MÜLLER-BBM

Müller-BBM GmbH
Robert-Koch-Str. 11
82152 Planegg bei München

Telephone +49(89)85602 0
Telefax +49(89)85602 111

www.MuellerBBM.de

M. Eng. Philipp Meistring
Telephone +49(89)85602 228
Philipp.Meistring@mbbm.com

2019-11-28
M76176/43 Version 1 MSG/MOL

Delius GmbH & Co KG, Curtain fabric Eos Delitherm

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

Report No. M76176/43

Client:	Delius GmbH & Co. KG Goldstraße 16 - 18 33602 Bielefeld Germany
Consultant:	M. Eng. Philipp Meistring Jan-Lieven Moll
Date of report:	2019-11-28
Delivery date of test objects:	2019-11-27
Date of test:	2019-11-27
Total number of pages:	In total 12 pages, thereof 6 pages text part, 1 page Appendix A, 1 page Appendix B and 4 pages Appendix C.

Table of contents

1	**Task**	**3**
2	**Basis**	**3**
3	**Test object and test assembly**	**4**
4	**Execution of the measurements**	**5**
5	**Evaluation**	**5**
6	**Measurement results**	**5**
7	**Remarks**	**6**

Appendix A: Test certificate

Appendix B: Figures

Appendix C: Description of test method, test facility and test equipment

1 Task

On behalf of the company Delius GmbH & Co. KG, 33602 Bielefeld, Germany, the sound absorption of the curtain fabric type Eos Delitherm (gathered with fabric addition of 100 %) was to be determined by measurements in the reverberation room according to DIN EN ISO 354 [1]. The fabric was arranged at a distance from the reflecting wall of 100 mm.

The results are to be evaluated according to DIN EN ISO 11654 [2] and ASTM C 423 [3].

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] E DIN EN ISO 12999-2 (draft): Acoustics - Determination and application of measurement uncertainties in building acoustics - Part 2: Sound absorption. August 2019. German and English version prEN ISO 12999-2:2019

[6] DIN EN ISO 9053-1: Acoustics –Determination of airflow resistance – Part 1: Static airflow method (ISO 9053-1:2018); German version EN ISO 9053-1:2018. March 2019

3 Test object and test assembly

3.1 Test object

The tested material is described by the client as follows:

- designation: Eos Delitherm, article no. 41777, colour 9000
- material: 100 % polyester FR

The following parameters were determined by the testing laboratory:

- thickness: t = 0.21 mm
- area specific mass: m'' = 122 g/m^2
- specific airflow resistance acc. to DIN EN ISO 9053-1 [6]: R_s = 3924 Pa · s/m

The determination of the airflow resistance was effected according to DIN EN ISO 9053-1 [6].

A factory-made ready-for-use, gathered curtain was delivered by the client:

- width: 3500 mm (addition 100 % - width of fabric 7000 mm)
- height: 2950 mm
- edging: 100 mm lower hem (with inserted lead tape 50 g/m), 20 mm lateral hem, at the top 50 mm universal curtain tape

3.2 Test assembly

The installation of the test object was carried out by employees of the test laboratory at the reverberation room of Müller-BBM. The mounting details for the tested arrangement are as follows:

- in style of mounting type G-100 according to DIN EN ISO 354 [1]
- arranged hanging folded, 100 % fabric addition
- fixed directly underneath the ceiling of the reverberation room, suspended from a metal rail (height 60 mm), distance to the back wall 100 mm
- test set-up without enclosing frame
- ready-for-use curtain, width 3500 mm (width of fabric 7000 mm, i. e. 100 % fabric addition), height 2950 mm
- total dimensions of the test surface (starting at the lower border of the metal rail): width x height = 3.50 m x 2.95 m = 10.33 m²

The test certificate in Appendix A and the photographs in Appendix B show further details of the test arrangement.

4 Execution of the measurements

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 423-17 [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

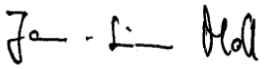
The sound absorption coefficients α_S in one-third octave bands, the practical sound absorption coefficients α_p in octave bands and the single values (α_w, *NRC* und *SAA*) are indicated in the test certificates in Appendix A.

Information on the uncertainty of measurement is given in Annex C. When assigning the absorption group, the measurement uncertainty was not taken into account in accordance with DIN EN ISO 11654 [2].

7 Remarks

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

M.Eng. Philipp Meistring
(Project manager)



Jan-Lieven Moll
(Responsible)

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: Delius GmbH & Co. KG, Goldstraße 16 - 18, 33602 Bielefeld, Germany

Test specimen: Curtain Fabric Eos Delitherm,
arranged hanging folded with 100 mm wall distance, 100 % fabric addition

Curtain fabric:

Information provided by the client

- designation Eos Delitherm, article no. 41777, colour 9000
- material 100 % Polyester FR

Information provided by testing laboratory

- area specific mass m'' = 122 g/m²
- airflow resistance R_S = 3924 Pa s/m
- thickness t = 0.21 mm

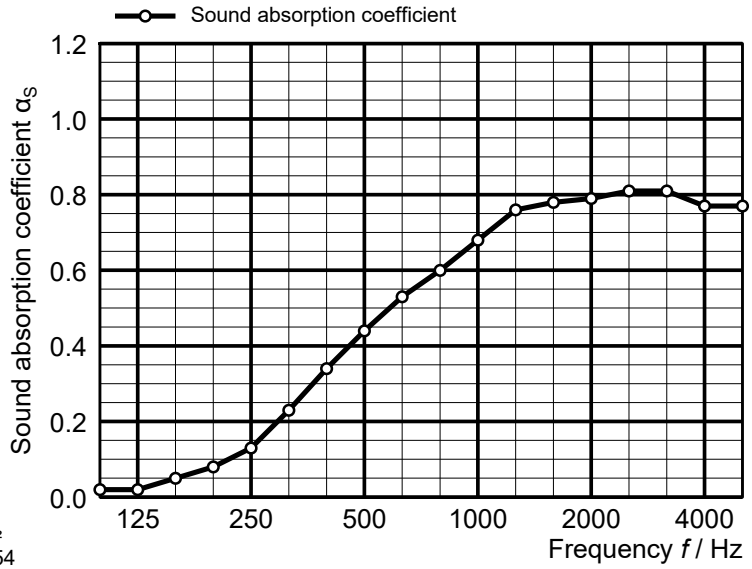
Test arrangement:

- hanging in front of a reflecting wall with 100 mm wall distance
- fixed on a metal rail (height 60 mm) at the ceiling of the reverberation room
- test arrangement without enclosing frame
- factory-made ready-for-use, gathered curtain 2950 mm x 3500 mm (100 % fabric addition; width of fabric 7000 mm), with 50 mm universal curtain tape, lateral hem 2 cm, lower hem 10 cm with, inserted lead tape
- test surface width x height = 3.50 m x 2.95 m (starting at the lower edge of the metal rail)

Room: E
Volume: 199.60 m³
Size: 10.33 m²
Date of test: 2019-11-27

	θ [°C]	*r. h.* [%]	*B* [kPa]
without specimen	18.9	42.9	93.5
with specimen	18.9	43.5	93.5

Frequency [Hz]	α_S 1/3 octave	α_p octave
100	∘ 0.02	
125	∘ 0.02	0.05
160	∘ 0.05	
200	∘ 0.08	
250	0.13	0.15
315	0.23	
400	0.34	
500	0.44	0.45
630	0.53	
800	0.60	
1000	0.68	0.70
1250	0.76	
1600	0.78	
2000	0.79	0.80
2500	0.81	
3150	0.81	
4000	0.77	0.80
5000	0.77	



∘ 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 = 0.45 (*MH*)	**Noise Reduction Coefficient *NRC* = 0.50**
Sound absorption class: D	**Sound Absorption Average *SAA* = 0.51**

MÜLLER-BBM

Planegg, 2019-11-28
No. of test report M76 176/43

Appendix A
Page 1

Curtain fabric Eos Delitherm by Delius GmbH & Co. KG

Figure B.1. Test object in the reverberation room: frontal view.

Figure B.2. Test object in the reverberation room: diagonal view.

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 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 E DIN EN ISO 12999-2 [5].

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 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.

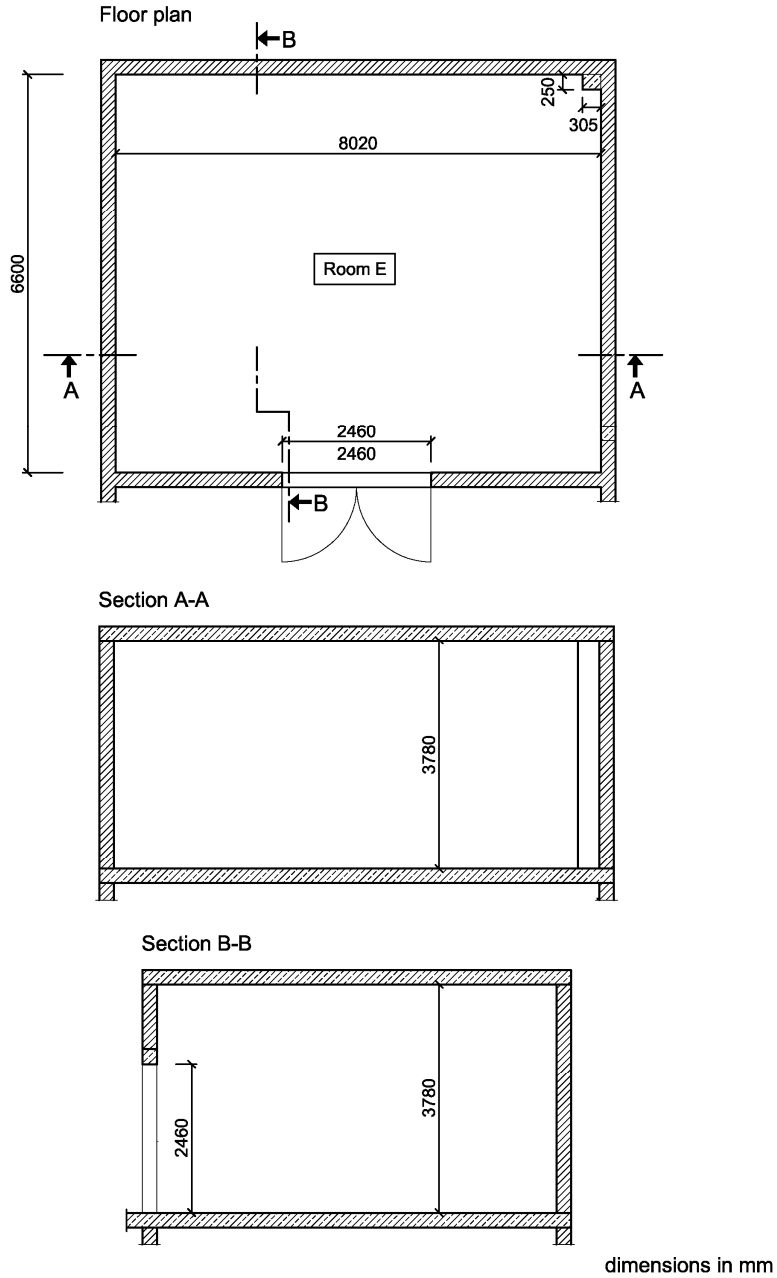


Figure C.1. Plan view and sections of the reverberation room.

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 DIN 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 are indicated in Table C.1.

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

Frequency *f* / Hz	**Reverberation time *T* / s**	
	T_1 (without test object)	**T_2 (with test object)**
100	5.26	5.08
125	5.21	5.06
160	5.52	5.11
200	5.28	4.68
250	5.29	4.34
315	5.18	3.75
400	5.48	3.41
500	5.47	3.09
630	5.37	2.82
800	4.96	2.54
1000	5.15	2.42
1250	5.23	2.29
1600	5.10	2.24
2000	4.79	2.16
2500	4.00	1.97
3150	3.19	1.75
4000	2.45	1.54
5000	1.92	1.31

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	09050048
Dodecahedron	Müller-BBM	DOD360A	372828
Dodecahedron	Müller-BBM	DOD360A	372829
Dodecahedron	Müller-BBM	DOD360A	372830
Dodecahedron	Müller-BBM	DOD360A	372831
Microphone	Microtech Gefell	M370	1355
Microphone	Microtech Gefell	M370	1356
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