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M76176/03 MSG/JRE

Curtain fabric DIMOUT gathered (fabric addition 100 %) Manufacturer Delius

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

Test Report No. M76176/03

Client:	Delius GmbH Goldstraße 16 – 18 33602 Bielefeld Germany
Consultant:	M. Eng. Philipp Meistring
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1 Task

On behalf of the company Delius GmbH, 33602 Bielefeld, Germany, the sound absorption of a curtain fabric (gathered with fabric addition of 100 %) type DIMOUT was to be determined by measurements in the reverberation room according to EN ISO 354 [1]. The fabric was arranged with a distance to the reflecting wall of 100 mm (mounting type G-100).

The results are to be evaluated according to EN ISO 11654 [2] and ASTM C 423-09a [4].

2 Basis

This test report is based on the following documents:

[1] EN ISO 354 "Acoustics – Measurement of the sound absorption in a reverberation room." 2003

[2] EN ISO 11654 "Acoustics – Sound absorbers for use in buildings – Rating of sound absorption." 1997

[3] ISO 9613-1 "Acoustics; Attenuation of sound during propagation outdoors; part 1: calculation of the absorption of sound by the atmosphere." 1993

[4] ASTM C 423-09a "Standard Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method. Revision: 09a." 2009

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

3 Test objects and measurement conditions

3.1 Measurements conditions

According to the client's specification the test assembly was effected according to EN ISO 354 [1], section 6.2.1 and Appendix B mounting type G-100.

Test objects were assembled in the reverberation room by employees of the testing laboratory.

3.2 Test objects

The tested material is described as follows:

- curtain fabric DIMOUT, article No. 38182, color No. 1558 (manufacturer's specification)
- material: 100 % polyester FR
- thickness t = 0.51 mm
- area specific mass m'' = 260 g/m^2 (manufacturer's specification)
- air flow resistance acc. to EN 29053: R_s = 1460 Pa · s/m

Thickness and air flow resistance were determined by the testing laboratory. The measurement of the air flow resistance was effected according to EN 29053 [5].

The construction in mounting type G-100 according to EN ISO 354 [1] consisted of one curtain with the dimensions width x height = 7000 mm x 3000 mm. Factory-provided the curtain had a bottom hem of 10 cm, lateral hems of each 2 cm and universal curtain tape at the top.

By means of magnets the gathered curtain (fabric addition of 100 %) was fixed on a metal rail (angle profile 50 mm x 50 mm) directly underneath the ceiling of the reverberation room.

There was no lateral enclosing frame. The test surface was dimensioned width x height = 3450 mm x 2950 mm (starting at the lower edge of the metal rail).

Further information on the test build-ups are presented in the test certificate in Appendix A and the figures in Appendix B.

4 Execution of the measurements

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

The test method, the test facility and the test equipment used 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 423-09a [4] 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 certificate in Appendix A.

7 Remarks

The test results exclusively refer to the conditions on the day of measurements.

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M. Eng. Philipp Meistring

MÜLLER-BBM
Accredited Test Laboratory
according to ISO/IEC 17025
Deutscher Akkreditierungs Rat
DAR
DGA-PL-2465.10

Sound absorption coefficient ISO 354

Measurement of sound absorption in reverberation rooms

Client: Delius GmbH, Goldstraße 16 - 18, 33602 Bielefeld, Germany

Test specimen: Curtain DIMOUT,
mounting type G-100, gathered (with fabric addition of 100 %)

Curtain fabric:

- manufacturer Delius
- curtain fabric type DIMOUT, article No. 38182, color No. 1558
- material 100 % polyester FR
- area specific mass m'' = 260 g/m² (manufacturer's specification)
- air flow resistance R_S = 1460 Pa s/m
- thickness t = 0.51 mm

Test arrangement:

- mounting type G-100 acc. EN ISO 354, without enclosing frame
- curtain W x H = 7000 mm x 3000 mm, 10 cm seamed
- mounted gathered with fabric addition of 100 %
- fixed on a metal rail (height 50 mm) at the ceiling of the reverberation room
- distance to the wall 100 mm
- dimensions of the test surface
  W x H = 3450 mm x 2950 mm (starting at the lower border of the metal rail)

Room: E
Volume: 199.60 m³
Size: 10.18 m²
Date of test: 2011-12-21

	θ [°C]	r. h. [%]	B [kPa]
without specimen	18.4	39.2	95.3
with specimen	18.2	37.4	95.3

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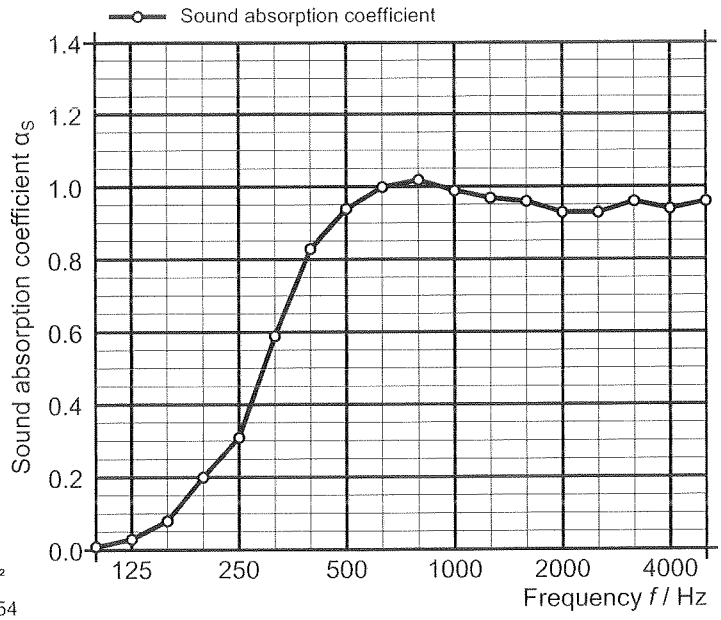
Frequency [Hz]	α_S 1/3 octave	α_p octave
100	∘ 0.01	
125	∘ 0.03	0.05
160	∘ 0.08	
200	0.20	
250	0.31	0.35
315	0.59	
400	0.83	
500	0.94	0.90
630	1.00	
800	1.02	
1000	0.99	1.00
1250	0.97	
1600	0.96	
2000	0.93	0.95
2500	0.93	
3150	0.96	
4000	0.94	0.95
5000	0.96	



∘ 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 **= 0.65 (*MH*)**	**Noise Reduction Coefficient *NRC* = 0,80**
Sound absorption class: C	**Sound Absorption Average *SAA* = 0,81**

Curtain fabric DIMOUT, gathered, Manufacturer Delius

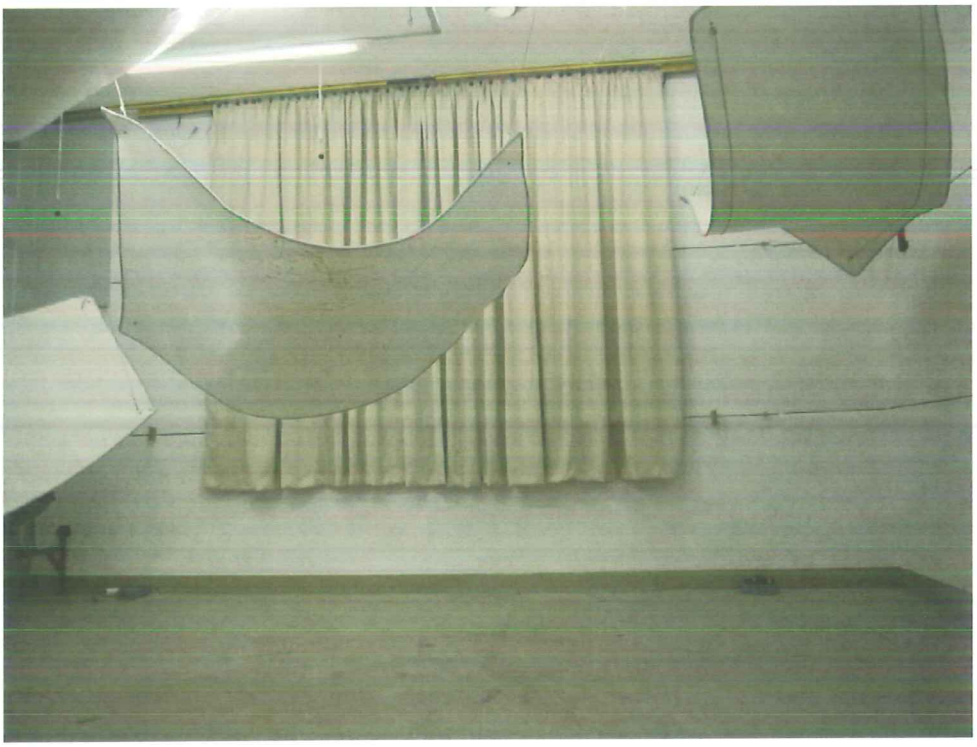


Figure B.1. Test arrangement in the reverberation room (total view)

Figure B.2. Test arrangement in the reverberation room (oblique 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}.

As area of the test object the area covered by the test object was used.

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 dissipation was calculated according to ISO 9613-1 [3]. 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 (1.2 m x 2.4 m) and six composite sheet metal boards (1.2 m x 1.2 m) were suspended curved and irregularly.

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

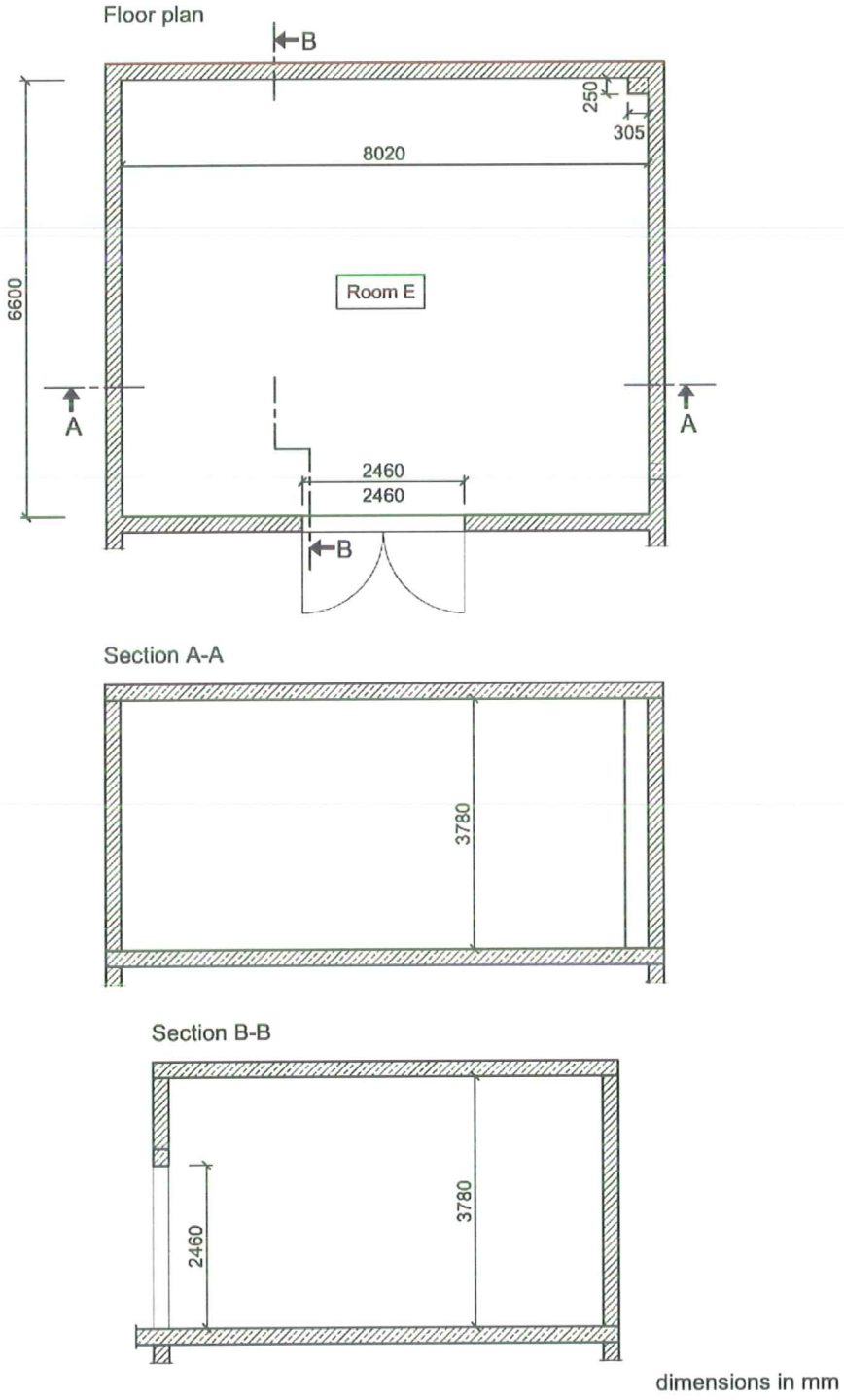


Figure C.1. Plan view and sections of the reverberation room

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 a 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 without and with test object

Frequency f / Hz	Reverberation time T / s	
	T_1 (without test object)	T_2 (with test object)
100	4.91	4.85
125	4.76	4.56
160	5.04	4.44
200	5.35	3.98
250	5.06	3.38
315	5.13	2.62
400	5.46	2.25
500	5.50	2.09
630	5.40	1.99
800	5.32	1.96
1000	5.44	2.02
1250	5.47	2.04
1600	5.16	2.00
2000	4.60	1.95
2500	3.89	1.80
3150	3.12	1.58
4000	2.36	1.36
5000	1.77	1.13

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.
Sound card	RME	Multiface II	22460388
Amplifier	APart	Champ One	09070394
Dodecahedron	Müller-BBM	DOD130B	265201
Dodecahedron	Müller-BBM	DOD130B	265202
Dodecahedron	Müller-BBM	DOD130B	265203
Dodecahedron	Müller-BBM	DOD130B	265204
Microphone	Microtech	M360	1783
Microphone	Microtech	M360	1785
Microphone	Microtech	M360	1786
Microphone	Microtech	M360	1787
Microphone	Microtech	M360	1788
Microphone	Microtech	M360	1789
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 1.6