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M121474/01 SRD/MOL

styleGREEN
Iceland Moss / Reindeer Moss
of the company FlowerArt

Measurement of sound absorption
in a reverberation room
according to EN ISO 354

Test Report No. M121474/01

Client:	FlowerArt GmbH Ständlerstraße 35 81549 Munich Germany
Consultant:	Dipl.-Phys. Elmar Schröder
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1 Task

On behalf of the company FlowerArt GmbH, 81549 Munich, Germany, the sound absorption coefficient of styleGREEN Iceland Moss / Reindeer Moss mats was to be determined by measurements in the reverberation room according to EN ISO 354 [1].

The results are to be evaluated according to EN ISO 11654 [3] and ASTM C 423-09a [4].

2 Basis

This test report is based on the following documents:

- [1] EN ISO 354: Acoustics - Measurement of sound absorption in a reverberation room. 2003-05
- [2] ISO 9613-1: Acoustics; Attenuation of sound during propagation outdoors; part 1: calculation of the absorption of sound by the atmosphere. 1993-06
- [3] EN ISO 11654: Acoustics – Sound absorbers for use in buildings – Rating of sound absorption. 1997-04
- [4] ASTM C 423-09a: Standard Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method. Revision: 09a. 2009-10

3 Test assembly and test objects

The test assembly was effected acc. to EN ISO 354 [1], section 6.2.1 Appendix B, assembly type A.

Test objects were assembled in the reverberation room by the client and employees of the testing laboratory on the day of measurement.

The test build-up was as follows (from top to bottom):

- 50 mm Iceland Moss / Reindeer Moss mats,
area-related mass approx. $m'' = 7.1 \text{ kg/m}^2$,
dimensions of the mats length x width = 0.57 m x 0.37 m,
eight rows with each five mats as well as one row with eight mats,
jointed bluntly among each other
- floor of the reverberation room

The test object was enclosed by a circumferential frame. The height of the frame was 50 mm. The enclosing frame was made of 19 mm coated MDF-boards.

The total dimensions of the test surface (without frame) were length x width = 3.53 m x 2.85 m.

The joints between the enclosing frame and the floor of the reverberation room were sealed with adhesive tape.

Appendix B shows figures of the test assemblies.

4 Execution of the measurements

The measurements of sound absorption in the reverberation room were effected and evaluated according to EN ISO 354 [1].

The test method, the test facility and the test equipment used are described in Appendix C.

5 Evaluation

The sound absorption coefficient α_s was determined in one-third octave bands between 100 Hz and 5000 Hz according to EN ISO 354 [1].

In addition to the sound absorption coefficients the following characteristic values were determined according to EN ISO 11654 [3].

- Practical sound absorption coefficient α_p in octave bands
- Weighted sound absorption coefficient α_w as single value:
The weighted sound absorption coefficient α_w is determined from the practical sound absorption coefficients α_p in the octave bands of 250 Hz to 4000 Hz.

According to ASTM C 423-09a [1] the following characteristic values were determined:

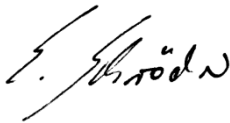
- noise reduction coefficient *NRC* as single value:
Arithmetical mean value of the sound absorption coefficients in the four one-third octave bands 250 Hz, 500 Hz, 1000 Hz and 2000 Hz; mean value rounded to 0.05
- sound absorption average *SAA* as single value:
Arithmetical mean value of the sound absorption coefficients in the twelve one-third octave bands between 250 Hz and 2500 Hz; mean value rounded to 0.01

6 Measurement results

The sound absorption coefficients α_s in one third-octave bands, the practical sound absorption coefficients α_p in octave bands and the single values (α_w , *NRC* and *SAA*) are indicated in the test certificate in Appendix A.

7 Remarks

The test results exclusively relate to the investigated subjects and conditions described.



Dipl.-Phys. Elmar Schröder

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Sound absorption coefficient ISO 354

Measurement of sound absorption in reverberation rooms

Client: FlowerArt GmbH, Ständlerstraße 35, 81549 Munich, Germany

Test specimen: styleGREEN Iceland Moss / Reindeer Moss

Test build-up (from top to bottom):

- 50 mm styleGREEN Iceland Moss / Reindeer Moss mats,
area-related mass approx. $m' = 7.1 \text{ kg/m}^2$
dimensions of the mats length x width = 0.57 m x 0.37 m,
8 rows with each 5 mats as well as 1 row with 8 mats,
jointed bluntly among each other
- floor of the reverberation room

Arrangement in the reverberation room:

- mounting type A according to EN ISO 354
- dimensions of the test surface length x width = 3.53 m x 2.85 m
- enclosing frame of 19 mm thick coated MDF boards (medium density fibreboards),
height of frame 50 mm
- joints between frame and reverberation room floor sealed with adhesive tape

Room: Hallraum

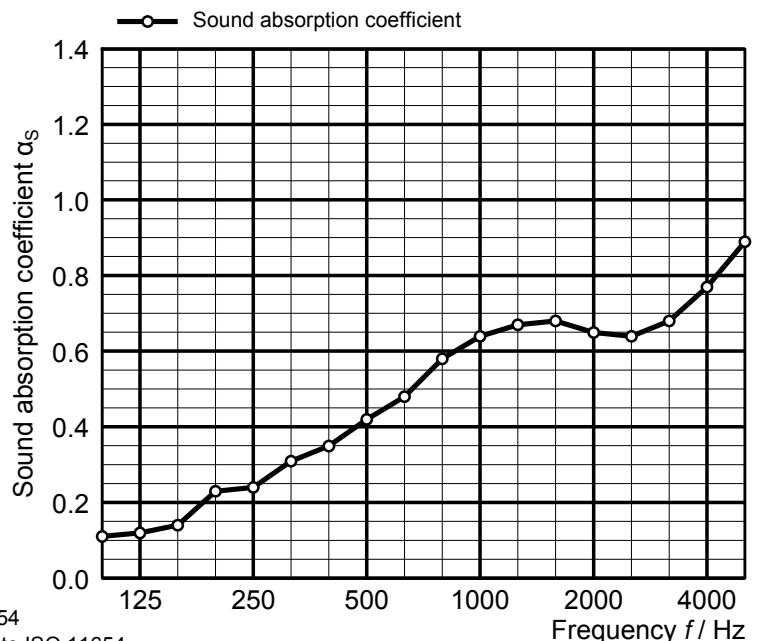
Volume: 199.60 m³

Size: 10.06 m²

Date of test: 2015-03-26

	θ [°C]	r. h. [%]	B [kPa]
without specimen	20.9	36.8	94.5
with specimen	21.0	37.6	94.5

Frequency [Hz]	α_s 1/3 octave	α_p octave
100	0.11	0.10
125	0.12	
160	0.14	
200	0.23	
250	0.24	0.25
315	0.31	
400	0.35	
500	0.42	0.40
630	0.48	
800	0.58	
1000	0.64	0.65
1250	0.67	
1600	0.68	
2000	0.65	0.65
2500	0.64	
3150	0.68	
4000	0.77	0.80
5000	0.89	



α_s Sound absorption coefficient according to ISO 354

α_p Practical sound absorption coefficient according to ISO 11654

Rating according to ISO 11654: Weighted sound absorption coefficient $\alpha_w = 0.45 (H)$ Sound absorption class: D	Rating according to ASTM C423: Noise Reduction Coefficient NRC = 0.50 Sound Absorption Average SAA = 0.49
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Appendix A

Page 1

styleGREEN Iceland Moss / Reindeer Moss



Figure B.1. Arrangement of the test object on the floor of the reverberation room.



Figure B.2. Enclosing frame sealed with adhesive tape.

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Description of the test procedure for the determination of the sound absorption in a reverberation room

1 Measurand

The sound absorption coefficient α of the test object was determined. For this purpose the mean value of the reverberation time in the reverberation room with and without the test object was measured. The sound absorption coefficient was calculated using the following equation:

$$\alpha_S = \frac{A_T}{S}$$

$$A_T = 55.3 V \left(\frac{1}{c_2 T_2} - \frac{1}{c_1 T_1} \right) - 4 V (m_2 - m_1)$$

With:

- α_S sound absorption coefficient;
- A_T equivalent sound absorption area of the test object in m^2 ;
- S area covered by the test object in m^2 ;
- V volume of the reverberation room in m^3 ;
- c_1 propagation speed of sound in air in the reverberation room without test object in m/s;
- c_2 propagation speed of sound in air in the reverberation room with test object in m/s;
- T_1 reverberation time in the reverberation room without test object in s;
- T_2 reverberation time in the reverberation room with test object in s;
- m_1 power attenuation coefficient in the reverberation room without test object in m^{-1} ;
- m_2 power attenuation coefficient in the reverberation room with test object in m^{-1} .

The different dissipation during the sound propagation in the air was taken into account according to paragraph 8.1.2 of EN ISO 354 [1]. The dissipation was calculated according to ISO 9613-1 [2]. The climatic conditions during the measurements are indicated in the test certificates.

Information on the repeatability and reproducibility of the test procedure are given in EN ISO 354 [1].

2 Test procedure

2.1 Description of the reverberation room

The reverberation room complies with the requirements according to EN ISO 354 [1]. The reverberation room has a volume of $V = 199.6 \text{ m}^3$ and a surface of $S = 216 \text{ m}^2$.

Six omni-directional microphones and four loudspeakers were installed in the reverberation room.

In order to improve the diffusivity, six composite sheet metal boards dimensioned 1.2 m x 2.4 m and six composite sheet metal boards dimensioned 1.2 m x 1.2 m were suspended curved and irregularly.

Figure C.1 shows the drawings of the reverberation room.

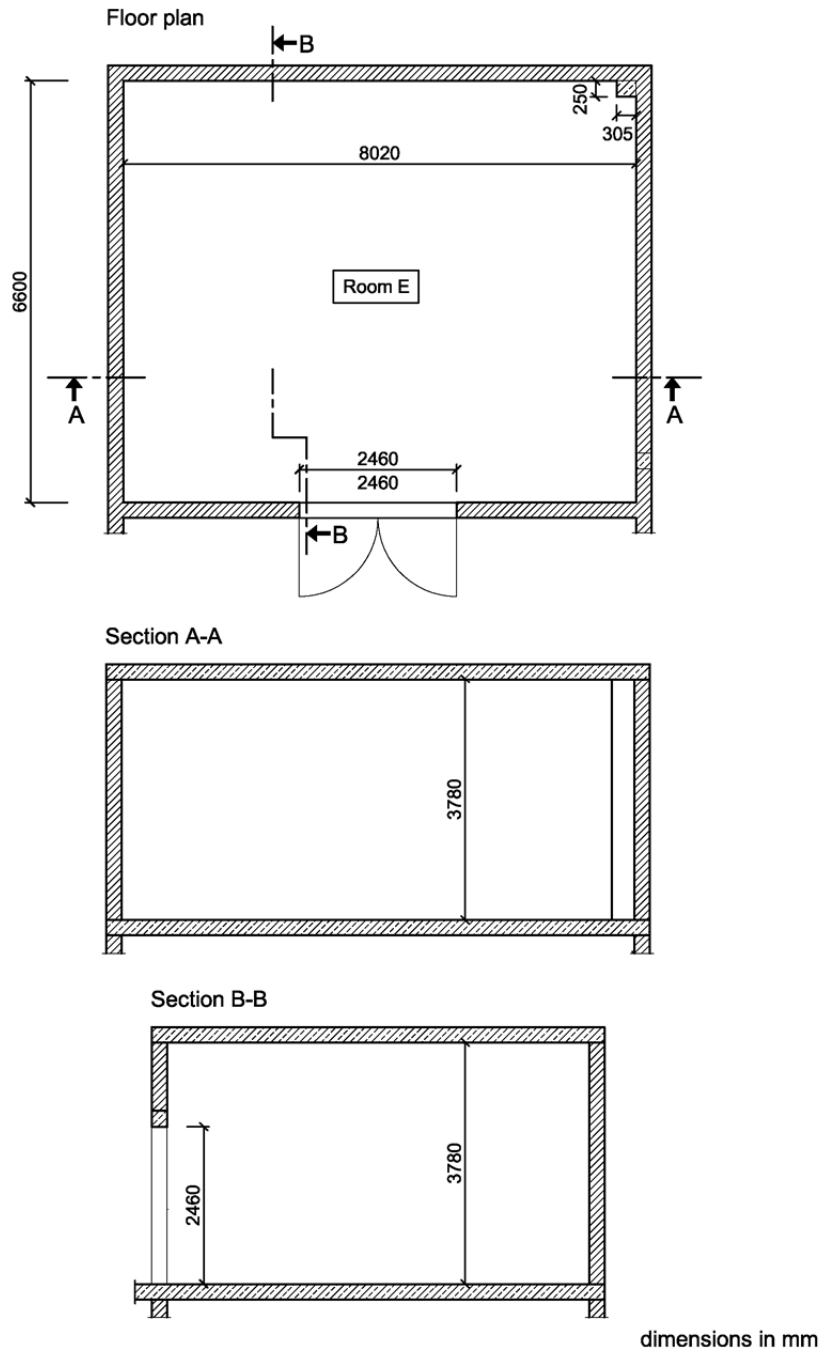


Figure C1. Plan view and sections of the reverberation room.

2.2 Measurement of reverberation time

The determination of the impulse responses were carried out according to the indirect method. In all tests, a sinusoidal sweep with pink noise spectrum was used as test signal. In the reverberation room with and without test objects each 24 independent combinations of loudspeakers and microphones were measured. The reverberation time was evaluated according to EN ISO 354 [1], using a linear regression for the calculation of the reverberation time T_{20} from the level of the a backward integrated impulse response.

The determined reverberation times in the reverberation room with and without test object are indicated in table C.1.

Table C.1. Reverberation times without and with test objects.

Frequency f in Hz	Reverberation time T in s	
	T_1 (without test object)	T_2 (with test object)
100	5.02	4.31
125	5.30	4.43
160	5.27	4.28
200	5.44	3.88
250	4.98	3.63
315	4.99	3.37
400	5.20	3.30
500	5.30	3.12
630	5.13	2.89
800	5.03	2.63
1000	5.26	2.56
1250	5.36	2.52
1600	5.16	2.47
2000	4.66	2.40
2500	3.92	2.21
3150	3.12	1.89
4000	2.37	1.52
5000	5.02	4.31

2.3 List of test equipment

Table C.2. Test equipment.

Name	Manufacturer	Type	Serial-No.
AD-/DA-converter	RME	Multiface II	22460388
Amplifier	APart	Champ One	09070394
Dodecahedron	Müller-BBM	DOD130B	265201
Dodecahedron	Müller-BBM	DOD130B	265202
Dodecahedron	Müller-BBM	DOD130B	265203
Dodecahedron	Müller-BBM	DOD130B	265204
Microphone	Microtech	M360	1783
Microphone	Microtech	M360	1785
Microphone	Microtech	M360	1786
Microphone	Microtech	M360	1787
Microphone	Microtech	M360	1788
Microphone	Microtech	M360	1789
Microphone power supply	MFA	IV80F	330364
Hygro-/Thermometer	Testo	Saveris H1E	01554624
Barometer	Lufft	Opus 10	030.0910.0003.9. 4.1.30
Software for measurement and evaluation	Müller-BBM	Bau 4	Version 1.6