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B129717/03 Version 1 RFD/LBN

Fabric “Avalon 2194” Manufacturer SAHCO GmbH

**Measurement of sound absorption
according to DIN EN ISO 354**

Test Report No. B129717/03

Client:	SAHCO GmbH Kreuzburger Straße 17 – 19 90471 Nürnberg Germany
Consultant:	Dipl.-Ing. (FH) Dominik Reif
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1 Task

On behalf of the company SAHCO GmbH, D-90471 Nürnberg, the sound absorption of the fabric "Avalon 2194" had to be measured according to DIN EN ISO 354 [1] in the reverberation room. The fabric was tested as a curtain in a flat and folded arrangement with a distance of 100 mm to the reflective wall.

2 Basis

This test report is based on the following documents:

- [1] DIN EN ISO 354: Acoustics – Measurement of sound absorption in a reverberation room (ISO 354:2003); German version EN ISO 354:2003. 2003-12
- [2] DIN EN ISO 11654: Acoustics – Sound absorbers for use in buildings – Rating of sound absorption (ISO 11654:1997); German version EN ISO 11654:1997. 1997-07
- [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
- [6] DIN EN ISO 12999-2: Acoustics – Determination and application of measurement uncertainties in building acoustics – Part 2: Sound absorption (ISO 12999-2:2020); German version EN ISO 12999-2:2020. 2020-11

3 Test object and test assembly

3.1 Test object

The tested material is described by the manufacturer as follows:

- Manufacturer SAHCO
- Type "Avalon 2194"
- Material 100 % PLF (Trevira CS)

The following parameters were determined by the testing laboratory based on a DIN A4 sample from the test material:

- Thickness: $d = 1.1 \text{ mm}$
- Specific air flow resistance according to DIN EN 29053 [5]: $R_s = 7299 \text{ Pa} \cdot \text{s/m}$
- Area specific mass: $m'' = 460 \text{ g/m}^2$

3.2 Test assembly

The installation of the test objects in the reverberation room was carried out by employees of the testing laboratory. The test objects were installed in a flat (G-100) and folded arrangement.

Both test assemblies were mounted as follows:

- Distance to the wall 100 mm (= distance between metal rail and wall)
- Fixed directly underneath the ceiling of the reverberation room, suspended from a metal rail (height 50 mm)
- Measurement without enclosing frame
- Fabric arranged with front side according to manufacturer's mark towards the reverberation room

The mounting details for the tested arrangements are as follows:

a) Flat arrangement

- Mounting type G-100 according to DIN EN ISO 354 [1], section 6.2.1, and appendix B of DIN EN ISO 354 [1]
- Test object made of three fabric panels, two panels width x height = 1.40 m x 3.06 m and one panel width x height = 0.76 m x 3.06 m overlap at the joint approx. 20 mm
- Total dimensions of the test surface (starting at the lower border of the steel angle) width x height = 3.52 m x 3.01 m = 10.60 m²

b) Folded arrangement

- 100 % fabric addition
- Test object made of five fabric panels,
each panel width x height = 1.40 m x 3.06,
overlap at the joint approx. 20 mm
- Total dimensions of the test surface
(starting at the lower border of the steel angle)
width x height = 3.55 m x 3.01 m = 10.69 m²

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

4 Test method

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

The test procedure, the test stand 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 DIN EN ISO 354 [1].

In addition, the following characteristic values were determined according to DIN 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 [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 200 Hz and 2500 Hz; mean value rounded to 0.01.

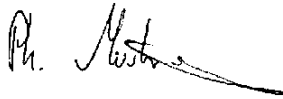
6 Measurement results

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.

Information on the measurement uncertainties is given in Appendix C. Measurement uncertainties were not considered for attribution of the classes of sound absorption according to DIN EN ISO 11654 [2].

7 Remarks

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



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Deutsche
Akkreditierungsstelle
D-PL-14119-07-00

Testing laboratory accredited by DAkkS according to DIN EN ISO/IEC 17025:2018.

The accreditation is valid only for the scope listed in the annex of the accreditation certificate.

Sound absorption coefficient ISO 354

Measurement of sound absorption in reverberation rooms

Client: SAHCO GmbH, Kreuzburger Str. 17-19, D-90471 Nürnberg
Test specimen: Fabric "Avalon 2194", SAHCO
Mounting type G-100, flat arrangement

Material details

- manufacturer SAHCO
- fabric type Avalon 2194
- material 100 % Trevira CS
- area specific mass $m'' = 460 \text{ g/m}^2$
- airflow resistance $R_s = 7299 \text{ Pa s/m}$
- thickness $t = 1.1 \text{ mm}$

Test arrangement

- test set-up made of 3 curtains: 2 curtains 1.40 m x 3.06 m, 1 curtain 0.76 m x 3.06 m
- mounting type G-100 acc. to ISO 354, flat hanging and 20 mm overlap at curtain splices
- hanging on a metal rail (0.05 m) at the ceiling of the reverberation room in front of a reflective wall, 100 mm clear distance to the wall, arranged without enclosing frame
- total dimensions of the test surface: width x height = 3.52 m x 3.01 m (starting at the lower edge of the metal rail)

Room: E

Volume: 199.60 m³

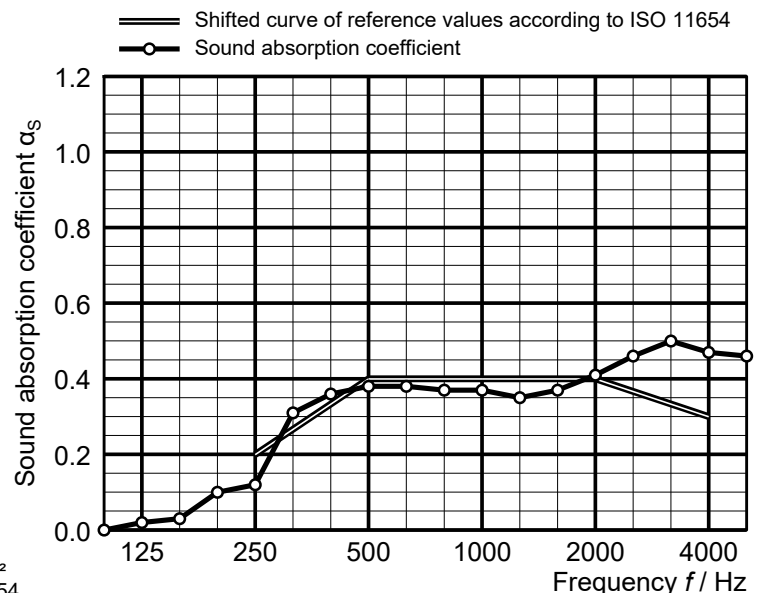
Size: 10.60 m²

Date of test: 2016-05-24

Frequency [Hz]	α_s 1/3 octave	α_p octave
100	0.00	
125	0.02	0.00
160	0.03	
200	0.10	
250	0.12	0.20
315	0.31	
400	0.36	
500	0.38	0.35
630	0.38	
800	0.37	
1000	0.37	0.35
1250	0.35	
1600	0.37	
2000	0.41	0.40
2500	0.46	
3150	0.50	
4000	0.47	0.50
5000	0.46	

◦ 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

	θ [°C]	$r. h.$ [%]	B [kPa]
without specimen	21.7	43.2	94.9
with specimen	21.9	45.9	94.9



Rating according to ISO 11654:
Weighted sound absorption coefficient
 $\alpha_w = 0.40$
Sound absorption class: D

Rating according to ASTM C423:
Noise Reduction Coefficient $NRC = 0.30$
Sound Absorption Average $SAA = 0.33$

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Appendix A
Page 1

Sound absorption coefficient ISO 354

Measurement of sound absorption in reverberation rooms

Client: SAHCO GmbH, Kreuzburger Str. 17-19, D-90471 Nürnberg
Test specimen: Fabric "Avalon 2194", SAHCO
Folded arrangement (100 % fabric addition), 100 mm distance to reflective wall

Material details

- manufacturer SAHCO
- fabric type Avalon 2194
- material 100 % Trevira CS
- area specific mass $m'' = 460 \text{ g/m}^2$
- airflow resistance $R_s = 7299 \text{ Pa s/m}$
- thickness $t = 1.1 \text{ mm}$

Test arrangement

- test set-up made of 5 curtains (each curtain: width x height = 1.40 m x 3.06 m)
- arranged folded with 100 % fabric addition and 20 mm overlap at curtain splices
- hanging on a metal rail (0.05 m) at the ceiling of the reverberation room in front of a reflective wall, 100 mm clear distance to the wall, arranged without enclosing frame
- total dimensions of the test surface: width x height = 3.55 m x 3.01 m (starting at the lower edge of the metal rail)

Room: E

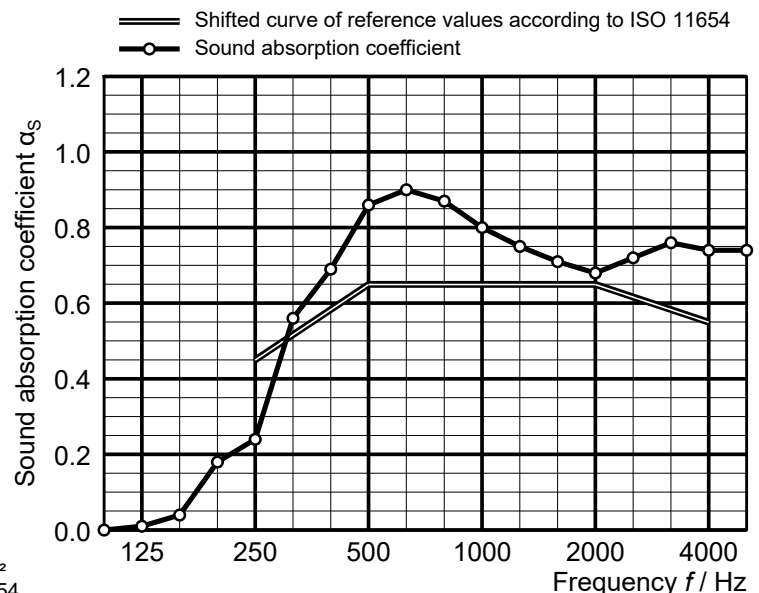
Volume: 199.60 m³

Size: 10.69 m²

Date of test: 2016-05-24

Frequency [Hz]	α_s 1/3 octave	α_p octave
100	0.00	
125	0.01	0.00
160	0.04	
200	0.18	
250	0.24	0.35
315	0.56	
400	0.69	
500	0.86	0.80
630	0.90	
800	0.87	
1000	0.80	0.80
1250	0.75	
1600	0.71	
2000	0.68	0.70
2500	0.72	
3150	0.76	
4000	0.74	0.75
5000	0.74	

	θ [°C]	$r. h.$ [%]	B [kPa]
without specimen	21.7	43.2	94.9
with specimen	21.9	45.6	94.9



◦ 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:
Weighted sound absorption coefficient
 $\alpha_w = 0.65$
Sound absorption class: C

Rating according to ASTM C423:
Noise Reduction Coefficient $NRC = 0.65$
Sound Absorption Average $SAA = 0.66$

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Appendix A
Page 2

Fabric “Avalon 2194”

Figure B.1. Flat arrangement, test object mounted in the reverberation room.



Figure B.2. Folded arrangement, test object mounted in 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 m²
- S area covered by the test object in m²
- V volume of the reverberation room in m³
- 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 area covered by the test object was used as testing area.

The different dissipation during the sound propagation in the air was taken into account according to paragraph 8.1.2 of DIN EN ISO 354 [1]. The power attenuation coefficient was calculated 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 DIN EN ISO 354 [1] and DIN EN ISO 12999-2 [6]. In [6] for the single-number α_w , a standard deviation of reproducibility of $\sigma_R = 0.035$ is indicated. This value was determined from reproducibility data of the test method based on round robin tests and describes the reproducibility of test results that was determined in test laboratories for similar constructions. An aspired confidence level of 95 % results in a coverage factor of $k = 2.0$ and an expanded uncertainty of $U = \pm 0.07$ for the weighted sound absorption coefficient α_w .

2 Test procedure

2.1 Description of the reverberation room

The reverberation room complies with the requirements according to DIN 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 $1.2 \text{ m} \times 2.4 \text{ m}$ and six composite sheet metal boards dimensioned $1.2 \text{ m} \times 1.2 \text{ m}$ were suspended curved and irregularly.

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

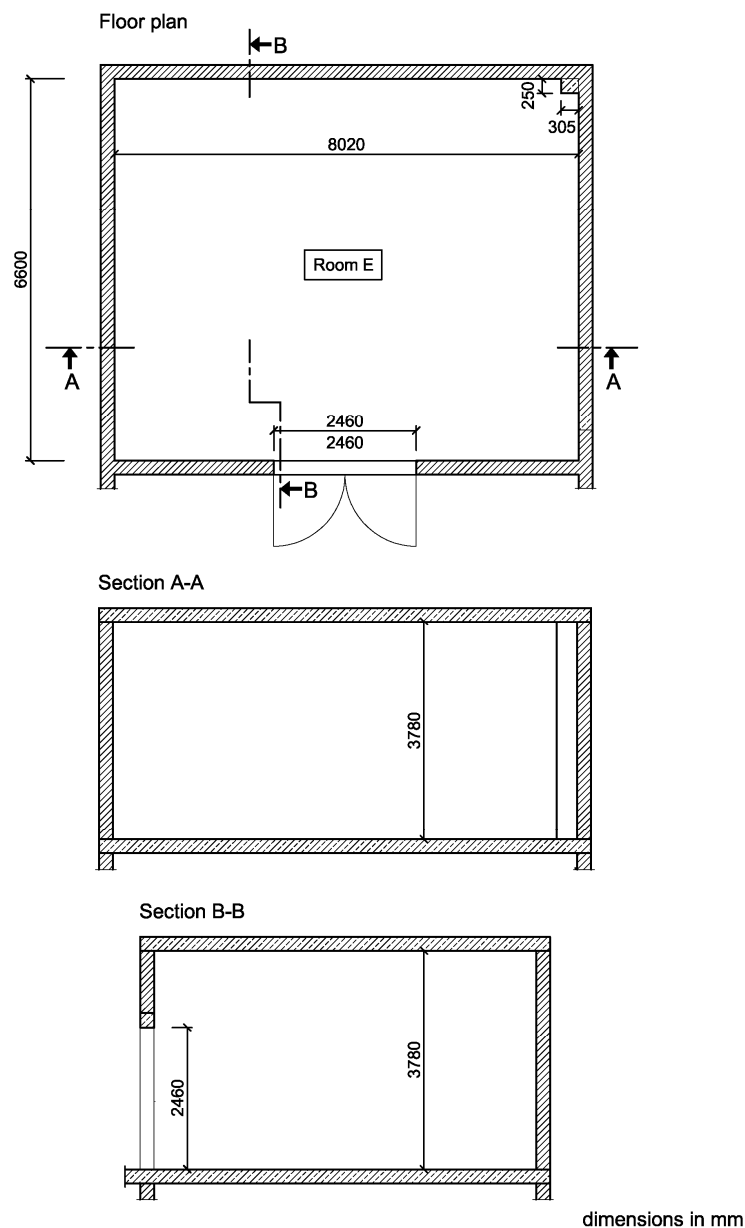


Figure C.1. Plan view and section of the reverberation room.

2.2 Measurement of reverberation time

The determination of the impulse responses was 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 DIN EN ISO 354 [1], using a linear regression for the calculation of the reverberation time T_{20} from the level of a backward integrated impulse response.

The determined reverberation times-are indicated in Table C1.

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

Frequency f / Hz	Reverberation time T / s		
	T_1 (without test object)	T_2 (with test object)	
		Appendix A, page 1 (flat)	Appendix A, page 2 (folded)
100	4.75	4.48	4.88
125	4.35	4.33	4.61
160	5.93	5.99	4.59
200	4.91	4.89	4.21
250	4.70	4.56	3.65
315	4.89	4.66	2.66
400	5.62	4.74	2.38
500	5.16	4.26	2.11
630	5.31	3.44	2.03
800	5.29	3.26	2.05
1000	5.29	3.18	2.19
1250	5.22	3.13	2.30
1600	5.06	3.11	2.38
2000	5.28	3.21	2.33
2500	5.45	3.34	2.11
3150	5.37	3.24	1.86
4000	4.90	2.96	1.62
5000	4.23	2.59	1.38

2.3 List of test equipment

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

Table C.2. List of test equipment.

Name	Manufacturer	Type	Serial No.
AD-/DA-converter	RME	Fireface 802	23811470
Amplifier	APart	Champ 2	17120171
Dodecahedron	Müller-BBM	DOD360A	372828
Dodecahedron	Müller-BBM	DOD360A	372829
Dodecahedron	Müller-BBM	DOD360A	372830
Dodecahedron	Müller-BBM	DOD360A	372831
Microphone	Microtech Gefell	M360	1783
Microphone	Microtech Gefell	M360	1785
Microphone	Microtech Gefell	M360	1786
Microphone	Microtech Gefell	M360	1787
Microphone	Microtech Gefell	M360	1788
Microphone	Microtech Gefell	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