

Report

Laboratory for Acoustics

Determination of the sound absorption (reverberation room method) of **curtains type Athens and Chicago, manufacturer Vescom**

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1. INTRODUCTION

At the request of Vescom bv based in Deurne (The Netherlands), laboratory measurements of the sound absorption (reverberation room method) were carried out on

curtains type Athens and Chicago, manufacturer Vescom

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



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 MLA¹

1 **EA MLA:** European Accreditation Organisation MultiLateral Agreement: <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

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

ISO 354:2003² Acoustics Measurement of sound absorption in a reverberation room

NOTE: this international standard has been accepted within all EU-countries as European Norm 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

2 According to this norm, the report should include for each measurement the mean reverberation times T1 and 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.

The following two different types of curtains are investigated:

1. velvet brown curtain, type ATHENS. Surface weight 720 gr/m²
2. velvet blue curtain, type CHICAGO. Surface weight 790 gr/m²

The test specimen (width x height = 4,0 x 2,5 m) is hanged parallel to the room surface by the principal. The distance from the face of the curtain to the room surface is 200 mm. A fold-rate of 100% is applied, meaning that the width of the cloth of 8 m is folded to a 4m curtain width. The measurement set-up is according to type G-mounting (Annex B of ISO 354:2003, test specimen mountings for sound absorption tests). The sides of the set-up were enclosed by 18 mm thick plastic covered chip wood board and sealed by tape.



Measurement set-up



Detail perimeter frame

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.

4. MEASUREMENTS

The measurement set-up is according to type G-200 mounting. The sides of the set-up were enclosed by 18 mm thick plastic covered chip wood board and sealed by tape.

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

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

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. Atmospheric conditions

The atmospheric conditions during the measurements are presented in table 1

Table 1 atmospheric conditions during the measurements at April 8th, 2013

reverberation room	temperature [°C]	atmospheric pressure [kPa]	relative humidity [%]
empty	15,8	100,9	52
occupied	16,3	100,8-100,9	49

4.4. Results


The results of the measurements are given in table 2 and in figure 3 and 4. 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 :

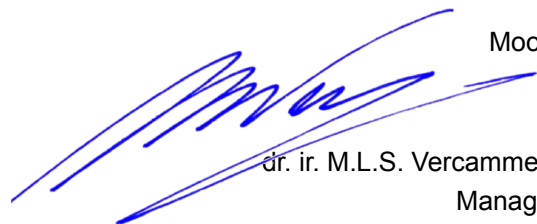
- the "weighted sound absorption coefficient α_w " according to ISO 11654
- the "Noise Reduction Coefficient NRC" according to ASTM-C423, being the average of the absorption coefficients (1/3 octave values) at the frequencies of 250, 500, 1000 and 2000 Hz, rounded to the nearest 0,05.

Table 2 Measurement results

variant	Sound absorption coefficient α_s			
	1		2	
record nr.	#73		#112	
curtain	Athens		Chicago	
see figure	3		4	
Frequency [Hz]	1/3 oct.	1/1 oct.	1/3 oct.	1/1 oct.
100	0,13		0,07	
125	0,20	0,23	0,15	0,17
160	0,36		0,28	
200	0,53		0,47	
250	0,65	0,66	0,63	0,61
315	0,81		0,72	
400	0,83		0,72	
500	0,80	0,82	0,73	0,74
630	0,84		0,78	
800	0,87		0,78	
1000	0,86	0,86	0,79	0,78
1250	0,84		0,77	
1600	0,83		0,74	
2000	0,85	0,84	0,76	0,75
2500	0,83		0,74	
3150	0,83		0,71	
4000	0,86	0,83	0,73	0,72
5000	0,79		0,73	
α_w	0,85		0,80	
NRC	0,80		0,75	

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.


Th. Scheers
Laboratory Supervisor

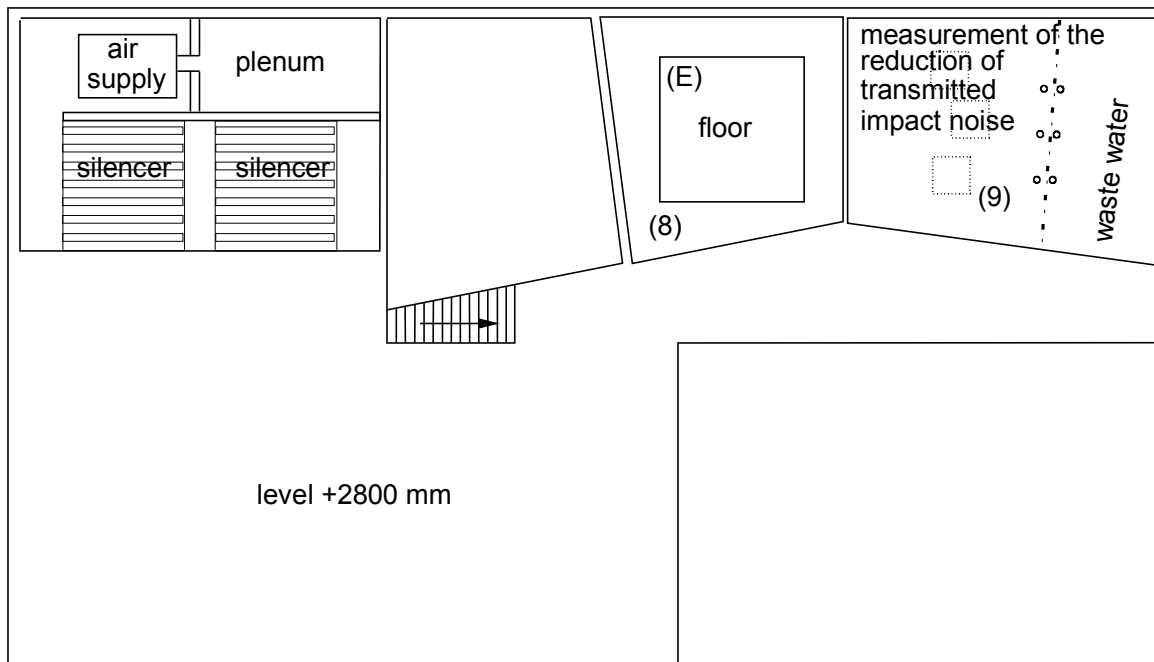

Mook,
dr. ir. M.L.S. Vercammen
Manager

This report contains: 9 pages and 4 figures.

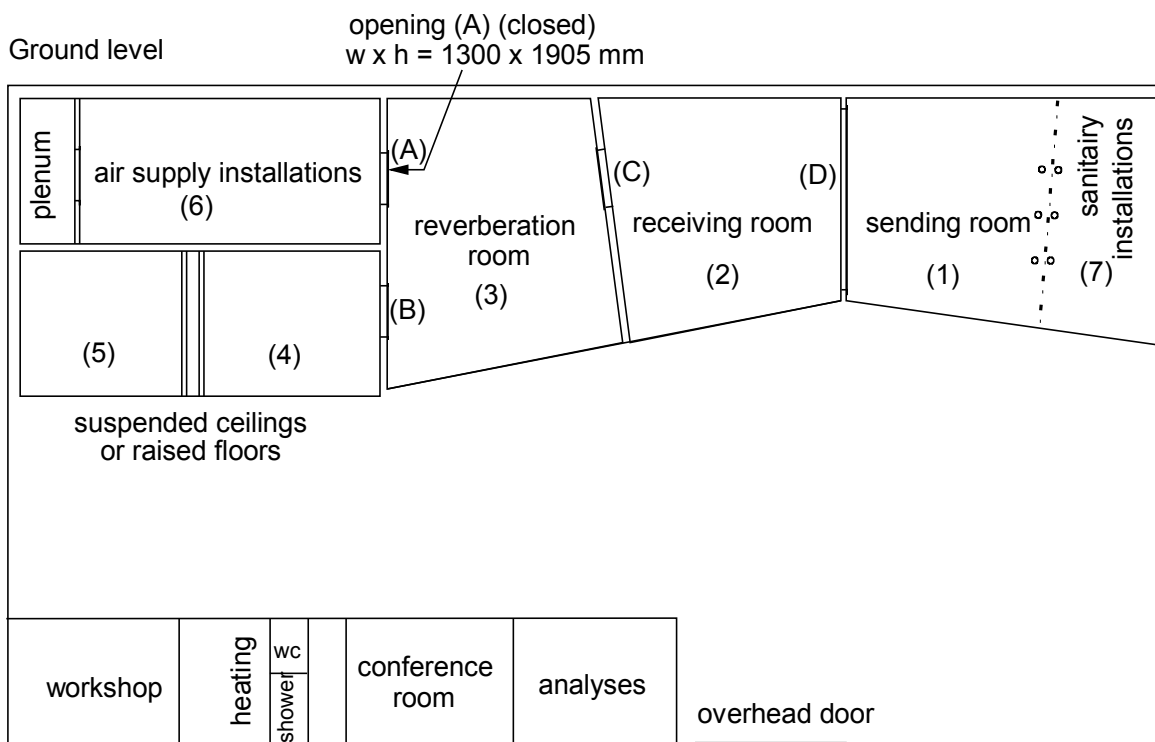
PEUTZ bv
 Lindenlaan 41, NL-6584 AC MOLENHOEK (LB), THE NETHERLANDS

OVERVIEW

Story

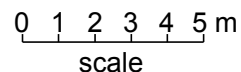


Ground level



TEST OPENINGS (w x h in mm)

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



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.

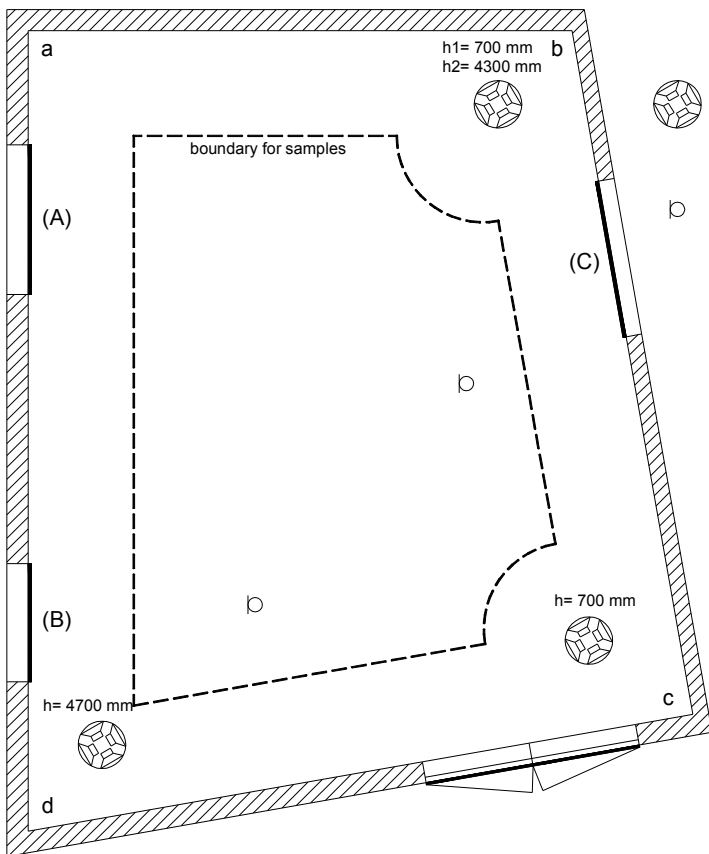
reverberation time of the empty reverberation room during measurements of 08-04-2013

frequency (1/1 oct.)	125	250	500	1000	2000	4000	Hz
reverberationtime	9,36	7,95	7,54	6,26	4,40	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

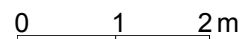


loudspeaker (4x)

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



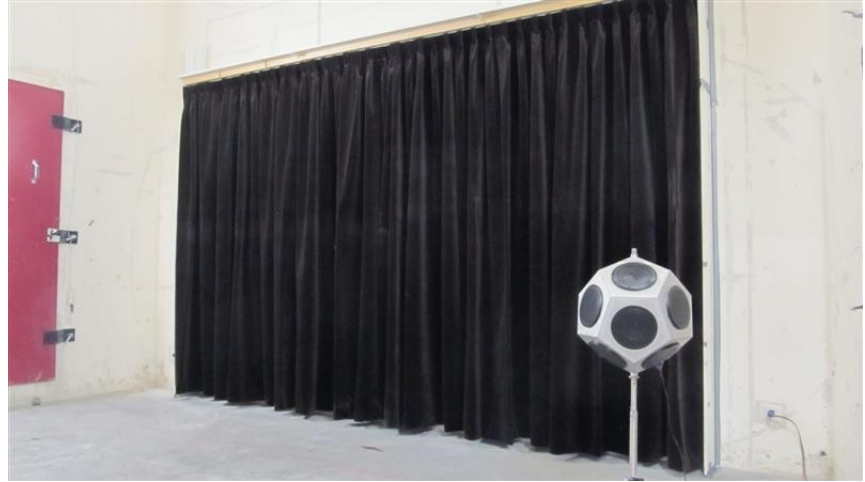
Absorb, versie 5.7.1 mode 7, file: a2514 E#: 1-36 T₁ = 15,8 °C p₁ = 100,9 kPa h₁ = 51,6 %

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



principal: Vescom bv

1. velvet brown curtain, type ATHENS. Surface weight 720 gr/m²



Absorb, v versie 5.7.1 mode 7, PM: JK, file: a2514 E#:1-36 F#:37-72 A#:73 T₁ = 15,8 °C T₂ = 16,3 °C p₁ = 100,9 kPa p₂ = 100,9 kPa h₁ = 51,6 % h₂ = 49,3 %

volume reverberation room: 214 m³

surface area sample: 10 m²

height of the construction: 0,200 m

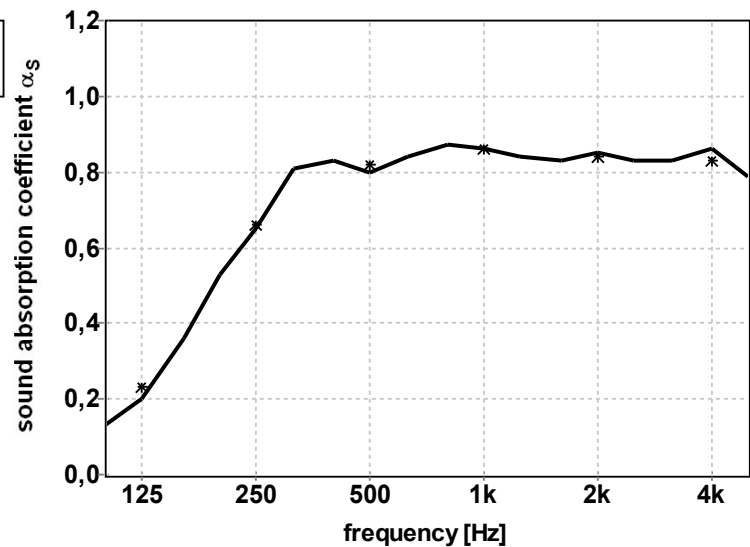
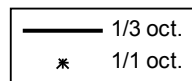
measured at:
Peutz Laboratory for Acoustics

signal: broad-band noise

bandwidth: 1/3 octave

α_w (ISO 11654) = 0,85

NRC (ASTM - C423) = 0,80



	0,13	0,53	0,83	0,87	0,83	0,83
1/3 oct.	0,20	0,65	0,80	0,86	0,85	0,86
	0,36	0,81	0,84	0,84	0,83	0,79
1/1 oct.	0,23	0,66	0,82	0,86	0,84	0,83

publication is permitted for the entire page only

Mook, 08-04-2013

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



principal: Vescombv

2. velvet blue curtain, type CHICAGO. Surface weight 790 gr/m²



Absorb, v versie 5.7.1 mode 7, PM: JK, file: a2514 E#:1-36 F#:76-111 A#:112 T₁ = 15,8 °C T₂ = 16,3 °C p₁ = 100,9 kPa p₂ = 100,8 kPa h₁ = 51,6 % h₂ = 48,9 %

volume reverberation room: 214 m³

surface area sample: 10 m²

height of the construction: 0,200 m

measured at:
Peutz Laboratory for Acoustics

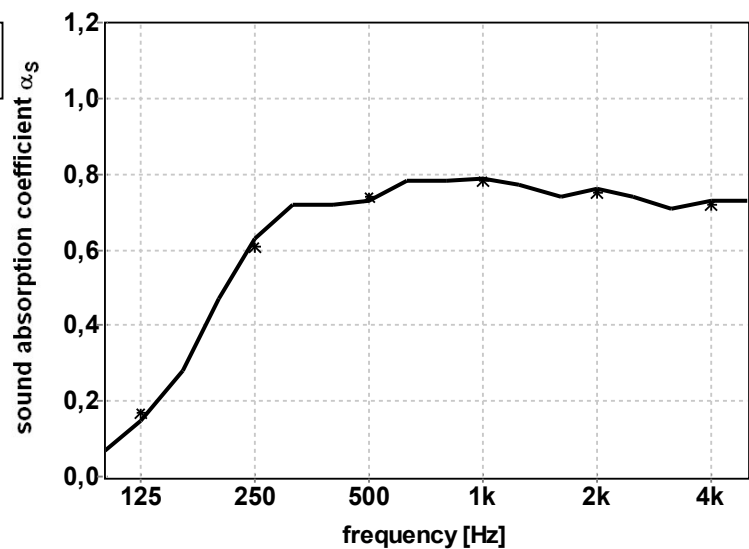
signal: broad-band noise

bandwidth: 1/3 octave

α_w (ISO 11654) = 0,80

NRC (ASTM - C423) = 0,75

— 1/3 oct.
* 1/1 oct.



	0,07	0,47	0,72	0,78	0,74	0,71
1/3 oct.	0,15	0,63	0,73	0,79	0,76	0,73
	0,28	0,72	0,78	0,77	0,74	0,73
1/1 oct.	0,17	0,61	0,74	0,78	0,75	0,72

publication is permitted for the entire page only

Mook, 08-04-2013