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M136562/02 SRD/STEG

Acoustic wall tiles Sound Balance of the company Sigel

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

Test Report No. M136562/02

Client:	Sigel GmbH Bäumenheimer Str. 10 86690 Mertingen GERMANY
Consultant:	Dipl.-Phys. Elmar Schröder
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Table of contents

1 Task

On behalf of the company Sigel GmbH the sound absorption of the acoustic wall tiles Sound Balance was to be determined in the reverberation room according to EN ISO 354.

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] EN ISO 11654: Acoustics – Sound absorbers for use in buildings – Rating of sound absorption. 1997-04

[3] ASTM C 423-17: Standard Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method. Revision: 17. 2017-02

[4] ISO 9613-1: Acoustics - Attenuation of sound during propagation outdoors - Part 1: calculation of the absorption of sound by the atmosphere. 1993-06

[5] EN 29053: Acoustics – Materials for acoustical applications – Determination of airflow resistance. 1993

3 Test object and test assembly

3.1 Test object

The acoustic wall tiles Sound Balance with dimensions of length x width = 800 mm x 400 mm had the following structure (from top to bottom):

-	1 mm	tissue, mass per unit are 227 g/m², specific airflow resistance 166 Pa s/m
-	39 mm	three-layer PET-sandwich, mass per unit area 6.3 kg/m², gross density 162 kg/m³, specific airflow resistance 1240 Pa s/m; consisting of: - 15 mm PET, punctually connected with hot glue with - 9 mm PET, punctually connected with hot glue with - 15 mm PET
-	1 mm	tissue, mass per unit area 227 g/m², specific airflow resistance 166 Pa s/m
-	1 mm	spacer to simulate the adhesive tape underneath the aluminium profile visible from the rear side

The wall panels consisted of a circumferential, 50 mm wide aluminium profile with a PET-sandwich clamped in-between. On the visible face of the aluminium profile, 9 mm thick panels of PET were incorporated. The aluminium profile was hollow, closed on all sides and narrowing to a thickness of 15 mm at the rim.

3.2 Test assembly

The test set-up was carried out according to EN ISO 354, Section 6.2.1 in mounting type A as per Appendix B.

The installation of the test objects was carried out by employees of the test laboratory at the reverberation room of Müller-BBM.

The test area consisted of a total of 31 wall panels with the dimensions 400 mm x 800 mm and one wall panel with the dimensions 400 mm x 400 mm arranged butt-jointed to form a rectangular area with the dimensions length x width = 3.60 m x 2.80 m

The acoustic wall panels were laid directly onto the floor of the reverberation room. The setup was enclosed by a 40 mm high frame of 19 mm thick MDF panels. The joints between the reverberation room floor and the enclosing frame were sealed with an adhesive tape.

The photographs in Appendix B show details of the test arrangements.

4 Execution of the measurements

The measurements were executed and evaluated according to EN ISO 354 [1].

The test procedure, the test facility and the test equipment used for the measurements 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 [2]:

- 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 423-17 [3] 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 certificates in Appendix A.

7 Remarks

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

Elmar Schröder

DAkkS
Deutsche
Akkreditierungsstelle
D-PL-14119-07-00

Durch die DAkkS Deutsche Akkreditierungsstelle GmbH
nach DIN EN ISO/IEC 17025 akkreditiertes Prüflaboratorium.
Die Akkreditierung gilt für die in der Urkunde aufgeführten Prüfverfahren.

Sound absorption coefficient ISO 354

Measurement of sound absorption in reverberation rooms

Client: Sigel GmbH
Bäumenheimer Str. 10, D-86690 Mertingen

Test specimen: Acoustic wall tiles Sound Balance

The acoustic wall panels Sound Balance were laid directly onto the floor of the reverberation room. The setup was enclosed by a 40 mm high frame of 19 mm thick MDF panels. The joints between the reverberation room floor and the enclosing frame were sealed with an adhesive tape.

The following wall panels sizes were distributed in the test area of the dimensions length x width = 3.6 m x 2.8 m (without frame):
31 pieces: 400 mm x 800 mm x 40 mm
1 piece: 400 mm x 400 mm x 40 mm

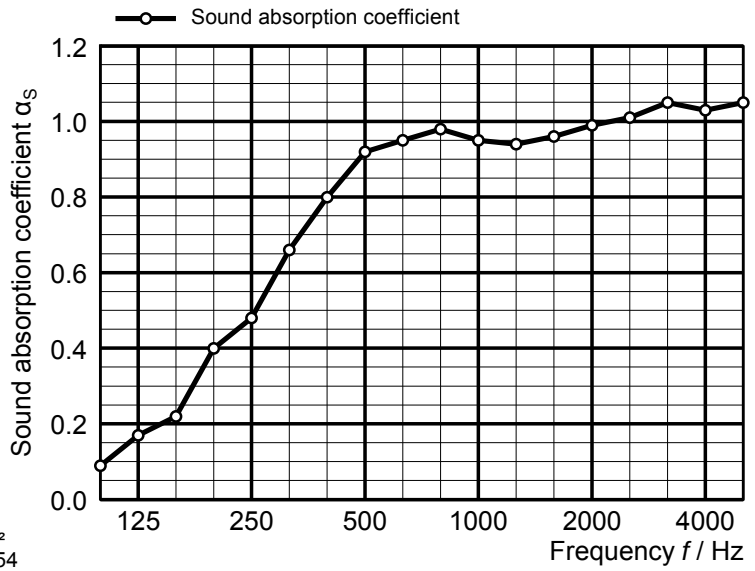
The wall panels had the following structure (beginning from the front face):
- 1 mm tissue, mass per unit area 227 g/m², specific airflow resistance 166 Pa s/m
- 39 mm three-layer PET-sandwich, mass per unit area 6327 g/m², gross density 162 kg/m³, specific airflow resistance 1240 Pa s/m; consisting of:
  - 15 mm PET, punctually connected with hot glue with
  - 9 mm PET, punctually connected with hot glue with
  - 15 mm PET
- 1 mm tissue, mass per unit area 227 g/m², specific airflow resistance 166 Pa s/m
- 1 mm spacer to simulate the adhesive tape
- floor of reverberation room

The wall panels consisted of a circumferential, 50 mm wide aluminium profile with a PET-sandwich clamped in-between. On the visible face of the aluminium profile, 9 mm thick panels of PET were incorporated. The aluminium profile was hollow, closed on all sides and narrowing to a thickness of 15 mm at the rim.

Room: reverberation room
Volume: 199.60 m³
Size: 10.08 m²
Date of test: 2018-09-05

	θ [°C]	*r. h.* [%]	*B* [kPa]
without specimen	22.1	57.1	95.4
with specimen	22.3	60.6	95.3

Frequency [Hz]	α_S 1/3 octave	α_p octave
100	○ 0.09	
125	0.17	0.15
160	0.22	
200	0.40	
250	0.48	0.50
315	0.66	
400	0.80	
500	0.92	0.90
630	0.95	
800	0.98	
1000	0.95	0.95
1250	0.94	
1600	0.96	
2000	0.99	1.00
2500	1.01	
3150	1.05	
4000	1.03	1.00
5000	1.05	



○ Equivalent sound absorption area less than 1.0 m²
α_S Sound absorption coefficient according to ISO 354
α_p Practical sound absorption coefficient according to ISO 11654

Rating according to ISO 11654:	Rating according to ASTM C423:
Weighted sound absorption coefficient α_w = 0.80 (*H*)	**Noise Reduction Coefficient *NRC* = 0.85**
Sound absorption class: B	**Sound Absorption Average *SAA* = 0.84**

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Planegg, 2018-11-29
No. of test report M136562/2

Acoustic wall tiles Sound Balance of the company Sigel

Figure B.1. Set-up of the wall panels in the reverberation room.

Figure B.2. Wall panels butt-jointed.

Acoustic wall tiles Sound Balance of the company Sigel

Figure B.3. Circumferential enclosing frame with sealing between frame and floor of the reverberation room.

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 calculation of the power attenuation coefficients was effected according to ISO 9613-1 [4]. 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 m^3 and a surface of S = 216 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.

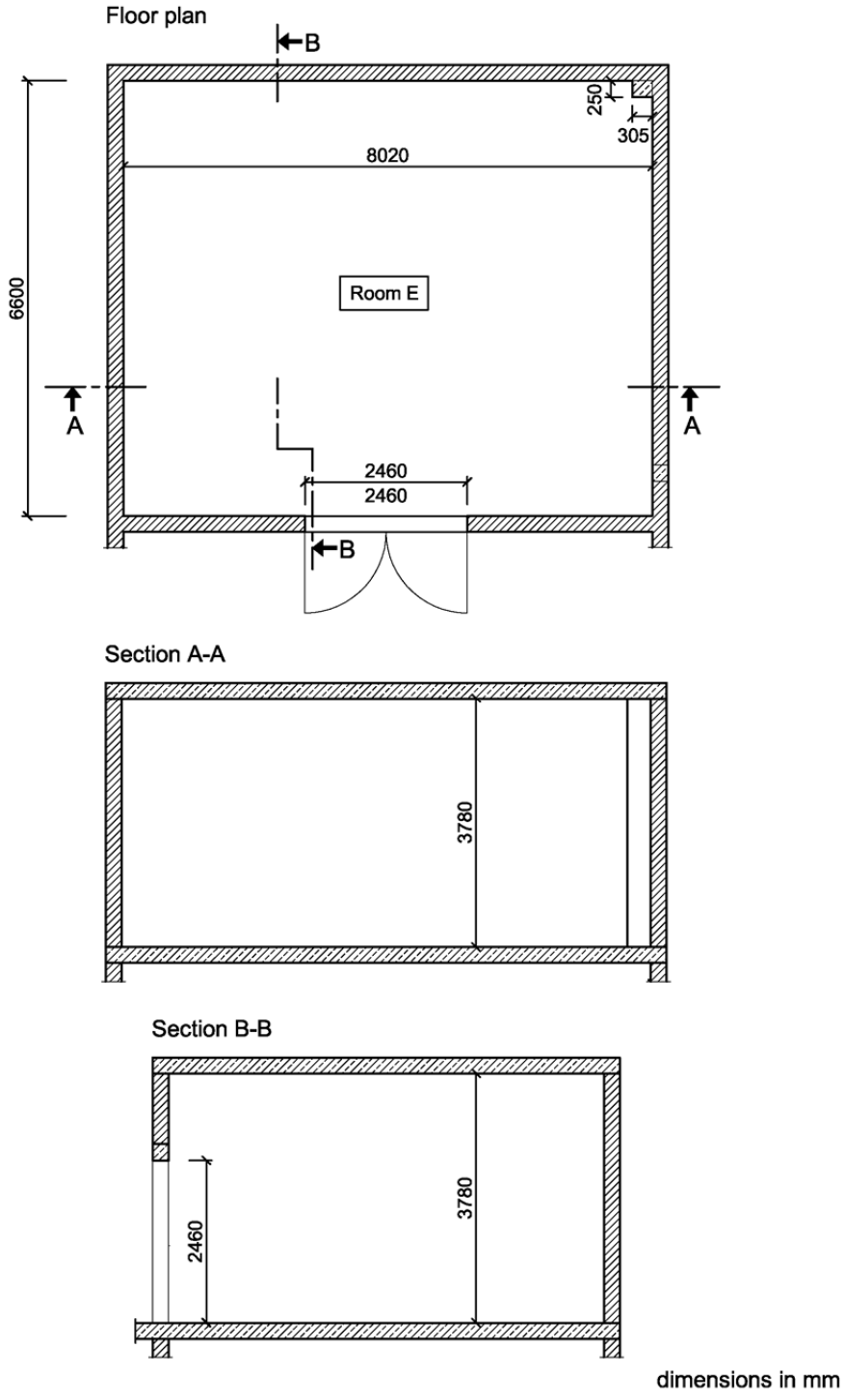

Figure C.1. Plan view and sections of the reverberation room.

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 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.

Frequency *f* / Hz	**Nachhallzeit *T* / s**	
	T_1 (without test object)	**T_2 (with test object)**
100	5.01	4.39
125	5.71	4.40
160	5.50	3.96
200	5.09	3.12
250	5.13	2.89
315	4.88	2.43
400	5.25	2.27
500	5.32	2.09
630	5.18	2.03
800	4.84	1.94
1000	5.13	2.02
1250	5.24	2.05
1600	5.20	2.02
2000	4.87	1.94
2500	4.23	1.80
3150	3.57	1.65
4000	2.88	1.50
5000	2.41	1.36

List of test equipment

The test equipment used is listed in Table C.2.

Table C.2. Test equipment.

Name	Manufacturer	Type	Serial-No.
AD-/DA-converter	RME	Fireface 802	23811470
Amplifier	APart	Champ 2	09050048
Dodecahedron	Müller-BBM	DOD360A	372828
Dodecahedron	Müller-BBM	DOD360A	372829
Dodecahedron	Müller-BBM	DOD360A	372830
Dodecahedron	Müller-BBM	DOD360A	372831
Microphone	Microtech	M370	1355
Microphone	Microtech	M370	1356
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 1.11