PEUTZ

Laboratory for Acoustics

Determination of the sound absorption (reverberation room method) of mineral wool, type MW 35, manufacturer Knauf Insulation B.V.

Report number A 3022-5E-RA-001 d.d. 22 maart 2016

Laboratory for Acoustics

Determination of the sound absorption (reverberation room method) of mineral wool, type MW 35, manufacturer Knauf Insulation B.V.

Table of contents

1 Introduction

At the request of Knauf Insulation B.V. based in Oosterhout (The Netherlands), laboratory measurements of the sound absorption (reverberation room method) were carried out on mineral wool panels

type Mineral Wool 35
manufacturer Knauf Insulation

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**: **E**uropean **A**ccreditation Organisation **M**ulti**L**ateral **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 aswell as:

ISO 354:2003 [1]   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
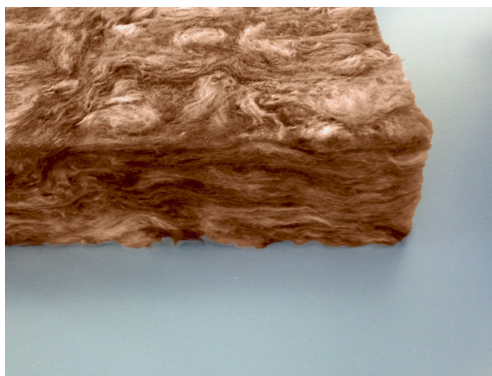
Various other related norms:

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

ASTM C423-09a   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. Measurements have been carried out on the following panels.

Material:	Mineral wool
Type:	Mineral Wool 35
Manufacturer:	Knauf Insulation BV
Panel dimensions:	600 x 1200 mm
Thickness	40 mm, 50 mm, 90 mm and 120 mm
Mass:	– [1]

The following configurations were tested:

variant	Panel type	cavity	total height	mounting type (see chapter 4)
1	40 mm Mineral Wool 35	-	40 mm	A
2	50 mm Mineral Wool 35	-	50 mm	A
3	50 mm Mineral Wool 35	150 mm	200 mm	E-200
4	90 mm Mineral Wool 35	-	90 mm	A
5	90 mm Mineral Wool 35	110 mm	200 mm	E-200
6	120 mm Mineral Wool 35	-	120 mm	A

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.

---

1   The mass of the tested materials is measured by the staff of Peutz' Laboratory for Acoustics. At the request of the principal these masses are not stated in this report.

4 Measurements

The panels to be measured (see chapter 3) have been put directly on the floor of the reverberation room or on a support structure at about 150 mm above it, 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 board (see figure 2).
The measurement setups are according to type A or type E-200 ISO 354:2003 (Test specimen mountings for sound absorption tests).

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

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

in which:

V	= the volume of the reverberation room	[m³]
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]

$$c = 331 + 0,6\,t \tag{2}$$

in which:

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

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

in which:

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

In the same manner the equivalent sound absorption A2 for the room with the test specimen is calculated according to formula 4, also expressed in m^2

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

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

$$A = A_2 - A_1 \tag{5}$$

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:

$$\alpha = \frac{A}{S} \tag{6}$$

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 at January 21th, 2016*

reverberation room	temperature	barometric pressure	relative humidity
	[°C]	[kPa]	[%]
empty	15,8	102,6	49
variant 1	16,2	102,7	51

4.4 Resuts

The results of the measurements are given in table 4.2, 4.3 and in figure 3 to 8. 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 αw" 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 tot en met 2500 Hz, rounded to the nearest 0,01.
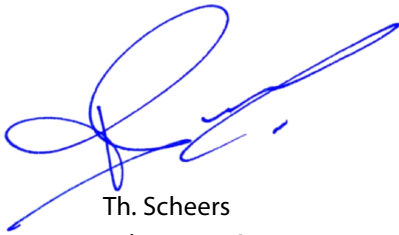
t4.2 *Measurement results Mineral Wool 35*

frequency [Hz]	sound absorption coefficient α_s					
Variant	**1**		**2**		**3**	
material thickness	**40 mm**		**50 mm**		**50 mm**	
construction height	**40 mm**		**50 mm**		**200 mm**	
record nr.	**#538**		**#686**		**#871**	
see figure	**3**		**4**		**5**	
	1/3 oct.	**1/1 oct.**	**1/3 oct.**	**1/1 oct.**	**1/3 oct.**	**1/1 oct.**
100	0,07		0,08		0,12	
125	0,15	0,13	0,18	0,17	0,43	0,40
160	0,17		0,24		0,65	
200	0,26		0,35		0,74	
250	0,41	0,39	0,56	0,53	0,88	0,87
315	0,50		0,67		0,98	
400	0,65		0,78		1,01	
500	0,69	0,70	0,87	0,86	1,04	1,02
630	0,76		0,93		1,00	
800	0,80		0,95		0,96	
1000	0,84	0,85	0,96	0,96	0,94	0,97
1250	0,91		0,98		1,02	
1600	0,95		1,02		1,02	
2000	0,97	0,97	1,02	1,03	1,06	1,05
2500	1,00		1,06		1,07	
3150	0,99		1,05		1,04	
4000	1,03	1,01	1,11	1,08	1,13	1,08
5000	1,02		1,08		1,06	
α_w	0,70(H)		0,85(H)		1,00	
NRC	0,75		0,85		1,00	
SAA	0,73		0,85		0,98	
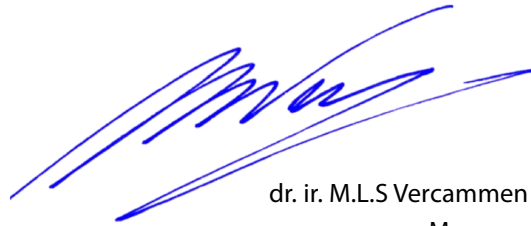
t4.3   Measurement results Mineral Wool 35

frequency [Hz]	sound absorption coefficient α_s					
Variant	**4**		**5**		**6**	
material thickness	**90 mm**		**90 mm**		**120 mm**	
construction height	**90 mm**		**200 mm**		**20 mm**	
record nr.	**#797**		**#834**		**#391**	
see figure	**6**		**7**		**8**	
	1/3 oct.	**1/1 oct.**	**1/3 oct.**	**1/1 oct.**	**1/3 oct.**	**1/1 oct.**
100	0,15		0,17		0,21	
125	0,39	0,39	0,61	0,55	0,70	0,60
160	0,62		0,86		0,90	
200	0,81		0,93		0,91	
250	0,93	0,93	1,00	1,00	1,12	1,04
315	1,04		1,07		1,09	
400	1,09		1,04		1,03	
500	1,08	1,08	1,08	1,04	0,96	1,00
630	1,07		1,00		1,00	
800	1,07		1,00		0,96	
1000	1,06	1,06	0,99	1,01	1,00	0,98
1250	1,06		1,03		0,99	
1600	1,07		1,03		1,02	
2000	1,07	1,09	1,04	1,05	1,03	1,05
2500	1,12		1,07		1,10	
3150	1,12		1,07		1,07	
4000	1,13	1,12	1,11	1,08	1,08	1,08
5000	1,10		1,06		1,10	
α_w	1,00		1,00		1,00	
NRC	1,05		1,05		1,05	
SAA	1,04		1,02		1,02	

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
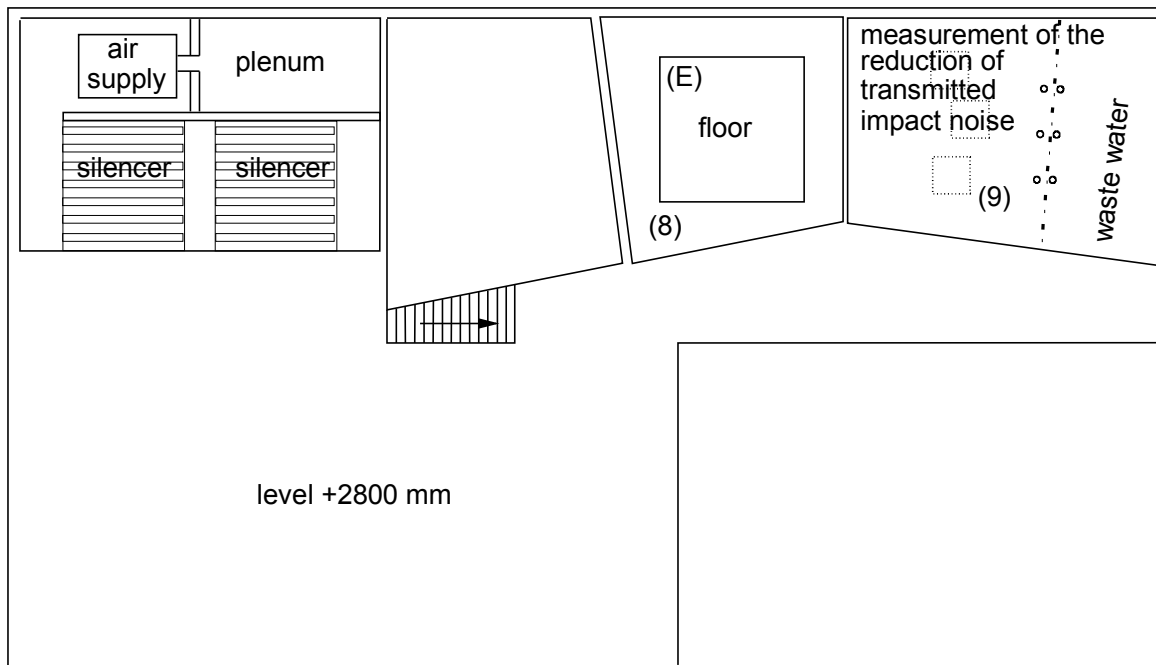Laboratory Supervisor

dr. ir. M.L.S Vercammen
Manager

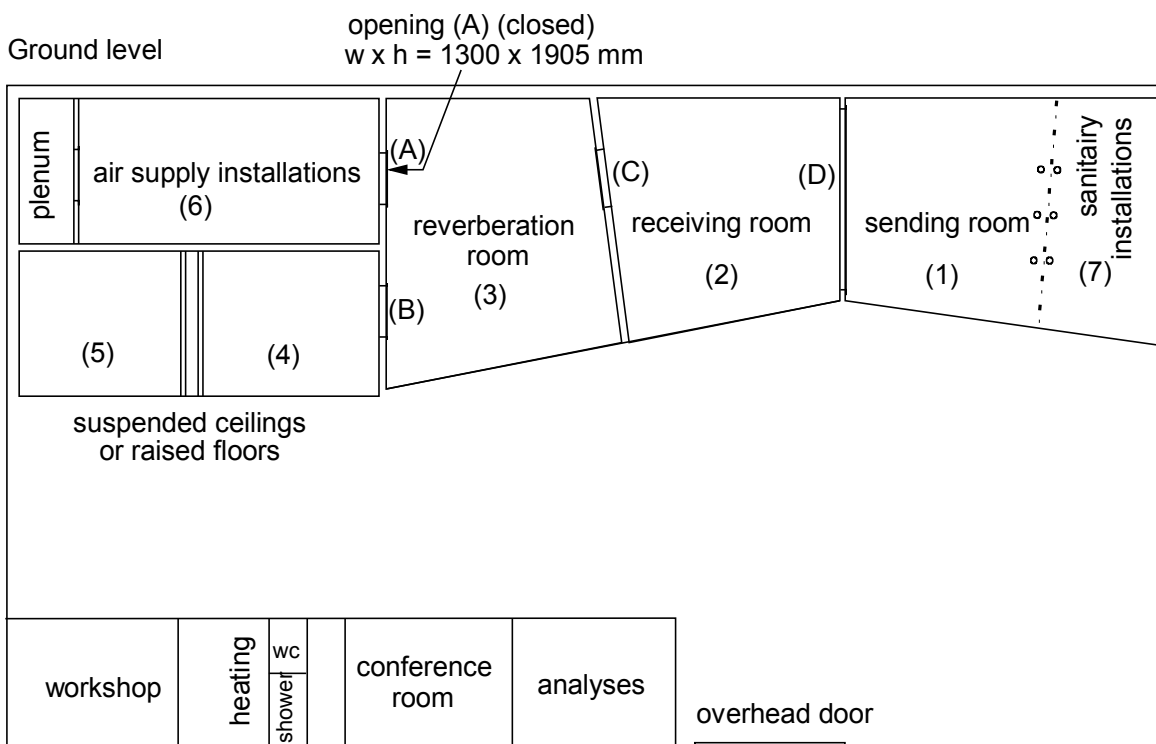This report contains 12 pages and 8 figures.

LABORATORY FOR ACOUSTICS

PEUTZ

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

OVERVIEW

Story

air supply

plenum

silencer   silencer

(E)

floor

(8)

measurement of the reduction of transmitted impact noise

waste water

(9)

level +2800 mm

Ground level

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

plenum

air supply installations
(6)

(A)

(C)   (D)

sanitairy installations

reverberation room
(3)

receiving room
(2)

sending room
(1)

(7)

(B)

(5)   (4)

suspended ceilings
or raised floors

workshop

heating

wc

shower

conference room

analyses

overhead door

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

LABORATORY FOR ACOUSTICS

PEUTZ

REVERBERATION ROOM

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

additional data:

volume : 214 m^3

total area S$_t$ (walls, floor and ceiling) : 219 m^2

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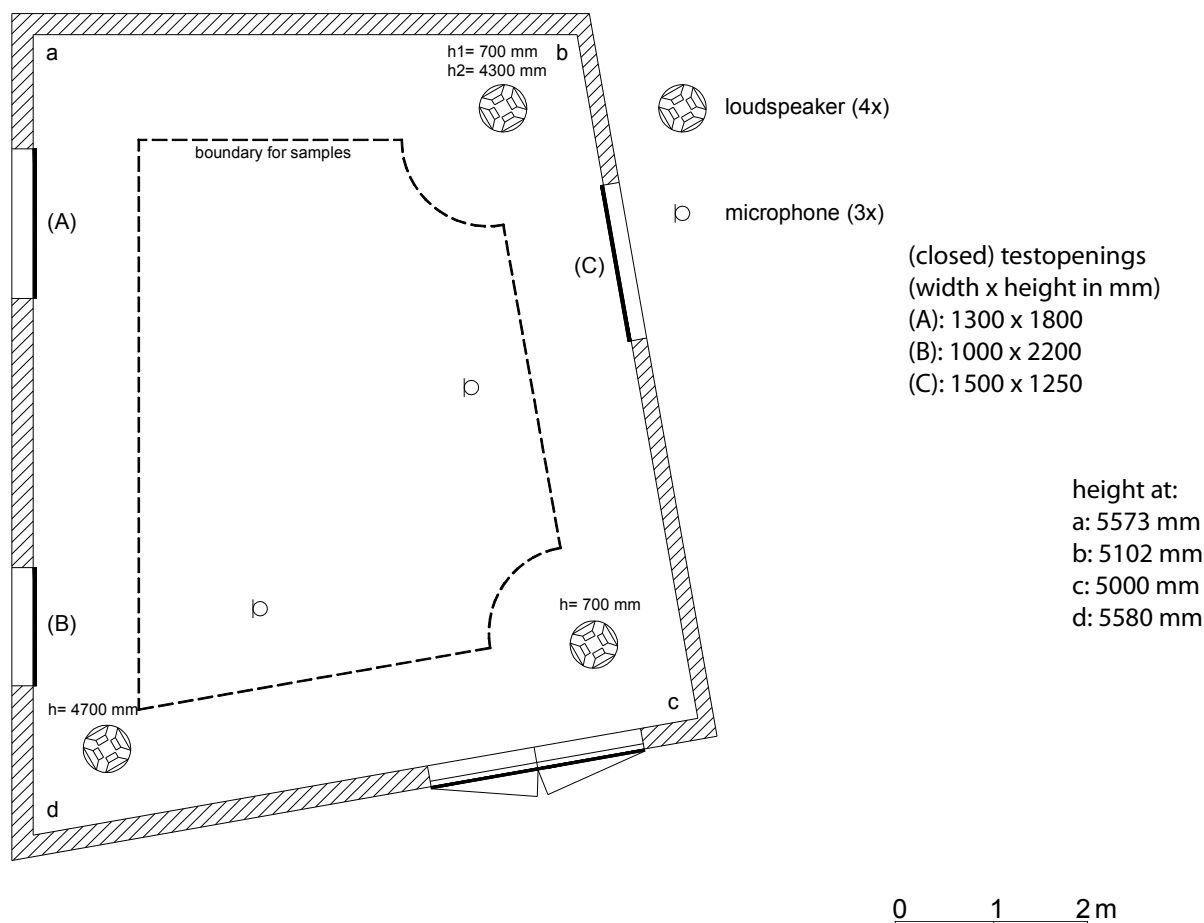

reverberation time of the empty reverberation room during measurements of 21-01-2016

frequency (1/1 oct.)	125	250	500	1000	2000	4000	Hz
reverberationtime	8,01	6,49	6,19	5,49	4,15	2,59	sec.

repeatibility 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 5.8.2 mode 7, file: a3022 E#429-464 T$_1$ = 15,8 °C p$_1$ = 102,6 kPa h$_1$ = 49,0 %

LABORATORY FOR ACOUSTICS
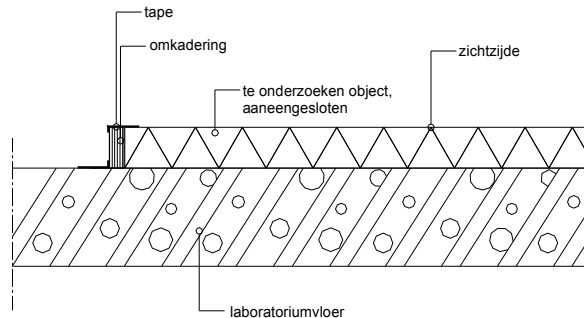
PEUTZ

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

TESTING
RvA L 334

principal: Knauf Insulation B.V.

Variant 1

Material:	Mineral wool
Type:	Mineral Wool 35
Manufacturer:	Knauf Insulation BV
Panel dimensions:	600 x 1200 mm
Thickness:	40 mm

tape
omkadering
zichtzijde
te onderzoeken object, aaneengesloten
laboratoriumvloer

volume reverberation room: 214 m^3

surface area sample: 10,91 m^2

heigth of the construction: 0,040 m

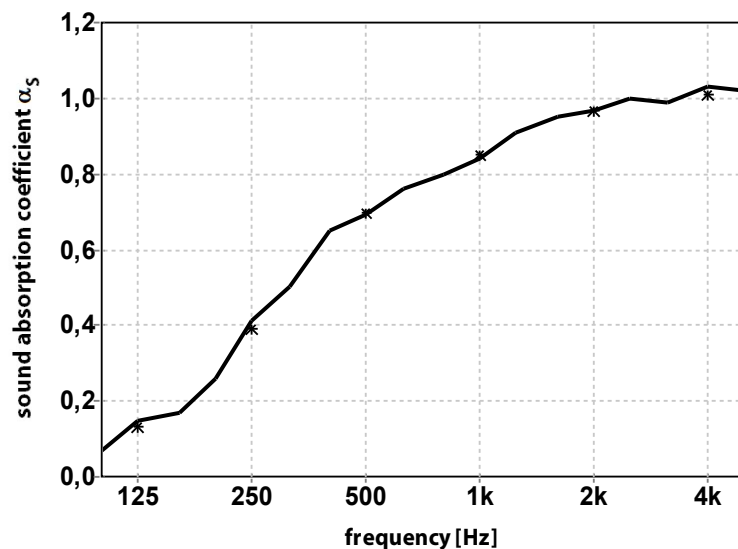measured at: Peutz Laboratory for Acoustics

signal: broad-band noise

bandwidth: 1/3 octave

α_w **(ISO 11654) = 0,70(H)**

NRC (ASTM - C423) = 0,75

SAA (ASTM - C423) = 0,73

	125	250	500	1k	2k	4k
	0,07	0,26	0,65	0,80	0,95	0,99
1/3 oct.	0,15	0,41	0,69	0,84	0,97	1,03
	0,17	0,50	0,76	0,91	1,00	1,02
1/1 oct.	**0,13**	**0,39**	**0,70**	**0,85**	**0,97**	**1,01**

Legend: 1/3 oct. (line), 1/1 oct. (*)

Mook, 21-01-2016

Absorb, versie 5.8.1 / 5.8.2 mode 7, PM: MH, file: a3022 E#:429-464 F#:502-537 A#:538 T$_1$ = 15,8 °C T$_2$ = 16,4 °C p$_1$ = 102,6 kPa p$_2$ = 102,7 kPa h$_1$ = 49,0 % h$_2$ = 49,3 %

A 3022-5E-RA-001 FB89C4FB/ THEO

LABORATORY FOR ACOUSTICS

PEUTZ

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

principal: Knauf Insulation B.V.

Variant 2

Material:	Mineral wool
Type:	Mineral Wool 35
Manufacturer:	Knauf Insulation BV
Panel dimensions:	600 x 1200 mm
Thickness:	50 mm

tape
omkadering
te onderzoeken object, aaneengesloten
zichtzijde
laboratoriumvloer
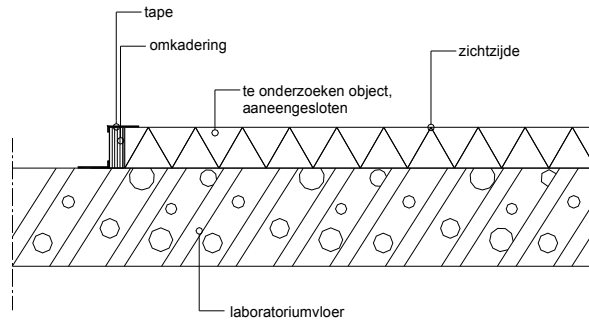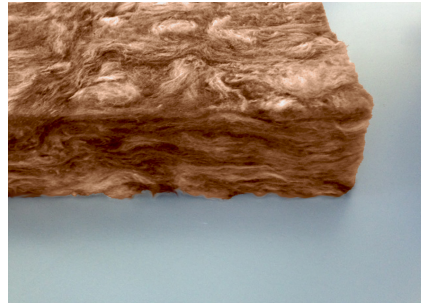
volume reverberation room: 214 m³

surface area sample: 10,91 m²

heigth of the construction: 0,050 m
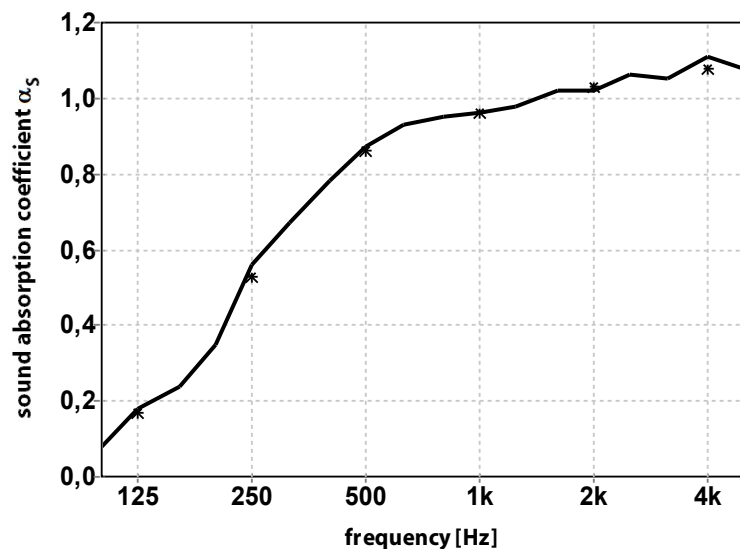
measured at: Peutz Laboratory for Acoustics

signal: broad-band noise

bandwidth: 1/3 octave

α_w **(ISO 11654) = 0,85(H)**

NRC (ASTM - C423) = 0,85

SAA (ASTM - C423) = 0,85

Legend: ── 1/3 oct.   * 1/1 oct.

sound absorption coefficient α_s vs frequency [Hz]

	125	250	500	1k	2k	4k
	0,08	0,35	0,78	0,95	1,02	1,05
1/3 oct.	0,18	0,56	0,87	0,96	1,02	1,11
	0,24	0,67	0,93	0,98	1,06	1,08
1/1 oct.	**0,17**	**0,53**	**0,86**	**0,96**	**1,03**	**1,08**

publication is permitted for the entire page only

Mook, 21-01-2016

LABORATORY FOR ACOUSTICS

PEUTZ

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

TESTING
RvA L 334

principal: Knauf Insulation B.V.

Variant 3

Material:	Mineral wool
Type:	Mineral Wool 35
Manufacturer:	Knauf Insulation BV
Panel dimensions:	600 x 1200 mm
Thickness:	50 mm

tape
draagconstructie
zichtzijde
te onderzoeken object, aaneengesloten
200 mm
omkadering
laboratoriumvloer
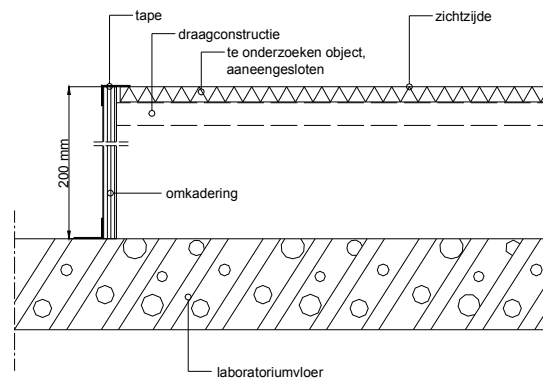
volume reverberation room: 214 m³

surface area sample: 10,97 m²

—— 1/3 oct.
✳ 1/1 oct.

heigth of the construction: 0,200 m
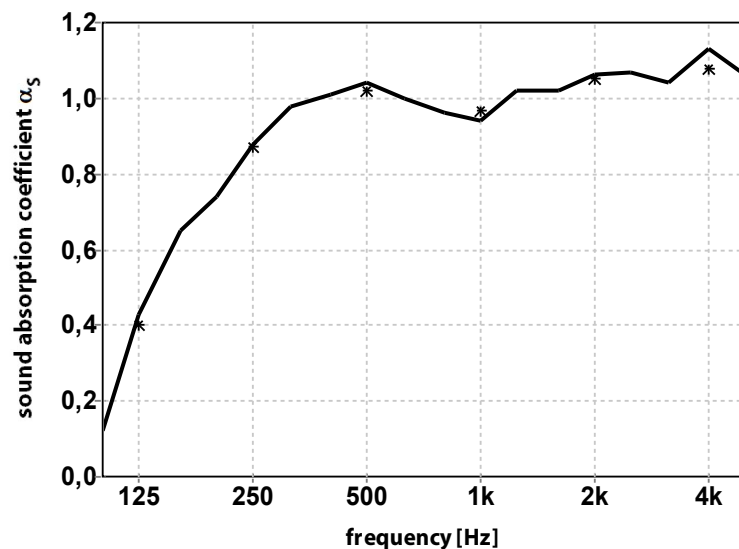
measured at: Peutz Laboratory for Acoustics

signal: broad-band noise

bandwidth: 1/3 octave

α_w (ISO 11654) = 1,00

NRC (ASTM - C423) = 1,00

SAA (ASTM - C423) = 0,98

	125	250	500	1k	2k	4k
1/3 oct.	0,12	0,74	1,01	0,96	1,02	1,04
	0,43	0,88	1,04	0,94	1,06	1,13
	0,65	0,98	1,00	1,02	1,07	1,06
1/1 oct.	**0,40**	**0,87**	**1,02**	**0,97**	**1,05**	**1,08**

Mook, 21-01-2016

Absorb, versie 5.8.1 / 5.8.2 mode 7, PM: MH, file: a3022 E#:429-464 F#:835-870 A#:871 T₁ = 15,8 °C T₂ = 16,6 °C p₁ = 102,6 kPa p₂ = 102,7 kPa h₁ = 49,0 % h₂ = 49,0 %

A 3022-5E-RA-001 IFB89C4FB/ THEO

LABORATORY FOR ACOUSTICS

PEUTZ

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

TESTING
RvA L 334

principal: Knauf Insulation B.V.

Variant 4

Material:	Mineral wool
Type:	Mineral Wool 35
Manufacturer:	Knauf Insulation BV
Panel dimensions:	600 x 1200 mm
Thickness:	90 mm

tape
omkadering
te onderzoeken object, aaneengesloten
zichtzijde
laboratoriumvloer

volume reverberation room: 214 m³

surface area sample: 10,97 m²

heigth of the construction: 0,090 m
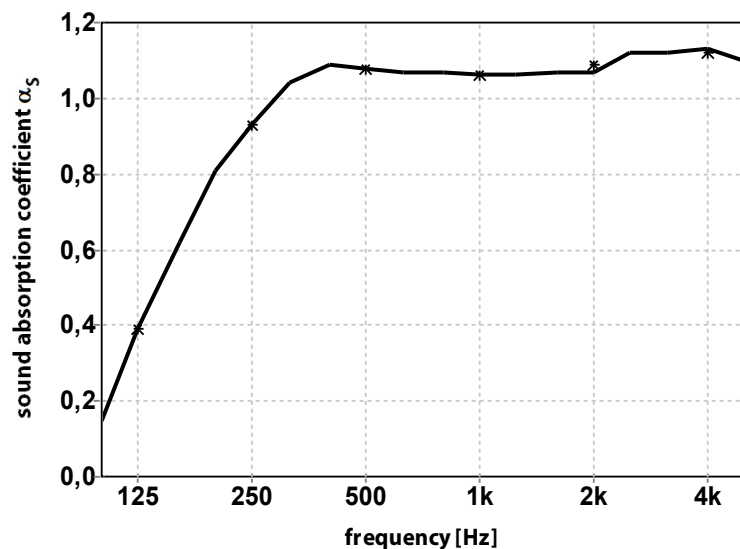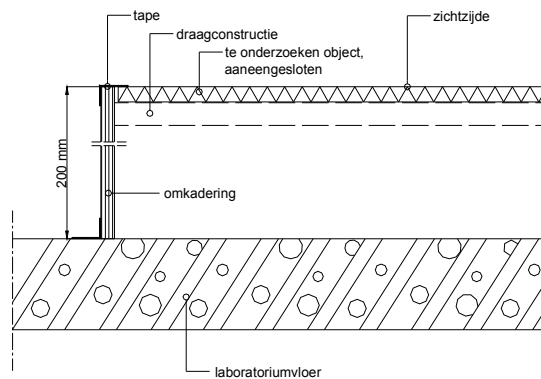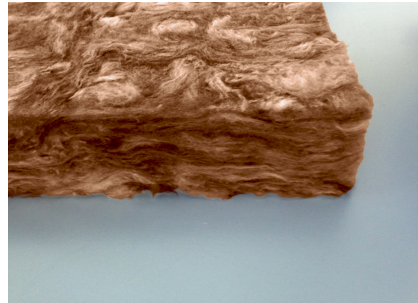
measured at: Peutz Laboratory for Acoustics

signal: broad-band noise

bandwidth: 1/3 octave

α_w (ISO 11654) = 1,00

NRC (ASTM - C423) = 1,05

SAA (ASTM - C423) = 1,04

Legend: —— 1/3 oct.   * 1/1 oct.

sound absorption coefficient α_S vs frequency [Hz]

	125	250	500	1k	2k	4k
	0,15	0,81	1,09	1,07	1,07	1,12
1/3 oct.	0,39	0,93	1,08	1,06	1,07	1,13
	0,62	1,04	1,07	1,06	1,12	1,10
1/1 oct.	**0,39**	**0,93**	**1,08**	**1,06**	**1,09**	**1,12**

publication is permitted for the entire page only

Mook, 21-01-2016

report A 3022-5E-RA

figure 6

LABORATORY FOR ACOUSTICS

PEUTZ

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

principal: Knauf Insulation B.V.

Variant 5

Material:	Mineral wool
Type:	Mineral Wool 35
Manufacturer:	Knauf Insulation BV
Panel dimensions:	600 x 1200 mm
Thickness:	90 mm

volume reverberation room: 214 m³

surface area sample: 10,97 m²

heigth of the construction: 0,200 m
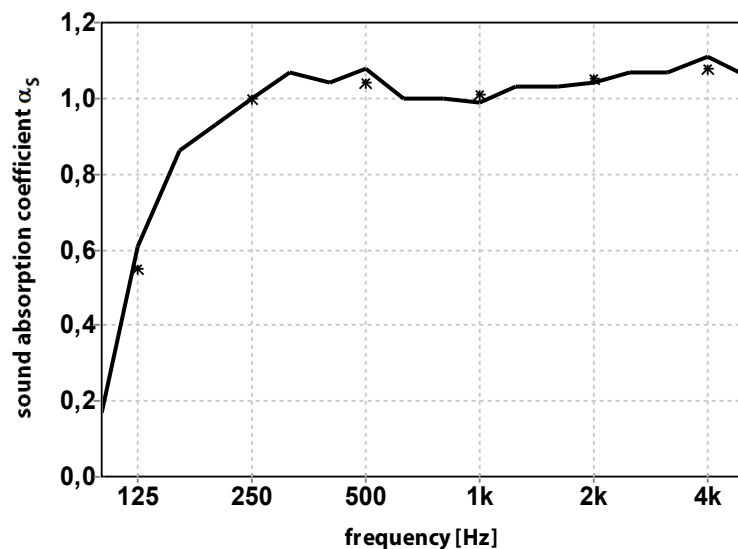
measured at: Peutz Laboratory for Acoustics

signal: broad-band noise

bandwidth: 1/3 octave

α_w (ISO 11654) = 1,00

NRC (ASTM - C423) = 1,05

SAA (ASTM - C423) = 1,02

	125	250	500	1k	2k	4k
	0,17	0,93	1,04	1,00	1,03	1,07
1/3 oct.	0,61	1,00	1,08	0,99	1,04	1,11
	0,86	1,07	1,00	1,03	1,07	1,06
1/1 oct.	**0,55**	**1,00**	**1,04**	**1,01**	**1,05**	**1,08**

publication is permitted for the entire page only

Mook, 21-01-2016

report A 3022-5E-RA

figure 7

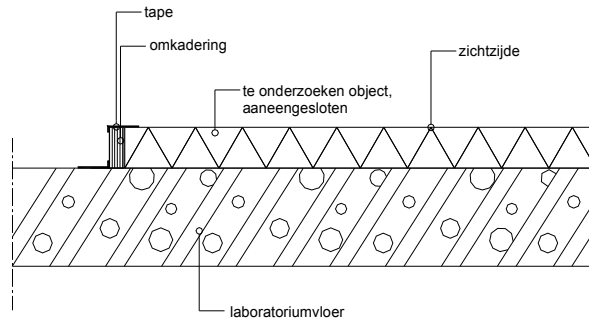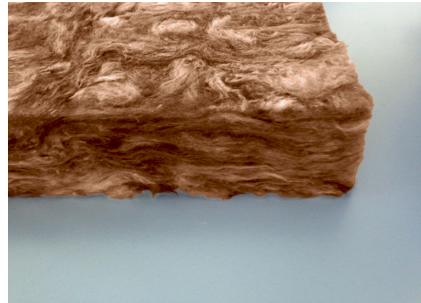# LABORATORY FOR ACOUSTICS

PEUTZ

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

TESTING
RvA L 334

principal: Knauf Insulation B.V.

Variant 6

Material:	Mineral wool
Type:	Mineral Wool 35
Manufacturer:	Knauf Insulation BV
Panel dimensions:	600 x 1200 mm
Thickness:	120 mm

volume reverberation room: 214 m³

surface area sample: 10,8 m²

heigth of the construction: 0,120 m

measured at:
Peutz Laboratory for Acoustics
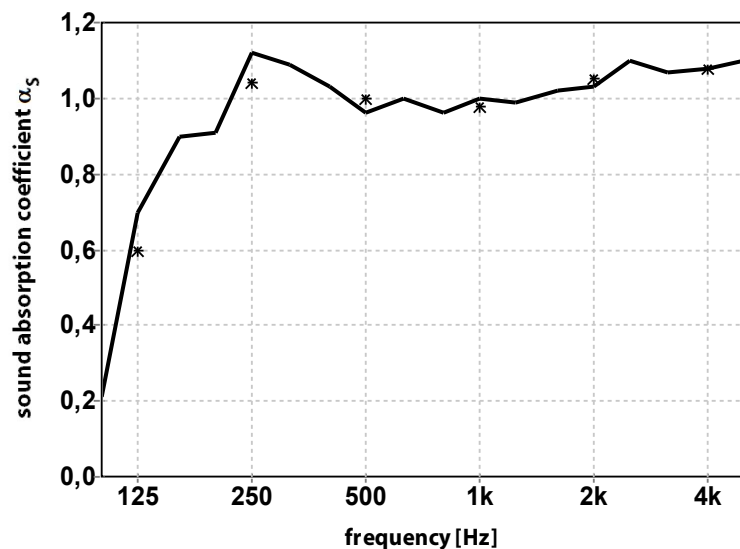
signal: broad-band noise

bandwidth: 1/3 octave

α_w (ISO 11654) = 1,00

NRC (ASTM - C423) = 1,05

SAA (ASTM - C423) = 1,02

	125	250	500	1k	2k	4k
	0,21	0,91	1,03	0,96	1,02	1,07
1/3 oct.	0,70	1,12	0,96	1,00	1,03	1,08
	0,90	1,09	1,00	0,99	1,10	1,10
1/1 oct.	**0,60**	**1,04**	**1,00**	**0,98**	**1,05**	**1,08**

Mook, 07-12-2015

Absorb, versie 5.8.1 / 5.8.2 mode 7, PM: RA, file: a3022 E#:1-36 F#:355-390 A#:391 T₁ = 17,5 °C T₂ = 17,3 °C p₁ = 103,0 kPa p₂ = 103,1 kPa h₁ = 54,6 % h₂ = 59,8 %

A 3022-5E-RA-001 lFB89C4FEI THEO