



# REPORT

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## Determination of sound absorption coefficients in a reverberation room according to ISO 354, EN 20354, EN ISO 11654

(4 appendices)

### Test object

Sound absorptive wool material delivered by ACQWOOL Innovation

### Date of test

April 20, 2007

### Arrival of test objects

April 2007

### Results

The sound absorption coefficient ( $\alpha_s$ ) and the practical sound absorption coefficient ( $\alpha_p$ ) are given in enclosure 1-4. The weighted sound absorption coefficient ( $\alpha_w$ ) and the sound absorption classes have been calculated according to EN ISO 11654. and the results are given in table 1. The results are valid for tested objects only.

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*Table 1 – Summary of results*

Test object:	EN ISO 11654		Enclosure
	Absorption class	$\alpha_w$	
<b>Double</b> Thickness: 10 mm. Mounting depth: 80 mm.	C	0,60(MH)	1
<b>Compact</b> Thickness: 7 mm. Mounting depth: 80 mm.	D	0,55(MH)	2
<b>Compact</b> Thickness: 7 mm. Mounting depth: 160 mm.	B	0,85	3
<b>Double</b> Thickness: 10 mm. Mounting depth: 160 mm.	B	0,85	4

### Measurement method

The measurements have been carried out according to SS-EN 20354:93 (ISO 354: 1985). 4 loudspeakers and 6 microphones have been used giving 24 different combinations. 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 following measurement uncertainty has been calculated

<b>Frequencies</b>	
<b>(Hz)</b>	<b>Uncertainty</b>
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.

### 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 on the floor in a frame with size 3 x 3,6 m. The edges were sealed with a wooden frame and a 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.

**List of instruments**

<b>Instrument</b>	<b>Manufacturer</b>	<b>Type</b>	<b>Serial no</b>
Microphone	Brüel & Kjaer	4943	2206272
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	726805
Microphone Preamplifier	Brüel & Kjaer	2619	970948
Microphone Preamplifier	Brüel & Kjaer	2619	469905
Microphone Preamplifier	Brüel & Kjaer	2619	726792
Microphone Preamplifier	Brüel & Kjaer	2619	726825
Microphone Preamplifier	Brüel & Kjaer	2619	970968
Microphone Multiplexer	Norsonic	834	10050
Real-Time Analyzer	Norsonic	830	11533
Sound Level Calibrator	Brüel & Kjaer	4230	1410947
Programme	SP	Absorp	960627
Power amplifier	PA1		
Noise generator	NG1 ( white noise )		
Loudspeakers	SP	HGT2, HGT7, HGT4, HGTtak	
Hygrometer	Vaisala	HM 132	42154
Temperature meter	Vaisala	HM 132	42154

**SP Sveriges Tekniska Forskningsinstitut  
Energy Technology - Acoustics**


 Hans Jonasson  
Technical Manager



 Mohammad Jalalian  
Technical Officer

**Appendices**

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

Client ACQWOOL Innovation  
Lars Karlsson

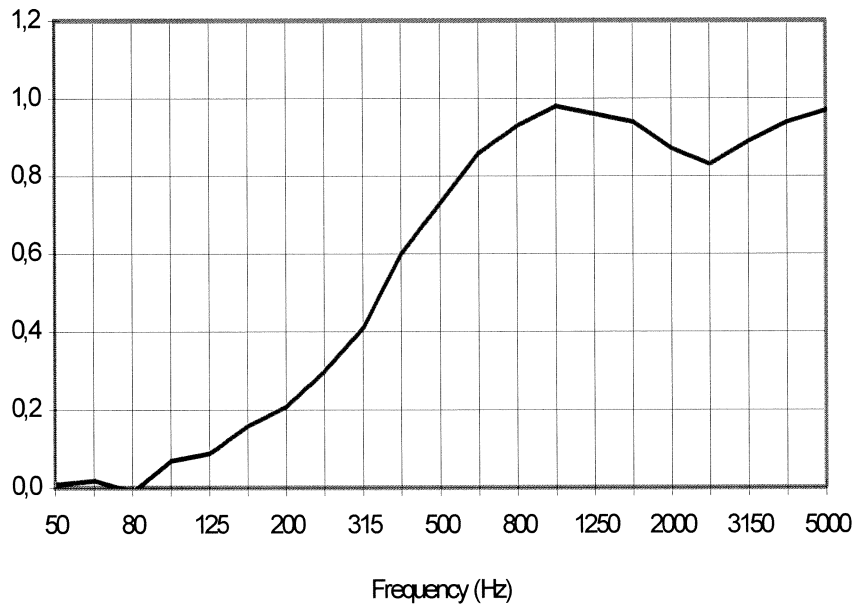
Object Double  
Thickness: 10 mm.  
Sample size: 600 mm x 3600 mm.

Date of test April 20, 2007

Conditions Mounting depth: 80 mm.  
Surface area: 10,8 m<sup>2</sup>.  
Room volume: 200 m<sup>3</sup>.  
Temperature at measurement on object/in empty room: 21/ 21 °C.  
Relative humidity at measurement on object/in empty room: 74/ 74 %.

Result Sound absorption class C.  
Weighted sound absorption coefficient  $\alpha_w = 0,6(\text{MH})$ .

Sound absorption coefficient



Frequency (Hz)	$\alpha_s$
50	0,01
63	0,02
80	-0,01
100	0,07
125	0,09
160	0,16
200	0,21
250	0,30
315	0,41
400	0,60
500	0,73
630	0,86
800	0,93
1000	0,98
1250	0,96
1600	0,94
2000	0,87
2500	0,83
3150	0,89
4000	0,94
5000	0,97

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

Client ACQWOOL Innovation  
Lars Karlsson

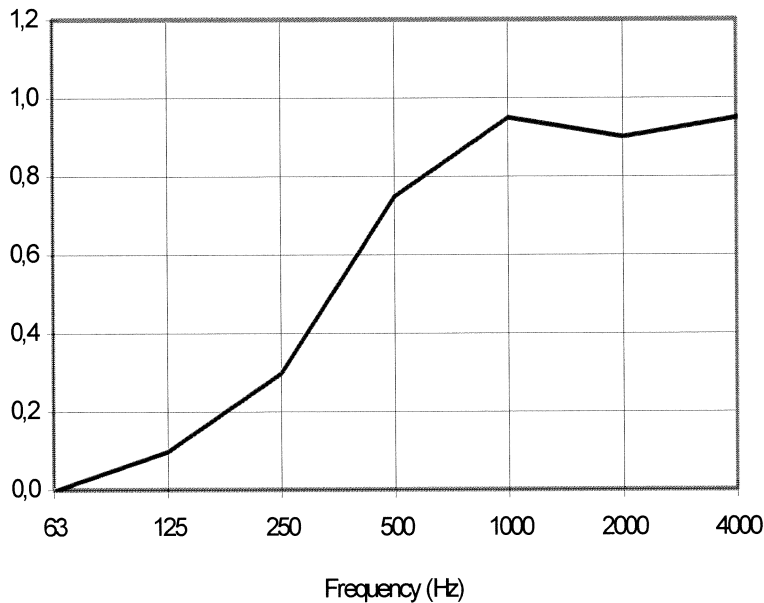
Object Double  
Thickness: 10 mm.  
Samole size: 600 mm x 3600 mm.

Date of test April 20, 2007

Conditions Mounting depth: 80 mm.  
Surface area: 10,8 m<sup>2</sup>.  
Room volume: 200 m<sup>3</sup>.  
Temperature at measurement on object/in empty room: 21/ 21 °C.  
Relative humidity at measurement on object/in empty room: 74/ 74 %.

Result Sound absorption class C.  
Weighted sound absorption coefficient  $\alpha_w = \mathbf{0,6(MH)}$ .

Practical sound absorption coefficient



Frequency (Hz)	$\alpha_p$
63	0,00
125	0,10
250	0,30
500	0,75
1000	0,95
2000	0,90
4000	0,95

Appendix 2

**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

Client ACQWOOL Innovation  
Lars Karlsson

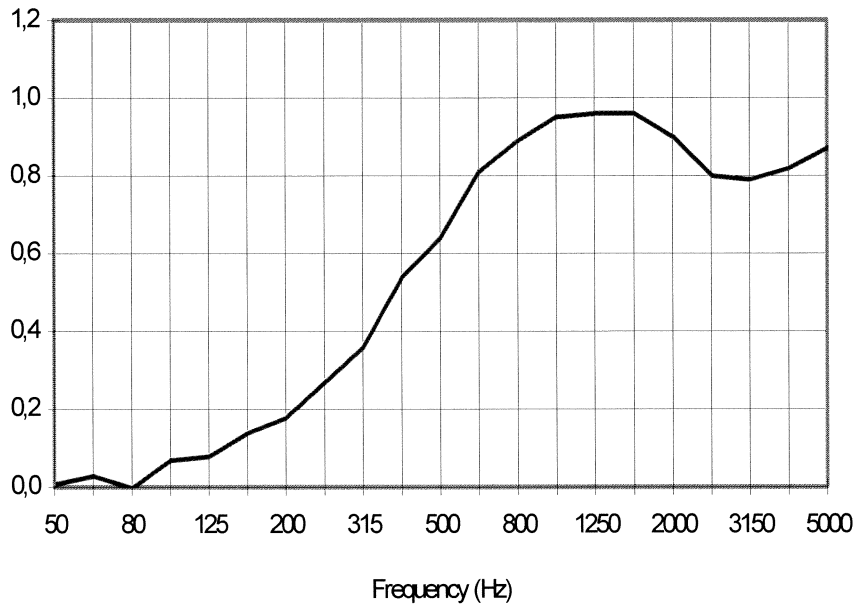
Object Compact  
Thickness: 7 mm.  
Sample size: 600 mm x 3600 mm.

Date of test April 20, 2007

Conditions Mounting depth: 80 mm.  
Surface area: 10,8 m<sup>2</sup>.  
Room volume: 200 m<sup>3</sup>.  
Temperature at measurement on object/in empty room: 21/ 21 °C.  
Relative humidity at measurement on object/in empty room: 74/ 74 %.

Result Sound absorption class **D**.  
Weighted sound absorption coefficient  $\alpha_w = 0,55(\text{MH})$ .

Sound absorption coefficient



Frequency (Hz)	$\alpha_s$
50	0,01
63	0,03
80	0,00
100	0,07
125	0,08
160	0,14
200	0,18
250	0,27
315	0,36
400	0,54
500	0,64
630	0,81
800	0,89
1000	0,95
1250	0,96
1600	0,96
2000	0,90
2500	0,80
3150	0,79
4000	0,82
5000	0,87

Appendix 2

**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

Client ACQWOOL Innovation  
Lars Karlsson

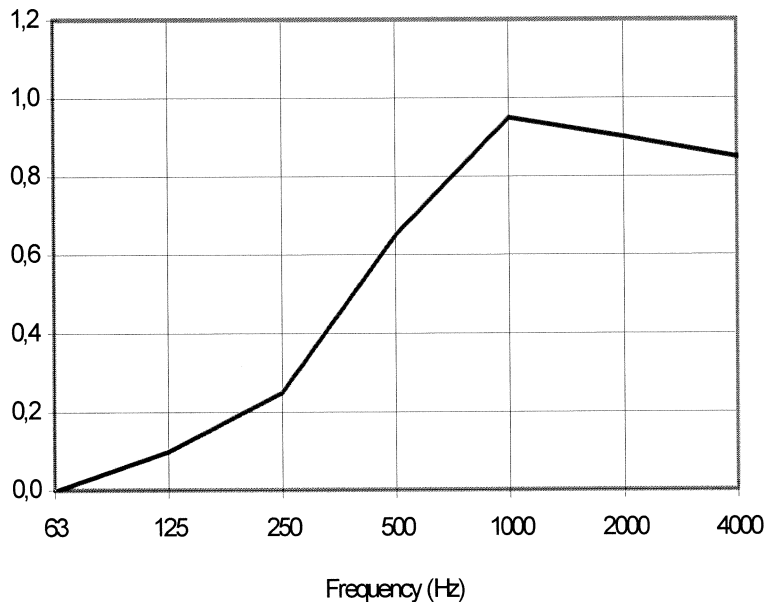
Object Compact  
Thickness: 7 mm.  
Sample size: 600 mm x 3600 mm.

Date of test April 20, 2007

Conditions Mounting depth: 80 mm.  
Surface area: 10,8 m<sup>2</sup>.  
Room volume: 200 m<sup>3</sup>.  
Temperature at measurement on object/in empty room: 21/ 21 °C.  
Relative humidity at measurement on object/in empty room: 74/ 74 %.

Result Sound absorption class **D**.  
Weighted sound absorption coefficient  $\alpha_w = 0,55(\text{MH})$ .

Practical sound absorption coefficient



Frequency (Hz)	$\alpha_p$
63	0,00
125	0,10
250	0,25
500	0,65
1000	0,95
2000	0,90
4000	0,85

Appendix 3

**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

Client ACQWOOL Innovation  
Lars Karlsson

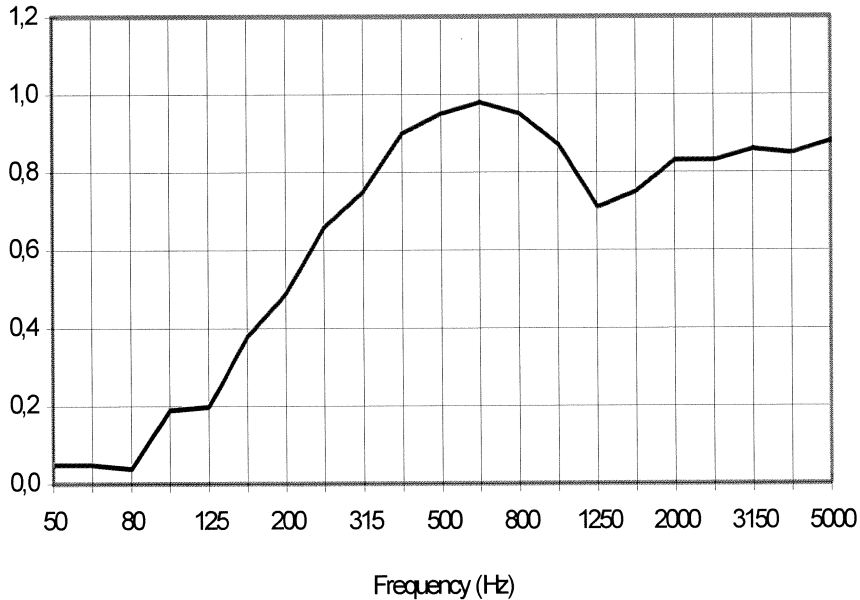
Object Compact  
Thickness: 7 mm.  
Sample size: 600 mm x 3600 mm.

Date of test April 20, 2007

Conditions Mounting depth: 160 mm.  
Surface area: 10,8 m<sup>2</sup>.  
Room volume: 200 m<sup>3</sup>.  
Temperature at measurement on object/in empty room: 21/ 21 °C.  
Relative humidity at measurement on object/in empty room: 74/ 74 %.

Result Sound absorption class **B**.  
Weighted sound absorption coefficient  $\alpha_w = 0,85$ .

Sound absorption coefficient



Frequency (Hz)	$\alpha_s$
50	0,05
63	0,05
80	0,04
100	0,19
125	0,20
160	0,38
200	0,49
250	0,66
315	0,75
400	0,90
500	0,95
630	0,98
800	0,95
1000	0,87
1250	0,71
1600	0,75
2000	0,83
2500	0,83
3150	0,86
4000	0,85
5000	0,88

Appendix 3

**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

**Client** ACQWOOL Innovation  
Lars Karlsson

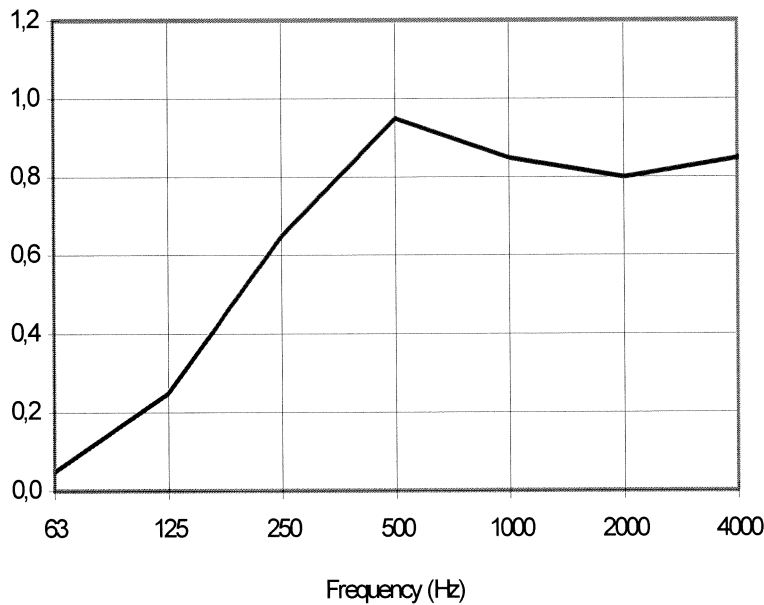
**Object** Compact  
Thickness: 7 mm.  
Panel size: 600 mm x 3600 mm.

**Date of test** April 20, 2007

**Conditions** Mounting depth: 160 mm.  
Surface area: 10,8 m<sup>2</sup>.  
Room volume: 200 m<sup>3</sup>.  
Temperature at measurement on object/in empty room: 21/ 21 °C.  
Relative humidity at measurement on object/in empty room: 74/ 74 %.

**Result** Sound absorption class **B**.  
Weighted sound absorption coefficient  $\alpha_w = \mathbf{0,85}$ .

Practical sound absorption coefficient



Frequency (Hz)	$\alpha_p$
63	0,05
125	0,25
250	0,65
500	0,95
1000	0,85
2000	0,80
4000	0,85

Appendix 4

**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

**Client** ACQWOOL Innovation  
Lars Karlsson

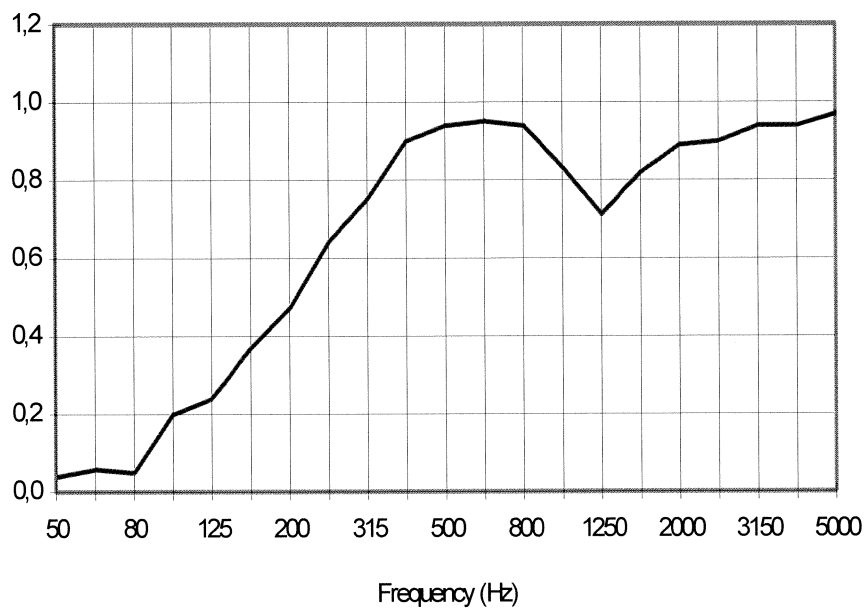
**Object** Double  
Thickness: 10 mm.  
Panel size: 600 mm x 3600 mm.

**Date of test** April 20, 2007

**Conditions** Mounting depth: 160 mm.  
Surface area: 10,8 m<sup>2</sup>.  
Room volume: 200 m<sup>3</sup>.  
Temperature at measurement on object/in empty room: 21/ 21 °C.  
Relative humidity at measurement on object/in empty room: 74/ 74 %.

**Result** Sound absorption class **B**.  
Weighted sound absorption coefficient  $\alpha_w = 0,85$ .

Sound absorption coefficient



Frequency (Hz)	$\alpha_s$
50	0,04
63	0,06
80	0,05
100	0,20
125	0,24
160	0,37
200	0,47
250	0,64
315	0,75
400	0,90
500	0,94
630	0,95
800	0,94
1000	0,83
1250	0,71
1600	0,82
2000	0,89
2500	0,90
3150	0,94
4000	0,94
5000	0,97

Appendix 4

**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

Client ACQWOOL Innovation  
Lars Karlsson

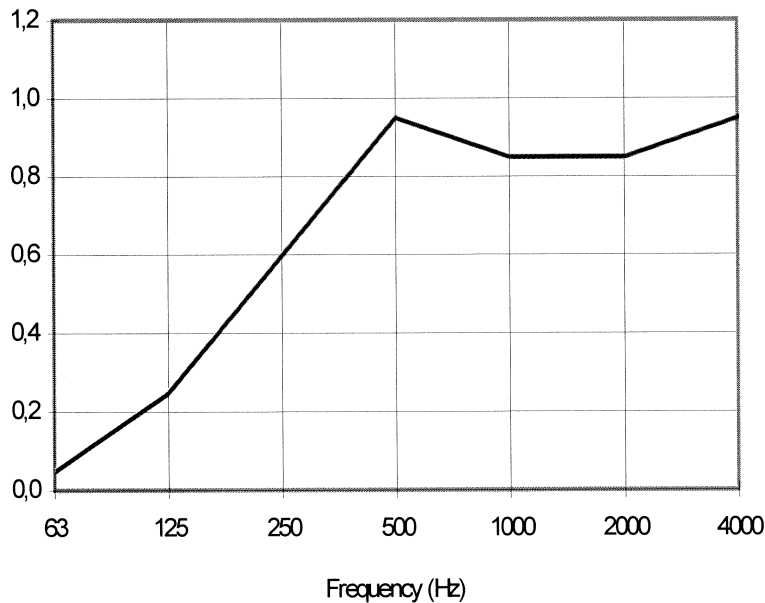
Object Double  
Thickness: 10 mm.  
Panel size: 600 mm x 3600 mm.

Date of test April 20, 2007

Conditions Mounting depth: 160 mm.  
Surface area: 10,8 m<sup>2</sup>.  
Room volume: 200 m<sup>3</sup>.  
Temperature at measurement on object/in empty room: 21/ 21 °C.  
Relative humidity at measurement on object/in empty room: 74/ 74 %.

Result Sound absorption class **B**.  
Weighted sound absorption coefficient  $\alpha_w = 0,85$ .

Practical sound absorption coefficient



Frequency (Hz)	$\alpha_p$
63	0,05
125	0,25
250	0,60
500	0,95
1000	0,85
2000	0,85
4000	0,95