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2018-11-29
M136562/05 SRD/STEG

Acoustic screen Sound Balance of the company Sigel

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

Test Report No. M136562/05

Client:	Sigel GmbH Bäumenheimer Str. 10 86690 Mertingen GERMANY
Consultant:	Dipl.-Phys. Elmar Schröder
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1 Task

On behalf of the company Sigel GmbH the sound absorption of the acoustic screen 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 room dividing partition acoustic screen Sound Balance had the following dimensions and sufaces:

- height: 1500 mm
- width: 1000 mm
- thickness: 60 mm over a width of 600 mm, narrowing on either side to 30 mm over a width of 200 mm
- face area one-sided = 1.50 m²
- test surface per room dividing partition = 3.00 m²
  = 2 x *B* x *H* according to ASTM C 423-17 [3]

The room dividing partition had the following standard structure:

- 1 mm — tissue, mass per unit area 227 g/m², specific airflow resistance 166 Pa s/m
- 15 mm — PET, gross density 160 kg/m³, glued with
- 9 mm — PET, gross density 130 kg/m³
- 20 mm — polyester nonwoven, 25 mm nominal thickness compressed to 20 mm, at nominal thickness: gross density 18 kg/m³ specific airflow resistance 67 Pa s/m
- 1 mm — tissue, mass per unit area 227 g/m², specific airflow resistance 166 Pa s/m

3.2 Test assembly

The test set-up was carried out according to EN ISO 354, Section 6.2.2. For testing the sound absorption of the room dividers, no specific directives are given in the EN ISO 354 [1].

The room dividers were placed in the middle of the reverberation room and installed, as used in practice, vertically standing on wooden feet on the floor of the reverberation room. The distance between divider and reverberation room floor was 30 mm. In total, two room dividing partitions were distributed irregularly in the reverberation room and tested at three different positions.

The installation of the test objects was carried out by employees of the test laboratory at the reverberation room of Müller-BBM. The photographs in Appendix C 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 D.

5 Evaluation

The equivalent absorption area per room divider A_{obj} was determined in third octave bands between 100 Hz and 5000 Hz according to EN ISO 354.

According to EN ISO 354 [1], the equivalent sound absorption area must be indicated per test object. The indication of a sound absorption coefficient does not correspond to the standard, because the standard does not give any definition of the test area to be used for partitions, as this would be necessary for a comparable test of products.

The sound absorption coefficient is indicated in the present report for the purpose of being applied in prediction models. For the determination of the sound absorption coefficient, both face areas of the room dividing partition of 3.00 m² were used in terms of test area. This approach complies with the directives of the ASTM C 423-17.

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

6.1 Equivalent absorption area per room divider

The equivalent absorption areas per room divider A_{obj} are indicated in Appendix A.

6.2 Sound absorption coefficient of the room divider

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 B.

7 Remarks

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

Elmar Schröder

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Equivalent sound absorption area ISO 354

Measurement of sound absorption in reverberation rooms

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

Test specimen: Acoustic screen Sound Balance

Two acoustic screens Sound Balance were tested at three positions each as individual objects free-standing in the reverberation room.

Each room dividing partition had the following dimensions:
height: 1500 mm
width: 1000 mm
tickness: 60 mm over a width of 600 mm,
narrowing on either side to 30 mm over a width of 200 mm

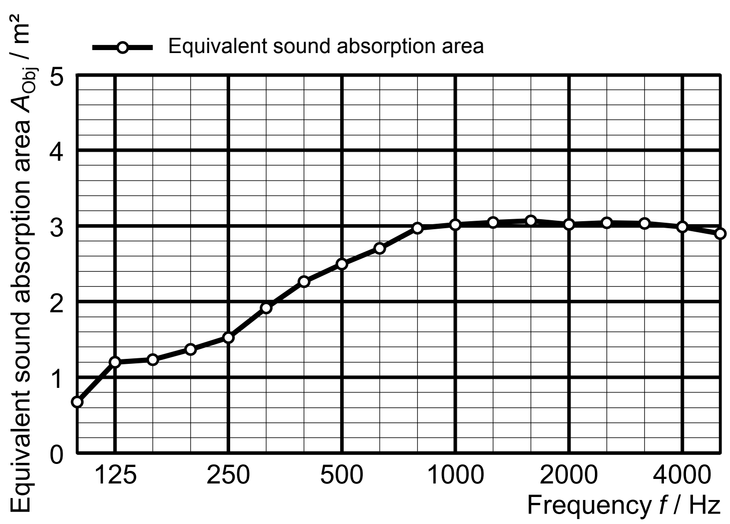
The room dividing partition had the following standard structure:
- 1 mm tissue, mass per unit area 227 g/m², specific airflow resistance 166 Pa s/m
- 15 mm PET, gross density 160 kg/m³
- 9 mm PET, gross density 130 kg/m³
- 20 mm polyester nonwoven, 25 mm nominal thickness compressed to 20 mm, at nominal thickness: gross density 18 kg/m³ and specific airflow resistance 67 Pa s/m
- 15 mm PET, gross density 160 kg/m³
- 1 mm tissue, mass per unit area 227 g/m², specific airflow resistance 166 Pa s/m

Visible face area per room dividing partition = 2 x 1.50 m²
Test surface = 2 objects x 3.00 m² = 6.00 m²

Room: reverberation room
Volume: 199.60 m³
Date of test: 2018-09-19
Sound absorption area per object
Number of objects: 2

Frequency [Hz]	A_{Obj} 1/3 octave [m²]
100	0.7
125	1.2
160	1.2
200	1.4
250	1.5
315	1.9
400	2.3
500	2.5
630	2.7
800	3.0
1000	3.0
1250	3.0
1600	3.1
2000	3.0
2500	3.0
3150	3.0
4000	3.0
5000	2.9

	θ [°C]	*r. h.* [%]	*B* [kPa]
without specimen	23.7	58.1	95.8
with specimen	23.7	58.2	95.8



Sound absorption coefficient ISO 354

Measurement of sound absorption in reverberation rooms

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

Test specimen: Acoustic screen Sound Balance

Two acoustic screens Sound Balance were tested at three positions each as individual objects free-standing in the reverberation room.

Each room dividing partition had the following dimensions:
height: 1500 mm
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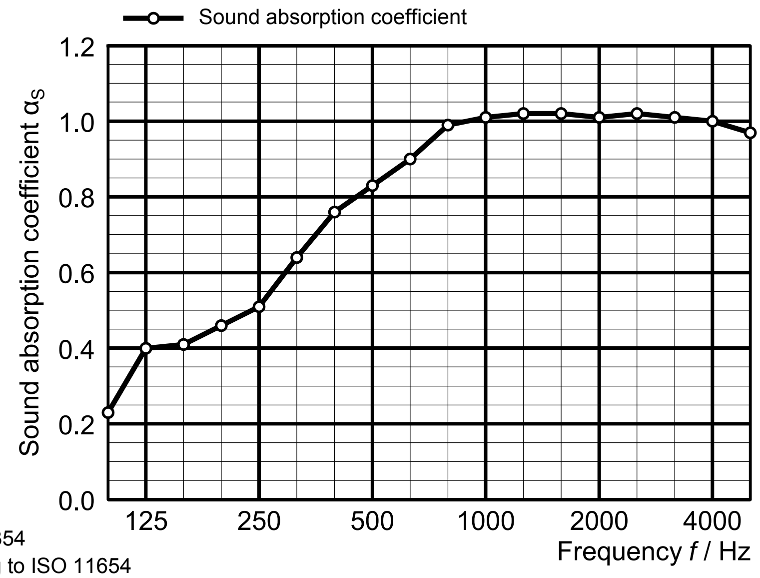
- 15 mm PET, gross density 160 kg/m³
- 1 mm tissue, mass per unit area 227 g/m², specific airflow resistance 166 Pa s/m

Visible face area per room dividing partition = 2 x 1.50 m²
Test surface = 2 objects x 3.00 m² = 6.00 m²

Room: reverberation room
Volume: 199.60 m³
Size: 6.00 m²
Date of test: 2018-09-19

	θ [°C]	*r. h.* [%]	*B* [kPa]
without specimen	23.7	58.1	95.8
with specimen	23.7	58.2	95.8

Frequency [Hz]	α_S 1/3 octave	α_p octave
100	0.23	
125	0.40	0.35
160	0.41	
200	0.46	
250	0.51	0.55
315	0.64	
400	0.76	
500	0.83	0.85
630	0.90	
800	0.99	
1000	1.01	1.00
1250	1.02	
1600	1.02	
2000	1.01	1.00
2500	1.02	
3150	1.01	
4000	1.00	1.00
5000	0.97	



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 = 0.85 (*H*)	**Noise Reduction Coefficient *NRC* = 0.85**
Sound absorption class: B	**Sound Absorption Average *SAA* = 0.85**

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Appendix B
Page 1

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Acoustic screen Sound Balance of the company Sigel

Figure C.1. Set-up of the room dividing partitions in the reverberation room.

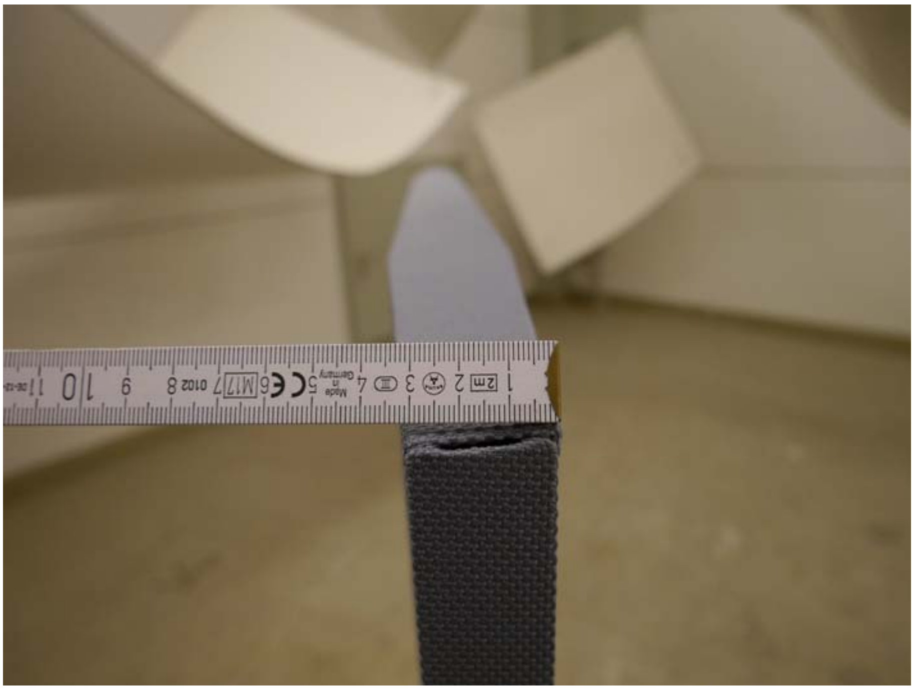

Figure C.2. Execution of the lateral edges.

Acoustic screen Sound Balance of the company Sigel

Figure C.3. Set-up on the floor of the reverberation room.

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

1 Measurands

1.1 Sound absorption coefficient

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].

1.2 Equivalent sound absorption area

The equivalent sound absorption area A_{obj} of the test object was determined. Therefore the mean value of the reverberation time in the reverberation room with and without the test object was measured. The calculation of the sound absorption coefficient was effected using the following equation:

$$A_{\text{Obj}} = \frac{A_T}{n}$$

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

With:

A_{Obj} equivalent sound absorption area of one test object in m^2;

A_T equivalent sound absorption area of n single test objects in m^2;

n number of equal test objects arranged for test

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 D.1 shows the drawings of the reverberation room.

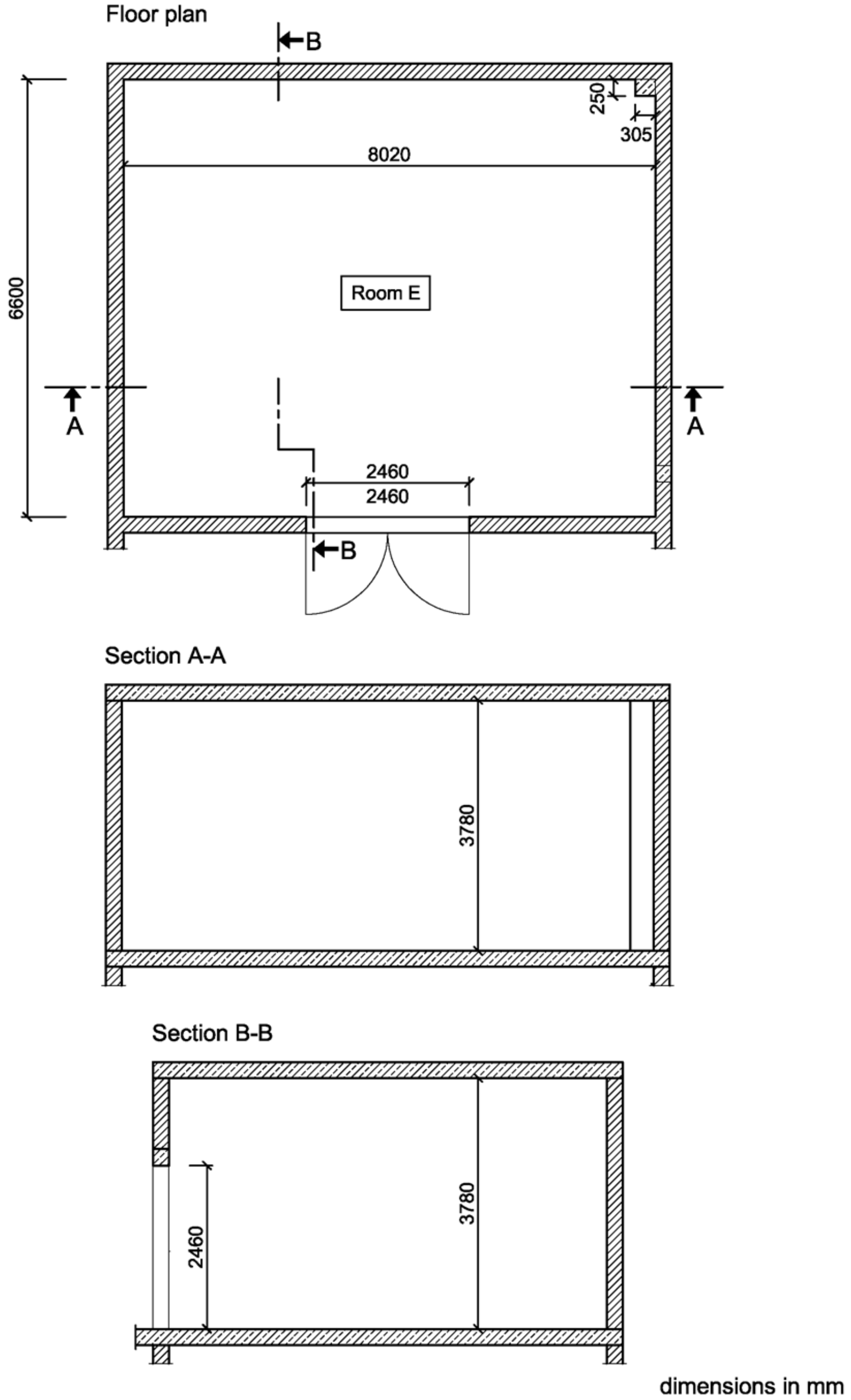

Figure D.1. Plan view and sections of the reverberation room.

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 D.1.

Table D.1. Reverberation times.

Frequency f / Hz	**Nachhallzeit T / s**	
	T_1 (without test object)	**T_2 (with test object)**
100	5.01	4.14
125	5.56	3.92
160	5.44	3.83
200	5.17	3.58
250	5.05	3.41
315	4.91	3.09
400	5.18	2.99
500	5.27	2.89
630	5.08	2.73
800	4.80	2.54
1000	4.96	2.56
1250	5.14	2.60
1600	5.20	2.60
2000	4.88	2.54
2500	4.28	2.36
3150	3.60	2.14
4000	2.91	1.88
5000	2.47	1.70

List of test equipment

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

Table D.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