

# Report

## Laboratory for Acoustics

Determination of the sound absorption (reverberation room method) of **Lightben Acoustic, manufacturer Bencore**

Reportnumber A 2026-2E-RA d.d. 16 July 2010

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Report number: A 2026-2E-RA

Date: 16 July 2010

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BTW: NL004933837B01  
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## 1. INTRODUCTION

At the request of Bencore Srl. based in Massa (Italy), laboratory measurements of the sound absorption (reverberation room method) were carried out on

### **Lightben Acoustic, manufacturer Bencore**

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 MLA<sup>1</sup>

<sup>1</sup> 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. NORMS AND GUIDELINES

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

ISO 354:2003<sup>2</sup>      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 C423-08a      Standard Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method

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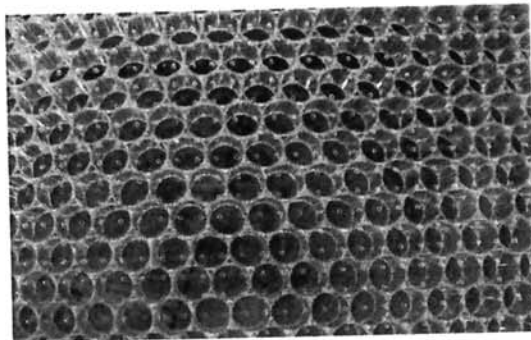
2 According to this norm, the report should include for each measurement the mean reverberation times T1 and T2 at each frequency. Because these figures are not relevant for judging the quality of the product being tested, but merely for judging the accuracy of the calculations, they have been omitted in this report. It is possible of course to reproduce those figures at any time if the principal requests this.

### 3. TESTED CONSTRUCTION

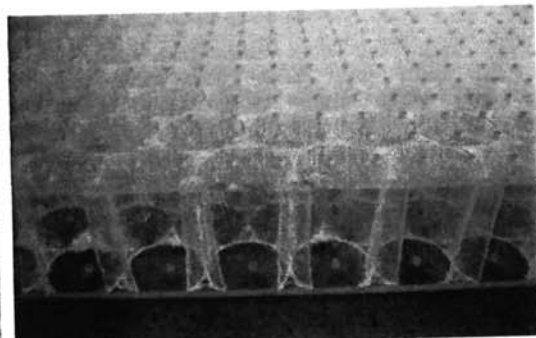
The following specifications were taken from the information supplied by the principal. The density of the materials as reported is derived from the actual weighing by the laboratory staff of the materials under test.

The following ceiling panel is tested.

type: **Lightben Acoustic**  
manufacturer: **Bencore**  
material: 2 layers acrylic with a micro perforation (thickness each layer c. 1 mm),  
between the layers an acrylic honeycomb  
perforation: square pattern; c.t.c. 15 mm; Ø 0,95 mm; perforation rate c. 0,3%  
perforated area: 1000 x 2695 mm  
panel sizes: 3005 x 1000 mm  
total thickness: 17 mm  
total mass: 3,9 kg/m<sup>2</sup> (checked by the laboratory)



view/rear side



detail of the edge

Two variants were tested:

- 1) panels mounted horizontal on a support structure at a distance of 200 mm above the floor
- 2) panels mounted vertical as a baffle (c.t.c. 1000 mm)

See figure 2 for some pictures.

*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

### **variant 1**

The ceiling panels to be measured (see chapter 3) are mounted on a support structure at a distance of 200 mm above the floor of the reverberation room, the facing side of the panels was up (Type E-200 mounting according to ISO 354:2003).

No suspension-system has been used, the panels were butted to each other. The sides of the set-up were enclosed by 18 mm thick plastic covered chipwood board and sealed by tape.

### **variant 2**

The baffles were arranged in parallel rows (type J-mounting (Well approach) according to ISO 354:2003).

### 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 3 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<sup>3</sup>]  
 $T_1$  = the reverberation time in the empty reverberation room [sec.]  
 $m_1$  = "power attenuation coefficient" in the empty room,  
 calculated according to formula [m<sup>-1</sup>]  
 $c$  = 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:

$\alpha$  = "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<sup>2</sup>

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

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<sup>-1</sup>]

The equivalent sound absorption  $A$  of the test specimen has been calculated according to formula 5 and is expressed in m<sup>2</sup>

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

When the test specimen consists of one plane with an area between 10 and 12 m<sup>2</sup> the sound absorption coefficient  $\alpha_s$  has to be calculated according to formula 6:

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

in which:

$S$  = the area of the test specimen [m<sup>2</sup>]

## 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 the table mentioned below:

reverberation room	temperature [°C]	atmospheric pressure [kPa]	relative humidity [%]
empty	16,8	102,3	54,5
variant 1	17,1	102,2	53,0
variant 2	17,3	102,1	51,9

## 4.4. Results

The results of the measurements are given in table 1 and 2 and in figure 4 and 5. 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  $\alpha_w$ " 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 1

variant record figure	sound absorption coefficient $\alpha_s$	
	1	
	#73	
	4	
frequency [Hz]	1/3 oct.	1/1 oct.
100	0,19	
125	0,21	0,23
160	0,28	
200	0,39	
250	0,48	0,45
315	0,47	
400	0,46	
500	0,42	0,41
630	0,34	
800	0,28	
1000	0,29	0,33
1250	0,43	
1600	0,51	
2000	0,68	0,62
2500	0,68	
3150	0,42	
4000	0,24	0,27
5000	0,16	
$\alpha_w$	0,40(L)	
NRC	0,45	

Table 2

variant record figure	sound absorption [m <sup>2</sup> /element]	
	2	
	#110	
	5	
frequency [Hz]	1/3 oct.	1/1 oct.
100	0,32	
125	0,30	0,36
160	0,47	
200	0,41	
250	0,64	0,57
315	0,67	
400	0,72	
500	0,79	0,78
630	0,83	
800	0,92	
1000	1,04	1,09
1250	1,30	
1600	1,76	
2000	2,13	2,04
2500	2,22	
3150	1,68	
4000	1,19	1,27
5000	0,94	

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

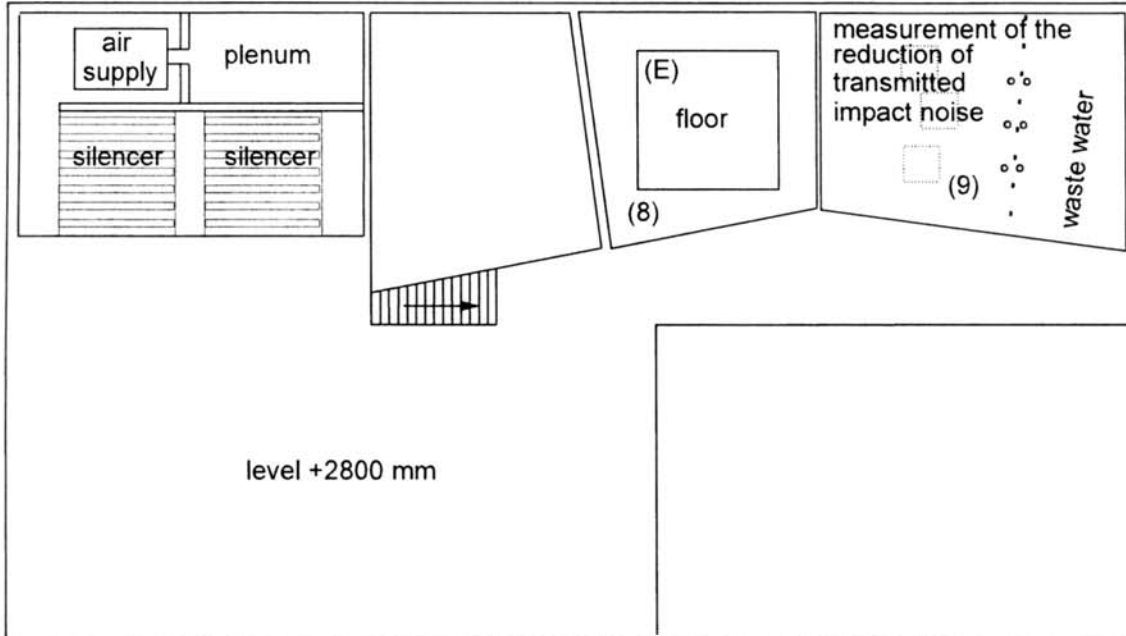
Mook,  
ir. M.L.S. Vercaemmen  
Manager

This report contains: 10 pages and 5 figures.

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

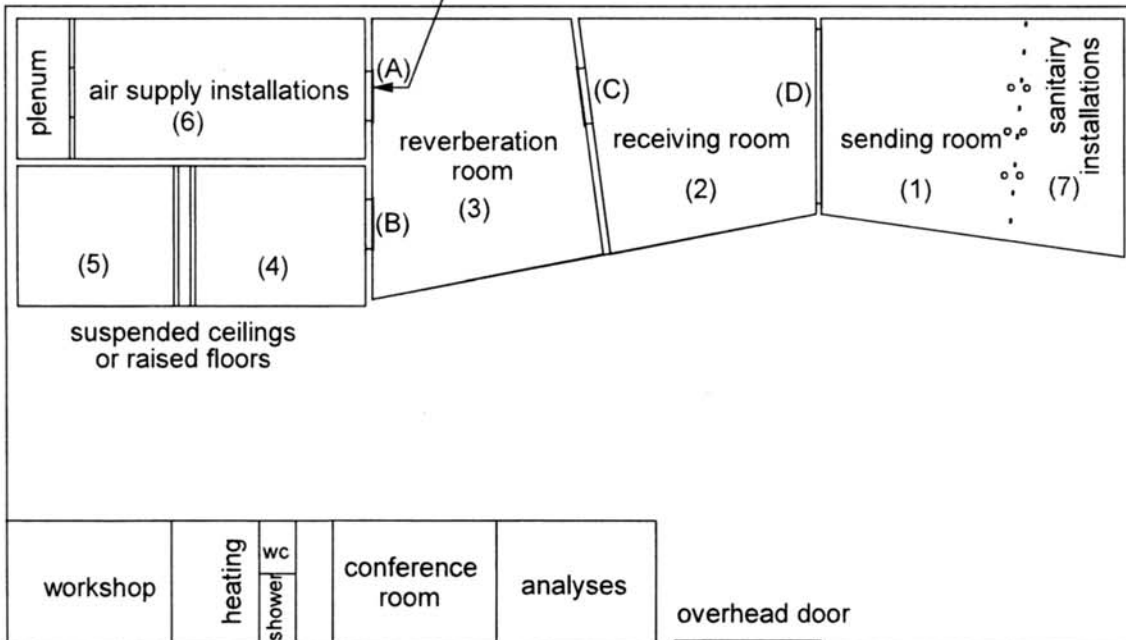
OVERVIEW

Story



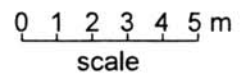
Ground level

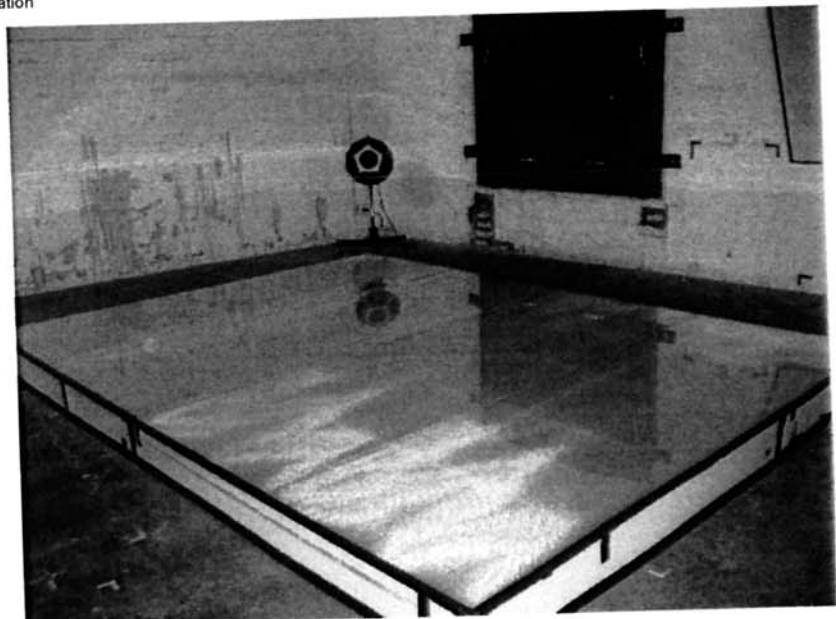
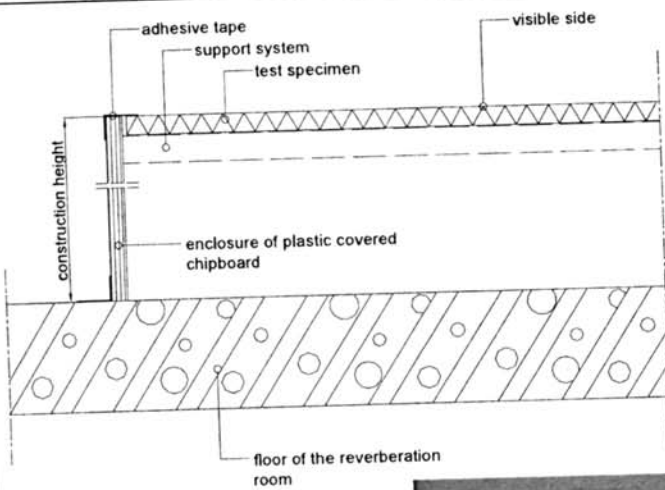
opening (A) (closed)  
w x h = 1300 x 1905 mm



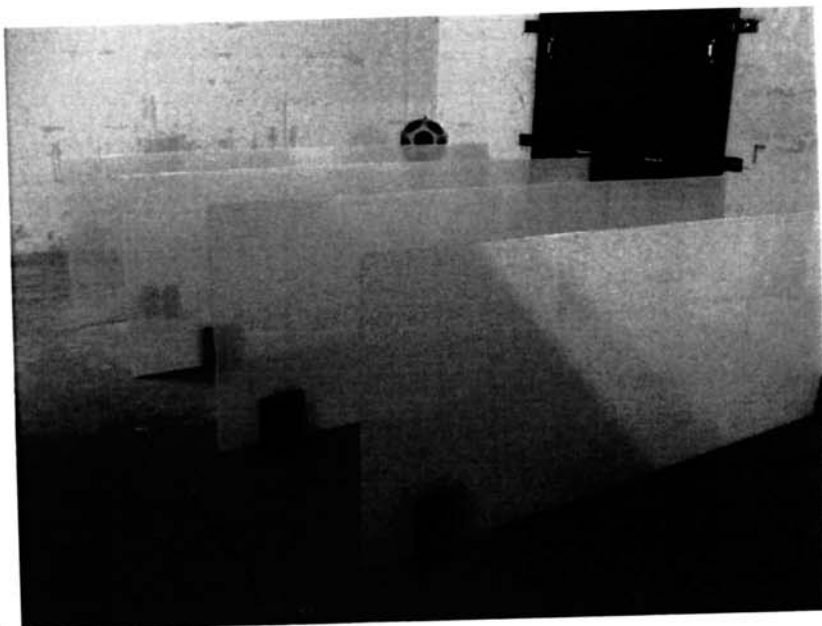
TEST OPENINGS (w x h in mm)

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





**variant 1**  
panels mounted horizontal on a support structure at a distance of 200 mm above the floor



**variant 2**  
panels mounted vertically as a baffle (c.t.c. 1000 mm)

PEUTZ bv  
Lindenlaan 41, 6584 AC MOLENHOEK (LB), the Netherlands

REVERBERATION ROOM

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

additional data:

volume : 214 m<sup>3</sup>

total area S<sub>i</sub> (walls, floor and ceiling) : 219 m<sup>2</sup>

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<sup>2</sup> a sufficient diffusion has been gained.

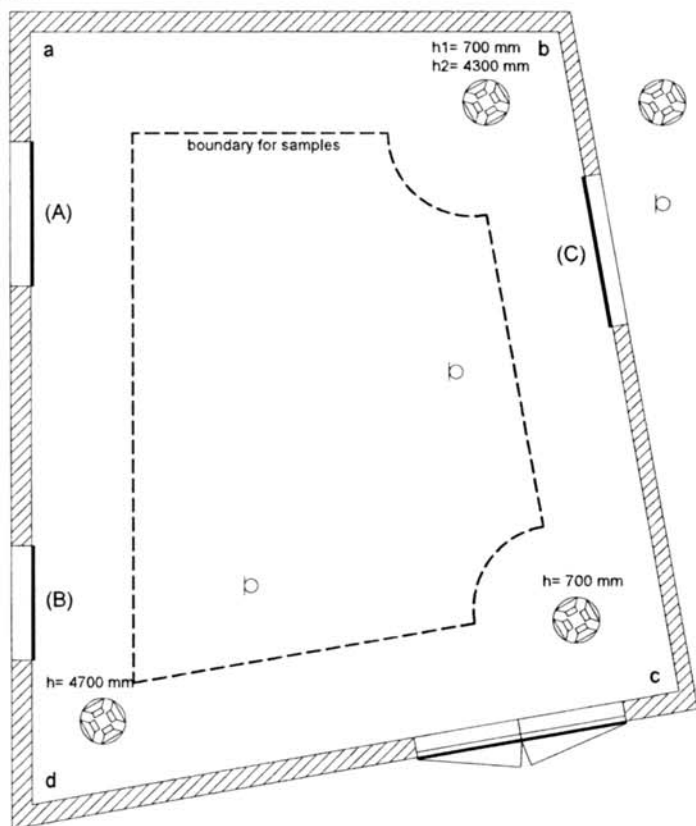
reverberation time of the empty reverberation room during measurements of 22-03-2010

frequenz (1/1 oct.)	125	250	500	1000	2000	4000	Hz
reverberation time	9,83	8,09	8,26	6,85	4,74	2,95	sec.

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

r at high $\alpha$	0,13	0,04	0,04	0,02	0,02	0,08	-
r at low $\alpha$	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

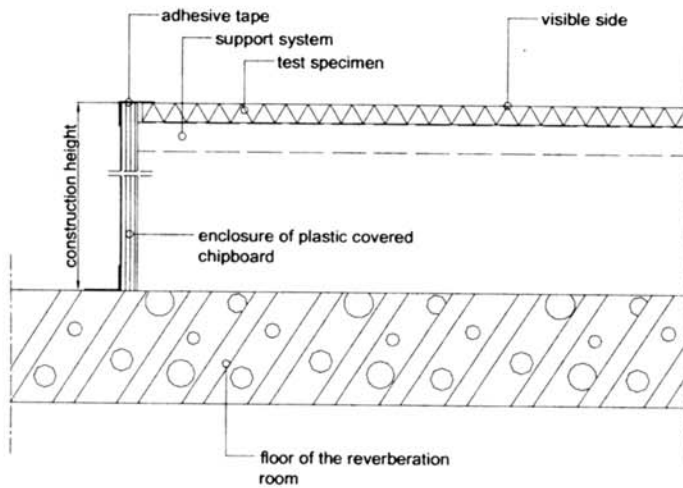
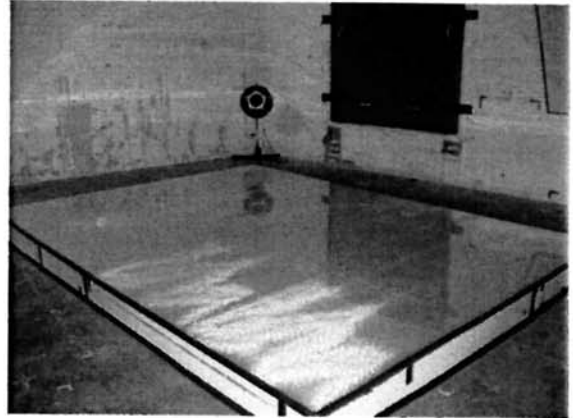
Absorb. versie 5.4.6 mode 7. file: a2026 ER#1-36 T<sub>1</sub> = 16,8 °C P<sub>1</sub> = 102,3 kPa h<sub>1</sub> = 54,5 %

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



principal: Bencore Srl.

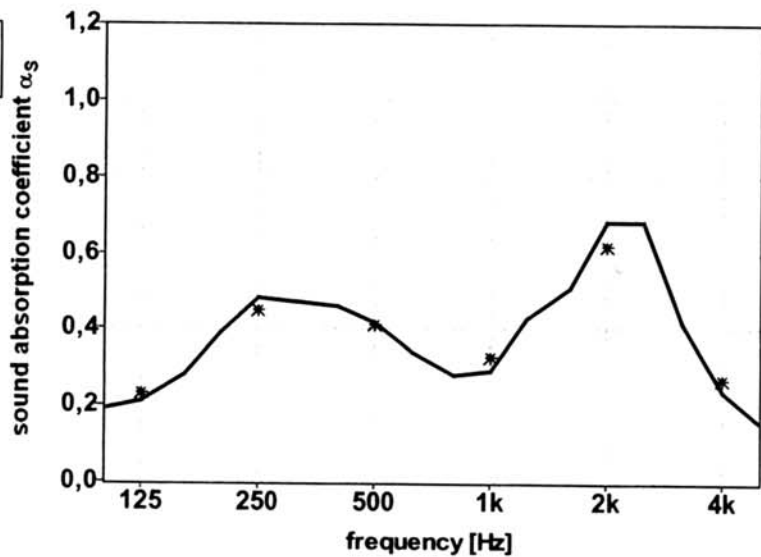
type: Lightben Acoustic  
 manufacturer: **Bencore**  
 material: 2 layers acrylic with a micro perforation (thickness each layer c. 1 mm), between the layers a honeycomb  
 perforation: square pattern; c.t.c. 15 mm; Ø 0,95 mm; perforation rate c. 0,3%  
 perforated area: 1000 x 2695 mm  
 panel sizes: 3005 x 1000 mm  
 total thickness: 17 mm  
 total mass: 3,9 kg/m<sup>2</sup> (checked by the laboratory)



Absorb. versie 5.4.6 mode 7. PM: YW. file: a2026 E#:1-36 F#:37-72 A#:73 T<sub>1</sub> = 16,8 °C T<sub>2</sub> = 17,1 °C p<sub>1</sub> = 102,3 kPa p<sub>2</sub> = 102,2 kPa h<sub>1</sub> = 54,5 % h<sub>2</sub> = 53,0 %

volume reverberation room: 214 m<sup>3</sup>  
 surface area sample: 12 m<sup>2</sup>  
 height of the construction: 0,200 m  
 measured at: laboratory conditions  
 signal: broad-band noise  
 bandwidth: 1/3 octave

— 1/3 oct.  
 \* 1/1 oct.



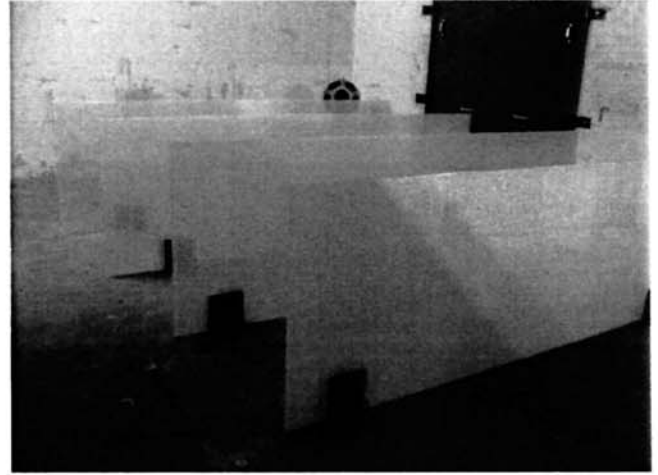
	0,19	0,39	0,46	0,28	0,51	0,42
1/3 oct.	0,21	0,48	0,42	0,29	0,68	0,24
	0,28	0,47	0,34	0,43	0,68	0,16
<b>alpha_w (ISO 11654) = 0,40(L)</b>	<b>1/1 oct.</b>	<b>0,23</b>	<b>0,45</b>	<b>0,41</b>	<b>0,33</b>	<b>0,62</b>
						<b>0,27</b>

EQUIVALENT SOUNDABSORPTION AREA PER OBJECT ACCORDING TO ISO 354:2003



principal: Bencore Srl.

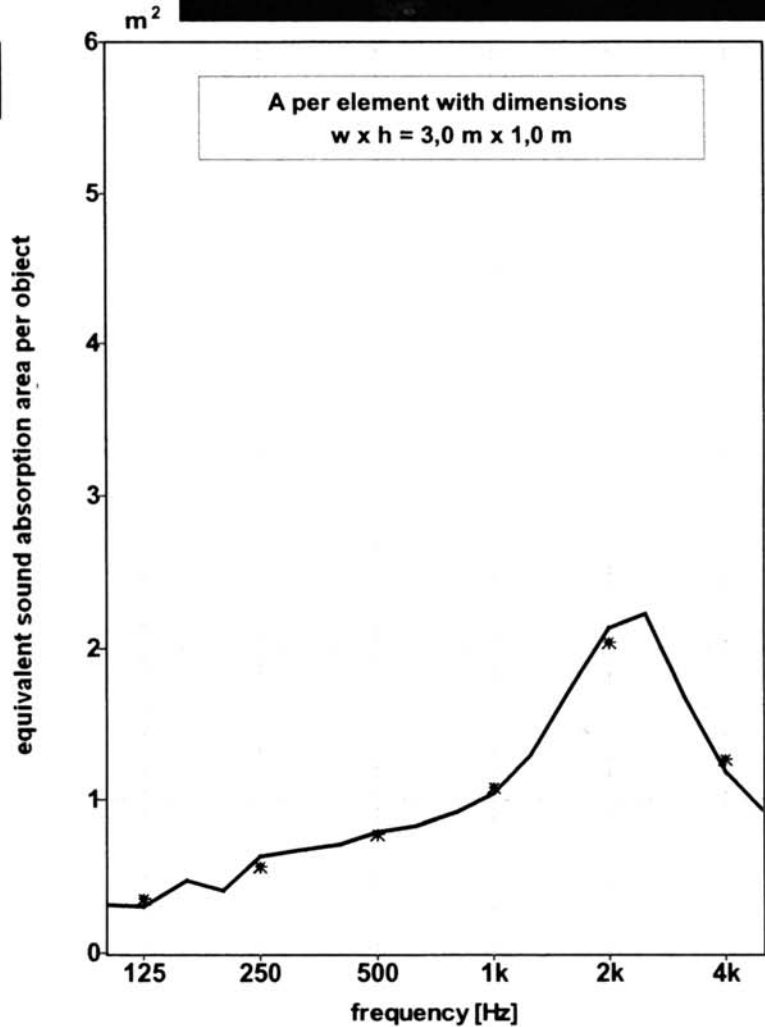
type: Lightben Acoustic  
 manufacturer: **Bencore**  
 material: 2 layers acrylic with a micro perforation (thickness each layer c. 1 mm), between the layers a honeycomb square pattern; c.t.c. 15 mm; Ø 0,95 mm;  
 perforation: perforation rate c. 0,3%  
 perforated area: 1000 x 2695 mm  
 panel sizes: 3005 x 1000 mm  
 total thickness: 17 mm  
 total mass: 3,9 kg/m<sup>2</sup> (checked by the laboratory)



Absorb. v ersie 5.4.6 mode 9. PM: YW. file: a2026 E#:1-36 F#:74-109 A#:110 T<sub>1</sub> = 16.8 °C T<sub>2</sub> = 17.3 °C p<sub>1</sub> = 102.3 kPa p<sub>2</sub> = 102.1 kPa h<sub>1</sub> = 54.5 % h<sub>2</sub> = 51.9 %

volume reverberation room: 214 m<sup>3</sup>  
 number of elements: 4  
 measured at: laboratory conditions  
 signal: broad-band noise  
 bandwidth: 1/3 octave

— 1/3 oct.  
 \* 1/1 oct.



	0,32	0,41	0,72	0,92	1,76	1,68
1/3 oct.	0,30	0,64	0,79	1,04	2,13	1,19
	0,47	0,67	0,83	1,30	2,22	0,94
1/1 oct.	0,36	0,57	0,78	1,09	2,04	1,27