ACOUSTICS AND BUILDING PHYSICS
NOISE CONTROL
ENVIRONMENTAL TECHNOLOGY
FIRE SAFETY

PEUTZ

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Report

Draft

Laboratory for Acoustics

Determination of the sound absorption (reverberation room method) of a suspended ceiling type **Luxalon 80B and Derako Wooden Grills, manufacturer Hunter Douglas**

Report number A 1906-1E dd. 2 June 2009

Principal:	Hunter Douglas Architectural Products Division Keys Business Park Hednesford United Kingdom
Report number:	A 1906-1E
Date:	2 June 2009
Ref.:	TS/TS/A 1906-1E-RA

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1. INTRODUCTION

At the request of Hunter Douglas based in Hednesford (United Kingdom), laboratory measurements of the sound absorption (reverberation room method) were carried out on suspended ceilings

type Luxalon 80B and Derako Wooden Grills, manufacturer Hunter Douglas

The measurements are carried out in the Laboratory for Acoustics of Peutz bv, at Mook, The Netherlands (see figure 1).

TESTING
RvA L 334

For this type of measurements the Laboratory for Acoustics has been accredited by the Dutch "Stichting Raad voor Accreditatie" (RvA).
The RvA is member of the EA MLA[1]

[1] **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. NORMS AND GUIDELINES

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

ISO 354:2003 [3)]	Acoustics - Measurement of sound absorption in a reverberation room
NOTE:	*this international standard has been accepted within all EU-countries as European Norm EN 354:2003*

Various other related norms:

ISO 11654:1997	Acoustics - Sound absorbers for use in buildings - Rating of sound absorption
ASTM-C423-90a	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 T1 end T2 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. For the measurements the following materials were used (see also figure 3):

Perforated Luxalon 80B panels:

type:	Luxalon 80B
manufacturer:	Hunter Douglas
panel sizes:	a square edged U-profile height 15 mm, width 80 mm, distance between the panels 20 mm
material:	painted aluminium, with a non woven acoustical fleece (Soundtex) glued to the inside of the panel
aluminium thickness:	0,6 mm
perforation:	top; diameter 2.0 mm, triangle pattern, 5.0 mm between the centres; perforation rate 15%.
Joint profiles	Aluminium strip, thickness ca. 0,65 mm

De ceiling panels are fixed on omega-profiles with a height of ca. 40 mm. These carriers are mounted on 45 mm softwood battens. Total construction height measures 100 mm.

Derako Wooden Grills

type:	Derako
manufacturer:	Hunter Douglas
material	wooden slats
slat width	15 mm
slat height	55 mm
slat distance	25 mm

De ceiling panels are mounted on 45 mm softwood battens. Total construction height measures 100 mm.

Insulation material 1

HI-Clinic washable Acoustic Ceiling Panels, manufacturer Hodgson&Hodgson, type PL40. These panels consist of mineral wool with a non-woven glass fibre tissue and a washable facing. Dimensions 1200 x 600 mm. Thickness 40 mm. Weight 3,2 kg/m^2.

Insulation material 2

Mineral wool pads. These panels consist of Rockwool wrapped in PE-foil. Dimensions 1000 x 300 mm. Thickness 50 mm. Weight 2,8 kg/m^2.

Variants:

The following variants are measured (top to bottom):

1. 55 mm Wooden Grills, 40 mm Hi Clinic, construction height ca. 100 mm;
2. 55 mm Wooden Grills, 45 air cavity, 40 mm Hi Clinic, construction height ca. 145 mm;
3. Luxalon 80 B elements, open joints, 40 mm air cavity, 40 mm Hi Clinic construction height ca. 100 mm;
4. Luxalon 80 B elements, closed joints, 40 mm air cavity, 40 mm Hi Clinic construction height ca. 100 mm;
5. Luxalon 80 B elements, closed joints, 50 mm Rockwool, construction height ca. 800 mm;
6. Luxalon 80 B elements, open joints, 50 mm Rockwool, construction height ca. 800 mm.

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 representability of the tested samples.

4. MEASUREMENTS

The ceiling elements to be measured (see chapter 3) are mounted on omega-profiles at various distances above the floor of the reverberation room, the view side of the elements was up (type E mounting according to ISO 354:2003). Reflective panels enclosed the sides of the set-up. See also figure 3.

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). 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

$$A_1 = \frac{55{,}3\ V}{c\ T_1} - 4Vm_1 \qquad (1)$$

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

$$c = 331 + 0{,}6\ t \quad [m/s] \qquad (2)$$

in which:

t = the temperature in degrees Celsius; this formula is valid for temperatures between 15 and 30 ºC

$$m = \frac{\alpha}{10 \lg (e)} \qquad (3)$$

in which :

α = "attenuation coefficient"calculated 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

$$A_2 = \frac{55{,}3\ V}{c\ T_2} - 4Vm_2 \qquad (4)$$

in which:

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

T_2 = the reverberation time (in s) of the reverberation room with the test specimen placed inside

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

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

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

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:

$$\alpha_S = \frac{A}{S} \ [-] \qquad (6)$$

in which:

S = the area of the test specimen (in 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. Atmospheric conditions

The atmospheric conditions during the measurements are presented in table 1.

Table 1 Atmospheric conditions during the measurements

reverberation room	temperature [°C]	atmospheric pressure [kPa]	relative humidity [%]
empty	18,8	102,6	51
occupied	19,1-19,3	102,4	47-49

4.4. Results

The results of the measurements are given in table 2 and 3 as well as in figures 4 to 9. 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 octave-band. 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.

Table 2 Measurement results Derako Wooden Grills

	sound absorption coefficient α_s			
variant	1		2	
record nr.	#149		#186	
See figure	4		5	
frequency [Hz]	1/3 oct.	1/1 oct.	1/3 oct.	1/1 oct.
100	0,13		0,12	
125	0,18	0,21	0,19	0,21
160	0,32		0,32	
200	0,44		0,47	
250	0,63	0,62	0,64	0,64
315	0,80		0,81	
400	0,91		0,96	
500	0,96	0,95	0,99	0,99
630	0,99		1,02	
800	1,01		1,01	
1000	0,97	0,98	0,95	0,94
1250	0,96		0,86	
1600	0,95		0,79	
2000	0,95	0,93	0,75	0,76
2500	0,90		0,75	
3150	0,84		0,78	
4000	0,78	0,79	0,76	0,75
5000	0,76		0,72	
α_w	0,90		0,85	
NRC	0,90		0,85	

Table 3 Measurement results Luxalon 80B panels

	sound absorption coefficient α_s							
variant	3		4		5		6	
record nr.	#112		#75		#223		#260	
See figure	6		7		8		9	
frequency [Hz]	1/3 oct.	1/1 oct.	1/3 oct.	1/1 oct.	1/3 oct.	1/1 oct.	1/3 oct.	1/1 oct.
100	0,13		0,12		0,43		0,47	
125	0,18	0,20	0,18	0,20	0,52	0,44	0,47	0,43
160	0,30		0,31		0,38		0,36	
200	0,42		0,44		0,40		0,41	
250	0,59	0,60	0,58	0,60	0,50	0,55	0,51	0,54
315	0,78		0,77		0,74		0,70	
400	0,89		0,88		0,84		0,83	
500	0,90	0,90	0,95	0,93	0,91	0,88	0,88	0,88
630	0,92		0,96		0,90		0,93	
800	0,97		0,99		0,95		0,95	
1000	0,92	0,95	0,96	0,98	0,95	0,95	0,93	0,95
1250	0,95		0,99		0,96		0,96	
1600	0,93		0,95		0,95		0,96	
2000	0,90	0,89	0,89	0,87	0,94	0,94	0,95	0,97
2500	0,85		0,78		0,94		1,00	
3150	0,79		0,65		0,92		1,01	
4000	0,75	0,78	0,59	0,61	0,78	0,81	0,95	0,94
5000	0,81		0,60		0,72		0,86	
α_w	0,90		0,80		0,85		0,85	
NRC	0,85		0,85		0,85		0,80	

The sound absorption coefficient of a material is not a material property. Is 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

ir. M.L.S. Vercammen
Manager

This report contains:

11 pages
9 figures

PEUTZ bv
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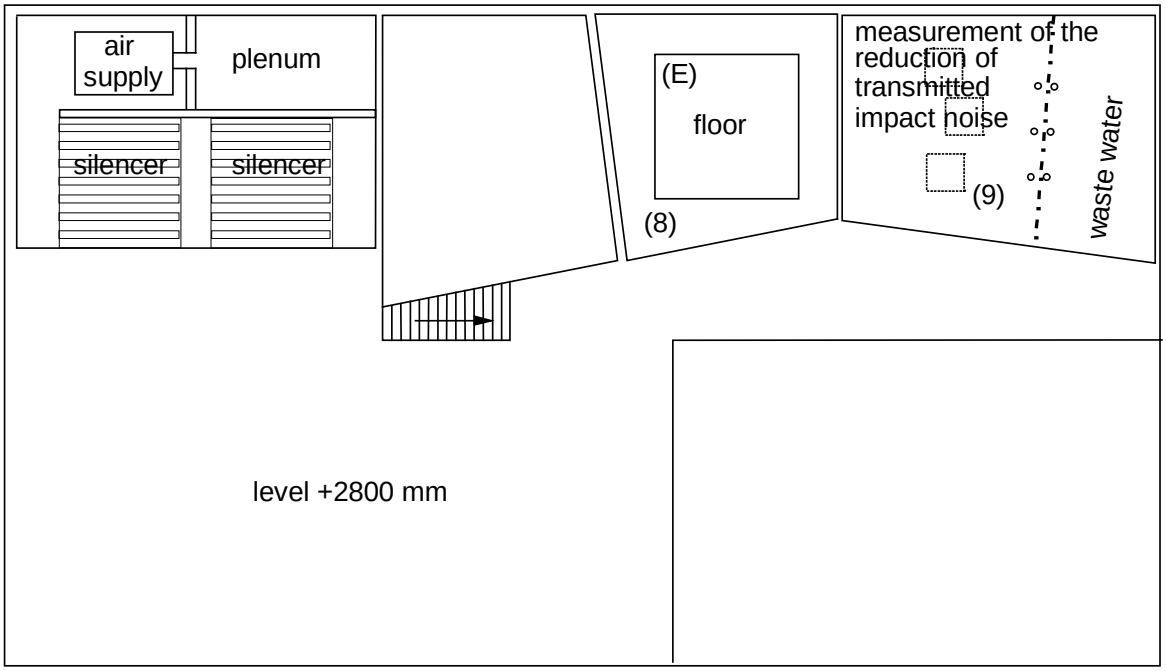
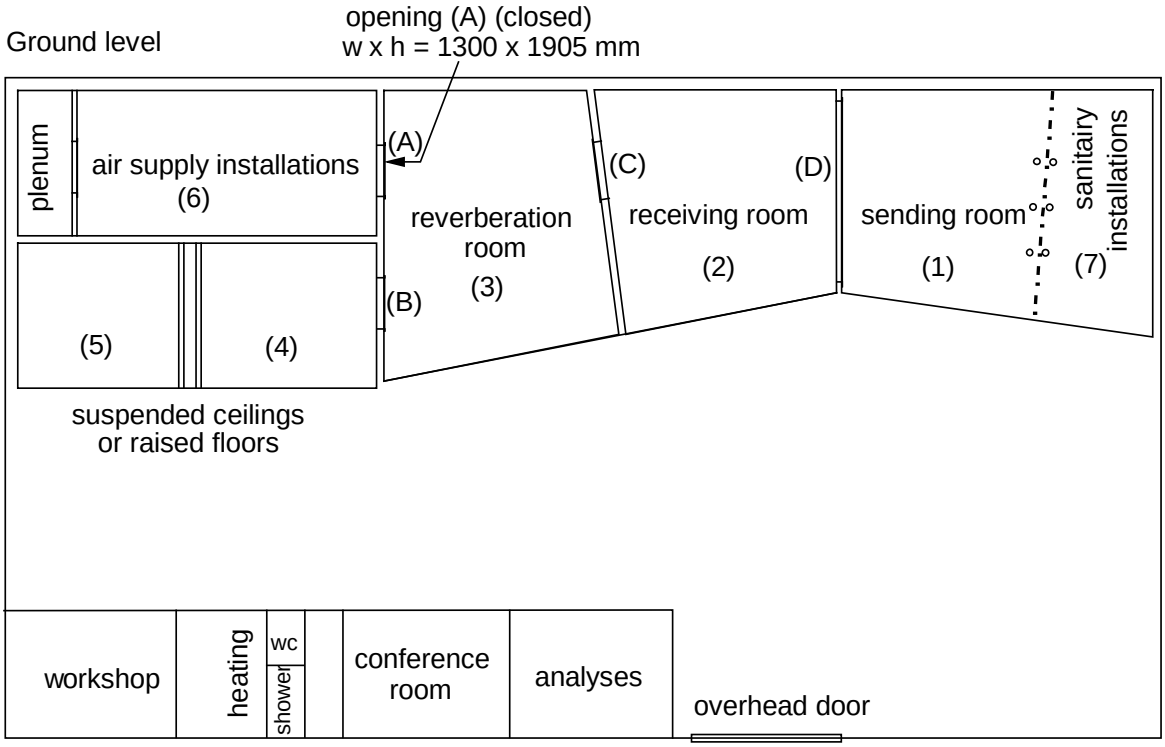
OVERVIEW

Story



Ground level



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), HOLLAND

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

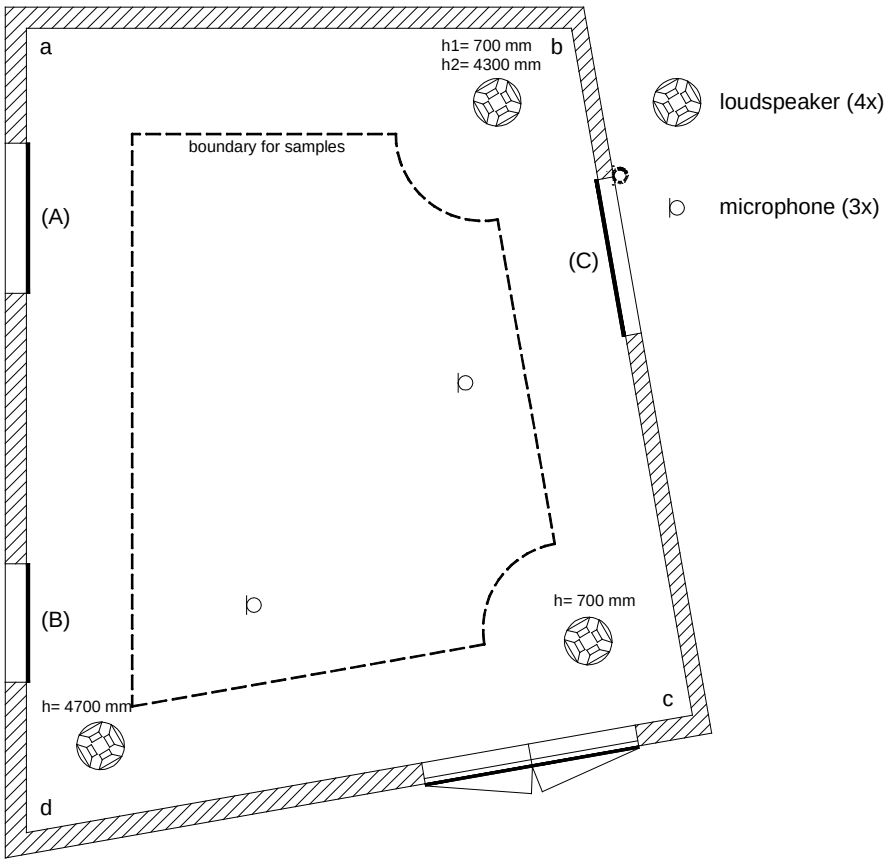
diffusion: by the shape of the room and by adding 6 curved and 2 flat reflecting elements with a total area of approx. 13 m^2 a sufficient diffusion has been gained.

reverberation time of the empty reverberation room during measurements of 21-04-2009

frequency (1/1 oct.)	125	250	500	1000	2000	4000	Hz
reverberation time	8,85	7,25	7,78	6,45	4,52	2,84	s

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

r at high α	0.13	0.08	0.06	0.03	0.05	0.09	-
r at low α	0.11	0.02	0.01	0.02	0.02	0.05	-

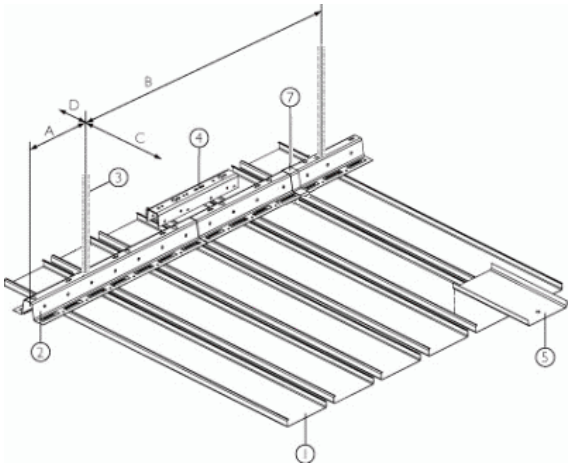


(closed) testopenings
(width x height in mm)
(A): 1300 x 1800
(B): 1000 x 2200
(C): 1500 x 1250

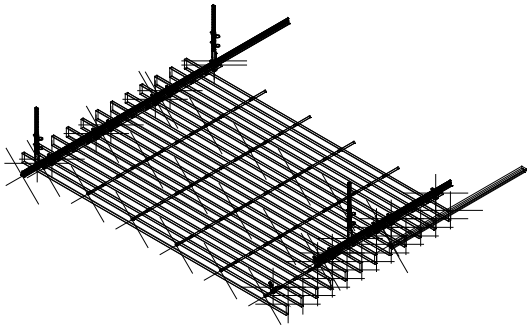
height at:
a: 5573 mm
b: 5102 mm
c: 5000 mm
d: 5580 mm

0 1 2 m

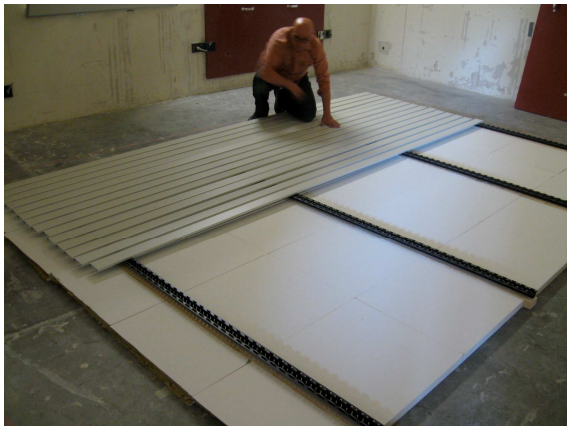
Absorb versie 4.6.1, mode 7 file: a1906 E#:3-38 T_1 = 18,8 °C p_1 = 102,6 kPa h_1 = 51,4 %



Luxalon 80B



Derako Wooden Grills



Luxalon 80B + HiClinic

Luxalon 80B + HiClinic

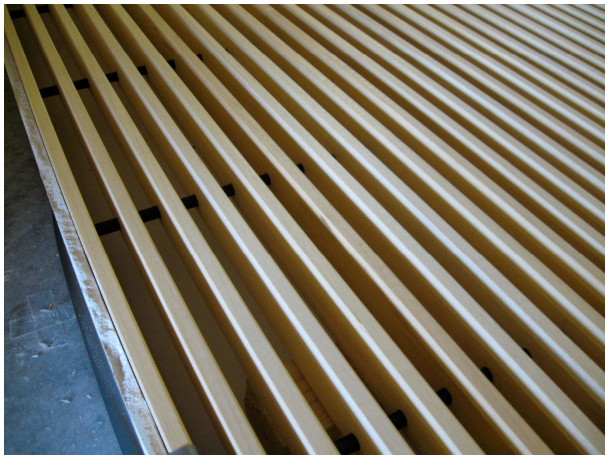
Measurement set up,
construction height 100 mm

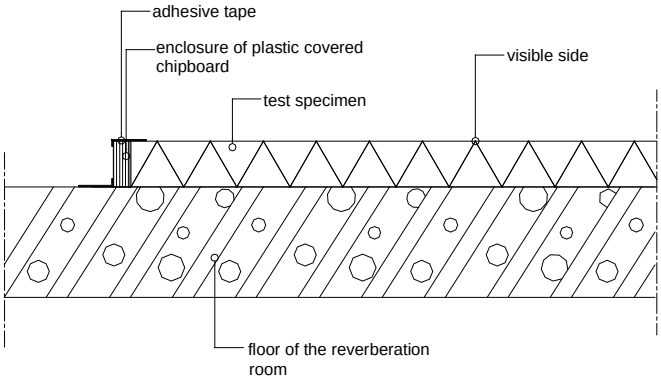
Measurement set up,
construction height 800 mm

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

TESTING RvA L 334

variant 1; **55 mm Wooden Grills, 40 mm Hi Clinic, construction height 100 mm;**





volume reverberation room: 214 m^3

surface area sample: 12 m^2

heigth of the construction: 0,100 m

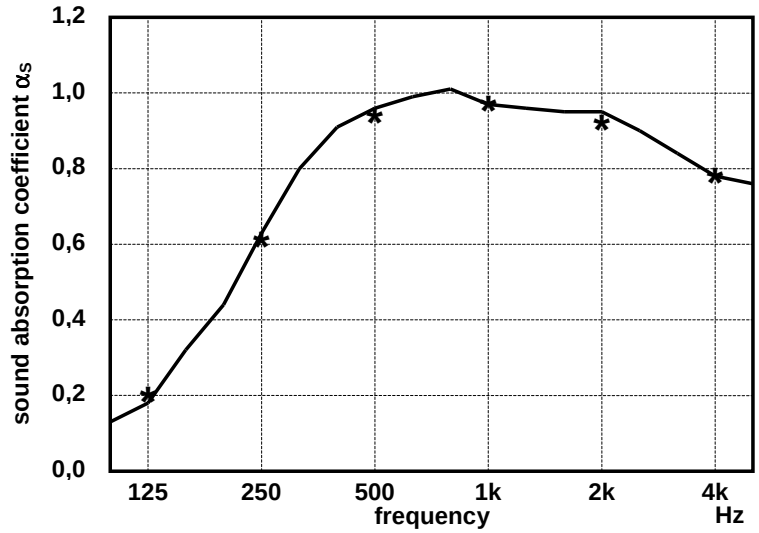
measured at: laboratory conditions

signal: broad-band noise

bandwidth: 1/3 octave

α_w (ISO 11654) = 0,90

NRC (ASTM - C423) = 0,90



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1/3 oct.	0,18	0,63	0,96	0,97	0,95	0,78
	0,32	0,80	0,99	0,96	0,90	0,76
1/1 oct.	**0,21**	**0,62**	**0,95**	**0,98**	**0,93**	**0,79**

——— 1/3 oct.

* 1/1 oct.

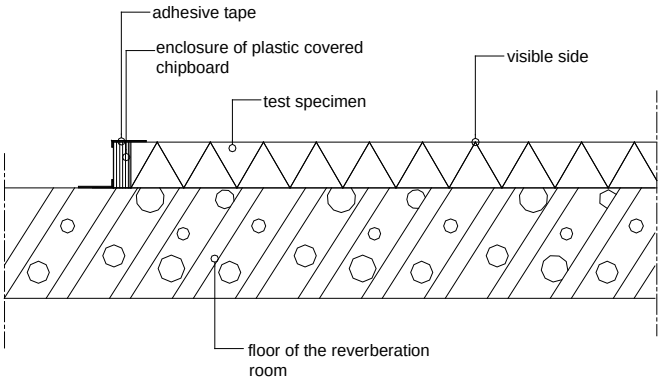
Mook, 21-04-2009

Absorb versie 4.6.1, mode 7 file: a1906 E#:3-38 F#:113-148 A#:149 T_1 = 18,8 °C T_2 = 19,1 °C p_1 = 102,6 kPa p_2 = 102,4 kPa h_1 = 51,4 % h_2 = 49,3 %

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

TESTING RvA L 334

variant 2: **55 mm Wooden Grills, 45 air cavity, 40 mm Hi Clinic, construction height 144 mm**



volume reverberation room: 214 m^3

surface area sample: 12 m^2

heigth of the construction: 0,144 m

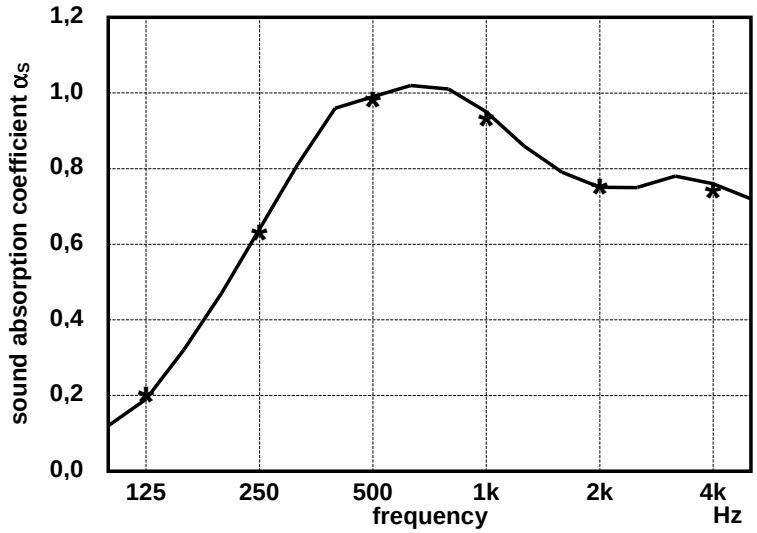
measured at: laboratory conditions

signal: broad-band noise

bandwidth: 1/3 octave

α_w (ISO 11654) = 0,85

NRC (ASTM - C423) = 0,85



	125	250	500	1k	2k	4k
	0,12	0,47	0,96	1,01	0,79	0,78
1/3 oct.	0,19	0,64	0,99	0,95	0,75	0,76
	0,32	0,81	1,02	0,86	0,75	0,72
1/1 oct.	**0,21**	**0,64**	**0,99**	**0,94**	**0,76**	**0,75**

——— 1/3 oct.

* 1/1 oct.

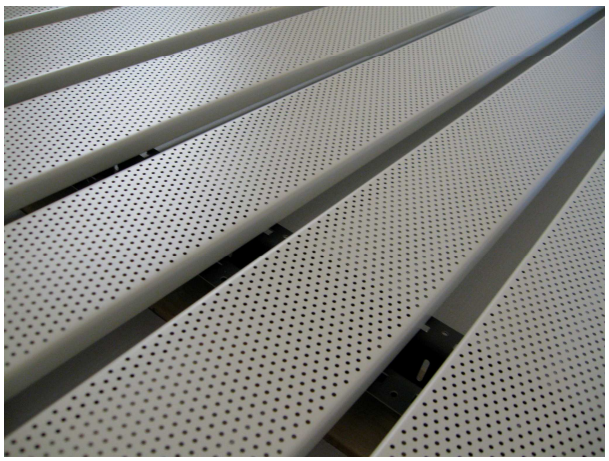
Mook, 21-04-2009

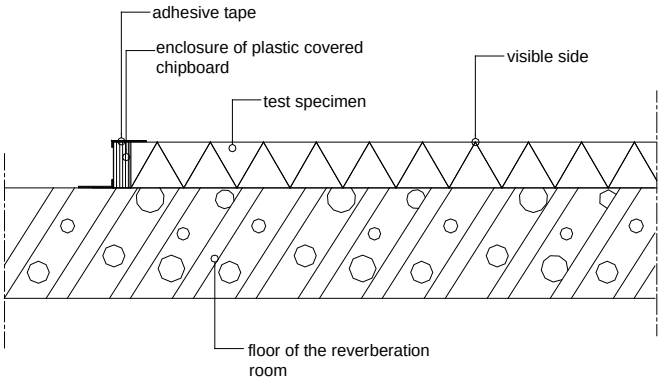
Absorb versie 4.6.1, mode 7 file: a1906 E#:3-38 F#:150-185 A#:186 T_1 = 18,8 °C T_2 = 19,2 °C p_1 = 102,6 kPa p_2 = 102,4 kPa h_1 = 51,4 % h_2 = 49,0 %

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

TESTING RvA L 334

variant 3: **Luxalon 80 B elements, open joints, 40 mm air cavity, 40 mm Hi Clinic construction height 100 mm**





volume reverberation room: 214 m^3

surface area sample: 12 m^2

heigth of the construction: 0,100 m

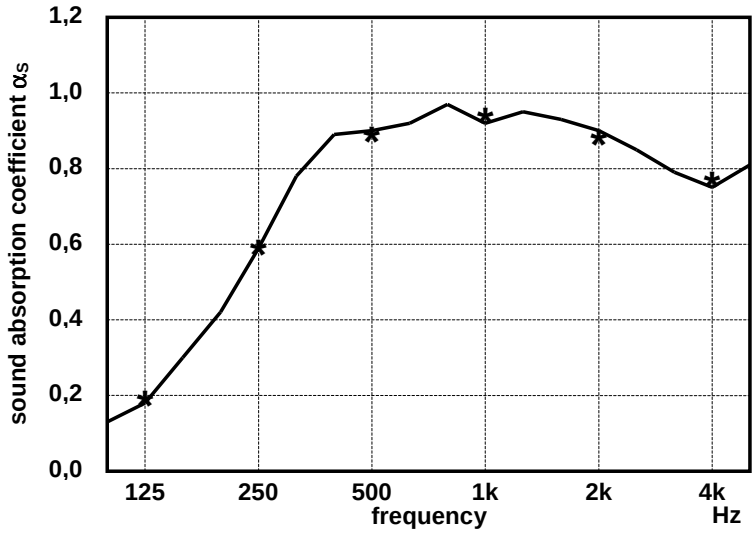
measured at: laboratory conditions

signal: broad-band noise

bandwidth: 1/3 octave

α_w (ISO 11654) = 0,90

NRC (ASTM - C423) = 0,85



	0,13	0,42	0,89	0,97	0,93	0,79
1/3 oct.	0,18	0,59	0,90	0,92	0,90	0,75
	0,30	0,78	0,92	0,95	0,85	0,81
1/1 oct.	**0,20**	**0,60**	**0,90**	**0,95**	**0,89**	**0,78**

——— 1/3 oct.

* 1/1 oct.

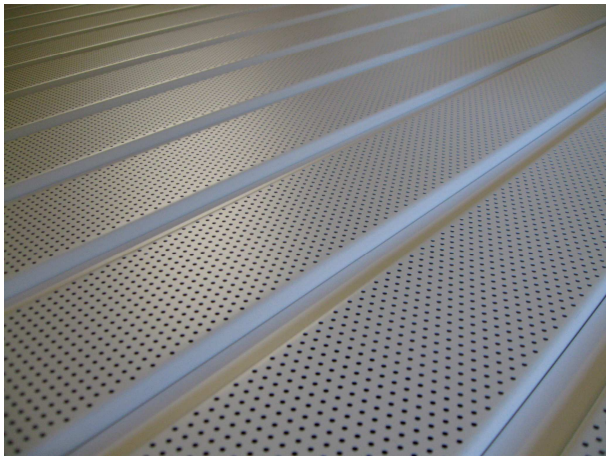
Mook, 21-04-2009

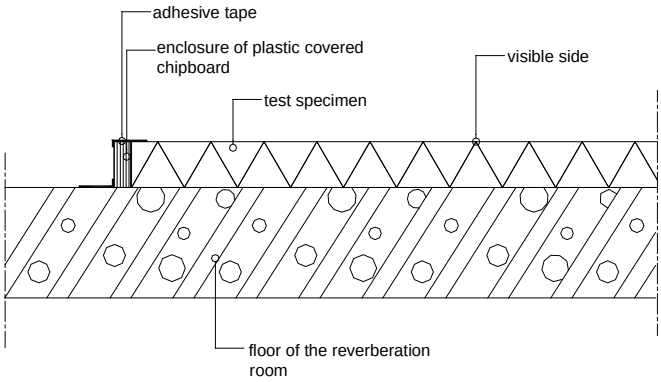
Absorb versie 4.6.1, mode 7 file: a1906 E#:3-38 F#:76-111 A#:112 T_1 = 18,8 °C T_2 = 19,1 °C p_1 = 102,6 kPa p_2 = 102,4 kPa h_1 = 51,4 % h_2 = 49,6 %

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

TESTING
RvA L 334

4: **Luxalon 80 B elements, closed joints, 40 mm air cavity, 40 mm Hi Clinic construction height 100 mm**





volume reverberation room: 214 m^3

surface area sample: 12 m^2

heigth of the construction: 0,100 m

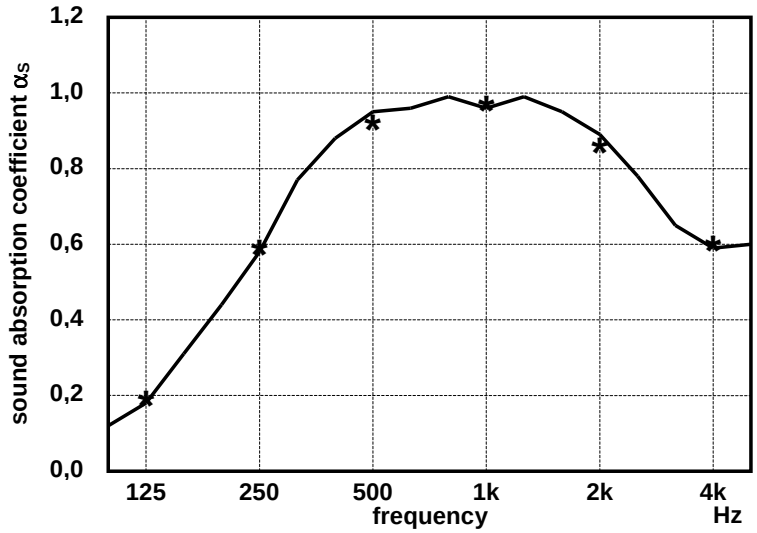
measured at: laboratory conditions

signal: broad-band noise

bandwidth: 1/3 octave

α_w (ISO 11654) = 0,80

NRC (ASTM - C423) = 0,85



	125	250	500	1k	2k	4k
	0,12	0,44	0,88	0,99	0,95	0,65
1/3 oct.	0,18	0,58	0,95	0,96	0,89	0,59
	0,31	0,77	0,96	0,99	0,78	0,60
1/1 oct.	**0,20**	**0,60**	**0,93**	**0,98**	**0,87**	**0,61**

——— 1/3 oct.
* 1/1 oct.

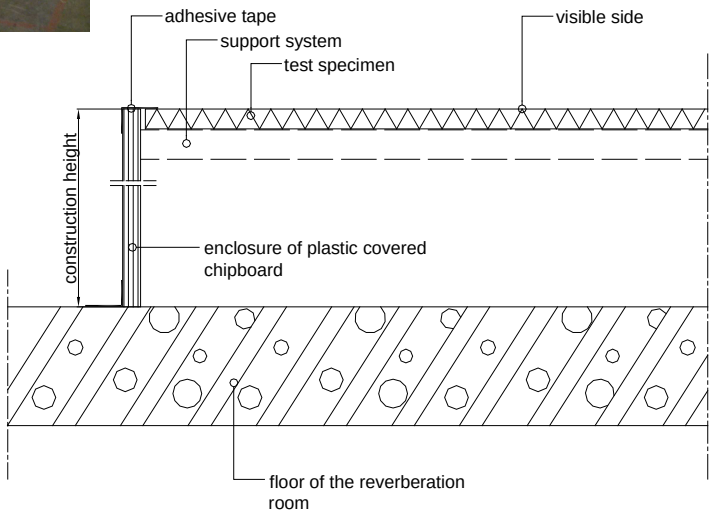
Mook, 21-04-2009

Absorb versie 4.6.1, mode 7 file: a1906 E#:3-38 F#:39-74 A#:75 T_1 = 18,8 °C T_2 = 19,1 °C p_1 = 102,6 kPa p_2 = 102,4 kPa h_1 = 51,4 % h_2 = 49,4 %

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

TESTING
RvA L 334

variant 5: **Luxalon 80 B elements, closed joints, 50 mm Rockwool, construction height 800 mm**



volume reverberation room: 214 m^3

surface area sample: 12 m^2

heigth of the construction: 0,800 m

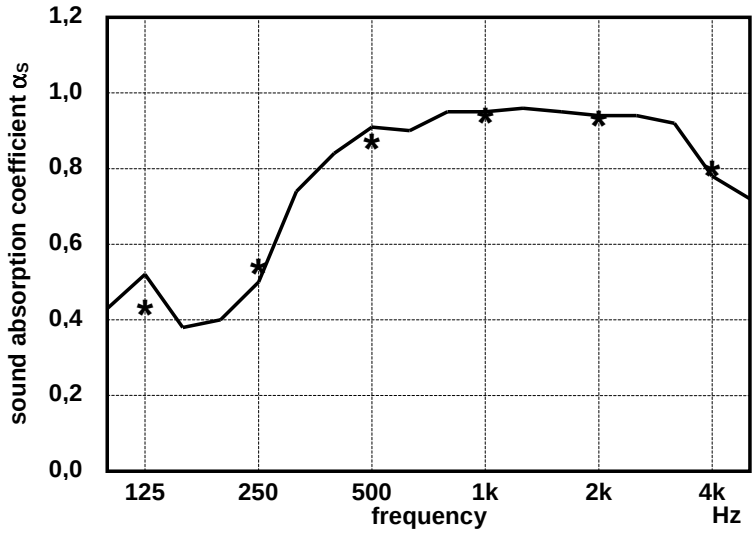
measured at: laboratory conditions

signal: broad-band noise

bandwidth: 1/3 octave

α_w (ISO 11654) = 0,85

NRC (ASTM - C423) = 0,85



	125	250	500	1k	2k	4k
	0,43	0,40	0,84	0,95	0,95	0,92
1/3 oct.	0,52	0,50	0,91	0,95	0,94	0,78
	0,38	0,74	0,90	0,96	0,94	0,72
1/1 oct.	**0,44**	**0,55**	**0,88**	**0,95**	**0,94**	**0,81**

——— 1/3 oct.
* 1/1 oct.

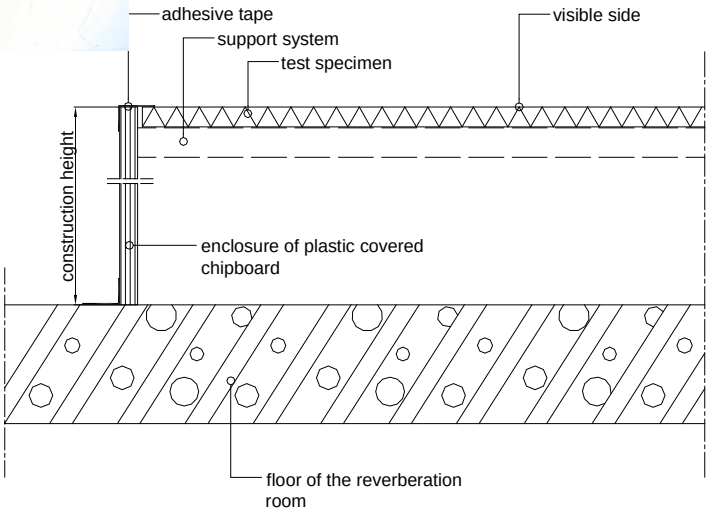
Mook, 21-04-2009

Absorb versie 4.6.1, mode 7 file: a1906 E#:3-38 F#:187-222 A#:223 T_1 = 18,8 °C T_2 = 19,5 °C p_1 = 102,6 kPa p_2 = 102,4 kPa h_1 = 51,4 % h_2 = 47,8 %

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

TESTING
RvA L 334

variant 6: **Luxalon 80 B elements,open joints, 50 mm Rockwool, construction height 800 mm;**



volume reverberation room: 214 m^3

surface area sample: 12 m^2

heigth of the construction: 0,800 m

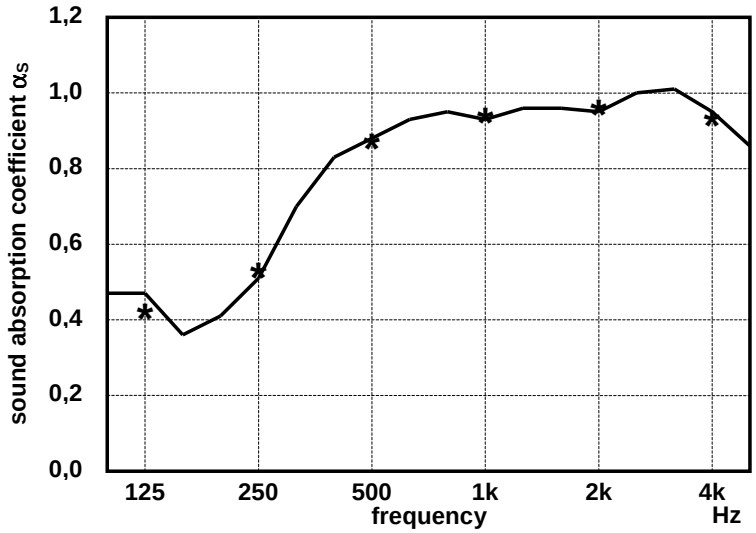
measured at: laboratory conditions

signal: broad-band noise

bandwidth: 1/3 octave

α_w (ISO 11654) = 0,85

NRC (ASTM - C423) = 0,80



	0,47	0,41	0,83	0,95	0,96	1,01
1/3 oct.	0,47	0,51	0,88	0,93	0,95	0,95
	0,36	0,70	0,93	0,96	1,00	0,86
1/1 oct.	**0,43**	**0,54**	**0,88**	**0,95**	**0,97**	**0,94**

——— 1/3 oct.
* 1/1 oct.

Mook, 21-04-2009

Absorb versie 4.6.1, mode 7 file: a1906 E#:3-38 F#:224-259 A#:260 T_1 = 18,8 °C T_2 = 19,3 °C p_1 = 102,6 kPa p_2 = 102,4 kPa h_1 = 51,4 % h_2 = 47,2 %