

Sounds Of Science Oü  
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## Determination of sound absorption coefficients in a reverberation room according to ISO 354 and ISO 11654

(1 appendix)

### Client

Sounds Of Science Oü

### Test object

Sound absorption panel type Hertz was tested. The test object is listed in table 1 and further described in the enclosure. Pictures of test object and its mounting is shown on page 3.

### Arrival of the test objects

September 17, 2014

### Date of test

September 24, 2014

### Results

The sound absorption coefficient ( $\alpha_s$ ) and the practical sound absorption coefficient ( $\alpha_p$ ) are given in enclosure 1. The weighted sound absorption coefficient ( $\alpha_w$ ) and the sound absorption classes have been calculated according to ISO 11654 and the results are given in table 1.

Table 1 – Summary of results

Test object:	ISO 11654		Enclosure
	Absorption class	$\alpha_w$	
<b>Hertz 43</b> Thickness: 43 mm Panel size: 1500 x 1000 mm Mounting depth: 68 mm	A	1	1

The results are valid for tested objects only.

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### Measurement method

The measurements have been carried out according to ISO 354:2003, which is equivalent to EN ISO 354 and SS-EN ISO 354. The evaluation has been carried out according to ISO 11654, which is equivalent to EN ISO 11654 and SS-EN ISO 11654. 4 loudspeaker positions and 6 microphone positions have been used giving 24 different combinations for the reverberation time measurements. For empty room 3 decays have been used for averaging the time and for test objects 5 decays have been used, for each combination of loudspeaker and microphone.

The absorption coefficient  $\alpha_s$  has been evaluated from:

$$\alpha_s = \frac{55.3 V}{c \cdot S} \left( \frac{1}{T_2} - \frac{1}{T_1} \right)$$

where

- V = Volume of the reverberation room (m<sup>3</sup>)
- S = Area of the test object (m<sup>2</sup>)
- c = Speed of sound in air (m/s)
- c = 331 + 0.6t
- t = Temperature in the air (°C)
- T<sub>1</sub> = Reverberation time of the room without test object (s)
- T<sub>2</sub> = Reverberation time of the room with test object (s)

### Measurement uncertainty

From a world wide Round Robin <sup>1)</sup>, in which SP took part, with 23 participating laboratories from 11 countries, the measurement uncertainties in table 2 has been calculated.

Table 2 – Measurement uncertainty

Frequencies (Hz)	Uncertainty <sup>1)</sup>
100-630	± 0,15
800-1250	± 0,10
1600-2500	± 0,15
3150-5000	± 0,20

<sup>1)</sup> The figures are calculated from twice the standard deviations, rounded to the nearest 0,05. The data from the Round Robin is documented in a letter from the ASTM to the participating laboratories.

## Pictures of the test object



*Picture 1 – Test object mounted in the reverberation room.*



*Picture 2 – A wooden frame was mounted around the test object and sealed with tape against the floor.*

## Test room

A reverberation room with the dimensions 7,64 m x 6,16 m x 4,25 m giving the volume 200 m<sup>3</sup> and the total surface area 211 m<sup>2</sup> was used.

## Mounting

The panels were placed at the centre of the reverberation room at least 1 m from the walls and not parallel with the walls. The edges of the test objects were sealed with a wooden frame and tape (made of an elastic woven material) to prevent air leakage. The mounting depth is the distance between the floor and the front surface (upper) of the test objects.

## Additional results

The following results are for information only and lies outside the accreditation. The results are determined in the same way as the results in enclosure 1 and table 1.

Test object: Herz 43

The test object is further described in enclosure 1.

*Table 3 – Sound absorption coefficient and practical sound absorption coefficient, for information only.*

Frequency (Hz)	$\alpha_s$	$\alpha_p$
6300	0,9	
8000	0,9	0,9
10000	0,9	

**List of instruments**

<b>Instrument</b>	<b>Manufacturer</b>	<b>Type</b>	<b>Serial no</b>
Microphone	Brüel & Kjaer	4943	2749979
Microphone	Brüel & Kjaer	4943	2206273
Microphone	Brüel & Kjaer	4943	2206274
Microphone	Brüel & Kjaer	4943	2206276
Microphone	Brüel & Kjaer	4943	2206277
Microphone	Brüel & Kjaer	4943	2206278
Microphone Preamplifier	Brüel & Kjaer	2619	726624
Microphone Preamplifier	Brüel & Kjaer	2619	970865
Microphone Preamplifier	Brüel & Kjaer	2619	469905
Microphone Preamplifier	Brüel & Kjaer	2619	726792
Microphone Preamplifier	Brüel & Kjaer	2619	726818
Microphone Preamplifier	Brüel & Kjaer	2619	970968
Microphone Multiplexer	Norsonic	834	10050
Real-Time Analyzer	Norsonic	830	11533
Sound Level Calibrator	Brüel & Kjaer	4230	1411048
Programme	SP	Absorp 960627	
Power amplifier	PA1		
Noise generator	NG1 ( white noise )		
Loudspeakers	SP	HGT2, HGT7, HGT4, HGTtak	
Hygrometer/ Temperature meter	Testo	615	502233

**SP Technical Research Institute of Sweden  
Energy Technology - Acoustics**

Performed by

Examined by

Malin Lindgren

Krister Larsson

**Appendix**

Appendix 1

**Measurement of sound absorption coefficient**

Test Measurement of sound absorption coefficient in a reverberation room according to EN ISO 354 and evaluation according to EN ISO 11654

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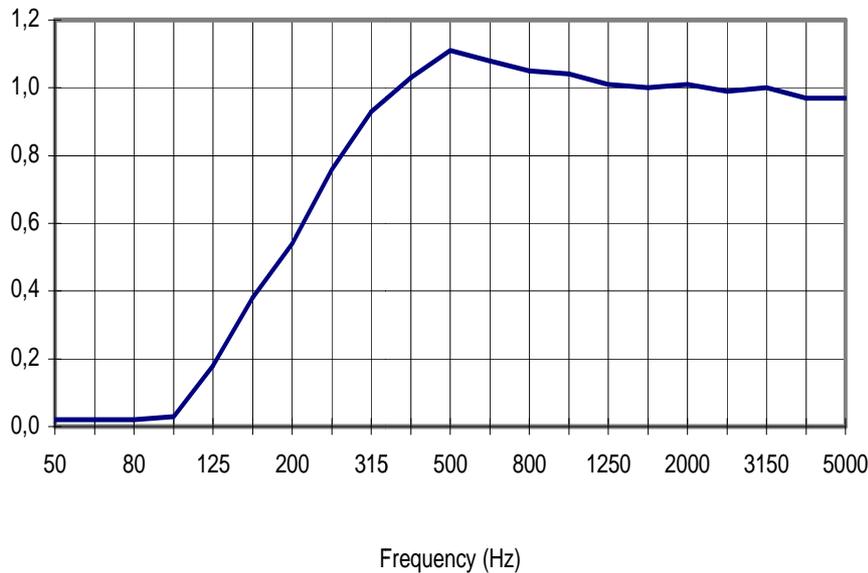
Object Hertz 43  
 Thickness: 43 mm  
 Panel size: 1500 mm x 1000 mm  
 Structure: Frame out of wood 43 x 15 mm (depth x thickness)  
 Polyester sheet 3225 g/m<sup>2</sup>, thickness 43 mm (in frame)  
 Panels were mounted contiguous

Date of test September 24, 2014

Conditions Mounting depth: 68 mm  
 Surface area: 12 m<sup>2</sup>  
 Room volume: 200 m<sup>3</sup>  
 Temperature at measurement on object/in empty room: 22/ 22 °C  
 Relative humidity at measurement on object/in empty room: 86/ 84 %

Result Sound absorption class **A**  
 Weighted sound absorption coefficient  $\alpha_w = 1$

Sound absorption coefficient



Frequency (Hz)	$\alpha_s$
50	0,02
63	0,02
80	0,02
100	0,03
125	0,18
160	0,38
200	0,54
250	0,76
315	0,93
400	1,03
500	1,11
630	1,08
800	1,05
1000	1,04
1250	1,01
1600	1,00
2000	1,01
2500	0,99
3150	1,00
4000	0,97
5000	0,97

Appendix 1

**Measurement of sound absorption coefficient**

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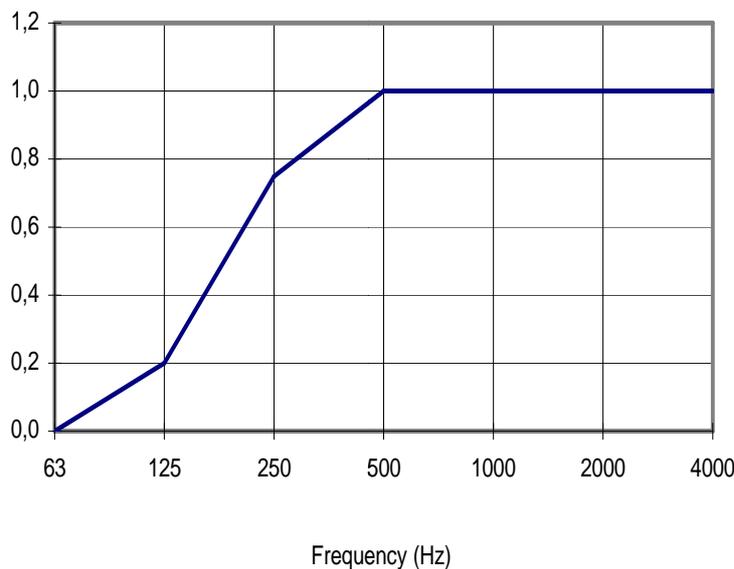
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 Temperature at measurement on object/in empty room: 22/ 22 °C  
 Relative humidity at measurement on object/in empty room: 86/ 84 %

Result Sound absorption class **A**.  
 Weighted sound absorption coefficient  $\alpha_w = 1$ .

Practical sound absorption coefficient



Frequency (Hz)	$\alpha_p$
63	0,00
125	0,20
250	0,75
500	1,00
1000	1,00
2000	1,00
4000	1,00