REPORT
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Determination of sound absorption coefficients in a reverberation room according to ISO 354 and ISO 11654

(4 appendices)

This report has been revised regarding the object names and replacing the previous report P906749

Client

AH Production AB

Test object

Sound absorption panels delivered by AH Production AB. The test objects are shown in pictures 1-4.

The test objects Dalhem Ribba Ceiling 38 x 38 mm and Dalhem Ribba Ceiling 22 x 38 mm consist of three different layers; 1200 x 600 mm absorption panels (Ceiling panels thickness 40 mm density approximately 70 kg/m3), MDF board 2400 x 20 x 20 (600 mm c/c) and different sizes Dalhem Ribba with gypsum core covered with veneer.

Dalhem Parawood 3000 x 84 x 19 mm consists of 1200 x 600 mm absorption panels (Ceiling panels thickness 40 mm density approximately 70 kg/m3), MDF board 2400 x 20 x 20 (600 mm c/c) and aluminium profiles covered with veneer.

Dalhem Ribba Wall 28 x 38 mm consists of two layers; 1200 x 600 mm absorption panels (Ceiling panels thickness 40 mm density approximately 70 kg/m3) and Dalhem Ribba with gypsum core covered with veneer.

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Arrival of test objects

Oct 29, 2009

Date of test

Oct 29, 2009

Results

The sound absorption coefficient (α_S) and the practical sound absorption coefficient (α_p) are given in enclosures 1-4. The weighted sound absorption coefficient (α_W) and the sound absorption classes have been calculated according to ISO 11654 and the results are given in table 1.
The results are valid for tested objects only.

Table 1 – Summary of results

Test object:	ISO 11654		Enclosure
	Absorption class	α_W	
Dalhem Ribba Ceiling38 x 38 mm Thickness: 98 mm. Spacing 12 mm. Mounting depth: 98 mm.	C	0,65(LM)	1
Dalhem Ribba Ceiling 22 x 38 mm Thickness: 82 mm. Spacing 12 mm. Mounting depth: 82 mm.	C	0,65(LM)	2
Dalhem Parawood 84 x19 Thickness: 79 mm. Spacing 16 mm. Mounting depth: 79 mm.	D	0,4(LM)	3
Dalhem Ribba Wall 28 x 38 mm Thickness: 68 mm. Spacing 22 mm. Mounting depth: 68 mm.	B	0,8	4

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 α_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^3)
S	=	Area of the test object (m^2)
c	=	Speed of sound in air (m/s)
c	=	331 + 0.6t
t	=	Temperature in the air (°C)
T_1	=	Reverberation time of the room without test object (s)
T_2	=	Reverberation time of the room with test object (s)

Measurement uncertainty

From a world wide Round Robin[1)], in which SP took part, with 23 participating laboratories from 11 countries, the following measurement uncertainty has been calculated

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

[1)] 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.

Picture 1 – Dalhem Ribba Ceiling (detail)

Picture 2 – Dalhem Ribba Ceiling (detail)

Picture 3 – Dalhem Parawood

Picture 4 –Dalhem Ribba Wall 28 x 38

Test room

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

Mounting

The panels were placed on the floor 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 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

Instrument	Manufacturer	Type	Serial no
Microphone	Brüel & Kjaer	4943	2479445
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	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	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

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Krister Larsson
Technical Manager

Mohammad Jalalian
Technical Officer

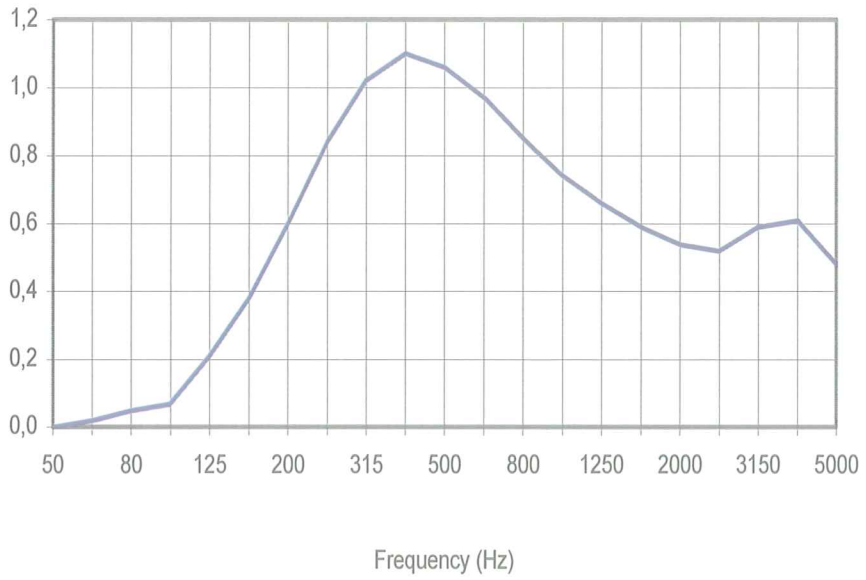
Appendices

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	AH Production AB Ulf Klenfeldt
Object	Dallhem Ribba Ceiling 38 x 38 mm Thickness: 98 mm. Spacing 12 mm. Ribba 2400 x 38 x 38 MDF 1500 x 20 x 20 mm Panel size: 1200 x 600 x 40 mm.
Date of test	October 29, 2009
Conditions	Mounting depth: 98 mm. Surface area: 10,8 m^2. Room volume: 200 m^3. Temperature at measurement on object/in empty room: 21/ 20 °C. Relative humidity at measurement on object/in empty room: 86/ 86 %.
Result	Sound absorption class **C**. Weighted sound absorption coefficient α_w = **0,65(LM)**.

Sound absorption coefficient



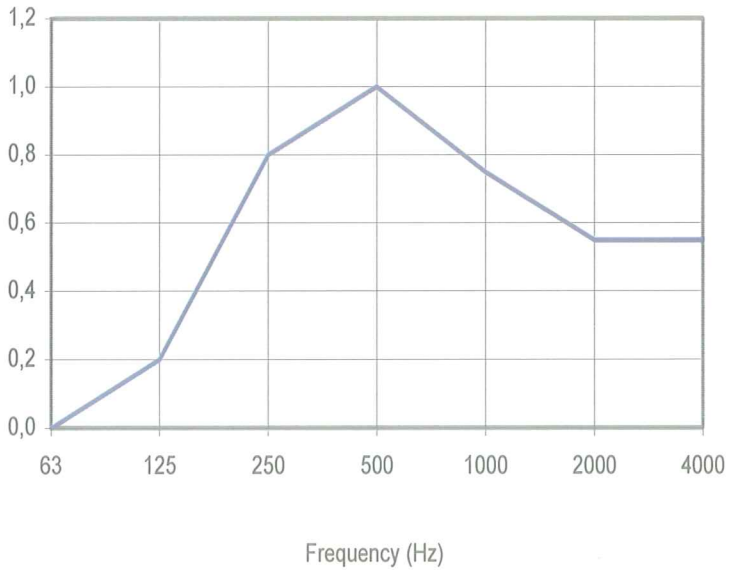
Frequency (Hz)	α_s
50	0,00
63	0,02
80	0,05
100	0,07
125	0,21
160	0,38
200	0,60
250	0,84
315	1,02
400	1,10
500	1,06
630	0,97
800	0,85
1000	0,74
1250	0,66
1600	0,59
2000	0,54
2500	0,52
3150	0,59
4000	0,61
5000	0,48

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	AH Production AB Ulf Klenfeldt
Object	Dallhem Ribba Ceiling 38 x 38 mm Thickness: 98 mm. Spacing 12 mm. Ribba 2400 x 38 x 38 MDF 1500 x 20 x 20 mm Panel size: 1200 x 600 x 40 mm.
Date of test	October 29, 2009
Conditions	Mounting depth: 98 mm. Surface area: 10,8 m^2. Room volume: 200 m^3. Temperature at measurement on object/in empty room: 21/ 20 °C. Relative humidity at measurement on object/in empty room: 86/ 86 %.
Result	Sound absorption class **C**. Weighted sound absorption coefficient α_w = **0,65(LM)**.

Practical sound absorption coefficient



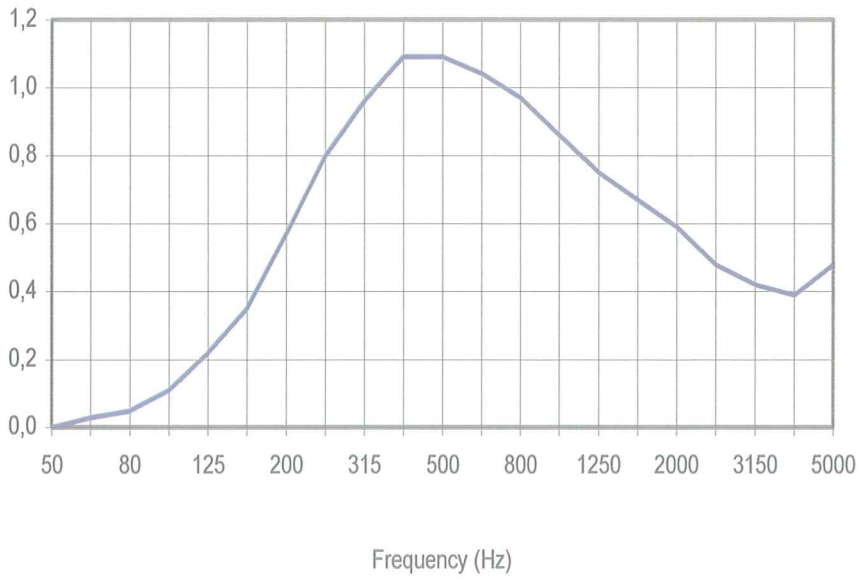
Frequency (Hz)	α_p
63	0,00
125	0,20
250	0,80
500	1,00
1000	0,75
2000	0,55
4000	0,55

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	AH Production AB Ulf Klenfeldt
Object	Dallhem Ribba Ceiling 22 x 38 mm Thickness: 82 mm. Spacing 12 mm. Ribba 2400 x 22 x 38 MDF 1500 x 20 x 20 mm Panel size: 1200 x 600 x 40 mm.
Date of test	October 29, 2009
Conditions	Mounting depth: 82 mm. Surface area: 10,8 m^2. Room volume: 200 m^3. Temperature at measurement on object/in empty room: 21/ 20 °C. Relative humidity at measurement on object/in empty room: 86/ 86 %.
Result	Sound absorption class **C**. Weighted sound absorption coefficient α_w = **0,6(LM)**.

Sound absorption coefficient



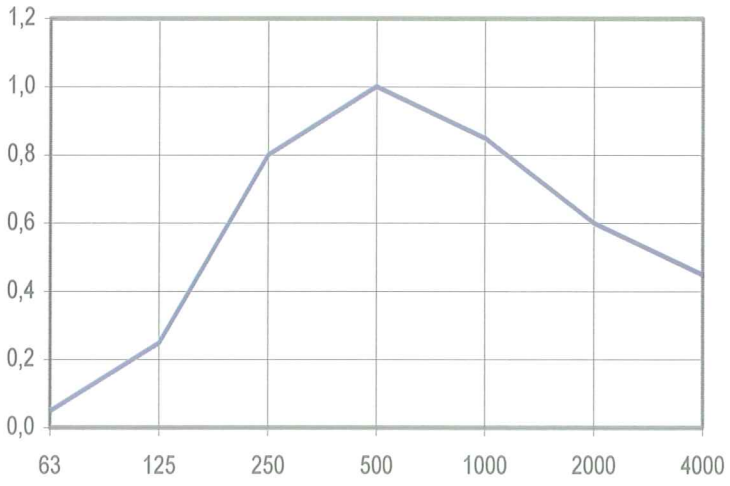
Frequency (Hz)	α_s
50	0,00
63	0,03
80	0,05
100	0,11
125	0,22
160	0,35
200	0,57
250	0,80
315	0,96
400	1,09
500	1,09
630	1,04
800	0,97
1000	0,86
1250	0,75
1600	0,67
2000	0,59
2500	0,48
3150	0,42
4000	0,39
5000	0,48

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	AH Production AB Ulf Klenfeldt
Object	Dallhem Ribba Ceiling 22 x 38 mm Thickness: 82 mm. Spacing 12 mm. Ribba 2400 x 22 x 38 MDF 1500 x 20 x 20 mm Panel size: 1200 x 600 x 40 mm.
Date of test	October 29, 2009
Conditions	Mounting depth: 82 mm. Surface area: 10,8 m^2. Room volume: 200 m^3. Temperature at measurement on object/in empty room: 21/ 20 °C. Relative humidity at measurement on object/in empty room: 86/ 86 %.
Result	Sound absorption class **C**. Weighted sound absorption coefficient α_w = **0,6(LM)**.

Practical sound absorption coefficient



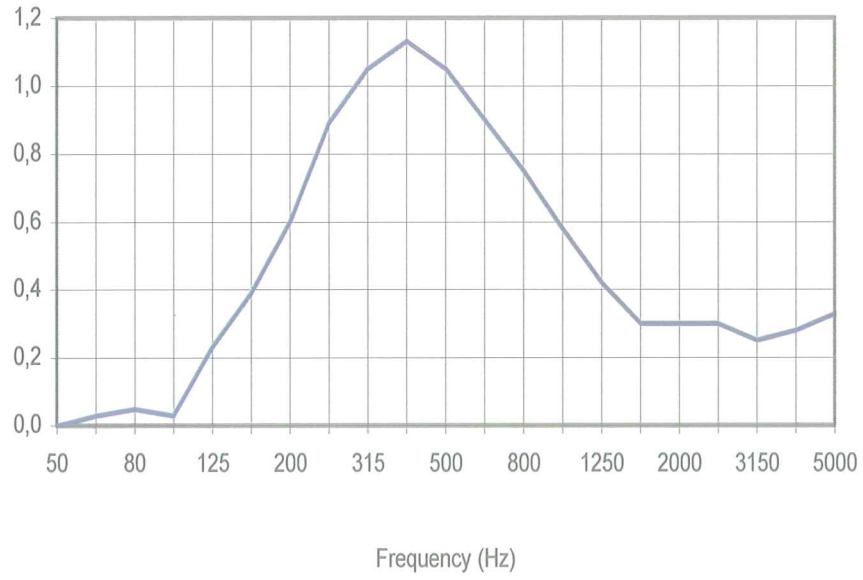
Frequency (Hz)	α_p
63	0,05
125	0,25
250	0,80
500	1,00
1000	0,85
2000	0,60
4000	0,45

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	AH Production AB Ulf Klenfeldt
Object	Dalhem Parawood 84 x 19 mm Thickness: 79 mm. Spacing 16 mm. Ribba 3000 x 84 x 19 mm MDF 1500 x 20 x 20 mm Panel size: 1200 x 600 x 40 mm.
Date of test	October 29, 2009
Conditions	Mounting depth: 79 mm. Surface area: 10,8 m^2. Room volume: 200 m^3. Temperature at measurement on object/in empty room: 21/ 20 °C. Relative humidity at measurement on object/in empty room: 86/ 86 %.
Result	Sound absorption class **D**. Weighted sound absorption coefficient α_w = **0,4(LM)**.

Sound absorption coefficient

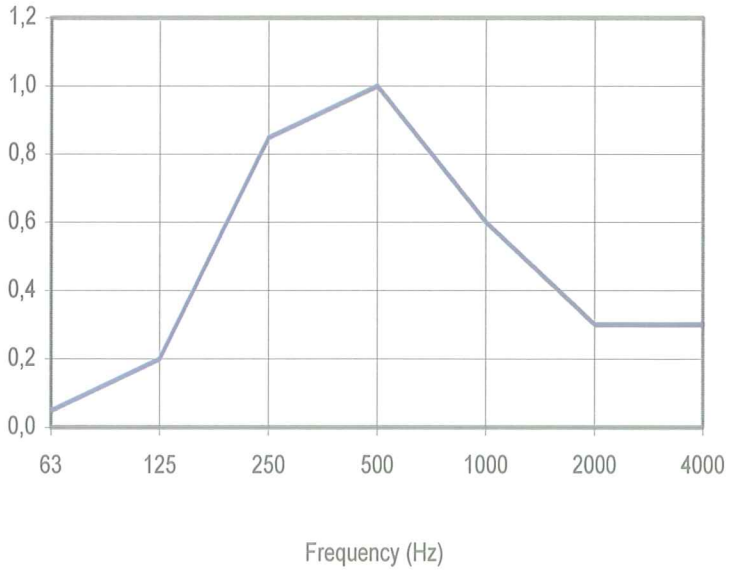


Frequency (Hz)	α_s
50	0,00
63	0,03
80	0,05
100	0,03
125	0,23
160	0,39
200	0,60
250	0,89
315	1,05
400	1,13
500	1,05
630	0,90
800	0,75
1000	0,58
1250	0,42
1600	0,30
2000	0,30
2500	0,30
3150	0,25
4000	0,28
5000	0,33

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	AH Production AB Ulf Klenfeldt
Object	Dalhem Parawood 84 x 19 mm Thickness: 79 mm. Spacing 16 mm. Ribba 3000 x 84 x 19 mm MDF 1500 x 20 x 20 mm Panel size: 1200 x 600 x 40 mm.
Date of test	October 29, 2009
Conditions	Mounting depth: 79 mm. Surface area: 10,8 m^2. Room volume: 200 m^3. Temperature at measurement on object/in empty room: 21/ 20 °C. Relative humidity at measurement on object/in empty room: 86/ 86 %.
Result	Sound absorption class **D**. Weighted sound absorption coefficient α_w = **0,4(LM)**.

Practical sound absorption coefficient



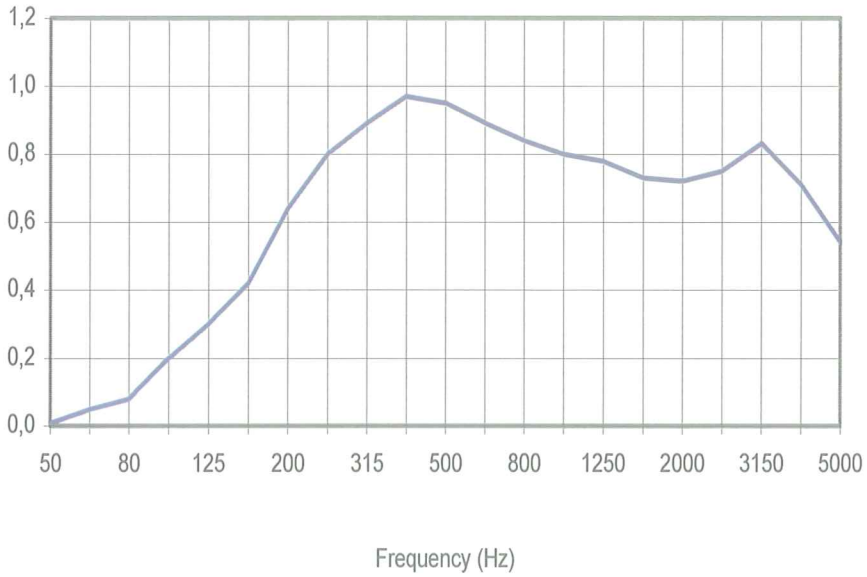
Frequency (Hz)	α_p
63	0,05
125	0,20
250	0,85
500	1,00
1000	0,60
2000	0,30
4000	0,30

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	AH Production AB Ulf Klenfeldt
Object	Dallhem Ribba Wall 28 x 38 mm Thickness: 68 mm. Spacing 22 mm. Ribba 2400 x 28 x 38 Panel size: 1200 x 600 x 40 mm.
Date of test	October 30, 2009
Conditions	Mounting depth: 68 mm. Surface area: 10,8 m^2. Room volume: 200 m^3. Temperature at measurement on object/in empty room: 21/ 20 °C. Relative humidity at measurement on object/in empty room: 86/ 86 %.
Result	Sound absorption class **B**. Weighted sound absorption coefficient α_w = **0,8**.

Sound absorption coefficient

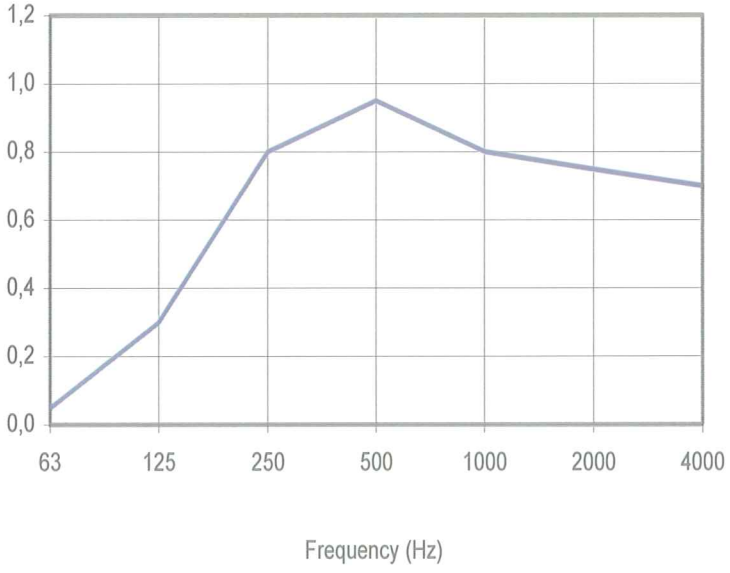


Frequency (Hz)	α_s
50	0,01
63	0,05
80	0,08
100	0,20
125	0,30
160	0,42
200	0,64
250	0,80
315	0,89
400	0,97
500	0,95
630	0,89
800	0,84
1000	0,80
1250	0,78
1600	0,73
2000	0,72
2500	0,75
3150	0,83
4000	0,71
5000	0,54

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	AH Production AB Ulf Klenfeldt
Object	Dallhem Ribba Wall 28 x 38 mm Thickness: 68 mm. Spacing 22 mm. Ribba 2400 x 28 x 38 Panel size: 1200 x 600 x 40 mm.
Date of test	October 30, 2009
Conditions	Mounting depth: 68 mm. Surface area: 10,8 m^2. Room volume: 200 m^3. Temperature at measurement on object/in empty room: 21/ 20 °C. Relative humidity at measurement on object/in empty room: 86/ 86 %.
Result	Sound absorption class **B**. Weighted sound absorption coefficient α_w = **0,8**.

Practical sound absorption coefficient



Frequency (Hz)	α_p
63	0,05
125	0,30
250	0,80
500	0,95
1000	0,80
2000	0,75
4000	0,70