



Laboratory for Acoustics

*Determination of the sound absorption
(reverberation room method) of BuzziSpace
designs, manufacturer BuzziSpace*



4 Measurements

The products are installed for the laboratory test in the same manner as they are typically installed in practice;

- free-standing on the floor of the reverberation room
- free hanging from the ceiling of the reverberation room

For discrete absorbers like this particular case, the results are expressed as the equivalent sound absorption area per object A (m²).

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 A₁ is calculated (per frequency band) according to formula 1 and expressed in m²

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

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] |

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

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

reverberation room	temperature [°C]	barometric pressure [kPa]	relative humidity [%]
empty	19.0	101.5	50.9
With objects	19.1 – 19.9	101.5 – 101.6	49.4 – 53.7

4.4 Results

The results of the measurements are given in table t4.2 to tabel t4.4 and in figure 3 up and including 12. 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.

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

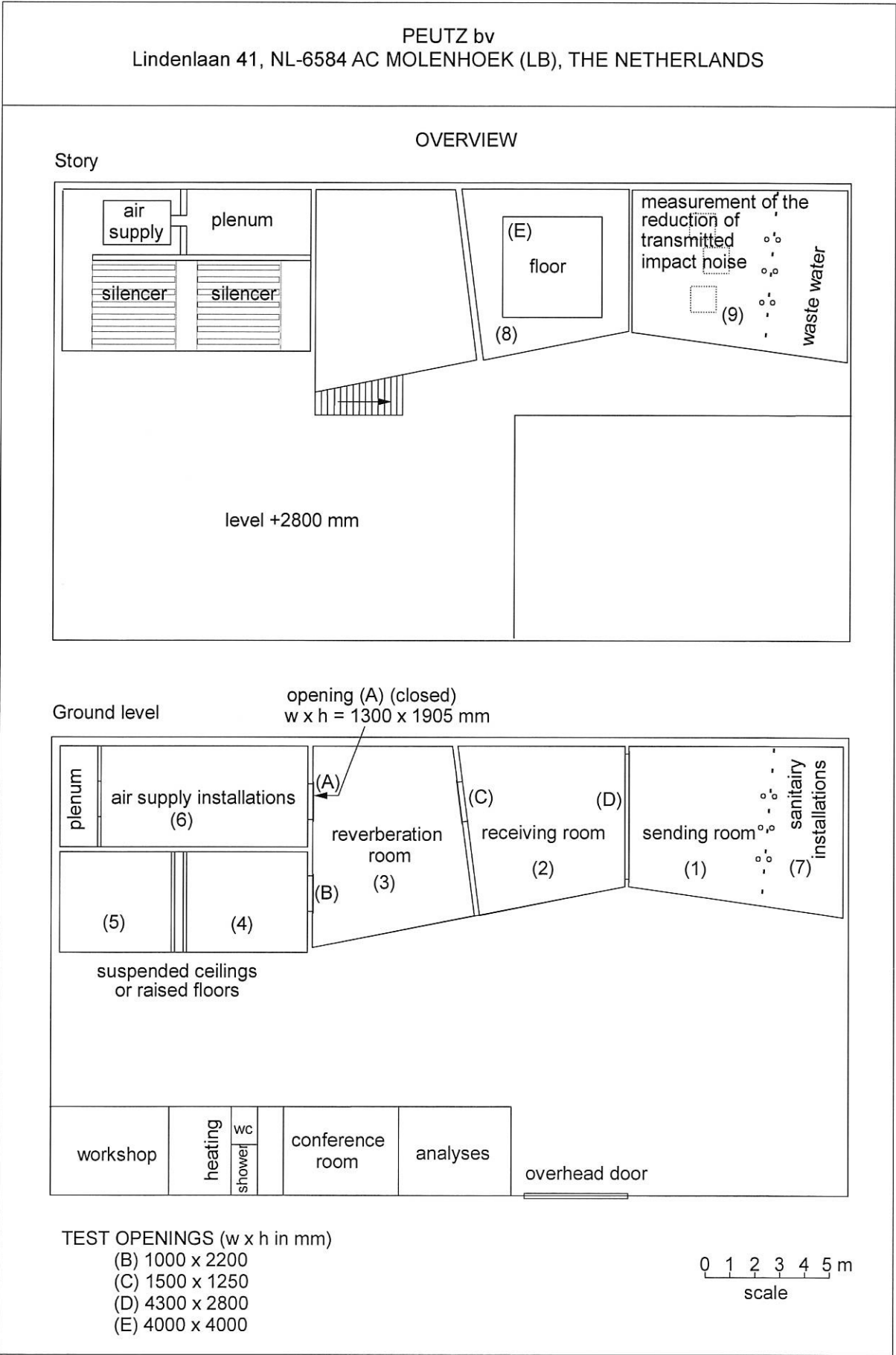


Figure 1

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 S_t (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.

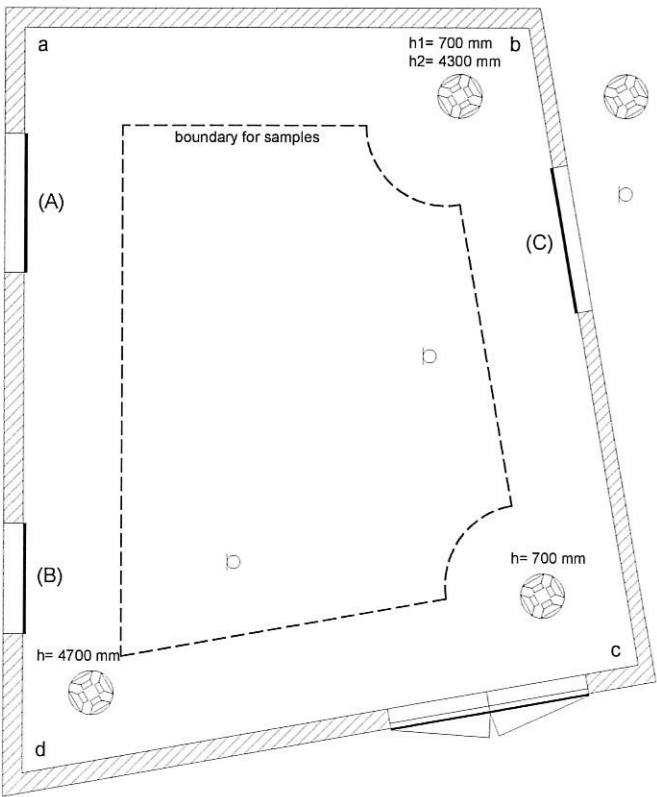
reverberation time of the empty reverberation room during measurements of 09-05-2016

frequency (1/1 oct.)	125	250	500	1000	2000	4000	Hz
reverberationtime	7,91	6,31	6,08	5,42	4,12	2,74	sec.

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

r bij hoge α	0,13	0,04	0,04	0,02	0,02	0,08	-
r bij lage α	0,09	0,02	0,01	0,02	0,02	0,04	-

plan



loudspeaker (4x)

microphone (3x)

(closed) testopenings
(width x height in mm)
(A): 1300 x 1800
(B): 1000 x 2200
(C): 1500 x 1250

height at:
a: 5573 mm
b: 5102 mm
c: 5000 mm
d: 5580 mm

0 1 2 m

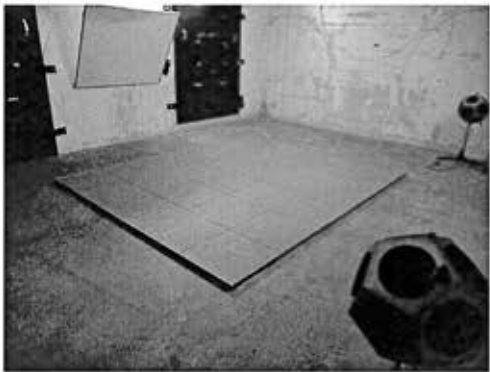
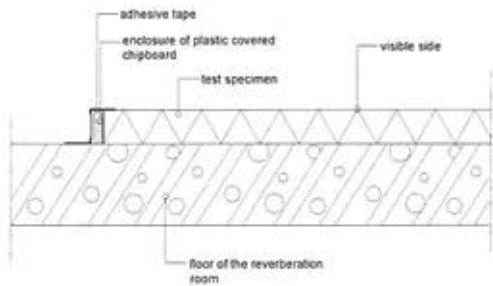
figure 2

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



principal: BuzziSpace

BuzziBlox SQ-4



volume reverberation room: 214 m³

surface area sample: 10,7 m²

height of the construction: 0,04 m

measured at: Peutz Laboratory for Acoustics

signal: broad-band noise

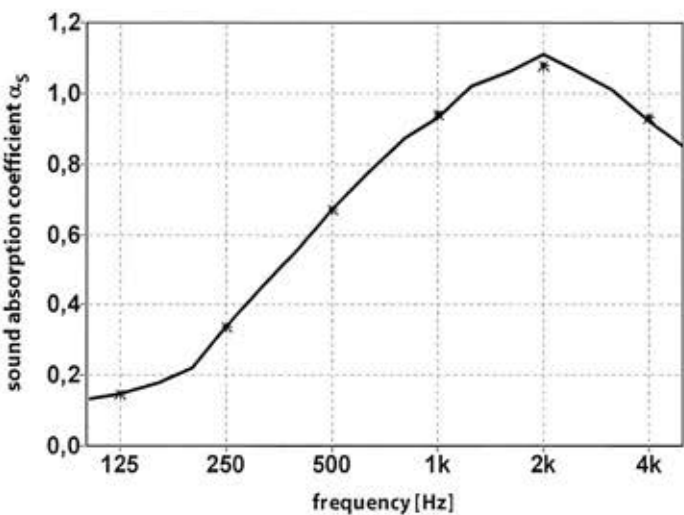
bandwidth: 1/3 octave

α_w (ISO 11654) = 0,65(MH)

CLASS (ISO 11654); C

NRC (ASTM - C423) = 0,75

SAA (ASTM - C423) = 0,76



	0,13	0,22	0,56	0,87	1,06	1,01
1/3 oct.	0,15	0,34	0,67	0,93	1,11	0,92
	0,18	0,45	0,77	1,02	1,06	0,85
1/1 oct.	0,15	0,34	0,67	0,94	1,08	0,93

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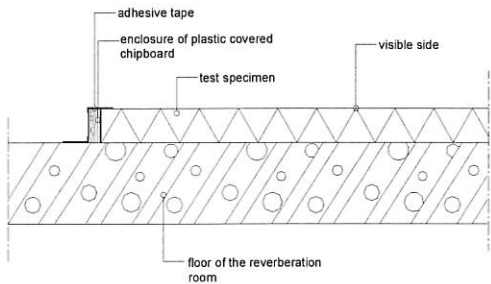
Mook, 03-11-2015

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



principal: BuzziSpace

BuzziBlox SQ-8



volume reverberation room: 214 m³

surface area sample: 10,7 m²

height of the construction: 0,08 m

measured at: Peutz Laboratory for Acoustics

signal: broad-band noise

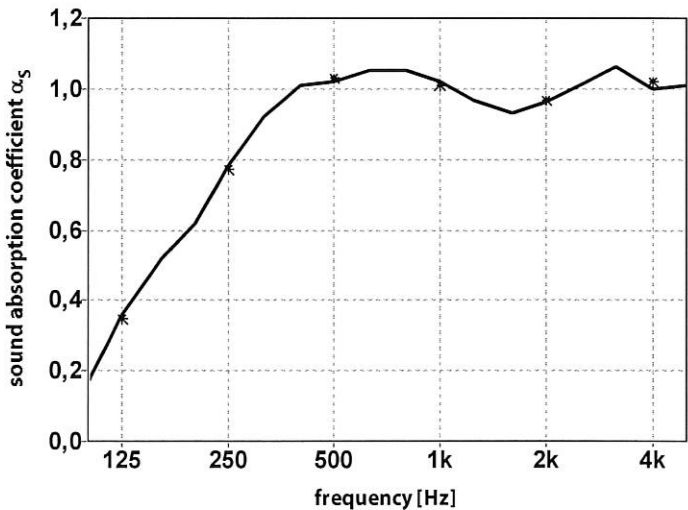
bandwidth: 1/3 octave

α_w (ISO 11654) = 1,00

CLASS (ISO 11654); A

NRC (ASTM - C423) = 0,95

SAA (ASTM - C423) = 0,95



	0,17	0,62	1,01	1,05	0,93	1,06
1/3 oct.	0,36	0,78	1,02	1,02	0,96	1,00
	0,52	0,92	1,05	0,97	1,01	1,01
1/1 oct.	0,35	0,77	1,03	1,01	0,97	1,02

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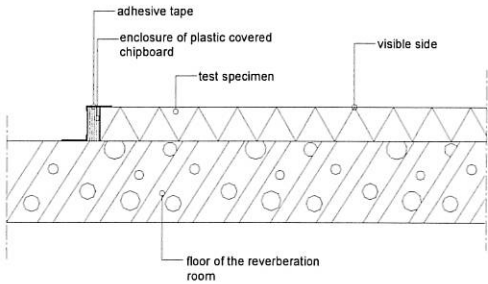
Mook, 03-11-2015

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



principal: BuzziSpace

BuzziBlox SQ-12



volume reverberation room: 214 m³

surface area sample: 10,7 m²

height of the construction: 0,120 m

measured at: Peutz Laboratory for Acoustics

signal: broad-band noise

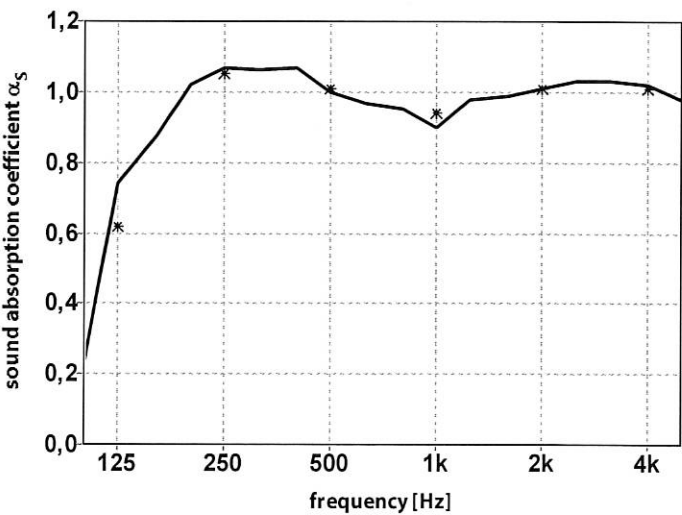
bandwidth: 1/3 octave

α_w (ISO 11654) = 1,00

CLASS (ISO 11654); A

NRC (ASTM - C423) = 1,00

SAA (ASTM - C423) = 1,00



	0,23	1,02	1,07	0,95	0,99	1,03
1/3 oct.	0,74	1,07	1,00	0,90	1,01	1,02
	0,88	1,06	0,97	0,98	1,03	0,98
1/1 oct.	0,62	1,05	1,01	0,94	1,01	1,01

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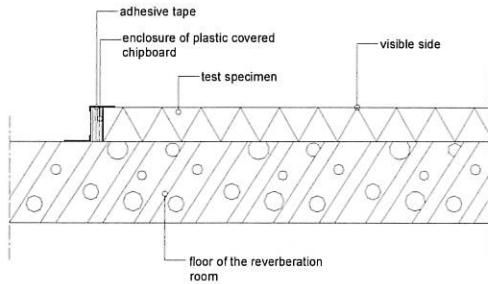
Mook, 03-11-2015

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



principal: BuzziSpace

BuzziBlox SQ Wedge



volume reverberation room: 214 m³

surface area sample: 10,7 m²

height of the construction: m

measured at: Peutz Laboratory for Acoustics

signal: broad-band noise

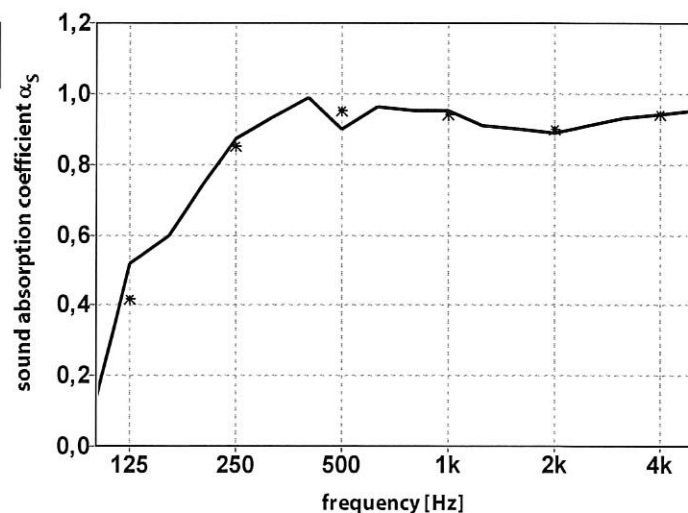
bandwidth: 1/3 octave

α_w (ISO 11654) = 0,95

CLASS (ISO 11654); A

NRC (ASTM - C423) = 0,90

SAA (ASTM - C423) = 0,91



	0,14	0,74	0,99	0,95	0,90	0,93
1/3 oct.	0,52	0,87	0,90	0,95	0,89	0,94
	0,60	0,93	0,96	0,91	0,91	0,95
1/1 oct.	0,42	0,85	0,95	0,94	0,90	0,94

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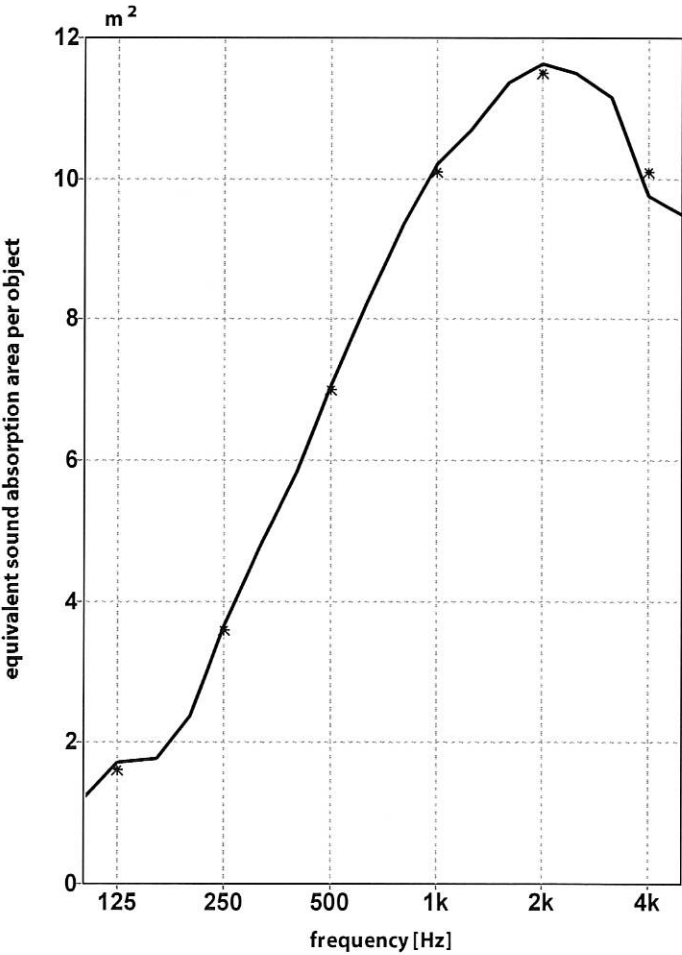
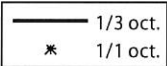
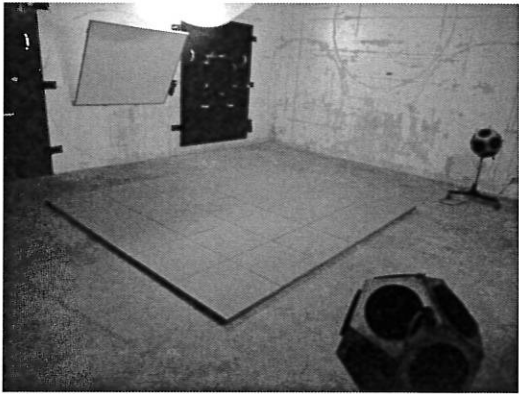
Mook, 03-11-2015

EQUIVALENT SOUNDABSORPTION AREA PER OBJECT conform ISO 354:2003



principal: BuzziSpace

BuzziBlox SQ-4, object area 10,7 m²



1/3 oct.	1,2	2,4	5,9	9,4	11,4	11,2	
	1,7	3,6	7,1	10,2	11,6	9,8	m²
	1,8	4,8	8,2	10,7	11,5	9,5	
1/1 oct.	1,6	3,6	7,0	10,1	11,5	10,1	m²

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Mook, 03-11-2015

EQUIVALENT SOUNDABSORPTION AREA PER OBJECT conform ISO 354:2003

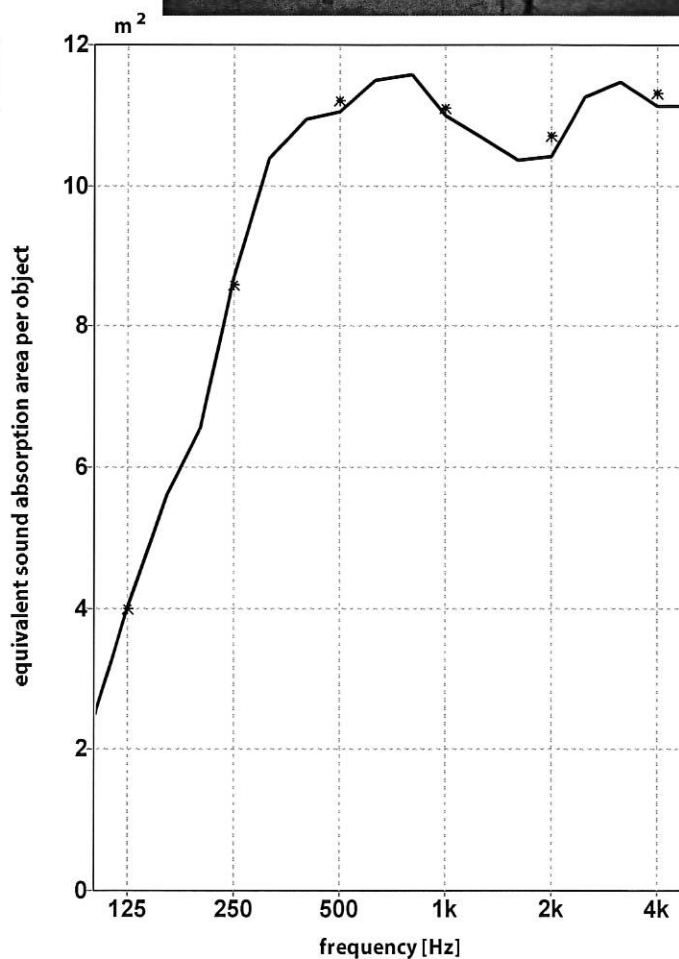
principal: BuzziSpace



BuzziBlox SQ-8, object area 10,7 m²



— 1/3 oct.
* 1/1 oct.



volume reverberation room: 214 m³

number of elements: 1 (10,7 m²)

measured at: Peutz Laboratory for Acoustics

signal: broad-band noise

bandwidth: 1/3 octave

	2,5	6,6	11,0	11,6	10,4	11,5
1/3 oct.	4,0	8,7	11,1	11,0	10,4	11,1
	5,6	10,4	11,5	10,7	11,3	11,1
1/1 oct.	4,0	8,6	11,2	11,1	10,7	11,3
						m ²

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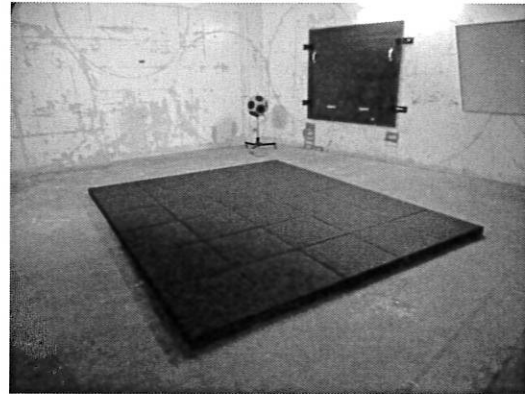
Mook, 03-11-2015

EQUIVALENT SOUNDABSORPTION AREA PER OBJECT conform ISO 354:2003

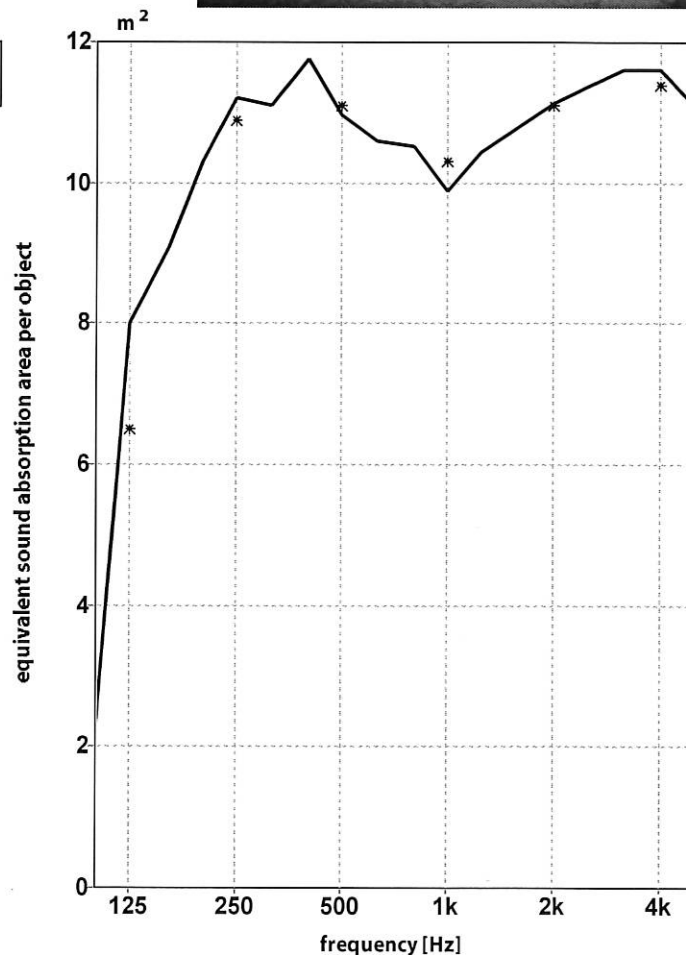
principal: BuzziSpace



BuzziBlox SQ-12, object area 10,7 m²



— 1/3 oct.
* 1/1 oct.



volume reverberation room: 214 m³

number of elements: 1 (10, m²)

measured at: Peutz Laboratory for Acoustics

signal: broad-band noise

bandwidth: 1/3 octave

	2,3	10,3	11,8	10,5	10,8	11,6
1/3 oct.	8,0	11,2	11,0	9,9	11,1	11,6 m ²
	9,1	11,1	10,6	10,4	11,4	11,1
1/1 oct.	6,5	10,9	11,1	10,3	11,1	11,4 m ²

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Mook, 03-11-2015

EQUIVALENT SOUNDABSORPTION AREA PER OBJECT conform ISO 354:2003

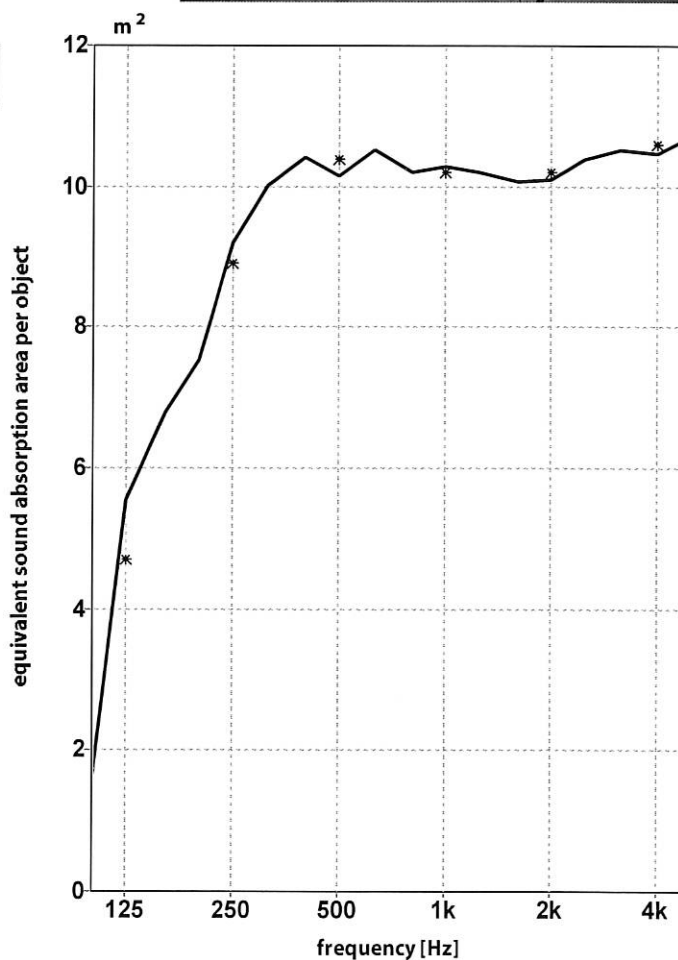
principal: BuzziSpace



BuzziBlox SQ Wedge, object area 10,7 m²



— 1/3 oct.
* 1/1 oct.



volume reverberation room: 214 m³

number of elements: 1 (10,7 m²)

measured at: Peutz Laboratory for Acoustics

signal: broad-band noise

bandwidth: 1/3 octave

	125	250	500	1k	2k	4k	
1/3 oct.	1,6	7,5	10,4	10,2	10,1	10,5	
	5,5	9,2	10,1	10,3	10,1	10,5	m ²
	6,8	10,0	10,5	10,2	10,4	10,7	
1/1 oct.	4,7	8,9	10,4	10,2	10,2	10,6	m ²

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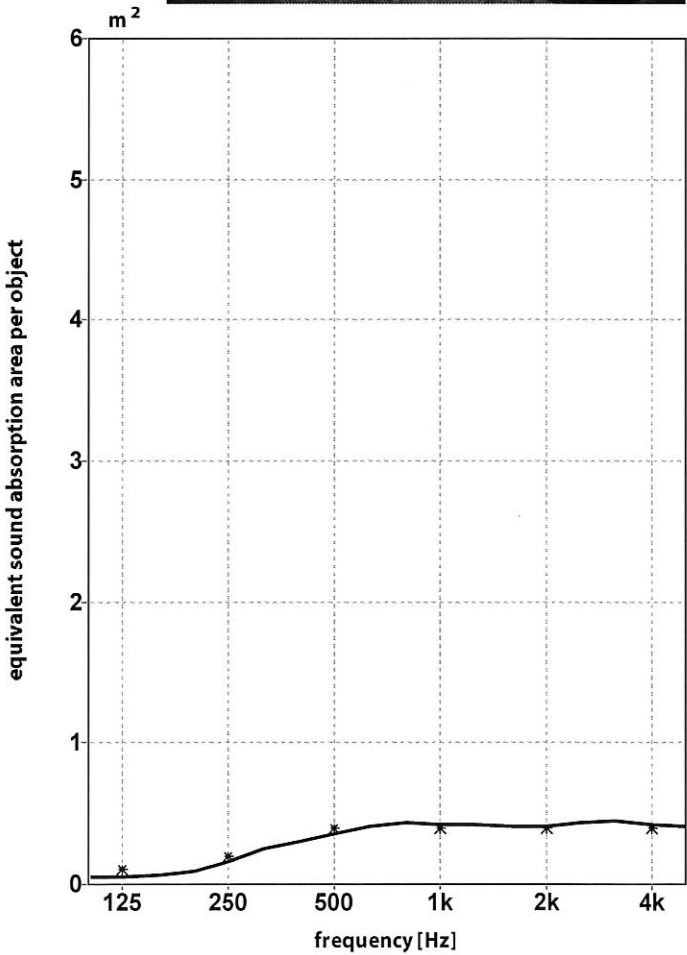
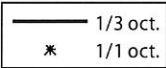
Mook, 03-11-2015

EQUIVALENT SOUNDABSORPTION AREA PER OBJECT conform ISO 354:2003



principal: BuzziSpace

BuzziBlox SQ-4, object area 0,35 m² (x 15), cavity 70 mm



volume reverberation room: 214 m³

number of elements: 15

measured at: Peutz Laboratory for Acoustics

signal: broad-band noise

bandwidth: 1/3 octave

	0,1	0,1	0,3	0,4	0,4	0,5	
1/3 oct.	0,1	0,2	0,4	0,4	0,4	0,4	m ²
	0,1	0,3	0,4	0,4	0,4	0,4	
1/1 oct.	0,1	0,2	0,4	0,4	0,4	0,4	m ²

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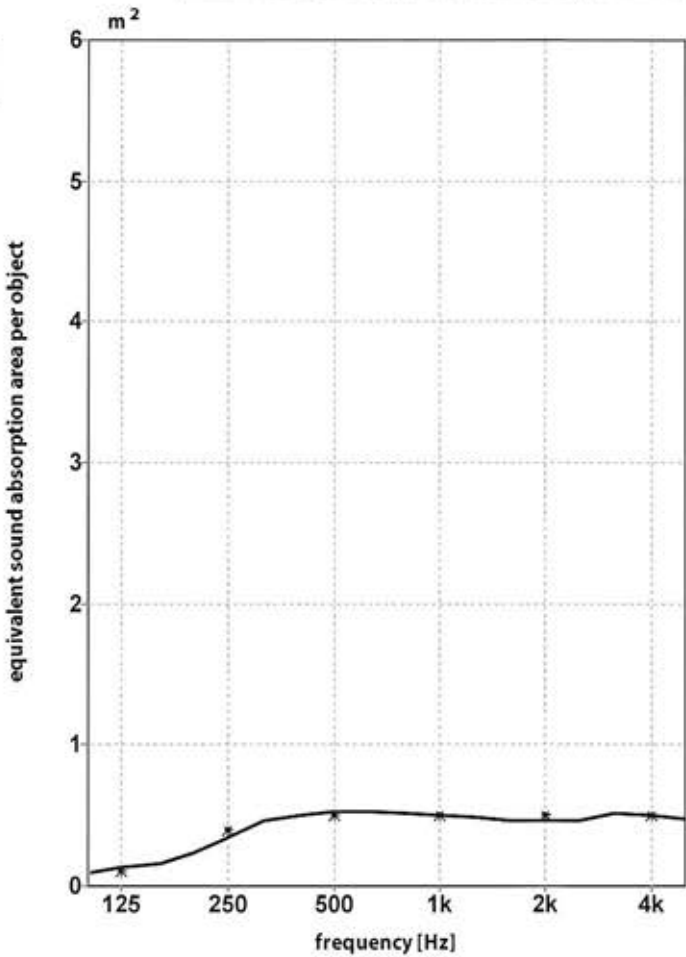
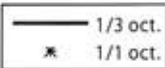
Mook, 03-11-2015

EQUIVALENT SOUNDABSORPTION AREA PER OBJECT conform ISO 354:2003

principal: BuzziSpace



BuzziBlox SQ-8, object area 0,35 m² (x 15), cavity 70 mm



volume reverberation room: 214 m³

number of elements: 15

measured at: Peutz Laboratory for Acoustics

signal: broad-band noise

bandwidth: 1/3 octave

1/3 oct.	0,1	0,2	0,5	0,5	0,5	0,5	m ²
	0,1	0,4	0,5	0,5	0,5	0,5	
	0,2	0,5	0,5	0,5	0,5	0,5	
1/1 oct.	0,1	0,4	0,5	0,5	0,5	0,5	m ²

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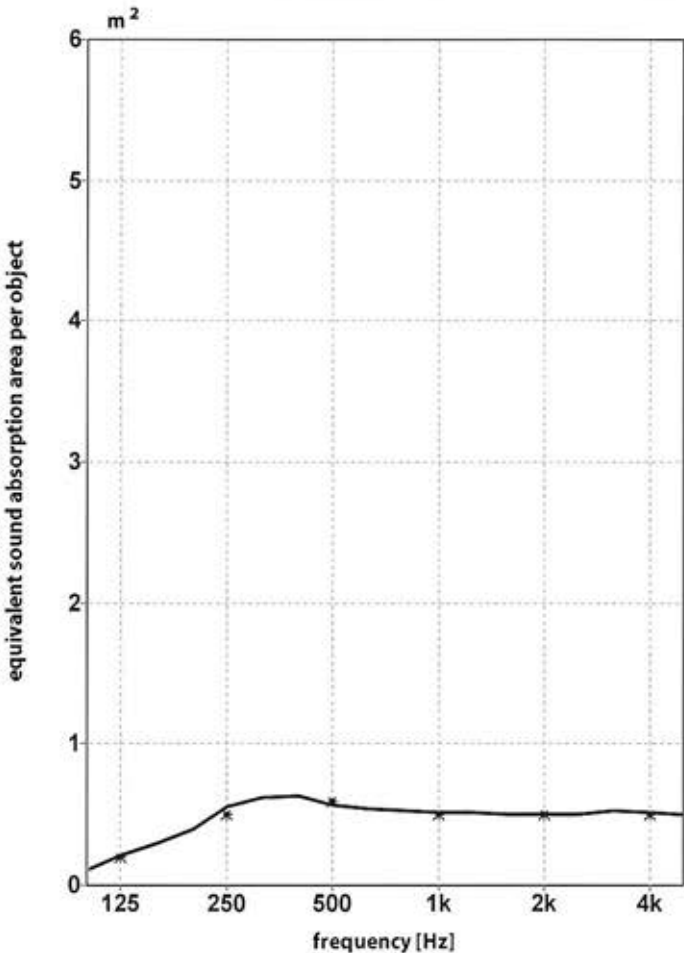
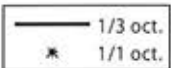
Mook, 03-11-2015

EQUIVALENT SOUNDABSORPTION AREA PER OBJECT conform ISO 354:2003



principal: BuzziSpace

BuzziBlox SQ-12, object area 0,35 m² (x 15), cavity 70 mm



	0,1	0,4	0,6	0,5	0,5	0,5	
1/3 oct.	0,2	0,6	0,6	0,5	0,5	0,5	m²
	0,3	0,6	0,5	0,5	0,5	0,5	
1/1 oct.	0,2	0,5	0,6	0,5	0,5	0,5	m²

publication is permitted for the entire page only

Mook, 03-11-2015

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



principal: BuzziSpace

Variant 12a: Buzzi Blox-RXL 8; 6 PCs, Serried, Total height of the construction: 80 mm



volume reverberation room: 214 m³

surface area sample: 12 m²

measured at: Peutz Laboratory for Acoustics

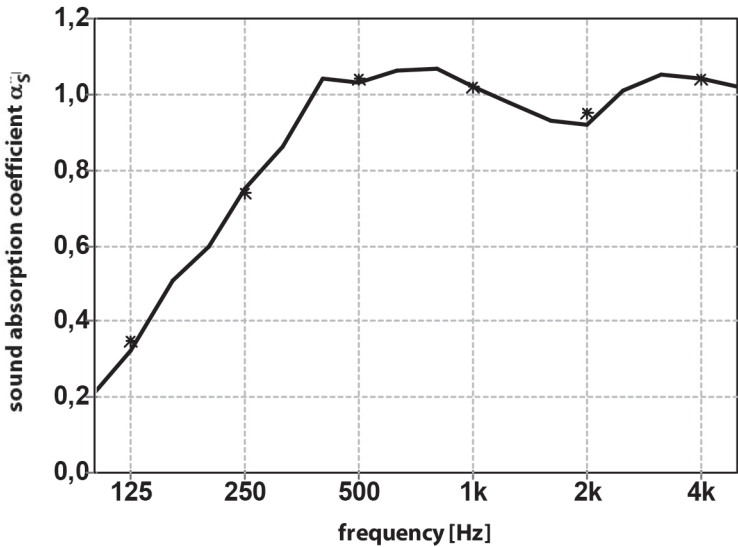
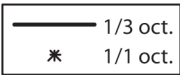
signal: broad-band noise

bandwidth: 1/3 octave

α_w (ISO 11654) = 1,00

NRC (ASTM - C 423) = 0,95

SAA (ASTM - C 423) = 0,94



	0,21	0,60	1,04	1,07	0,93	1,05
1/3 oct.	0,32	0,75	1,03	1,02	0,92	1,04
	0,51	0,86	1,06	0,98	1,01	1,02
1/1 oct.	0,35	0,74	1,04	1,02	0,95	1,04

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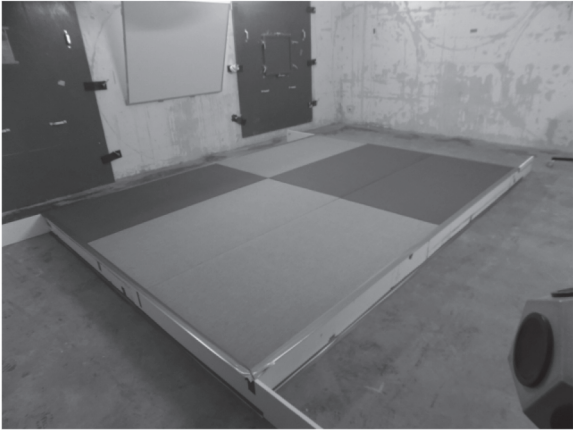
Mook, measured at
24-01-2017

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



principal: BuzziSpace

Variant 12b: Buzzi Blox-RXL 8; 6 PCs, Serried, Total height of the construction: 200 mm



volume reverberation room: 214 m³

surface area sample: 12 m²

measured at: Peutz Laboratory for Acoustics

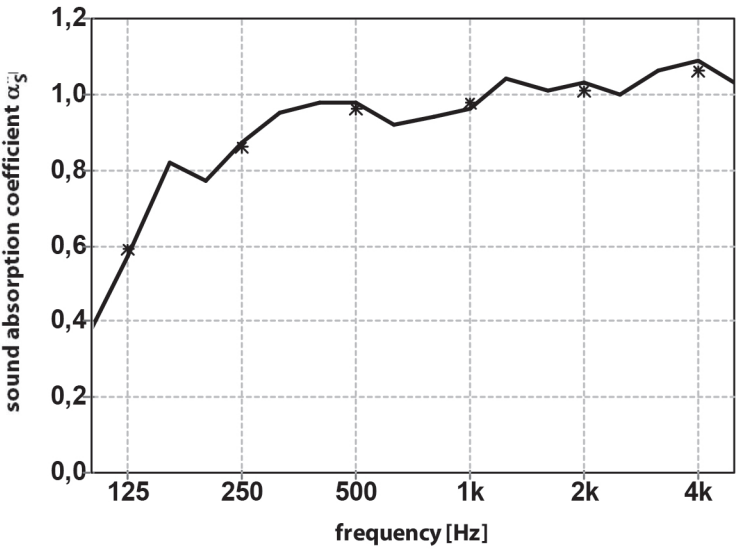
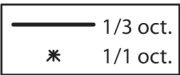
signal: broad-band noise

bandwidth: 1/3 octave

α_w (ISO 11654) = 1,00

NRC (ASTM - C423) = 0,95

SAA (ASTM - C423) = 0,95



	0,38	0,77	0,98	0,94	1,01	1,06
1/3 oct.	0,57	0,87	0,98	0,96	1,03	1,09
	0,82	0,95	0,92	1,04	1,00	1,03
1/1 oct.	0,59	0,86	0,96	0,98	1,01	1,06

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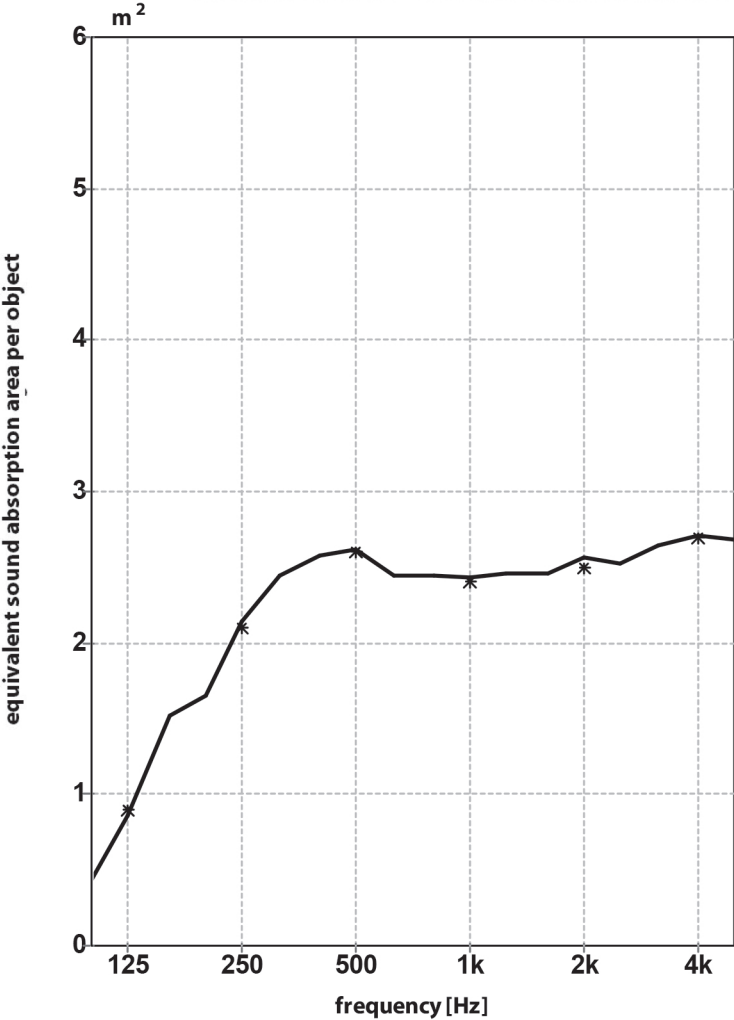
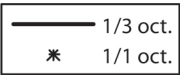
Mook, measured at
24-01-2017

EQUIVALENT SOUNDABSORPTION AREA PER OBJECT conform ISO 354:2003

principal: BuzziSpace



Variant 12c: Buzzi Blox-RXL 8; 4 PCs, freely, distance between:500 m, Total height of the construction: 200 mm



volume reverberation room: 214 m³

number of elements: 4

measured at: Peutz Laboratory for Acoustics

signal: broad-band noise

bandwidth: 1/3 octave

1/3 oct.	0,4	1,7	2,6	2,4	2,5	2,6	
	0,9	2,1	2,6	2,4	2,6	2,7	m²
	1,5	2,5	2,5	2,5	2,5	2,7	
1/1 oct.	0,9	2,1	2,6	2,4	2,5	2,7	m²

publication is permitted for the entire page only

Mook, measured at
24-01-2017

figure 17

Absorb, versie 5.8.4 mode 9, PM: RA, file: a 2979 E#:1709-1744 F#:2088-2123 A#:2124 T₁ = 15,3 °C T₂ = 15,9 °C p₁ = 102,7 kPa p₂ = 103,0 kPa h₁ = 50,3 % h₂ = 50,7 %