

Laboratory for Acoustics



*Determination of the sound absorption
(reverberation room method) of ReFelt
Melange panels, manufacturer ReFelt*



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Determination of the sound absorption (reverberation room method) of ReFelt Melange panels, manufacturer ReFelt

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1 Introduction

At the request of De Vorm based in Arnhem (The Netherlands), laboratory measurements of the sound absorption (reverberation room method) were carried out on:

ReFelt Melange panels
manufacturer ReFelt

in the Laboratory for Acoustics of Peutz bv, at Mook, the Netherlands (see figure 1).



For these type of measurements the Laboratory for Acoustics has been accredited by the Dutch Accreditation Council (RvA).

The RvA is member of the EA MLA (**EA MLA**: European Accreditation Organisation **Multi**Lateral **A**greement: <http://www.european-accreditation.org>).

EA: "Certificates and reports issued by bodies accredited by MLA and MRA members are considered to have the same degree of credibility, and are accepted in MLA and MRA countries."

2 Standards and guidelines

The measurements have been carried out according to the Quality Manual of the Laboratory for Acoustics as well as:

ISO 354:2003¹ Acoustics Measurement of sound absorption in a reverberation room
NOTE: this international standard has been accepted within all EU-countries
 as European standard EN ISO 354:2003

Various other related norms:

EN ISO 11654:1997 Acoustics Sound absorbers for use in buildings Rating of sound
 absorption

ASTM C423-17 Standard Test Method for Sound Absorption and Sound Absorption
 Coefficients by the Reverberation Room Method

¹ According to this norm, the report should include for each measurement the mean reverberation times T_1 and T_2 at each frequency. Because these figures are not relevant for judging the quality of the product being tested, but merely for judging the accuracy of the calculations, they have been omitted in this report. It is possible of course to reproduce those figures at any time if the principal requests this.

3 Tested construction

The data presented here have been received from the principal or obtained by own observations. Used materials:

ReFelt Melange

material: PET Felt
 manufacturer: ReFelt
 thickness: approx. 12 mm
 mass: approx. 2,4 kg/m²

Stone wool

thickness: approx. 50 and 100 mm
 mass: approx. 45 kg/m³

The following systems have been tested

variant	Top	cavity	cavity filling	
1	ReFelt Melange	none	-	
2	ReFelt Melange	50 mm	-	
3	ReFelt Melange	50 mm	50 mm stone wool	
4	ReFelt Melange	100 mm	-	
5	ReFelt Melange	100 mm	100 mm stone wool	



The results as presented here relate only to the tested items and laboratory conditions as described in this report. The laboratory can make no judgement about the representativity of the tested samples. The test report ahead is valid as long as the tested constructions and/or materials are unchanged.

4 Measurements

The panels to be measured (see chapter 3) have been put directly on the floor of the reverberation room (Type A mounting according to ISO 354:2003) or on a support structure at about 50 and 100 mm above it (Type E-50 / E-100 mounting according to ISO 354:2003), the facing side of the panels was up. No suspension-system has been used, the panels were put tight to each other. The sides of the setup were enclosed by 18 mm thick plastic covered chipwood.

4.1 Method

The tests were conducted in accordance with the provisions of the test method ISO 354 in the reverberation room of "Peutz bv" in Mook (the Netherlands) (see figure 1). The relevant data regarding the reverberation room are given in figure 2 of this report.

By means of reverberation measurements the reverberation time of the room is measured under two conditions:

- when the reverberation room is empty
- when the construction under test is inside the reverberation room

In general, once material is placed into the reverberation room a lower reverberation time will result.

The difference in reverberation times is a measure of the amount of absorption brought into the room.

Measurements and calculations were carried out in 1/3-octave bandwidth from 100 to 5000 Hz, according to the norms. Where applicable the octave values have been calculated from these 1/3-octave values.

From the reverberation measurements in the empty reverberation room the equivalent sound absorption A_1 is calculated (per frequency band) according to formula 1 and expressed in m^2

$$A_1 = \frac{55,3 V}{c T_1} - 4 V m_1 \quad (1)$$

in which:

- | | |
|---|--------------|
| V = the volume of the reverberation room | [m^3] |
| T_1 = the reverberation time in the empty reverberation room | [sec.] |
| m_1 = "power attenuation coefficient" in the empty room,
calculated according to formula | [m^{-1}] |
| c = the speed of sound in the air, in m/s, calculated according to | [m/s] |

$$c = 331 + 0,6 t \quad (2)$$

in which:

t = the temperature; this formula is valid for temperatures between 15 and 30 °C [°C]

$$m = \frac{\alpha}{10 \log(e)} \quad (3)$$

in which:

α = "attenuation coefficient" according to ISO 9613-1

In the same manner the equivalent sound absorption A_2 for the room with the test specimen is calculated according to formula 4, also expressed in m^2

$$A_2 = \frac{55,3 V}{c T_2} - 4 V m_2 \quad (4)$$

in which:

c and V have the same definition as in formula 1 and

T_2 = the reverberation time of the reverberation room with the test specimen placed inside [sec]

m_2 = "power attenuation coefficient" in the room with the test specimen placed inside, calculated according to formula 3 [m^{-1}]

The equivalent sound absorption A of the test specimen has been calculated according to formula 5 and is expressed in m^2

$$A = A_2 - A_1 \quad (5)$$

When the test specimen consists of one plane with an area between 10 and 12 m^2 the sound absorption coefficient α_s has to be calculated according to formula 6:

$$\alpha = \frac{A}{S} \quad (6)$$

in which:

S = the area of the test specimen [m^2]

4.2 Accuracy

The accuracy of the sound absorption as calculated can be expressed in terms of repeatability (tests within one laboratory) and reproducibility (between various laboratories).

When:

- two tests are performed on identical test material
- within a short period of time
- by the same person or team

- using the same instrumentation
- under unchanged environmental conditions

the probability will be 95% that the difference between the two test results will be less than or equal to r .

In order to evaluate the repeatability r for the sound absorption measurements performed in the reverberation room of "Peutz bv" in Mook (the Netherlands) eight series of measurements have been carried out according to ISO 354:1985 annex C. From the results of those measurements the repeatability r has been calculated. It was found that for the frequency range from 100 to 200 Hz and at 5000 Hz the repeatability r is 0,21 as a maximum. For the frequency range 250 to 4000 Hz the repeatability r is 0,09 as a maximum.

4.3 Environmental conditions during the measurements

t4.1 *Environmental conditions during the measurements 30-10-2020*

reverberation room	temperature [°C]	barometric pressure [kPa]	relative humidity [%]
empty	18	101,4	60
with panels	18	101,4 – 1041,6	63 - 67

4.4 Results

The results of the measurements are given in table 4.2 and in the figures 3 up till and including 7. The measurements were made in 1/3-octave bands. The results presented in octave-bands are the arithmetic average of the results of the three 1/3-octave bands belonging to that octaveband.

From those values the following one-figure ratings have been calculated and stated :

- the "weighted sound absorption coefficient α_w " according to ISO 11654;
- the "Noise Reduction Coefficient NRC" according to ASTM C423, being the average of the absorption coefficients (1/3 octave values) at the frequencies of 250, 500, 1000 and 2000 Hz, rounded to the nearest 0,05;
- the "Sound Absorption Average SAA" according to ASTM-C423, being the average of the absorption coefficients (1/3 octave values) at the frequencies of 200 Hz up to 2500 Hz, rounded to the nearest 0,01;
- the "sound absorption classes" according to ISO 11654.

t4.2 measurement results **ReFelt Melange**

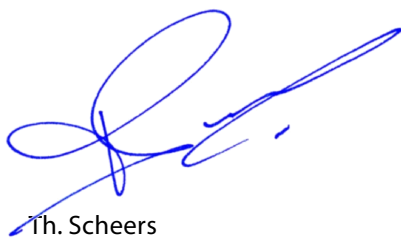
	sound absorption coefficient α_s					
variant nr.	1		2		3	
cavity	none		50 mm		50 mm	
cavity filling	-		none		50 mm stone wool	
record nr.	#147		#184		#332	
figure nr.	3		4		5	
frequency [Hz]	1/3 oct.	1/1 oct.	1/3 oct.	1/1 oct.	1/3 oct.	1/1 oct.
100	0,01		0,06		0,20	
125	0,00	0,01	0,09	0,10	0,38	0,42
160	0,02		0,15		0,67	
200	0,02		0,20		0,82	
250	0,06	0,06	0,30	0,31	0,88	0,88
315	0,09		0,44		0,93	
400	0,11		0,58		0,96	
500	0,19	0,19	0,71	0,71	0,97	0,99
630	0,27		0,85		1,03	
800	0,38		0,95		1,00	
1000	0,49	0,49	0,99	0,99	0,98	0,98
1250	0,61		1,03		0,97	
1600	0,72		1,00		0,98	
2000	0,81	0,81	0,98	0,96	1,01	0,99
2500	0,91		0,89		0,99	
3150	0,98		0,91		1,01	
4000	1,01	1,01	1,00	0,97	0,99	1,01
5000	1,03		1,00		1,03	
α_w	0,25(MH)		0,60(MH)		1,00	
NRC	0,40		0,75		0,95	
SAA	0,39		0,74		0,96	
Class	D		C		A	

t4.3 measurement results **ReFelt Melange**

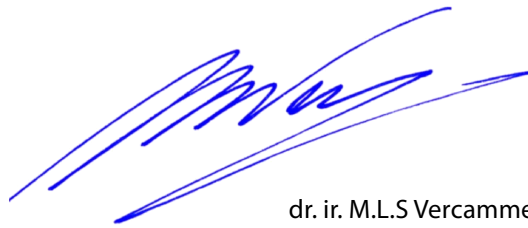
	sound absorption coefficient α_s			
variant nr.	4		5	
cavity	100 mm		100 mm	
cavity filling	none		100 mm stone wool	
record nr.	#480		#591	
figure nr.	6		7	
frequency [Hz]	1/3 oct.	1/1 oct.	1/3 oct.	1/1 oct.
100	0,16		0,70	
125	0,18	0,22	0,85	0,86
160	0,31		1,02	
200	0,33		0,86	
250	0,49	0,52	0,88	0,88
315	0,74		0,90	
400	0,74		0,86	
500	0,85	0,84	0,90	0,89
630	0,92		0,91	
800	1,01		0,96	
1000	0,99	0,98	0,96	0,97
1250	0,95		1,00	
1600	0,82		0,99	
2000	0,85	0,88	1,00	1,00
2500	0,97		1,02	
3150	0,97		1,04	
4000	0,96	0,97	1,02	1,03
5000	0,99		1,02	
α_w	0,80(H)		0,95	
NRC	0,80		0,95	
SAA	0,81		0,94	
Class	B		A	

The sound absorption coefficient of a material is not a material property. It should be taken into account that the sound absorption of a construction depends on the dimensions, the way of mounting of the material and its position in the room.

Mook,



Th. Scheers
Laboratory Supervisor



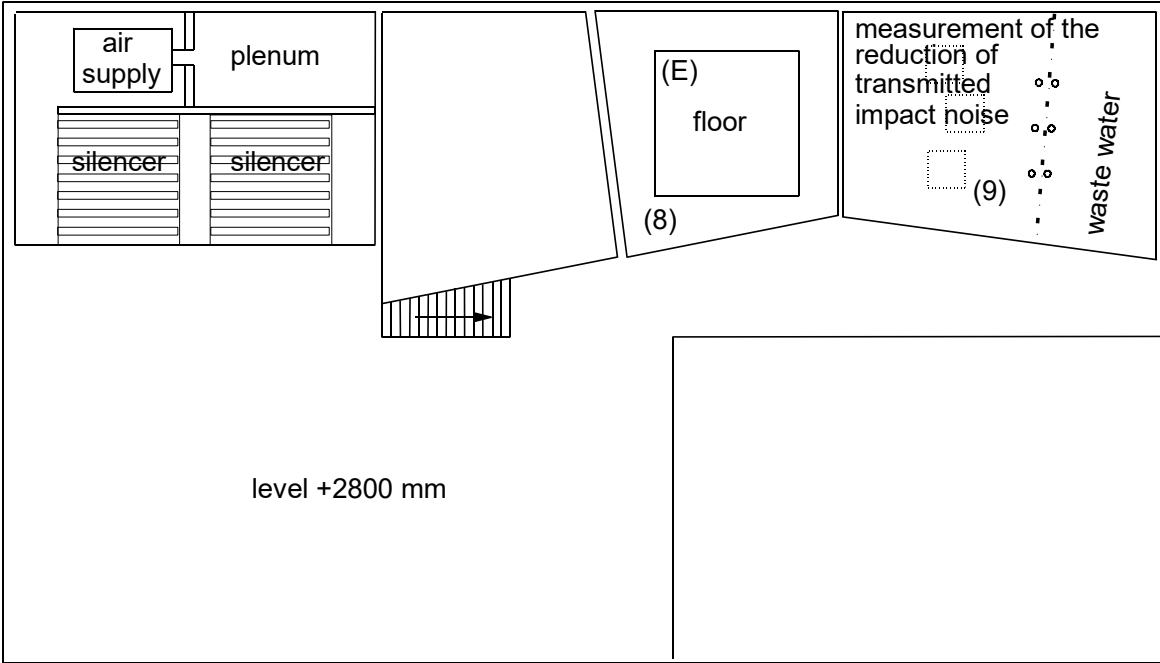
dr. ir. M.L.S Vercammen
Manager

This report contains 13 pages, 7 figures.

PEUTZ bv
Lindenlaan 41, NL-6584 AC MOLENHOEK (LB), THE NETHERLANDS

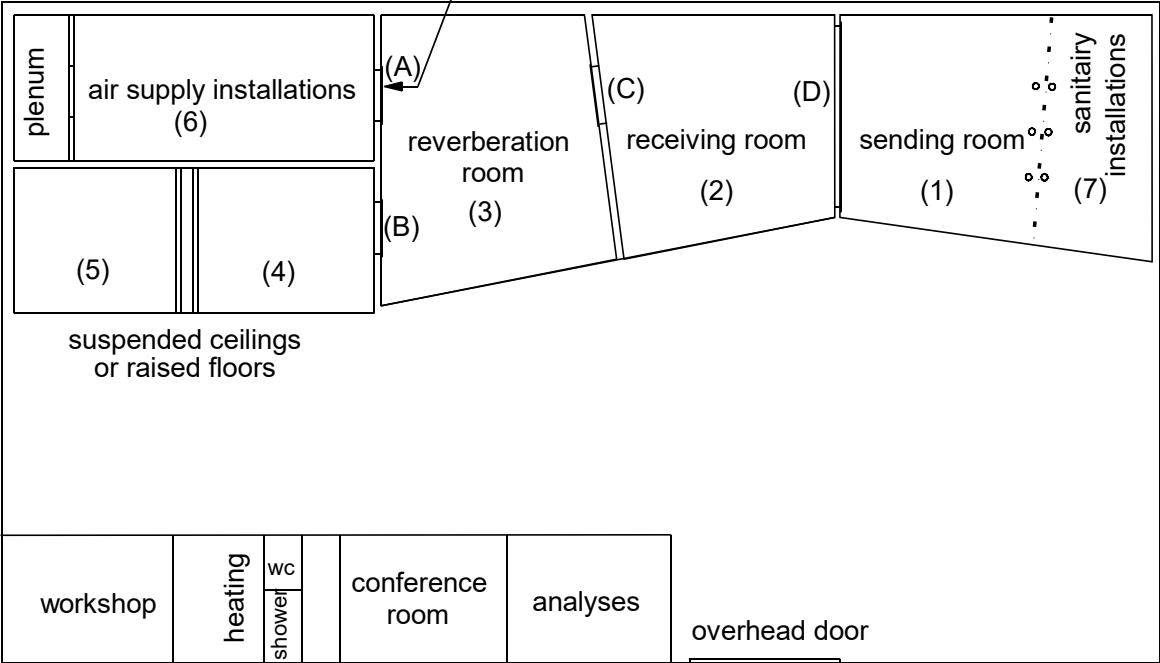
OVERVIEW

Story



Ground level

opening (A) (closed)
w x h = 1300 x 1905 mm



TEST OPENINGS (w x h in mm)

- (B) 1000 x 2200
- (C) 1500 x 1250
- (D) 4300 x 2800
- (E) 4000 x 4000

0 1 2 3 4 5 m
scale

PEUTZ bv
Lindenlaan 41, 6584 AC MOLENHOEK (LB)

REVERBERATION ROOM

The reverberation room meets the requirements of ISO 354:2003.

additional data:

volume : 214 m³
total area St (walls, floor and ceiling) : 219 m²

diffusion: by the shape of the room and by adding 6 curved and 2 flat reflecting elements with a total area of approx. 13 m² a sufficient diffusion has been gained.

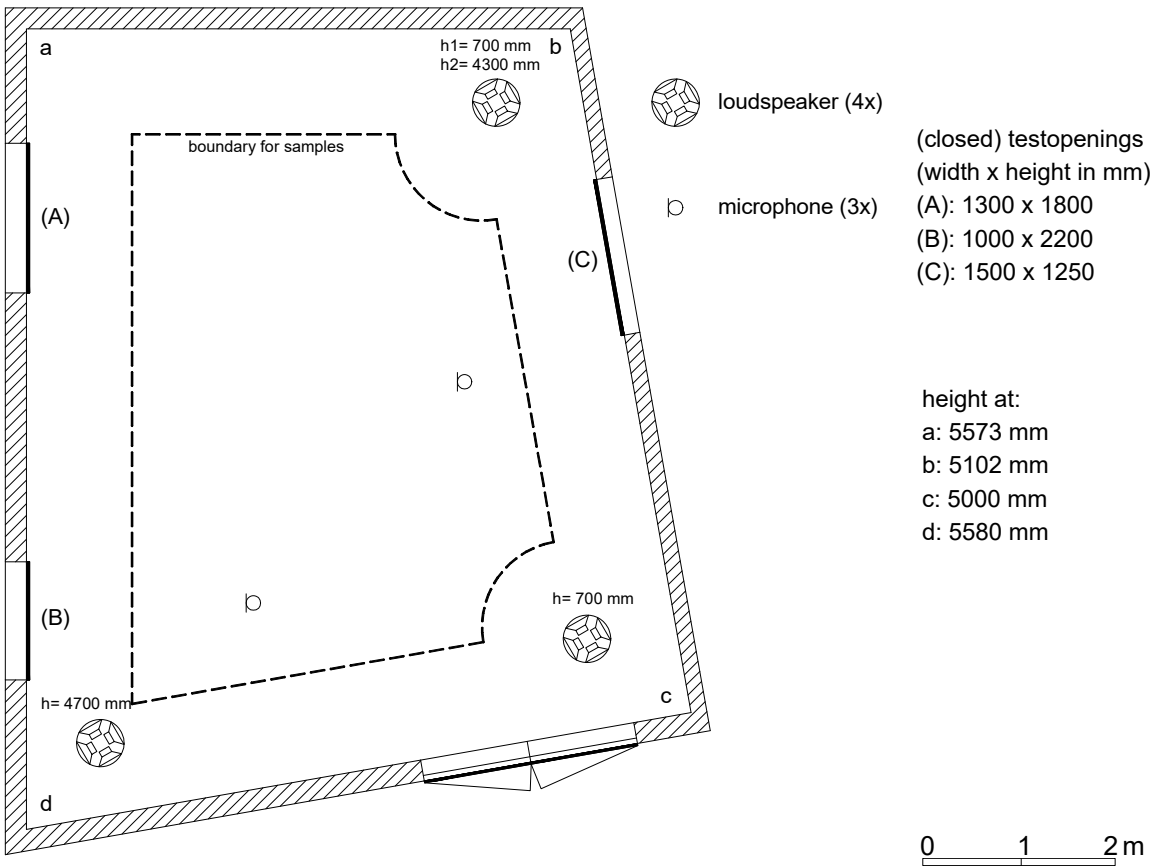
reverberation time of the empty reverberation room during measurements of 30-10-2020

frequency (1/1 oct.)	125	250	500	1000	2000	4000	Hz
reverberationtime	8,90	7,29	6,95	6,47	4,81	3,08	sec.

repeatability r (1/1 oct.) c.f. ISO 354:1985 annex C (see chapter 4.2 of this report).

r at high α	0,13	0,04	0,04	0,02	0,02	0,08	-
r at low α	0,09	0,02	0,01	0,02	0,02	0,04	-

plan



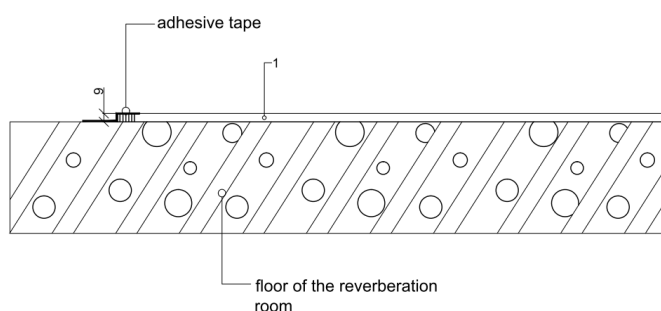
Absorb, versie 5.9 mode 7, file: a3906 E#:1-36 T₁ = 17,5 °C p₁ = 101,4 kPa h₁ = 59,6 %

MEASUREMENT OF SOUND ABSORPTION IN A REVERBERATION ROOM ACCORDING TO ISO 354:2003



principal: De Vorm

variant	Top (1)	cavity	cavity filling
1	ReFelt Melange	-	-



volume reverberation room: 214 m³

surface area sample: 11,34 m²

height of the construction: 0,012 m

measured at: Peutz Laboratory for Acoustics

signal: broad-band noise

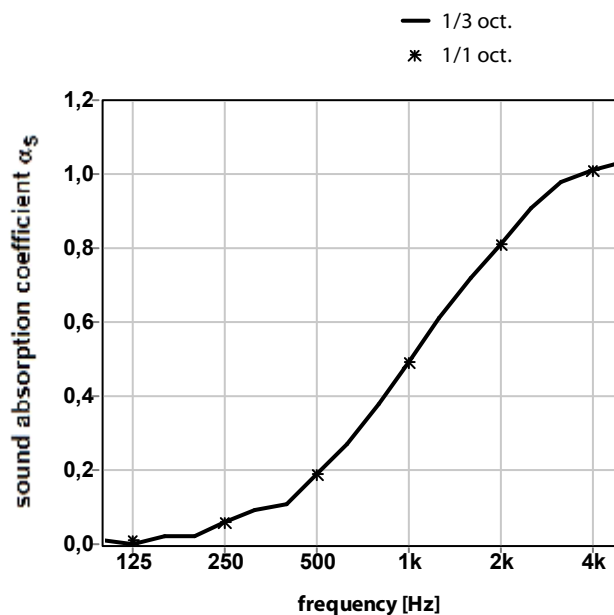
bandwidth: 1/3 octave

α_w (ISO 11654) = 0,25(MH)

SAA (ASTM - C423) = 0,39

NRC (ASTM - C423) = 0,40

Class (ISO 11654) = D



	0,01	0,02	0,11	0,38	0,72	0,98
1/3 oct.	0,00	0,06	0,19	0,49	0,81	1,01
	0,02	0,09	0,27	0,61	0,91	1,03
1/1 oct.	0,01	0,06	0,19	0,49	0,81	1,01

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Mook, measured at 30-10-2020

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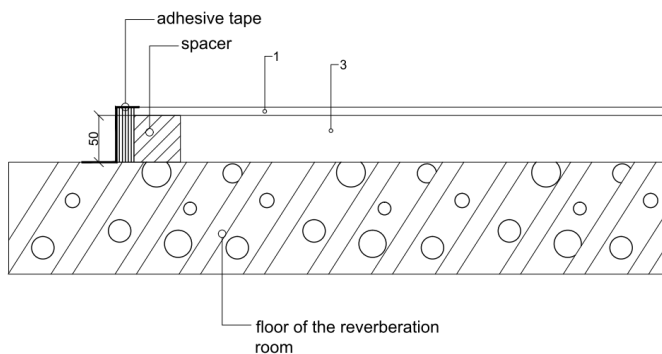
figure 3

MEASUREMENT OF SOUND ABSORPTION IN A REVERBERATION ROOM ACCORDING TO ISO 354:2003



principal: De Vorm

variant	Top (1)	Cavity (3)	cavity filling
2	ReFelt Melange	50 mm	-



volume reverberation room: 214 m³

surface area sample: 11,34 m²

height of the construction: 0,062 m

measured at: Peutz Laboratory for Acoustics

signal: broad-band noise

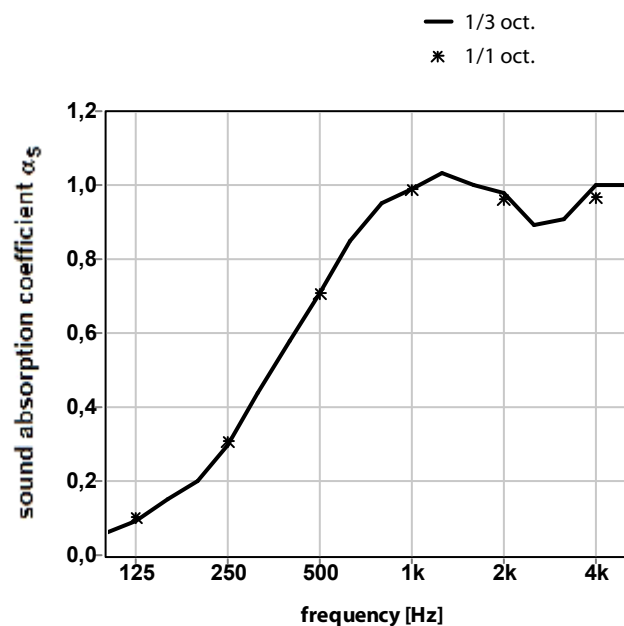
bandwidth: 1/3 octave

α_w (ISO 11654) = 0,60(MH)

SAA (ASTM - C423) = 0,74

NRC (ASTM - C423) = 0,75

Class (ISO 11654) = C



	0,06	0,20	0,58	0,95	1,00	0,91
1/3 oct.	0,09	0,30	0,71	0,99	0,98	1,00
	0,15	0,44	0,85	1,03	0,89	1,00
1/1 oct.	0,10	0,31	0,71	0,99	0,96	0,97

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Mook, measured at 30-10-2020

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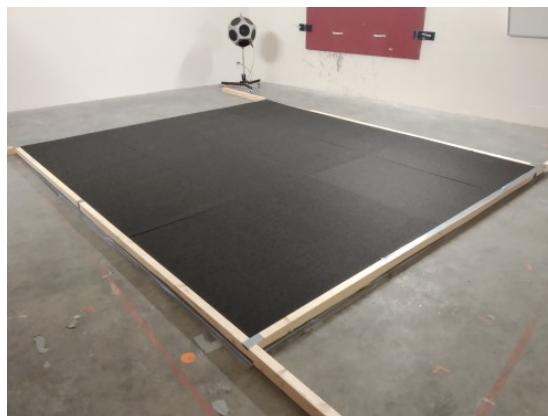
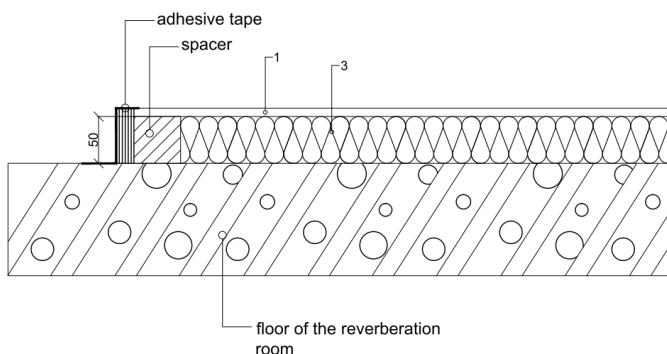
figure 4

MEASUREMENT OF SOUND ABSORPTION IN A REVERBERATION ROOM ACCORDING TO ISO 354:2003



Principal: De Vorm

variant	Top (1)	Cavity (3)	cavity filling
3	ReFelt Melange	50 mm	50 mm stone wool



volume reverberation room: 214 m³

surface area sample: 11,34 m²

height of the construction: 0,062 m

measured at: Peutz Laboratory for Acoustics

signal: broad-band noise

bandwidth: 1/3 octave

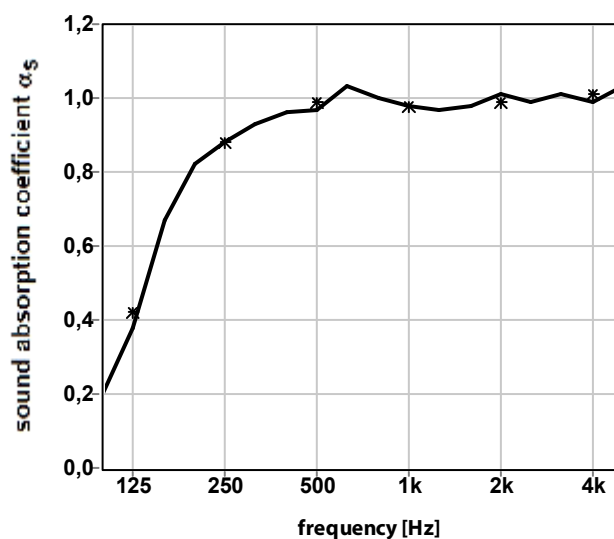
α_w (ISO 11654) = 1,00

SAA (ASTM - C423) = 0,96

NRC (ASTM - C423) = 0,95

Class (ISO 11654) = A

— 1/3 oct.
* 1/1 oct.



	0,20	0,82	0,96	1,00	0,98	1,01
1/3 oct.	0,38	0,88	0,97	0,98	1,01	0,99
	0,67	0,93	1,03	0,97	0,99	1,03
1/1 oct.	0,42	0,88	0,99	0,98	0,99	1,01

publication is permitted for the entire page only

Mook, measured at 30-10-2020

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Figure 5

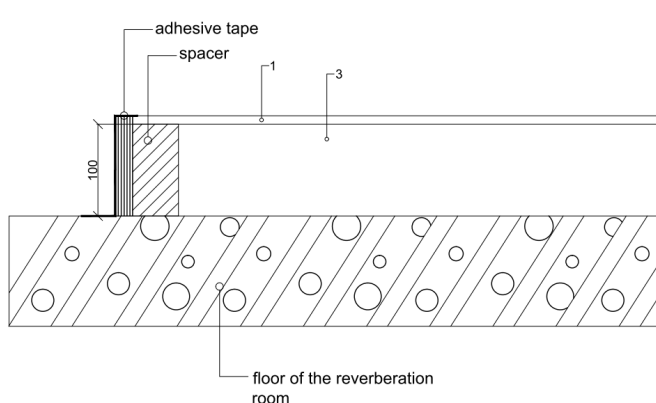
Absorb, versie 5.9 mode 7, PM: MH, file: a3906 E#:1-36 F#:296-331 A#:332 T₁ = 17,5 °C T₂ = 17,5 °C p₁ = 101,4 kPa p₂ = 101,5 kPa h₁ = 59,6 % h₂ = 65,7 %

MEASUREMENT OF SOUND ABSORPTION IN A REVERBERATION ROOM ACCORDING TO ISO 354:2003



principal: De Vorm

variant	Top (1)	Cavity (2)	cavity filling
4	ReFelt Melange	100 mm	-



volume reverberation room: 214 m³

surface area sample: 11,34 m²

height of the construction: 0,112 m

measured at: Peutz Laboratory for Acoustics

signal: broad-band noise

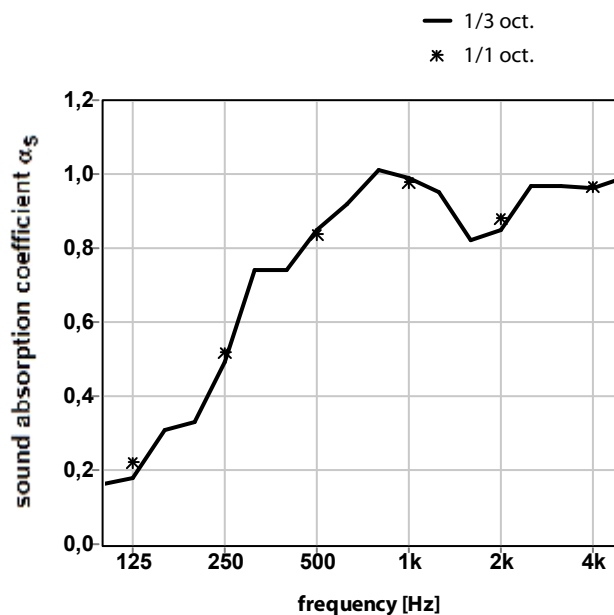
bandwidth: 1/3 octave

α_w (ISO 11654) = 0,80(H)

SAA (ASTM - C423) = 0,81

NRC (ASTM - C423) = 0,80

Class (ISO 11654) = B



	0,16	0,33	0,74	1,01	0,82	0,97
1/3 oct.	0,18	0,49	0,85	0,99	0,85	0,96
	0,31	0,74	0,92	0,95	0,97	0,99
1/1 oct.	0,22	0,52	0,84	0,98	0,88	0,97

publication is permitted for the entire page only

Mook, measured at 30-10-2020

report A 3906-4E-RA

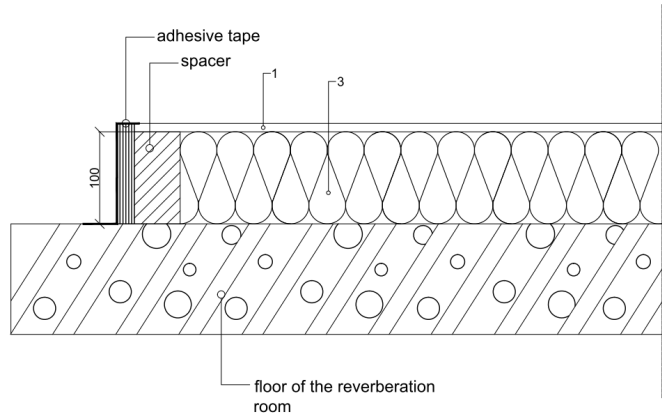
figure 6

MEASUREMENT OF SOUND ABSORPTION IN A REVERBERATION ROOM
ACCORDING TO ISO 354:2003



principal: De Vorm

variant	Top (1)	Cavity	cavity filling (3)
5	ReFelt Melange	100 mm	100 mm stone wool (45 kg/m³)



volume reverberation room: 214 m³

surface area sample: 11,34 m²

height of the construction: 0,112 m

measured at: Peutz Laboratory for Acoustics

signal: broad-band noise

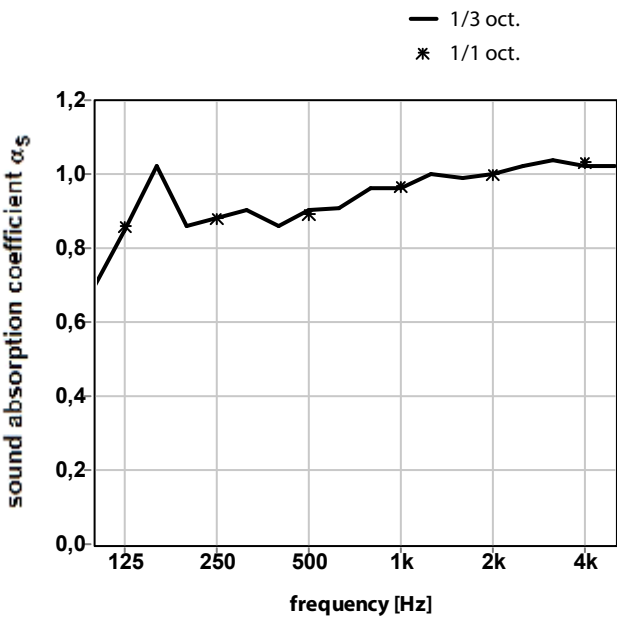
bandwidth: 1/3 octave

α_w (ISO 11654) = 0,95

SAA (ASTM - C423) = 0,94

NRC (ASTM - C423) = 0,95

Class (ISO 11654) = A



	0,70	0,86	0,86	0,96	0,99	1,04
1/3 oct.	0,85	0,88	0,90	0,96	1,00	1,02
	1,02	0,90	0,91	1,00	1,02	1,02
1/1 oct.	0,86	0,88	0,89	0,97	1,00	1,03

publication is permitted for the entire page only

Mook, measured at 30-10-2020

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figure 7