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M136562/07 SRD/STEG

Acoustic column Sound Balance of the company Sigel

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

Test Report No. M136562/07

Client:	Sigel GmbH Bäumenheimer Str. 10 86690 Mertingen GERMANY
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test facility and test equipment

1 Task

On behalf of the company Sigel GmbH the sound absorption of the acoustic column 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 horizontal cross section of the acoustic element had the geometry of an octagon. The eight lateral lengths of the octagon were 300 mm and 105 mm in alternation. The height was 1800 mm. The wall surfaces consisted of 15 mm thick PET-panels (gross density 160 kg/m²). The topside of the column was finished with a metal sheet. The entire column was covered by a tissue (mass per unit area 227 g/m², specific airflow resistance 166 Pa s/m). The cavity contained a filling of 50 mm thick polyester fibre (gross density 15 kg/m³).

3.2 Test assembly

The test set-up was carried out according to EN ISO 354, Section 6.2.2.

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

The test object was tested as an individual object in the reverberation room free-standing on the floor of the reverberation room. The measurements were performed at five positions for spatial averaging.

The visible overall face area of the walls (without floor and ceiling) was 2.92 m².

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

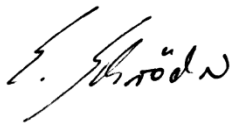
The equivalent sound absorption area of the test object A_{obj} was determined in one-third octave bands between 100 Hz and 5000 Hz according to EN ISO 354.

6 Measurement results

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

7 Remarks

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



Elmar Schröder

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

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 column Sound Balance

The acoustic column Sound Balance was tested as an individual object in the reverberation room free-standing on the floor of the reverberation room. The measurements were performed at five positions for spatial averaging.

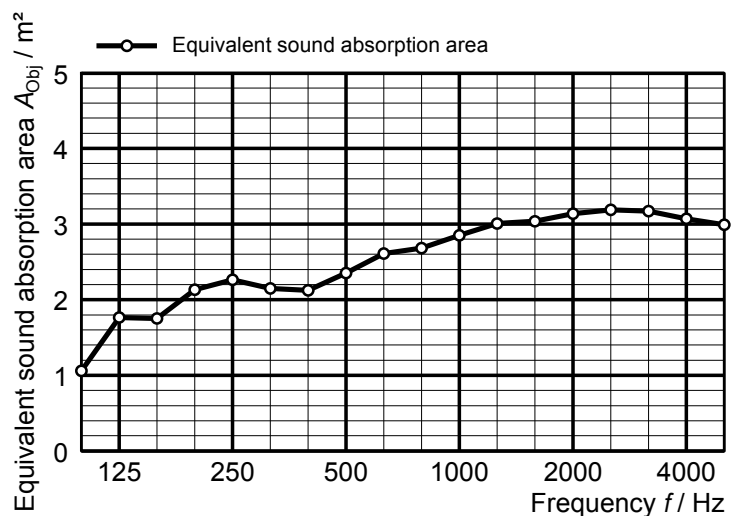
The horizontal cross section of the acoustic element had the geometry of an octagon. The eight lateral lengths of the octagon were 300 mm and 105 mm in alternation. The height was 1800 mm. The wall surfaces consisted of 15 mm thick PET-panels (gross density 160 kg/m²). The topside of the column was finished with a metal sheet. The entire column was covered by a tissue (mass per unit area 227 g/m², specific airflow resistance 166 Pa s/m). The cavity contained a filling of 50 mm thick polyester fibre (gross density 15 kg/m³).

The visible overall face area of the walls (without floor and ceiling) was 2.92 m².

Room: reverberation room
Volume: 199.60 m³
Date of test: 2018-08-09

Frequency [Hz]	A_{Obj} 1/3 octave [m ²]
100	1.1
125	1.8
160	1.8
200	2.1
250	2.3
315	2.2
400	2.1
500	2.4
630	2.6
800	2.7
1000	2.9
1250	3.0
1600	3.0
2000	3.1
2500	3.2
3150	3.2
4000	3.1
5000	3.0

	θ [°C]	$r. h.$ [%]	B [kPa]
without specimen	25.9	53.3	95.2
with specimen	25.9	53.3	95.2



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Appendix A

Page 1

Acoustic column Sound Balance of the company Sigel



Figure B.1. Set-up of the column in the reverberation room (one out of five positions in total).



Figure B.2. Top cover of the column.

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Acoustic column Sound Balance of the company Sigel

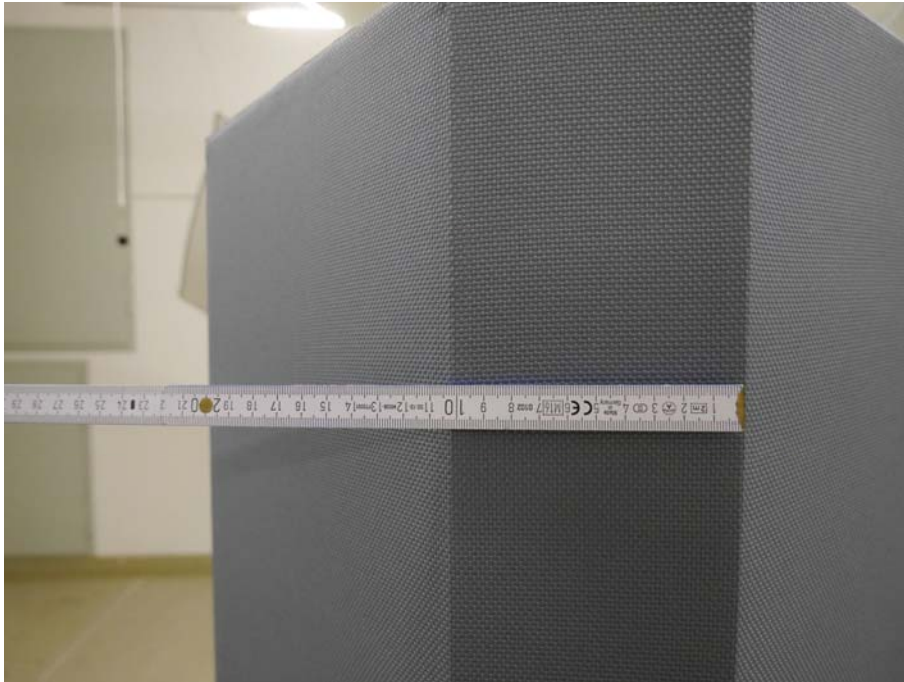


Figure B.3. Lateral face of the column.

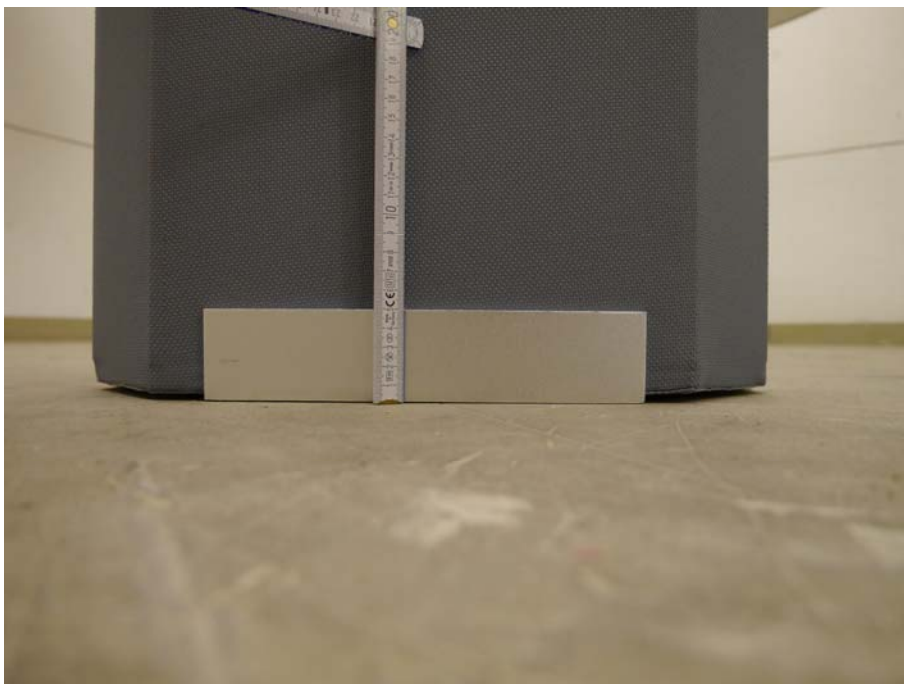


Figure B.4. Bottom closure of the column.

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

1 Measurand 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 $V = 199.6 \text{ m}^3$ 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.

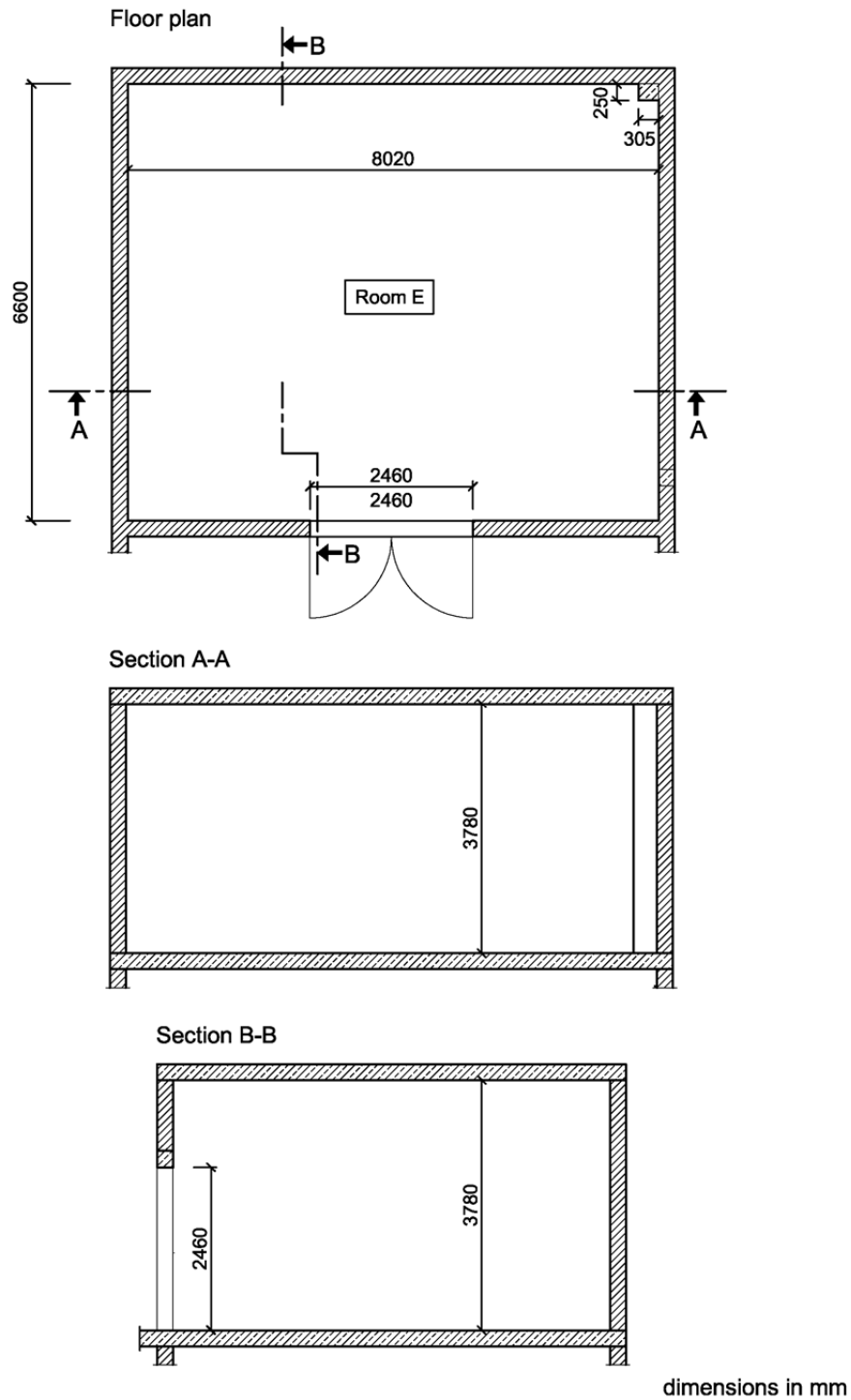


Figure C.1. Plan view and sections of the reverberation room.

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	5.04	4.32
125	5.69	4.32
160	5.39	4.16
200	5.12	3.81
250	5.06	3.72
315	4.91	3.69
400	5.24	3.88
500	5.20	3.75
630	5.06	3.57
800	4.77	3.40
1000	4.96	3.44
1250	5.12	3.45
1600	5.09	3.42
2000	4.75	3.23
2500	4.15	2.93
3150	3.52	2.60
4000	2.86	2.24
5000	2.44	1.98

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