Technical Report

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Project

The Laboratory Determination of The Random Incidence Sound Absorption Coefficient of Various Types of Material

Prepared for

Armacell GmbH
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By

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1.0 Summary

Tests have been done in SRL's Laboratory at Holbrook House, Sudbury, Suffolk, to determine the sound absorption coefficient of various types of absorbent material in accordance with BS EN ISO 354:2003.

From these measurements the required results have been derived and are presented in both tabular and graphic form in Data Sheets 1 to 3.

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.

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Contents

2.0 Details of Measurements

2.1 Location

Sound Research Laboratories Ltd
Holbrook House
Little Waldingfield
Sudbury
Suffolk
CO10 OTH

2.2 Test Dates

6 September 2010

2.3 Instrumentation and Apparatus Used

Make	Description	Type
E D I	Microphone Multiplexer	
	Microphone Power Supply Unit	
Norwegian Electronics	Real Time Analyser	830
Brüel & Kjaer	12mm Condenser Microphones	4166
	Windshields	UA0237
	Pre Amplifiers	2639, 2669C
	Microphone Calibrator	4231
	Omnipower Sound Source	4296
Larson Davis	12mm Condenser Microphone	2560
Darton	Fortin Barometer	P411
TOA	Graphic Equalizer	E-1231
	Power Amplifier	DPA-800

2.4 References

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
BS EN ISO 354:2003	Measurement of sound absorption in a reverberation room

2.5 Personnel Present

Mark Swift	Armacell UK Ltd

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3.0 Description of Test

3.1 Description of Sample

Various thicknesses of material were tested, see section 4.0 for details.

Sampling plan:	Correct quantities of sample supplied
Sample condition:	New
Details supplied by:	Armacell GmbH
Sample installed by:	Armacell UK Ltd

3.2 Sample Delivery date

2 September 2010

3.3 Test Procedures

The sample was mounted/located and tested in accordance with the relevant standard. The method and procedure is described in Appendix 1 and Appendix 2.

4.0 Results

The results of the measurements and subsequent analysis are given in Data Sheets 1 to 3, summarised below.

Results relate only to the items tested.

SRL Test No.	Description in Brief	α_w
8	AF Armaflex 10mm thick	0.10(H)
9	AF Armaflex 25mm thick	0.30(M)
10	AF Armaflex 32mm thick	0.45(M)

______________________ *End of Text* ______________________

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Data Sheet 1

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

Client: Armacell GmbH
Test Date: 06/09/2010
Empty Room: **Temperature:** 18.5 °C **Humidity:** 60 %RH **Pressure:** 1008 mbar
Room with Sample: **Temperature:** 19.0 °C **Humidity:** 58 %RH **Pressure:** 1008 mbar
Sample Description: AF Armaflex 10mm thick
Mounting Method: A
Sample Area: 12.12 m2
Chamber Volume: 300 m3

	Test 8			
Freq Hz	T1 sec	T2 sec	Absorp Coeff	Practical Absorp Coeff #
*50**	*4.90*	*5.05*	*-0.02*	
*63**	*4.88*	*4.95*	*-0.01*	*n/a*
*80**	*6.07*	*6.16*	*-0.01*	
100	7.44	7.25	0.01	
125	7.83	8.10	-0.02	0.00
160	7.21	7.04	0.01	
200	7.66	7.57	0.01	
250	7.89	7.74	0.01	0.00
315	8.07	7.60	0.03	
400	7.35	7.09	0.02	
500	5.77	5.39	0.05	0.05
630	5.22	4.92	0.04	
800	5.74	5.34	0.05	
1000	6.45	5.59	0.09	0.10
1250	6.23	5.39	0.10	
1600	5.66	4.76	0.13	
2000	5.10	4.20	0.16	0.15
2500	4.54	3.66	0.21	
3150	3.79	2.98	0.28	
4000	3.13	2.44	0.35	0.30
5000	2.54	2.09	0.33	
*6300**	*1.81*	*1.64*	*0.21*	
*8000**	*1.36*	*1.28*	*0.16*	*n/a*
*10000**	*0.97*	*0.97*	*-0.04*	

α_w 0.10(H)

Not Classified

Calculated to EN ISO 11654:1997

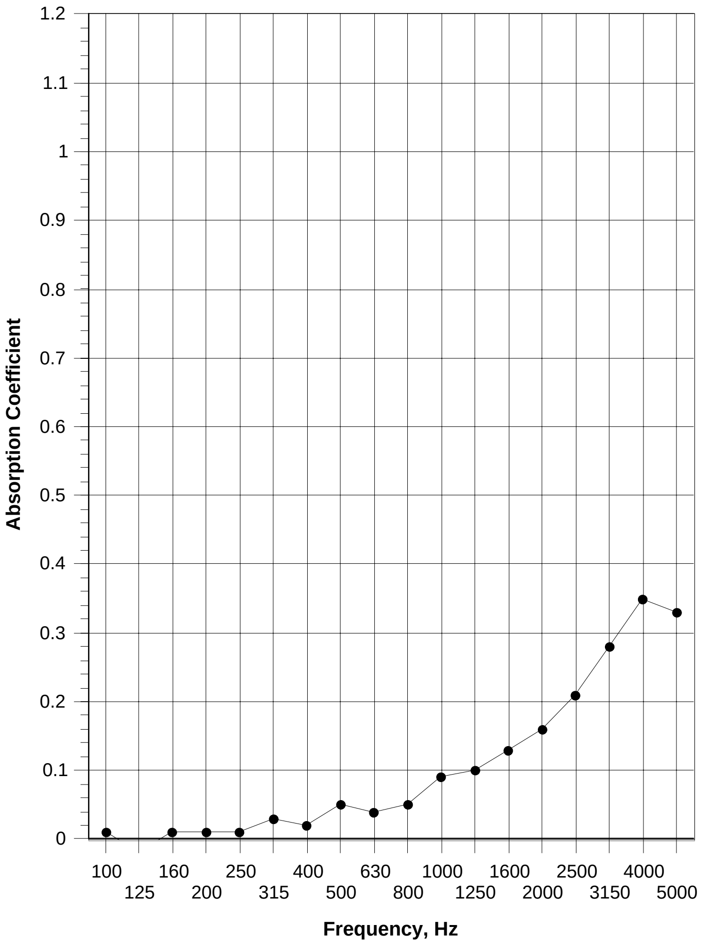
NRC 0.10

Calculated to ASTM C 423-01

** Denotes frequencies outside the range covered by BS EN ISO 354:2003*

T1, empty room reverberation time
T2, room reverberation time with sample

Sound Absorption Coefficient



Practical absorption coefficient, BS EN ISO 11654:1997

v3.1

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Data Sheet 2

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

Client: Armacell GmbH

Test Date: 06/09/2010

Empty Room: **Temperature:** 18.5 °C **Humidity:** 60 %RH **Pressure:** 1008 mbar

Room with Sample: **Temperature:** 19.0 °C **Humidity:** 58 %RH **Pressure:** 1008 mbar

Sample Description: AF Armaflex 25mm thick

Mounting Method: A

Sample Area: 12.23 m2

Chamber Volume: 300 m3

	Test 9			
Freq Hz	**T1 sec**	**T2 sec**	**Absorp Coeff**	**Practical Absorp Coeff #**
*50**	*4.90*	*4.94*	*-0.01*	
*63**	*4.88*	*5.48*	*-0.09*	*n/a*
*80**	*6.07*	*5.69*	*0.04*	
100	7.44	6.46	0.08	
125	7.83	7.77	0.00	0.05
160	7.21	6.28	0.08	
200	7.66	6.84	0.06	
250	7.89	6.82	0.08	0.10
315	8.07	6.35	0.13	
400	7.35	5.56	0.17	
500	5.77	4.00	0.30	0.30
630	5.22	3.34	0.43	
800	5.74	3.07	0.60	
1000	6.45	3.03	0.69	0.60
1250	6.23	3.39	0.53	
1600	5.66	3.72	0.36	
2000	5.10	3.74	0.28	0.30
2500	4.54	3.35	0.31	
3150	3.79	2.88	0.32	
4000	3.13	2.57	0.27	0.25
5000	2.54	2.22	0.21	
*6300**	*1.81*	*1.67*	*0.17*	
*8000**	*1.36*	*1.25*	*0.23*	*n/a*
*10000**	*0.97*	*0.91*	*0.23*	

α_w 0.30(M)

Class D

Calculated to EN ISO 11654:1997

NRC 0.35

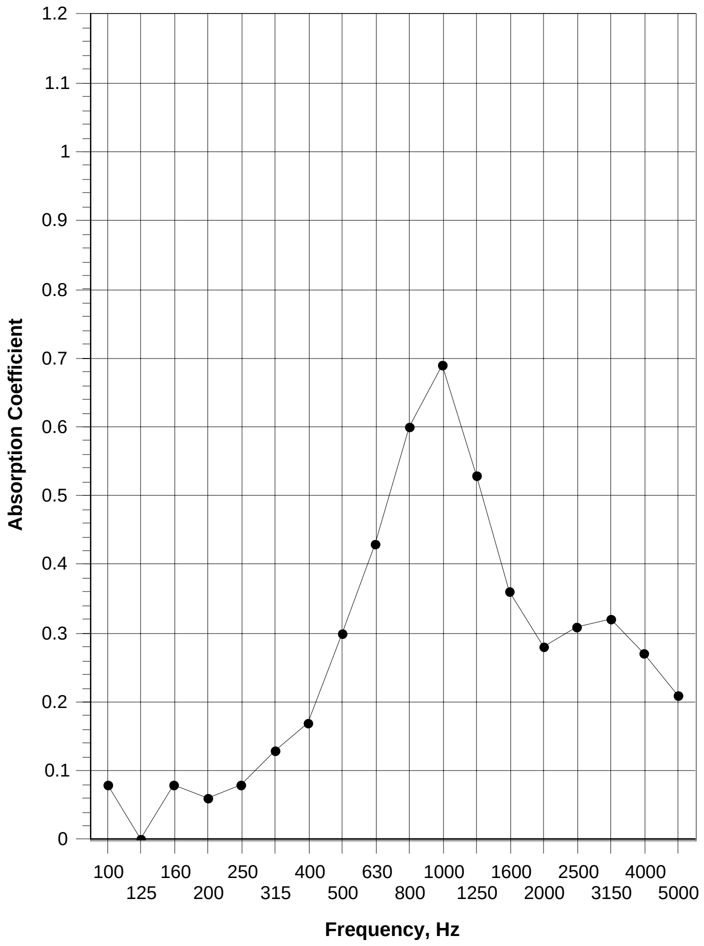
Calculated to ASTM C 423-01

** Denotes frequencies outside the range covered by BS EN ISO 354:2003*

T1, empty room reverberation time

T2, room reverberation time with sample

Sound Absorption Coefficient



Practical absorption coefficient, BS EN ISO 11654:1997

v3.1

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Data Sheet 3

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

Client: Armacell GmbH
Test Date: 06/09/2010
Empty Room: **Temperature:** 18.5 °C **Humidity:** 60 %RH **Pressure:** 1008 mbar
Room with Sample: **Temperature:** 18.7 °C **Humidity:** 62 %RH **Pressure:** 1005 mbar
Sample
Description: AF Armaflex 32mm thick
Mounting Method: A
Sample Area: 12.76 m2
Chamber Volume: 300 m3

	Test 10			
Freq Hz	**T1 sec**	**T2 sec**	**Absorp Coeff**	**Practical Absorp Coeff #**
*50**	*4.90*	*4.73*	*0.03*	
*63**	*4.88*	*4.84*	*0.01*	*n/a*
*80**	*6.07*	*5.92*	*0.02*	
100	7.44	6.41	0.08	
125	7.83	7.14	0.05	0.10
160	7.21	5.88	0.12	
200	7.66	5.67	0.17	
250	7.89	5.26	0.24	0.25
315	8.07	4.51	0.37	
400	7.35	3.47	0.58	
500	5.77	2.44	0.90	0.75
630	5.22	2.47	0.81	
800	5.74	3.22	0.52	
1000	6.45	3.82	0.40	0.40
1250	6.23	3.96	0.35	
1600	5.66	3.41	0.44	
2000	5.10	3.12	0.47	0.45
2500	4.54	3.09	0.40	
3150	3.79	2.82	0.35	
4000	3.13	2.43	0.37	0.35
5000	2.54	2.08	0.36	
*6300**	*1.81*	*1.58*	*0.35*	
*8000**	*1.36*	*1.22*	*0.40*	*n/a*
*10000**	*0.97*	*0.91*	*0.37*	

α_w 0.45(M)

Class D

Calculated to EN ISO 11654:1997

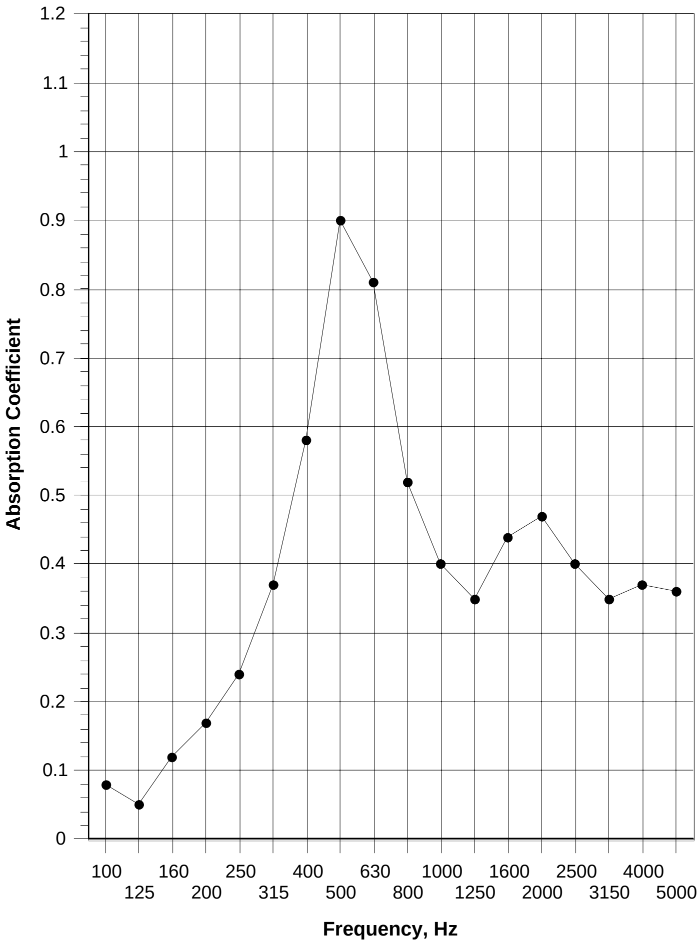
NRC 0.50

Calculated to ASTM C 423-01

** Denotes frequencies outside the range covered by BS EN ISO 354:2003*

T1, empty room reverberation time
T2, room reverberation time with sample

Sound Absorption Coefficient



Practical absorption coefficient, BS EN ISO 11654:1997

v3.1

Appendix 1

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 room is rectangular and has a volume of 300 cubic metres and a total surface area of 275m^2. From the ceiling hang 10 randomly positioned diffusers, each measuring 1.2m x 2.14m. 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 area should normally be between 10m^2 and 15.7m^2, this may be larger if it is suspected that the absorption properties will be low. The sample 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)

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

$$A_T = 55.3V\left(\frac{1}{c_2T_2} - \frac{1}{c_1T_1}\right) - 4V\,(m_2 - m_1)$$

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 rooms 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.

Appendix 2

Measurement Uncertainty
BS EN ISO 354:2003 - TP14

1. Introduction

The estimated values of uncertainty are based on a standard uncertainty multiplied by a coverage factor of K = 2, which provides a level of confidence of approximately 95%.

Table 1: Uncertainty For Equivalent Absorption Area Measurement

Frequency, Hz	**Expanded uncertainty K = 2, 95% % of A_1 or A_2**
100	9.0
125	8.1
160	5.6
200	6.7
250	4.3
315	8.1
400	4.6
500	5.0
630	5.3
800	3.2
1000	3.5
1250	3.1
1600	2.8
2000	2.7
2500	2.2
3150	1.8
4000	1.6
5000	1.6

2. Estimation of Expanded Uncertainty For Sample Equivalent Sound Absorption Area

The expanded uncertainty, U_A,m^2 is estimated by using the following formulae:-

$$U_A = \sqrt{\left(\frac{uA_1}{100}\right)^2 + \left(\frac{uA_2}{100}\right)^2}$$

where U_A is the expanded uncertainty for the sample equivalent sound absorption area, for K = 2, 95%, m^2

u is the estimated expanded uncertainty for the equivalent sound absorption area, taken from Table 1 above, K = 2, 95%, % of A_1 or A_2

A_1 is the equivalent sound absorption area of the empty room, m^2

A_2 is the equivalent sound absorption area of the room with the sample, m^2

3. Estimation of expanded Uncertainty For Sound Absorption Coefficients

The expanded uncertainty for sound absorption coefficients, U_{α_s}, is estimated using the following formulae:-

$$U_{\alpha_s} = \frac{\alpha_s U_A}{A}$$

where U_{α_s} is the expanded uncertainty for sound absorption coefficients, K=2, 95%

α_s is the sound absorption coefficient

U_A is the expanded uncertainty for the sample equivalent sound absorption area, K=2, 95%, m^2

A is the sample equivalent sound absorption area, m^2

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