ACOUSTICS AND BUILDING PHYSICS
NOISE CONTROL
ENVIRONMENTAL TECHNOLOGY
FIRE SAFETY

PEUTZ

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TESTING
RvA L 334

Report

Laboratory for Acoustics

Determination of the sound absorption (reverberation room method) and the sound insulation of a noise barrier type **NoiStop Wood, manufacturer RockDelta A/S (Rockwool A/S)**

Reportnumber A 2151-3E-RA d.d. 12 juli 2011

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1. INTRODUCTION

At the request of RockDelta A/S based in Hedehusene (Denmark), laboratory measurements of the sound absorption and the sound insulation were carried out on a

noise barrier type NoiStop Wood, manufacturer RockDelta A/S

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[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. STANDARDS

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

ISO 354:2003[2]	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
ISO 140-3:1995	Acoustics - Measurements of sound insulation in buildings and of building elements: Part 3: Laboratory measurements of airborne sound insulation of building elements
NOTE:	this international standard has been accepted within all EU-countries as European Norm EN ISO 140-3:1995

Various other related standards:

EN ISO 11654:1997	Acoustics Sound absorbers for use in buildings Rating of sound absorption
EN 1793-1:1997	Road traffic noise reducing devices Test method for determining the acoustic performance Part 1: Intrinsic characteristics of sound absorption
EN 1793-2:1997	Road traffic noise reducing devices - Test method for determining the acoustic performance - Part 2: Intrinsic characteristics of airborne sound insulation
EN 1793-3:1997	Road traffic noise reducing devices - Test method for determining the acoustic performance - Part 3: Normalised traffic noise spectrum
ISO 717-1:1996	Acoustics - Rating of sound insulation in buildings and of building elements - Part 1: Airborne sound insulation
N.B.	De norm ISO 717-1 is binnen alle landen van de EG aanvaard als Europese Norm EN ISO 717-1:1996

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.

ISO 717-1:1996/A1:2006

Acoustics - Rating of sound insulation in buildings and of building elements- Part 1: Airborne sound insulation - Amendment 1 : Rounding rules related to single number ratings and single number quantities

3. TESTED CONSTRUCTION

The data presented here have been received from the principal or obtained by own observations. The measurements have been carried out a barrier, dimensions width x height 4000 x 2680.

Description of the tested noise barrier:

Make:	RockDelta A/S
Type:	NoiStop Wood
Material:	Rockwool core covered with a black plastic mesh and wooden laths
Dimension laths	width x thickness 45x15 mm mounted at a c.t.c. distance of 75 mm
Element thickness:	131 mm
Width:	2000 mm
Hight:	900 mm
Weight:	20,8 kg/m^2 (measured)

detail NoiStop Wood element

The test specimen is mounted and assembled in the same manner as the barrier is used in practice with the same connections and seals between the elements. In the centre one post is included in the specimen with elements attached on both sides.

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. SOUND ABSORPTION MEASUREMENTS

The barrier to be measured (see chapter 3) is placed directly onto the floor with the view side of the elements up, according to EN 1793-1. The sides of the set-up were enclosed by reflecting panels and sealed by tape. 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) (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 m^2

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

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]

$$c = 331 + 0{,}6t \qquad (2)$$

in which :

t = the temperature; this formula is valid for temperatures between 15 and 30 ºC [°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 A2 for the room with the test specimen is calculated according to formula 4, also expressed in m^2

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

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^{-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 below.

Table 1 Atmospheric conditions during the test

reverberation room	temperature [°C]	atmosperic pressure [kPa]	relative humidity [%]
empty	19,7	102,3	51
With specimen	19,5	102,5	54

4.4. Results

The results of the measurements are given in table 2 and figure 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.
- the "single-number rating of sound absorption DL_α" according to EN 1793-1.

Table 2 Measurement results

	sound absorption coefficient α_s	
type	NoiStop Wood	
record nr.	#221	
See figure	4	
frequency [Hz]	1/3 oct.	1/1 oct.
100	0,55	
125	0,60	0,60
160	0,65	
200	0,55	
250	0,74	0,69
315	0,79	
400	0,86	
500	0,92	0,92
630	0,98	
800	1,00	
1000	1,00	1,00
1250	1,00	
1600	0,97	
2000	0,96	0,95
2500	0,91	
3150	0,78	
4000	0,65	0,66
5000	0,54	
α_w	0,85	
NRC	0,90	
DL_α	11 dB	
Category	A3	

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.

5. AIRBORNE SOUND INSULATION MEASUREMENTS

The client built the test arrangement into the test opening D (c. 4300 x 2800 mm) between testing rooms 1 and 2. The test specimen is composed with 6 elements and a post in the center of the construction. The panels are attached on both sides of the post and sealed as in practice.
The edge supports are built with a wall construction of sufficient airborne sound insulation and sealed to prevent sound leakages.

5.1. Method

The tests were conducted in accordance with the provisions of the test method ISO 140-3 in the Laboratory for Acoustics of Peutz bv in Mook. A detailed description of the test set up has been given in figures 1 and 5 of this report.

The construction to be tested is placed into a test opening between two measuring rooms. In one of the rooms (the so-called sending room) loudspeakers generate broadband noise.

In this sending room as well as in the adjacent room (the "receiving room") the resulting sound pressure level is measured by means of a continuous rotating boom, so the (time- and space-) averaged sound pressure level is determined.

The reverberation time of the receiving room is also measured.

The instruments and the method used meet the requirements of ISO 140-3

As allowed by the test method the test procedure is repeat-ed reversing the sending and receiving rooms. The reported value of each sound insulation is the arithmetic average of the two results.

In ISO 140-3 the airborne sou-nd insulation of an object is defined as the "sound reduction index R" to be evaluated according to formula 1 and expressed in dB:

$$R = L_1 - L_2 + 10 \log\left(\frac{S}{A}\right) \qquad (7)$$

in which:

L_1 = sound pressure level in the sending room [dB]
L_2 = sound pressure level in the receiving room [dB]
S = area of the object to be tested [m^2]
A = equivalent sound absorption [m^2] in the receiving room according to:

$$A = \frac{0{,}16\,V}{T} \qquad (8)$$

in which :

V = volume of the receiving room [m^3]

T = reverberation time in the receiving room [s]

5.2. Accuracy

The accuracy of the airborne sound insulation as calculated can be expressed in terms of repeatability (tests within one laboratory) and reproducibility (between various laboratories).

5.2.1. Repeatability r

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 insulation measurements performed in the laboratories of Peutz bv in Mook eight series of measurements have been carried out according to ISO 140-2. From the results of those measurements the repeatability r has been calculated. It was found that for the frequency range from 100 to 250 Hz the repeatability r is 2,0 dB as a maximum. For the frequency range 315 to 3150 Hz the repeatability r is 1,3 dB as a maximum.

The repeatability r regarding the single-figure rating R_w is 0,7 dB as a maximum. As ISO 717-1 prescribes rounding of the R_w-values to the nearest dB repeatability r of 1 dB is applicable for the R_w-value.

From these results it may be concluded that the repeatability r as found satisfies the demands of ISO 140-2.

5.2.2. Reproducibility R

When: - two tests are performed on identical test material - in different laboratories - by different person(s) - under different environmental conditions - the probability will be 95% that the difference between the two test results will be less than or equal to R.

In ISO 140-2 there is a statement on the reproducibility R to be expected, based on the results of various inter-laboratory tests. The reproducibility of the single figure rating R_w is about 3 dB.

5.2.3. Environmental conditions during the tests

Table 3 Atmospheric conditions during the test

room	temperature [°C]	relative humidity [%]
1	19,0	49
2	18,7	47

5.3. Results

The results of the measurements are given in table 4 and figure 7 to 9. In the table and graph the values of the insulation found are presented in 1/3 octave bands.

From those values the following one-figure ratings have been calculated and stated :

- the "weighted sound reduction index R_w" and the spectrum adaptation terms C and C_{tr} according to ISO 717-1;
- the single-number rating of airborne sound insulation DLR" according to EN 1793-2.

Table 4 Measurement results

	airborne sound insulation R [dB]	
Type	NoiStop Wood	
record nr.	#254	
See figure	6	
frequency [Hz]	1/3 oct.	1/1 oct.
100	15,0	
125	13,3	13,7
160	13,1	
200	14,2	
250	14,7	15,1
315	16,8	
400	17,9	
500	16,2	17,3
630	18,0	
800	25,3	
1000	28,1	27,1
1250	28,8	
1600	35,2	
2000	37,4	37,2
2500	40,8	
3150	43,6	
4000	47,5	46,2
5000	49,8	
$R_w(C;C_{tr})$	24(-1;-3) dB	
DL_R	21 dB(A)	
Category	B2	

The results as presented here are based on a testing area of 10,7 m2. In situations where different dimensions and/or method of mounting differ from the ones tested, different results may be found.

Mook,

Th. Scheers
Laboratory Supervisor

ir. M.L.S. Vercammen
Manager

This report contains: 14 pages and 6 figures.

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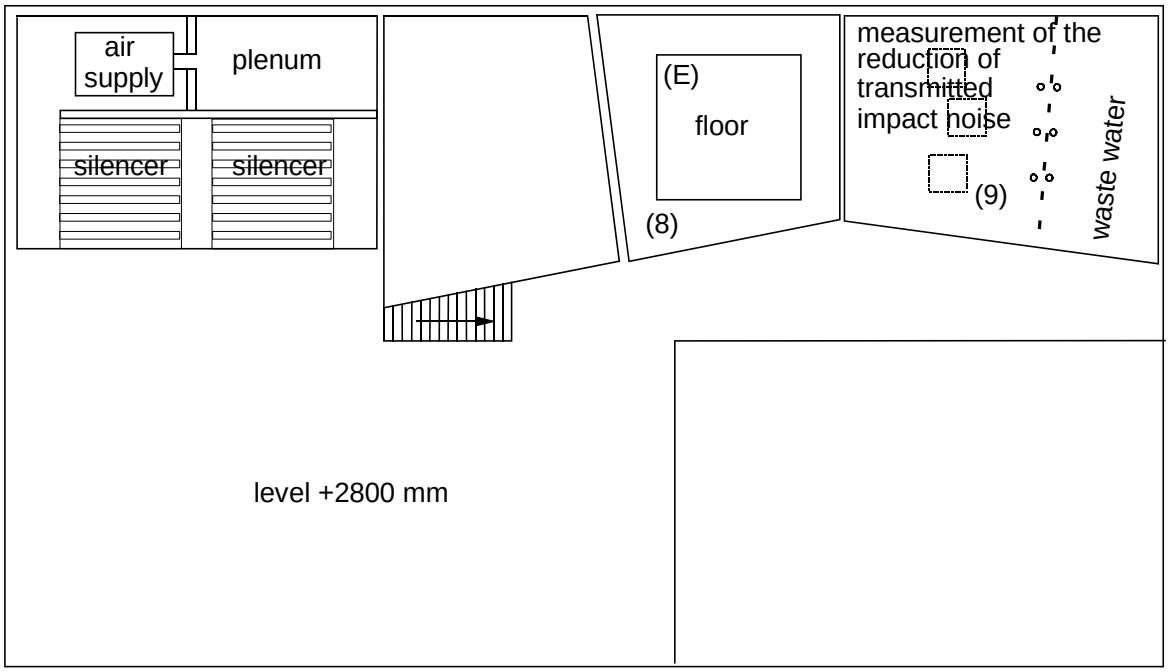
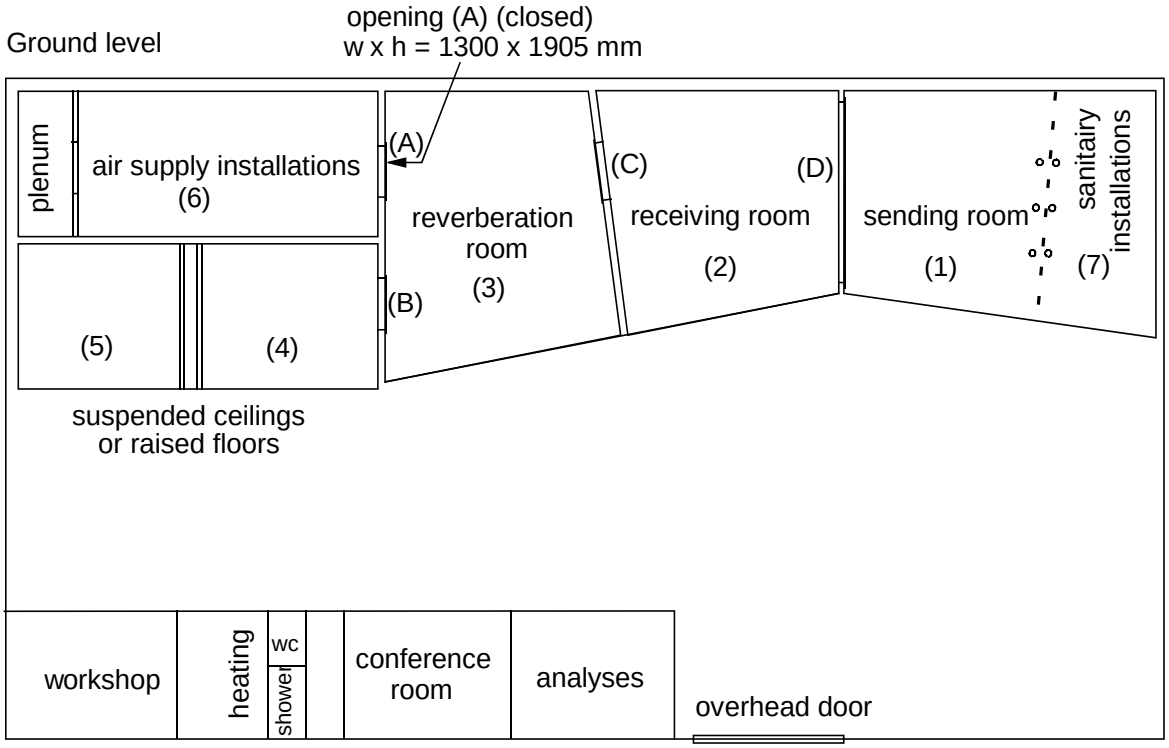
OVERVIEW

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

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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.

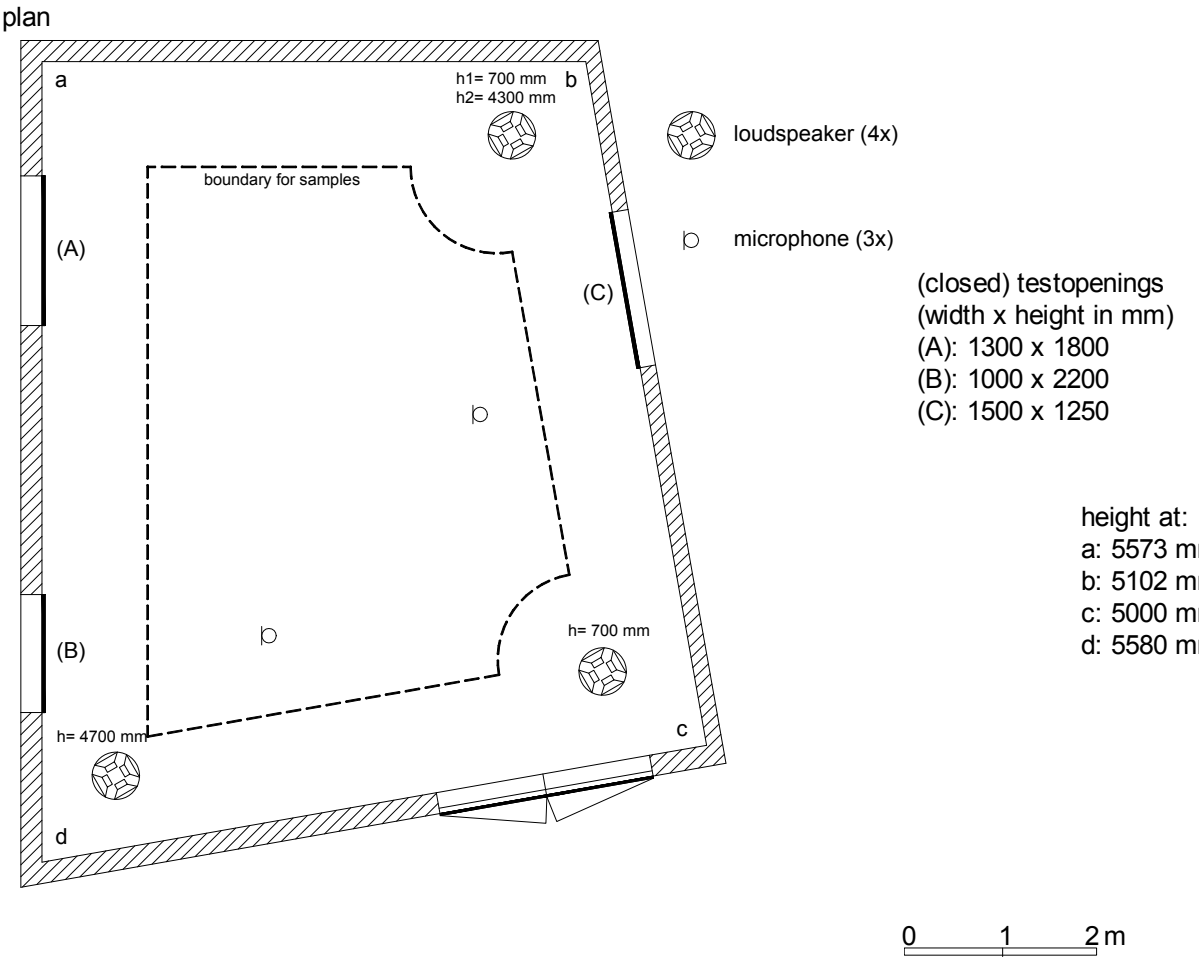
reverberation time of the empty reverberation room during measurements of 24-05-2011

frequentie (1/1 oct.)	125	250	500	1000	2000	4000	Hz
nagalmtijd	9,41	7,81	7,74	6,44	4,62	2,95	sec.

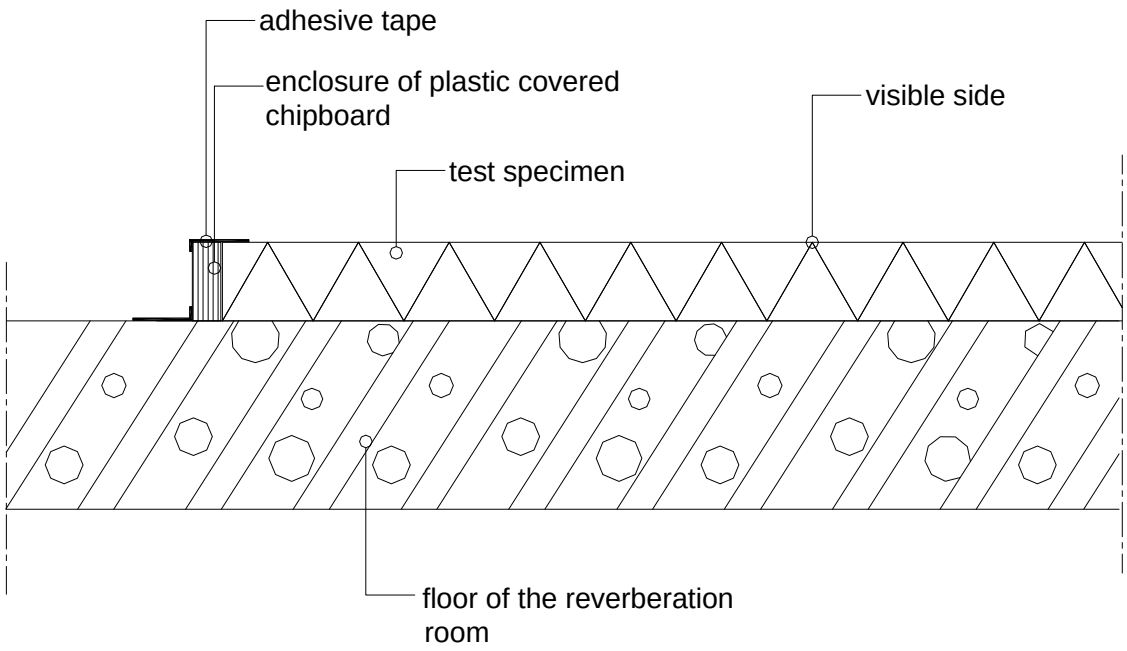
repeatibility r (1/1 oct.) c.f. ISO 354:1985 annex C (see chapter 4.2 of this report).

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



Absorb, versie 5.6.2 mode 7, file: a2151 E#:109-144 T_1 = 19,7 °C p_1 = 102,3 kPa h_1 = 51,4 %



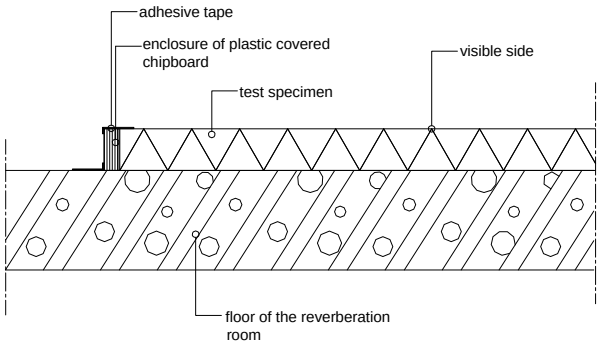
NoiStop Wood

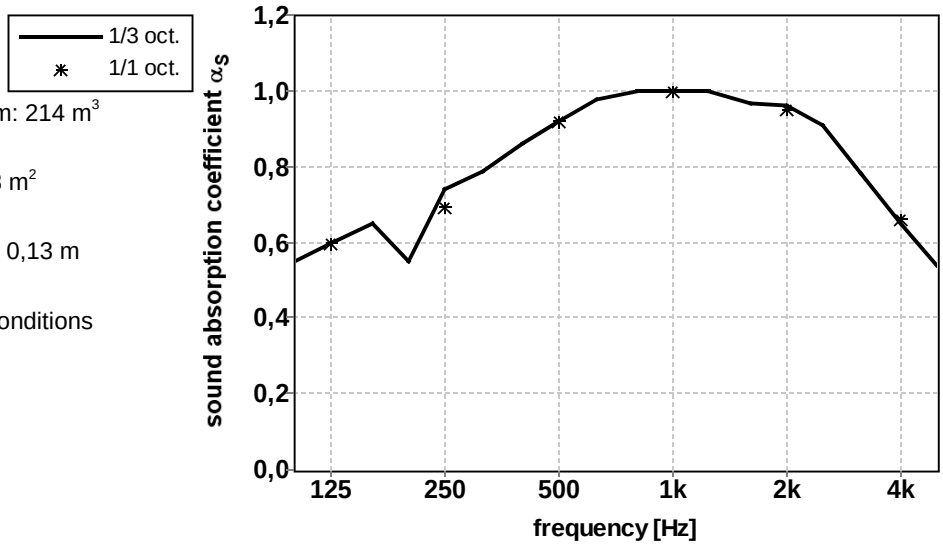
MEASUREMENT OF SOUND ABSORPTION IN A REVERBERATION ROOM ACCORDING TO ISO 354:2003

TESTING RvA L 334

principal: RockDelta A/S

NoiStop Wood





volume reverberation room: 214 m^3

surface area sample: 10,8 m^2

heigth of the construction: 0,13 m

measured at: laboratory conditions

signal: broad-band noise

bandwidth: 1/3 octave

	125	250	500	1k	2k	4k
	0,55	0,55	0,86	1,00	0,97	0,78
1/3 oct.	0,60	0,74	0,92	1,00	0,96	0,65
	0,65	0,79	0,98	1,00	0,91	0,54
1/1 oct.	**0,60**	**0,69**	**0,92**	**1,00**	**0,95**	**0,66**

α_w (ISO 11654) = 0,85

NRC (ASTM - C423) = 0,90

DLα (EN 1793-1) = 11 dB

Mook, 24-05-2011

Absorb, versie 5.6.2 mode 7, PM: JK, file: a2151 E#:109-144 F#:185-220 A#:221 T_1 = 19,7 °C T_2 = 19,5 °C p_1 = 102,3 kPa p_2 = 102,5 kPa h_1 = 51,4 % h_2 = 53,8 %

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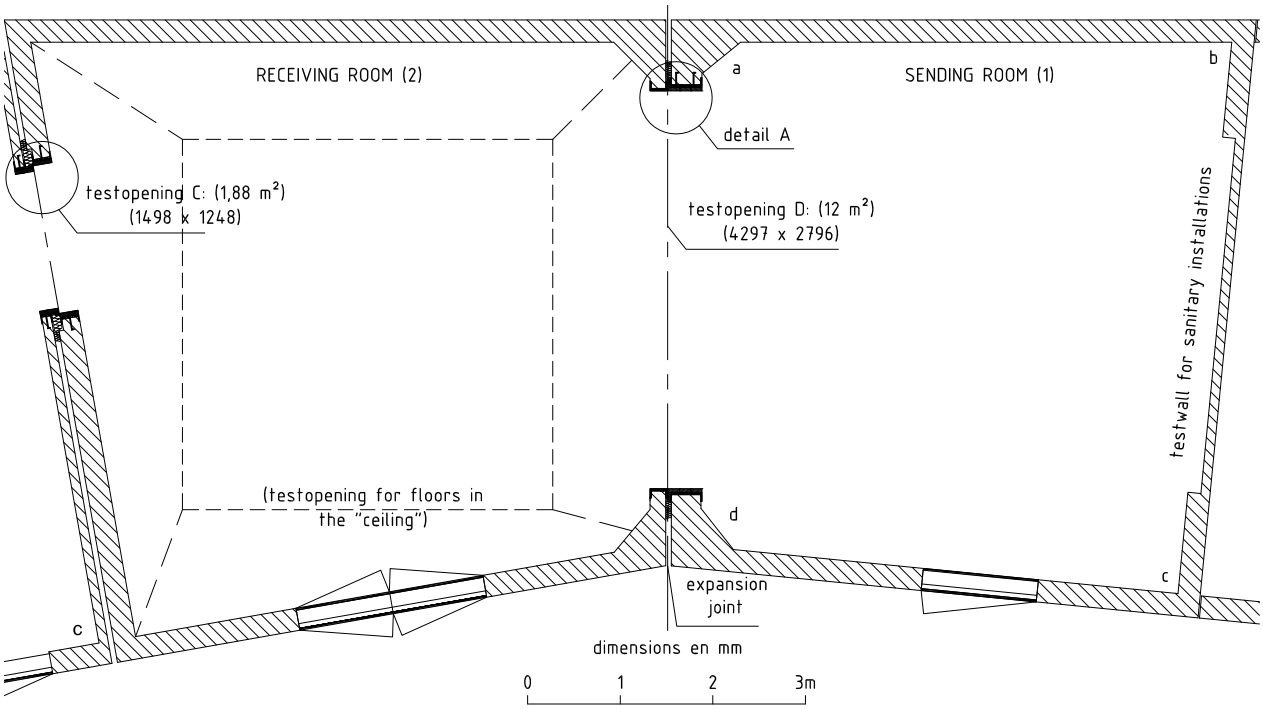
SOUND INSULATION TEST FACILITIES

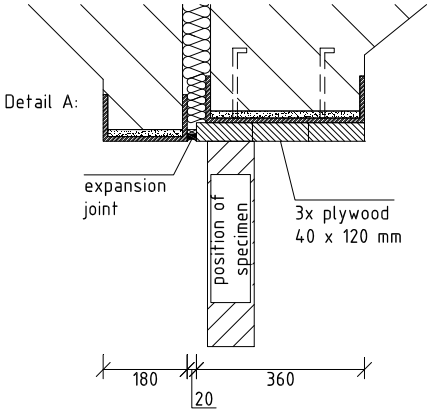
The testrooms meet the requirements of ISO 140-3.
Additional data:
- volume of the receivingroom: 111 m^3
- volume of the sourceroom: 94 m^3
- area of the test specimen: 12,0 m^2

Both rooms are isolated for vibrations by using a so called room-in-room construction. Flanking transmission is thus minimised.

height: allong the walls 2840 mm increasing to 2920 mm at the perimeter of the testopening for floors

height at a: 3055 mm
height at b: 3058 mm
height at c: 3052 mm
height at d: 3062 mm



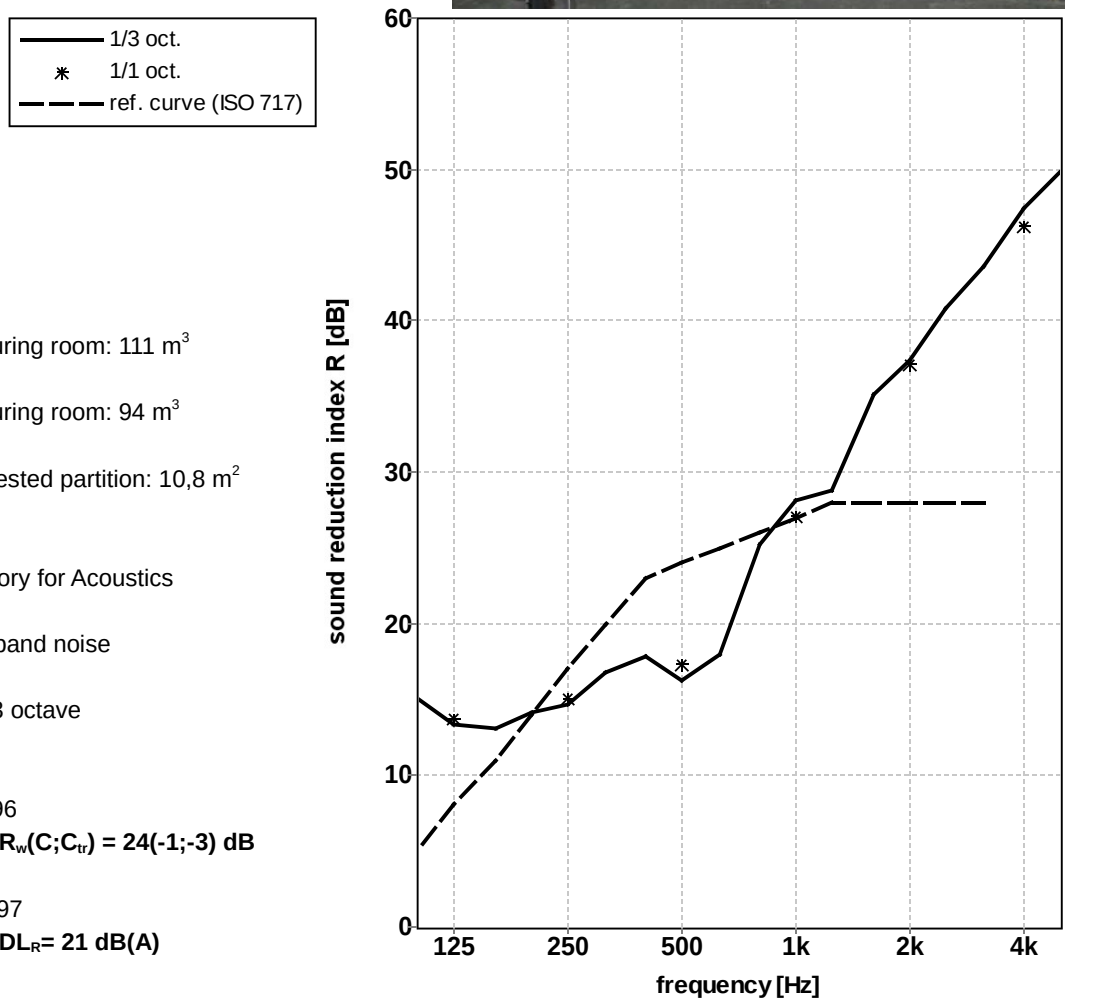


MEASUREMENT OF THE SOUND INSULATION ACCORDING TO ISO 140-3:1995

TESTING RvA L 334

principal: RockDelta A/S

construction tested: NoiStop Wood



volume measuring room: 111 m^3

volume measuring room: 94 m^3

surface area tested partition: 10,8 m^2

measured at:
Peutz Laboratory for Acoustics

signal: broad-band noise

bandwidth: 1/3 octave

ISO 717-1:1996
$R_w(C;C_{tr})$ = 24(-1;-3) dB

EN 1793-2:1997
DL_R= 21 dB(A)

	125	250	500	1k	2k	4k	
	15,0	14,2	17,9	25,3	35,2	43,6	
1/3 oct.	13,3	14,7	16,2	28,1	37,4	47,5	dB
	13,1	16,8	18,0	28,8	40,8	49,8	
1/1 oct.	**13,7**	**15,1**	**17,3**	**27,1**	**37,2**	**46,2**	**dB**

Mook, 24-05-2011