0.089 |
| 80 | 0.205 |
| 100 | 0.254 |
| 125 | 0.346 |
| 160 | 0.536 |
| 200 | 0.7 |
| 250 | 0.845 |
| 315 | 0.928 |
| 400 | 0.946 |
| 500 | 0.939 |
| 630 | 0.918 |
| 800 | 0.902 |
| 1000 | 0.799 |
| 1250 | 0.818 |
| 1600 | 0.839 |
| 2000 | 0.837 |
| 2500 | 0.802 |
| 3150 | 0.806 |
| 4000 | 0.775 |
| 5000 | 0.772 |
| 6300 | 0.751 |