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

Juri Schwezow
Telephone +49(89)85602 3175
Juri.Schwezow@mbbm.com

2018-05-03
M100827/152 SCW/STEG

Curtain Fabric Type Noir, Manufacturer Kvadrat A/S

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

Test Report No. M100827/152

Client:	Kvadrat A/S Lundbergsvej 10 8400 Ebeltoft Denmark
Consultant:	Juri Schwezow Jan-Lieven Moll M. Eng. Philipp Meistring
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Müller-BBM GmbH
HRB Munich 86143
VAT Reg. No. DE812167190

Managing directors:
Joachim Bittner, Walter Grotz,
Dr. Carl-Christian Hantschk, Dr. Alexander Ropertz,
Stefan Schierer, Elmar Schröder

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1 Task

On behalf of the company Kvadrat A/S, 8400 Ebeltoft, Denmark, the sound absorption of the curtain fabric Noir had to be measured according to EN ISO 354 [1] in the reverberation room. The fabric was tested in a flat and a folded arrangement with a distance of 100 mm to the reflective wall.

The results are to be evaluated according to EN ISO 11654 [2] and ASTM C 423-17 [4].

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

[4] ASTM C 423-17: Standard Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method. Revision: 17. 2017-02

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

[6] Müller-BBM test report No. M100827/151 dated April 17, 2018

3 Test object and test assembly

3.1 Test object

The tested material is described by the manufacturer as follows:

- manufacturer Kvadrat A/S
- type Noir, color 551
- material 35% Polyester, 65% acrylic

The testing laboratory has measured as follows:

- area specific mass: m'' = 260 g/m²
- thickness: t = 0.65 mm
- air flow resistance acc. to EN 29053 [5][6]: R_S > 40.000 Pa s/m

3.2 Test assembly

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 installed in a flat (G-100) and a folded arrangement.

The mounting details for the tested arrangements are as follows:

- clear distance to the wall 100 mm, construction without enclosing frame
- fixed directly underneath the ceiling, suspended from a metal rail, height 50 mm

a) flat arrangement G-100

- mounting type G-100 according to EN ISO 354 [1] section 6.2.1 and appendix B.5 of EN ISO 354 [1]
- arranged in two curtain webs:
  one web 2.78 m x 3.00 m and one web 0.74 m x 3.00 m
  approx. 20 mm overlap
- 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
- total test surface S = 10.33 m^2

b) folded arrangement

- 100 % fabric addition
- arranged in three curtain webs:
  two webs 2.78 m x 3.00 m and one web 1.48 m x 3.00 m
  approx. 20 mm overlap
- 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
- total test surface S = 10.33 m^2

The tested arrangements are shown in Table 1.

Table 1. Test arrangements, fabric Noir.

Appendix A, page	**Arrangement type**
1	a) flat, G-100
2	b) 100 % folded, 100 mm distance

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 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 [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

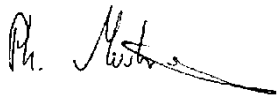
  Arithmetical mean value of the sound absorption coefficients in the twelve one-third octave bands between 250 Hz and 2500 Hz; mean value rounded to 0.01.

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* and *SAA* are indicated in the test certificates in Appendix A.

7 Remarks

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



M. Eng. Philipp Meistring

(Project Manager)

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: Kvadrat A/S
DK-8400 Ebeltoft

Test specimen: Curtain fabric Noir
Flat arrangement, 100 mm distance to reflective wall

Material details

- curtain Noir
- material 35% polyester, 65% acrylic
- area specific mass m'' = 260 g/m²
- airflow resistance R_S > 40.000 Pa s/m
- thickness t = 0.65 mm

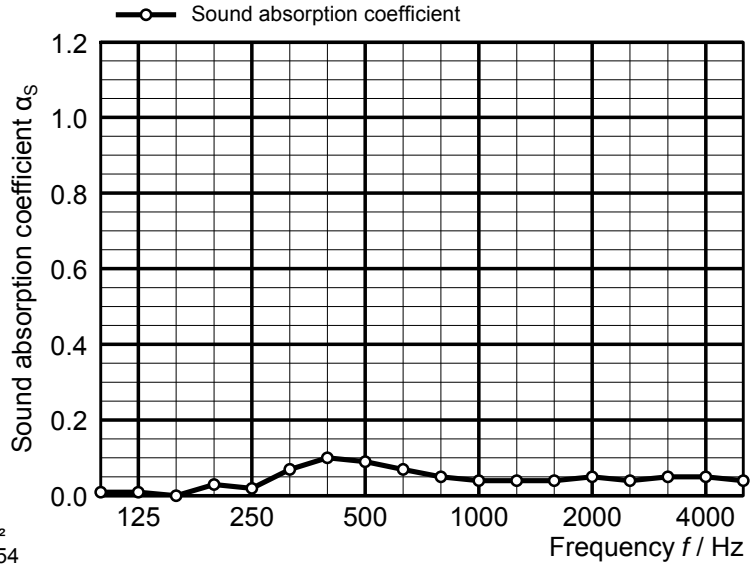
Test arrangement

- test set-up made of two webs, one web 2.78 m x 3.00 m, one web 0.74 m x 3.00 m, 20 mm overlap at curtain splices
- hanging on a metal rail 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 = 3.50 m x 2.95 m

Room: E
Volume: 199.60 m³
Size: 10.33 m²
Date of test: 2018-04-12

	θ [°C]	*r. h.* [%]	*B* [kPa]
without specimen	21.7	31.0	93.7
with specimen	21.7	31.0	93.7

Frequency [Hz]	α_S 1/3 octave	α_p octave
100	◦ 0.01	
125	◦ 0.01	0.00
160	◦ -0.00	
200	◦ 0.03	
250	◦ 0.02	0.05
315	◦ 0.07	
400	0.10	
500	◦ 0.09	0.10
630	◦ 0.07	
800	◦ 0.05	
1000	◦ 0.04	0.05
1250	◦ 0.04	
1600	◦ 0.04	
2000	◦ 0.05	0.05
2500	◦ 0.04	
3150	◦ 0.05	
4000	◦ 0.05	0.05
5000	◦ 0.04	



◦ 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 = 0.10	**Noise Reduction Coefficient *NRC* = 0.05**
Sound absorption class: not classified	**Sound Absorption Average *SAA* = 0.05**

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Planegg, 2018-05-03
No. of test report M100827/152

Sound absorption coefficient ISO 354

Measurement of sound absorption in reverberation rooms

Client: Kvadrat A/S
DK-8400 Ebeltoft

Test specimen: Curtain fabric Noir
Folded arrangement (100 % fabric addition), 100 mm distance to reflective wall

Material details

- curtain Noir
- material 35% polyester, 64% acrylic
- area specific mass m'' = 260 g/m²
- airflow resistance R_S > 40.000 Pa s/m
- thickness t = 0.65 mm

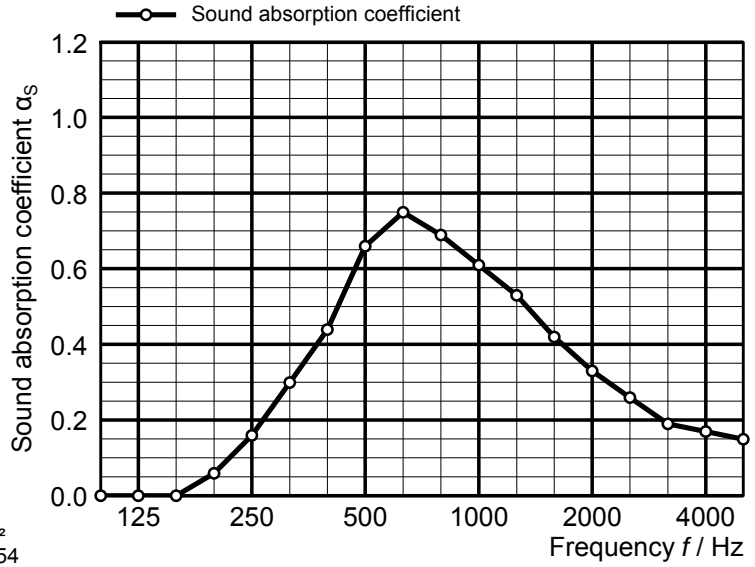
Test arrangement

- test set-up made of three single webs, two webs 2.78 m x 3.00 m and one web 1.48 m 3.00 m, folded with 100 % fabric addition, 20 mm overlap at curtain splices
- hanging on a metal rail 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 = 3.50 m x 2.95 m

Room: E
Volume: 199.60 m³
Size: 10.33 m²
Date of test: 2018-04-12

	θ [°C]	*r. h.* [%]	*B* [kPa]
without specimen	21.4	35.1	93.6
with specimen	21.7	32.4	93.7

Frequency [Hz]	α_S 1/3 octave	α_p octave
100	◦ -0.00	
125	◦ -0.00	0.00
160	◦ 0.00	
200	◦ 0.06	
250	0.16	0.15
315	0.30	
400	0.44	
500	0.66	0.60
630	0.75	
800	0.69	
1000	0.61	0.60
1250	0.53	
1600	0.42	
2000	0.33	0.35
2500	0.26	
3150	0.19	
4000	0.17	0.15
5000	0.15	



◦ 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 = 0.35 (*M*)	**Noise Reduction Coefficient *NRC* = 0.45**
Sound absorption class: D	**Sound Absorption Average *SAA* = 0.43**

Curtain fabric Noir, Manufacturer Kvadrat A/S

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

Figure B.2. Flat arrangement: test object mounted in the reverberation room, diagonal view.

Curtain fabric Noir, Manufacturer Kvadrat A/S

Figure B.3. Folded arrangement: test object mounted in the reverberation room, frontal view.

Figure B.4. Folded arrangement: test object mounted 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 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 [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 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.

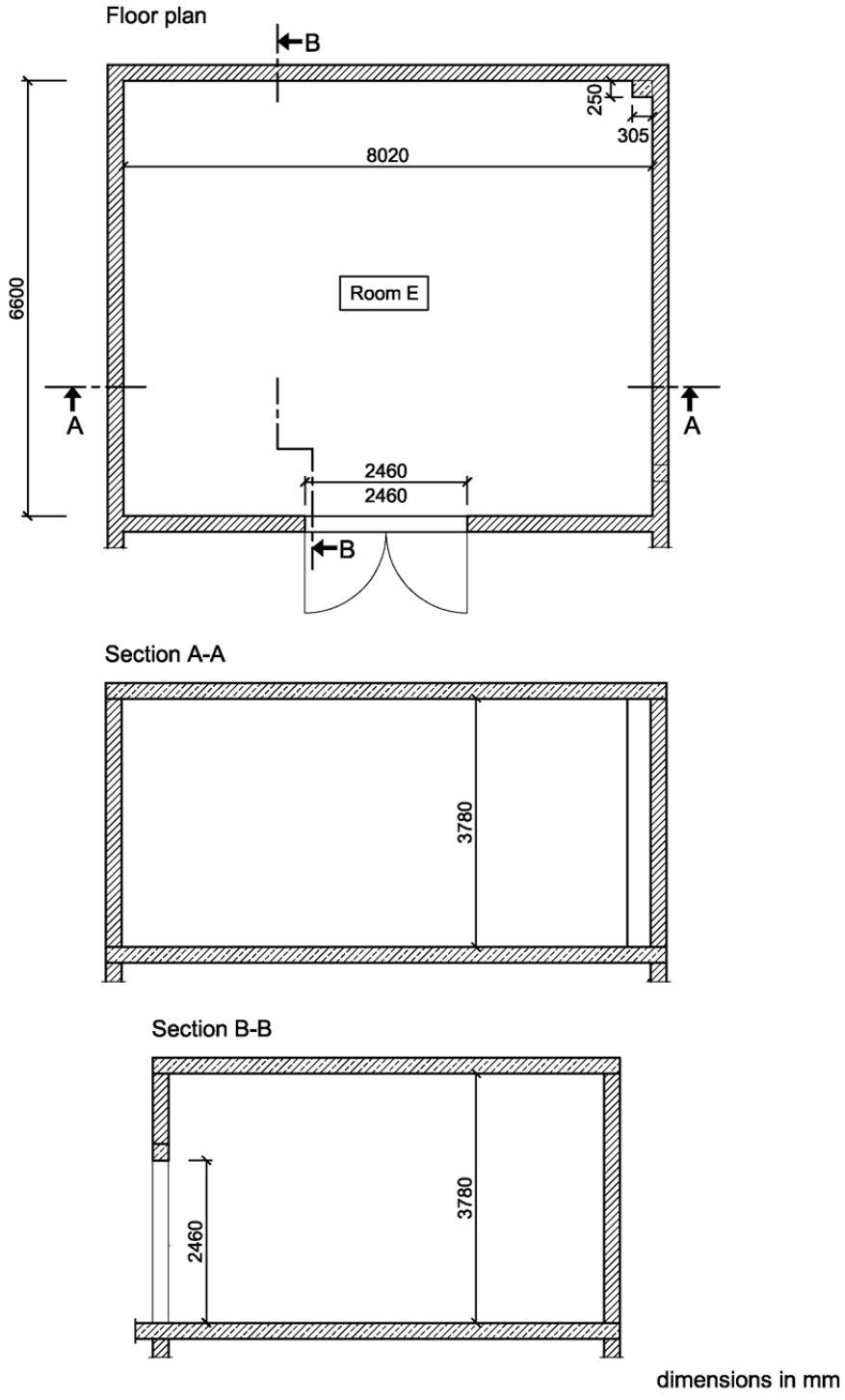


Figure C.1. Plan view and sections of the reverberation room.

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 in Hz	**Reverberation time *T* in s**			
	Appendix A, page 1 G-100 flat		**Appendix A, page 2 folded, 100 %**	
	T_1 (without test object)	**T_2 (with test object)**	**T_1 (without test object)**	**T_2 (with test object)**
100	5.38	5.31	5.37	5.40
125	5.18	5.13	5.32	5.34
160	5.20	5.22	5.22	5.18
200	5.05	4.84	5.06	4.57
250	5.25	5.09	5.16	4.08
315	5.10	4.59	5.00	3.37
400	5.36	4.59	5.25	3.01
500	5.40	4.69	5.33	2.50
630	5.16	4.63	5.13	2.29
800	4.95	4.56	4.97	2.37
1000	5.04	4.72	5.16	2.57
1250	5.07	4.77	5.18	2.75
1600	4.86	4.54	5.00	2.98
2000	4.39	4.11	4.58	3.04
2500	3.56	3.40	3.78	2.83
3150	2.82	2.69	3.01	2.47
4000	2.12	2.06	2.30	1.98
5000	1.64	1.60	1.79	1.59

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 1.10