0444

Technical Report

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Project

The Laboratory Measurement of The Random Incidence Sound Absorption Coefficient of Ceiling Tiles

Prepared for

BASWA Acoustic AG

By

Kieron Farrow

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1.0 Description of Test

Tests have been done in SRL's Laboratory at Holbrook House, Sudbury, Suffolk, to determine the random incidence sound absorption coefficient of ceiling tiles in accordance with BS EN ISO 354:2003 and the single number rating in accordance with BS EN ISO 11654:1997.

The results are given in 1/3rd octave bands over the frequency range 50Hz to 10kHz, which is beyond that required by the test standard. Measurements outside the standard frequency range are not UKAS accredited.

1.1 Description of Sample

Tests were performed on ceiling tiles with nominal dimensions of 1200x600mm. See Section 2.0 and Data Sheet 1 for more details.

Sampling plan:	Selected at Random
Sample condition:	New
Details supplied by:	BASWA Acoustic AG
Sample installed by:	BASWA Acoustic AG and SRL Technical Services Ltd

1.2 Sample Delivery Date

07 February 2023

1.3 Test Procedures

The sample was mounted/located and tested in accordance with the relevant standard. The details of measurements are given in Appendix A. The method and procedure are described in Appendix B. The measurement uncertainty is given in Appendix C. The mounting methods are given in Appendix D.

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2.0 Results

The results of the measurements and subsequent analysis are given in Data Sheet 1 and summarised below.

Results relate only to the items as received and tested.

SRL Test No.	Description in Brief	Mounting Method	α_w
8	BASWA Phon Base 50mm 1200x600x50mm with joints covered with tape	A	1.00

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Data Sheet 1

Laboratory Measurement of Random Incidence Sound Absorption to BS EN ISO 354:2003

Test Number:	8	**Test Room:**	**Empty**	**With Sample**
Client:	BASWA Acoustic	**Air Temperature:**	16.2 °C	15.7 °C
Test Date:	07/03/2023	**Air Humidity:**	47 % RH	45 % RH
Chamber Volume:	300.1 m³	**Air Pressure:**	990 mbar	991 mbar
Mounting Method:	A	**Sample Area:**	10.8 m²	
Sample Description:	BASWA Phon Base 50mm 1200x600x50mm with joints covered with tape			

Frequency Hz	T1, empty room reverberation time sec	T2, room reverberation time with sample sec	Sound Absorption Coefficient α_s	Practical Sound Absorption Coefficient α_p
*50**	*4.67*	*4.61*	*0.01*	*n/a*
*63**	*4.30*	*4.09*	*0.06*	
*80**	*6.69*	*5.99*	*0.08*	
100	*7.39*	*5.71*	*0.18*	*0.25*
125	*6.79*	*5.16*	*0.21*	
160	*6.33*	*4.29*	*0.34*	
200	*6.61*	*3.88*	*0.48*	*0.70*
250	*6.67*	*3.34*	*0.68*	
315	*6.63*	*2.74*	*0.96*	
400	*6.26*	*2.57*	*1.03*	*1.00*
500	*5.62*	*2.29*	*1.17*	
630	*4.89*	*2.19*	*1.14*	
800	*4.97*	*2.16*	*1.19*	*1.00*
1000	*5.45*	*2.33*	*1.11*	
1250	*5.27*	*2.29*	*1.11*	
1600	*4.89*	*2.23*	*1.10*	*1.00*
2000	*4.56*	*2.25*	*1.00*	
2500	*3.95*	*2.08*	*1.00*	
3150	*3.21*	*1.86*	*0.98*	*1.00*
4000	*2.51*	*1.56*	*1.03*	
5000	*1.95*	*1.32*	*1.02*	
*6300**	*1.38*	*0.99*	*1.13*	*n/a*
*8000**	*1.14*	*0.84*	*1.21*	
*10000**	0.78	0.62	1.26	

α_w 1.00

Class A

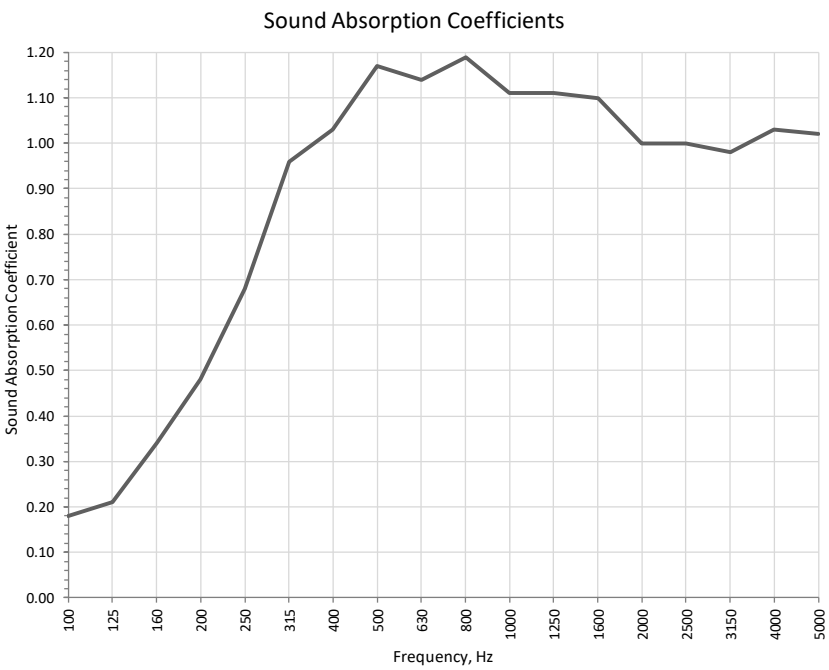
Calculated to BS EN ISO 11654:1997

NRC 1.00

Calculated to ASTM C 423-01

** Denotes frequencies outside the range covered by BS EN ISO 354:2003 and not UKAS accredited*

v1



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Appendix A - Details of Measurements

A1. Location

Sound Research Laboratories

Holbrook House

Little Waldingfield

Sudbury

Suffolk

CO10 0TF

A2. Test Date

07 March 2023

A3. Tester

Kieron Farrow of SRL Technical Services Limited

A4. Instrumentation and Apparatus Used

Make	Description	Type
Abtronix	Microphone Multiplexer	
EDI	Microphone Power Supply Unit	
Norwegian Electronics	Multichannel Sound Level Meter	Nor850
Brüel & Kjaer	Windshields	UA0237

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	Pre Amplifiers	2669C
	Microphone Calibrator	4231
	Omnipower Sound Source	4296
Larson Davis	12mm Condenser Microphone	2560, 377A60
Oregon Scientific	Temperature & Humidity & Probe	THGR810
TOA	Graphic Equalizer	E-1231
Crown	Power Amplifier	1502
G.R.A.S	Pre Amplifier	26AK
	Microphone	40AR

A5. References

BS EN ISO 354:2003	Measurement of sound absorption in a reverberation room.
BS EN ISO 11654:1997	Sound absorbers for use in buildings. Rating of sound absorption.
ATSM C423-01	Sound Absorption and sound Absorption Coefficients by the Reverberation Room Method.

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Appendix B – Test Procedure

Measurements of Random Incidence Sound Absorption Coefficients to BS EN ISO 354:2003 - TP14 (Plane Absorbers)

In the laboratory, random incidence sound absorption coefficients are determined from the rate of decay of a sound field in a reverberation room, with and without a test sample installed. The rate of decay is described by the time a sound field takes to decay by 60dB, known as the reverberation time.

The reverberation room is constructed from 215mm brick, which is internally plastered with a reinforced concrete roof and floor. The reverberation room is rectangular, measuring 8.3 metres long, 6.7 metres wide and 5.4 metres high. The volume is 300m^3, the total surface area, 275m^2. From the ceiling hang 10 randomly positioned diffusers, with a total surface area (for one side) of 20m^2. The room is isolated from the surrounding structure by the use of resilient mountings and seals, ensuring good acoustic isolation.

Using at least two omnidirectional loudspeaker positions, broad band random noise is produced in the room using an electronic generator and power amplifier. When the amplification system is switched off, the decay of sound is filtered into one-third octave band widths and the reverberation times measured. This process is repeated for each of six microphone positions and the values arithmetically averaged to obtain a final value for each frequency.

The sample, which has an area between 10m^2 and 15.7m^2, is laid on the floor of the reverberation room so that no part of it is closer than one metre from any edge of the boundaries. The procedure of measuring the reverberation times then repeated.

The sound absorption coefficients are calculated from the difference in decay rates for each frequency according to the formula:

$$a_s = \frac{A_T}{S}$$

where

a_s is the random incidence absorption coefficient
A_T is the increase in equivalent sound absorption area of the test specimen (m^2)
S is the area covered by the test specimen (m^2)

The equivalent absorption area of the test specimen is further defined as:

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$$A_T = 55.3V\left(\frac{1}{c_2 T_2} - \frac{1}{c_1 T_1}\right) - 4V(m_2 - m_1)$$

where

V	is the volume of the empty reverberation room (m^3)
c_1	is the speed of sound in the empty room (m/sec)
T_1	is the reverberation time in the empty room (sec)
m_1	is the power attenuation coefficient calculated according to ISO 9613-1 using the climatic conditions that have been present in the empty room during the measurement.

c_2, T_2 and m_2 have the same meanings as c_1, T_1 and m_1 but with the test specimen in the room.

It is occasionally found that the absorption coefficient derived in this manner reaches a value greater than unity. This is impossible, by definition, and investigation has shown that this anomaly is due to diffraction of the impinging sound waves at the edges of the sample. In practical terms this is insignificant.

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Appendix C – Measurement Uncertainty

This Appendix gives the measurement uncertainties for the various sound absorption test measurements. The measurement uncertainties have been calculated in accordance with BS EN ISO 12999-2:2020 and based on repeatability conditions with a coverage factor of k=2.

Weighted sound absorption coefficient, α_w, (according to BS EN ISO 11654)

Expanded measurement uncertainty ±0.07

1/3 octave band sound absorption coefficient measurements, α_s

Measured sound absorption coefficient, α_s																					
0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95	1.00

f, Hz	Expanded uncertainties ±U (k=2) Derived from BS EN ISO 12999-2:2020 based on repeatability conditions and a coverage factor of k=2																				
50*	n/a																				
63*	0.02	0.05	0.07	0.10	0.13	0.15	0.18	0.21	0.23	0.26	0.29	0.32	0.34	0.37	0.40	0.42	0.45	0.48	0.50	0.53	0.56
80*	0.02	0.04	0.06	0.08	0.10	0.12	0.14	0.16	0.18	0.20	0.22	0.24	0.26	0.28	0.30	0.32	0.33	0.35	0.37	0.39	0.41
100	0.02	0.03	0.05	0.06	0.08	0.09	0.10	0.12	0.13	0.15	0.16	0.18	0.19	0.21	0.22	0.23	0.25	0.26	0.28	0.29	0.31
125	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	0.10	0.12	0.13	0.14	0.15	0.16	0.17	0.18	0.19	0.20	0.21	0.22	0.23
160	0.02	0.03	0.03	0.04	0.05	0.06	0.07	0.08	0.09	0.09	0.10	0.11	0.12	0.13	0.14	0.14	0.15	0.16	0.17	0.18	0.19
200	0.02	0.02	0.03	0.04	0.04	0.05	0.06	0.06	0.07	0.08	0.08	0.09	0.10	0.10	0.11	0.12	0.12	0.13	0.14	0.14	0.15
250	0.02	0.02	0.03	0.03	0.04	0.05	0.05	0.06	0.06	0.07	0.07	0.08	0.08	0.09	0.09	0.10	0.10	0.11	0.12	0.12	0.13
315	0.02	0.02	0.03	0.03	0.04	0.04	0.05	0.05	0.05	0.06	0.06	0.07	0.07	0.08	0.08	0.09	0.09	0.09	0.10	0.10	0.11
400	0.02	0.02	0.03	0.03	0.03	0.04	0.04	0.04	0.05	0.05	0.05	0.06	0.06	0.06	0.07	0.07	0.08	0.08	0.08	0.09	0.09
500	0.02	0.02	0.02	0.03	0.03	0.03	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.07	0.07	0.07	0.08	0.08
630	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.07	0.07	0.07
800	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.07
1000	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.07
1250	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.07
1600	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.06
2000	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.07	0.07
2500	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.07	0.07
3150	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.07	0.07
4000	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.08	0.08	0.08
5000	0.07	0.07	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.09	0.09	0.09	0.10	0.10	0.10	0.10	0.10	0.10
6300*	n/a																				
8000*																					
10000*																					

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Practical sound absorption coefficient measurements, α_p

Measured practical sound absorption coefficient, α_p																					
0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95	1.00

f, Hz	Expanded uncertainties ±U (k=2) Derived from BS EN ISO 12999-2:2020 based on repeatability conditions and a coverage factor of k=2																				
63*	n/a																				
125																					
250	0.02	0.02	0.03	0.03	0.03	0.04	0.04	0.04	0.05	0.05	0.05	0.06	0.06	0.07	0.07	0.07	0.08	0.08	0.08	0.09	0.09
500	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
1000	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
2000	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
4000	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
8000*	n/a																				

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Equivalent sound absorption area of the test specimen, A_T

Measured equivalent sound absorption area, A_T, m^2																				
0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0

f, Hz	Expanded uncertainties ±U (k=2) Derived from BS EN ISO 12999-2:2020 based on repeatability conditions and a coverage factor of k=2																			
50*	n/a																			
63*	0.2	0.5	0.7	1.0	1.3	1.5	1.8	2.1	2.3	2.6	2.9	3.2	3.4	3.7	4.0	4.2	4.5	4.8	5.0	5.3	5.6
80*	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.3	3.5	3.7	3.9	4.1
100	0.2	0.3	0.5	0.6	0.8	0.9	1.0	1.2	1.3	1.5	1.6	1.8	1.9	2.1	2.2	2.3	2.5	2.6	2.8	2.9	3.1
125	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3
160	0.2	0.3	0.3	0.4	0.5	0.6	0.7	0.8	0.9	0.9	1.0	1.1	1.2	1.3	1.4	1.4	1.5	1.6	1.7	1.8	1.9
200	0.2	0.2	0.3	0.4	0.4	0.5	0.6	0.6	0.7	0.8	0.8	0.9	1.0	1.0	1.1	1.2	1.2	1.3	1.4	1.4	1.5
250	0.2	0.2	0.3	0.3	0.4	0.5	0.5	0.6	0.6	0.7	0.7	0.8	0.8	0.9	0.9	1.0	1.0	1.1	1.2	1.2	1.3
315	0.2	0.2	0.3	0.3	0.4	0.4	0.5	0.5	0.5	0.6	0.6	0.7	0.7	0.8	0.8	0.9	0.9	0.9	1.0	1.0	1.1
400	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.5	0.6	0.6	0.6	0.7	0.7	0.8	0.8	0.8	0.9	0.9
500	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.7	0.7	0.7	0.8	0.8
630	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.7	0.7	0.7
800	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.7
1000	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.7
1250	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.7
1600	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.6
2000	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.7	0.7
2500	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.7	0.7
3150	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.7	0.7	0.7	0.7	0.7	0.7
4000	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.8	0.8	0.8
5000	0.7	0.7	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.9	0.9	0.9	0.9	0.9	0.9	1.0	1.0	1.0	1.0	1.0	1.0
6300*	n/a																			
8000*																				
10000*																				

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Appendix D – Mounting Methods

Descriptions of Test Specimen Mountings for Sound Absorption Tests

BS EN ISO 354:2003 describes various test specimen mountings. The methods of mounting used for these tests are briefly described as follows:

Type A Mounting

Test specimen placed directly against a room surface. The specimen may be held in place with adhesive or mechanical fasteners providing there is no resulting air space between the specimen and room surface.

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