MÜLLER-BBM

**Curtain fabric Ginger
Manufacturer Kvadrat A/S**

**Measurement of
sound absorption acc. to EN ISO 354**

Test Report No. M60 836/73

Client:	Kvadrat A/S Lundbergsvej 10 DK – 8400 Ebeltoft
Consultant:	Jan-Lieven Moll M. Eng. Philipp Meistring
Date of report:	2011-06-23
Date of delivery of test objects:	2011-06-21
Date of measurements	2011-06-23
Total number of pages:	In total 13 pages: 5 pages text, 2 pages Appendix A, 1 page Appendix B, 1 page Appendix C and 4 pages Appendix D.

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Appendix A: Test certificates sound absorption

Appendix B: Figures

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Appendix D: Description of the test procedure

1 Task

On behalf of the Kvadrat A/S company, DK – 8400 Ebeltoft, the sound absorption of the curtain fabric Ginger 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 to the reflecting wall of 100 mm.

2 Basis

This test report is based on the following documents:

[1] EN ISO 354 „Acoustics – Measurement of the sound absorption in a reverbera-tion 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

3 Test objects and measurement conditions

3.1 Measurements conditions

The test build-ups were arranged in mounting type G according to EN ISO 354 [1] section 6.2.1 and appendix B.5 of EN ISO 354 [1].

The installation of the test objects was conducted 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 are as follows:

- clear distance to the wall 100 mm, construction without enclosing frame

- fixed directly underneath the ceiling, suspended on a metal rail, height 50 mm

The mounting details for the tested arrangements are as follows:

a) flat arrangement G-100

- mounting type G-100 according to appendix B.5 of EN ISO 354 [1]

- arranged in 2 curtains (1 curtain width = 3000 mm, 1 curtain width = 520 mm), overlap approx. 20 mm

- total dimensions (starting at the lower boarder of the metal rail: H x B = 2950 mm x 3500 mm)

- total test surface S = 10.32 m^2

b) folded arrangement

- 100 % folded as shown in figures C.1 – C.3 in appendix C

- arranged in 3 curtains (2 curtains width = 3000 mm, 1 curtain width = 1040 mm), overlap approx. 20 mm

- total dimensions (starting at the lower border of the metal rail): height x width = 2950 mm x 3500 mm

- total test surface S = 10.32 m²

The tested arrangements are indicated in table 1.

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

Table 1 Test arrangements

The figures in appendix B and C show details of the test build-ups.

3.2 Test objects

The tested material is described by the manufacturer as follows:

- manufacturer Kvadrat A/S
- type Ginger
- curtain fabric
- single layer, material 100 % Trevira CS

Testing laboratory has measured as follows:

- area specific mass: $m'' = 260$ g/m²
- thickness: $t = 0.60$ mm
- air flow resistance acc. to EN 29053: $R_S = 45$ Pa s/m

4 Execution of the measurements

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

The test procedure, the test stand and the test equipment used for the measurements are described in appendix D.

5 Evaluation

The sound absorption coefficients α_S were 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.

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 are indicated in the test certificates in appendix A.
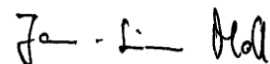
7 Remarks

The determined test results only refer to the test specimens and prevailing conditions on the day of measurements.

This test report may only be published and copied as a whole including all of its appendixes. The publishing of extracts requires the prior written consent of Müller-BBM GmbH.

M. Eng. Philipp Meistring   Jan-Lieven Moll

MÜLLER-BBM
Accredited Testing Laboratory
according to DIN EN ISO/IEC 17025

Deutscher
Akkreditierungs
Rat

DGA-PL-2465.10

Sound absorption coefficient ISO 354
Measurement of sound absorption in reverberation rooms

Client: Kvadrat A/S
DK 8400 Ebeltoft

Test specimen: Fabric "Ginger" Kvadrat A/S,
Type G-100 mounting, flat arrangement

Material details
- manufacturer Kvadrat A/S
- curtain fabric type "Ginger",
- woven fabric, single layer, material 100 % Trevira CS
- area specific mass app. $m'' = 260$ g/m²
- air flow resistance $R_S = 45$ Pa s/m
- thickness $t = 0.60$ mm

Tested construction
-     0.60   mm   fabric "Ginger"
-     100   mm   air gap
-                   reflective wall

Mounting
- type G-100 mounting acc. to ISO 354, arranged without enclosing frame
- arranged in 2 curtains (1 curtain width 3000 mm, 1 curtain width 520 mm), flat arrangement, overlap 20 mm
- total dimensions of the test surface: width x height = 3.50 m x 2.95 m

Room: Hallraum E
Volume: 199.60 m³
Size: 10.32 m²
Date of test: 2011-06-23

	θ [°C]	r. h. [%]	B [kPa]
without specimen	22.6	62.2	95.5
with specimen	22.7	61.4	95.5

Accredited testing laboratory according to ISO/IEC 17025

Deutscher Akkreditierungs Rat

DAP-PL-2465.10

Frequency [Hz]	α_S 1/3 octave	α_p octave
100	∘ 0.02	
125	∘ 0.02	0.00
160	∘ 0.03	
200	∘ 0.04	
250	∘ 0.05	0.05
315	∘ 0.08	
400	0.11	
500	0.16	0.15
630	0.21	
800	0.27	
1000	0.30	0.25
1250	0.25	
1600	0.19	
2000	0.17	0.20
2500	0.25	
3150	0.26	
4000	0.26	0.25
5000	0.30	
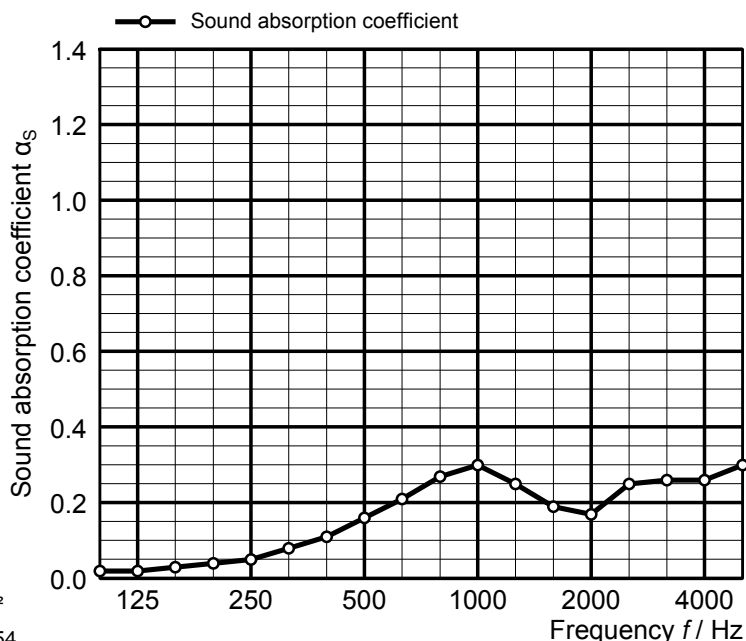
∘ Equivalent sound absorption area less than 1.0 m²

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 $\alpha_w = 0.20$
Sound absorption class: E

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Sound absorption coefficient ISO 354
Measurement of sound absorption in reverberation rooms

Client: Kvadrat A/S
DK 8400 Ebeltoft

Test specimen: Fabric "Ginger" Kvadrat A/S,
folded arrangement, 100 mm distance to the wall

Material details
- manufacturer Kvadrat A/S
- curtain fabric type "Ginger",
- woven fabric, single layer, material 100 % Trevira CS
- area specific mass app. $m'' = 260$ g/m²
- air flow resistance $R_S = 45$ Pa s/m
- thickness $t = 0.60$ mm

Tested construction
-     0.60   mm   fabric "Ginger"
-     100   mm   air gap
-                       reflective wall

Mounting
- clear distance to the wall 100 mm, arranged without enclosing frame
- arranged folded (100 %) in 3 curtains (2 curtains width 3000 mm, 1 curtain width 1040 mm) overlap 20 mm
- total dimensions of the test surface: width x height = 3.50 m x 2.95 m

Room: Hallraum E
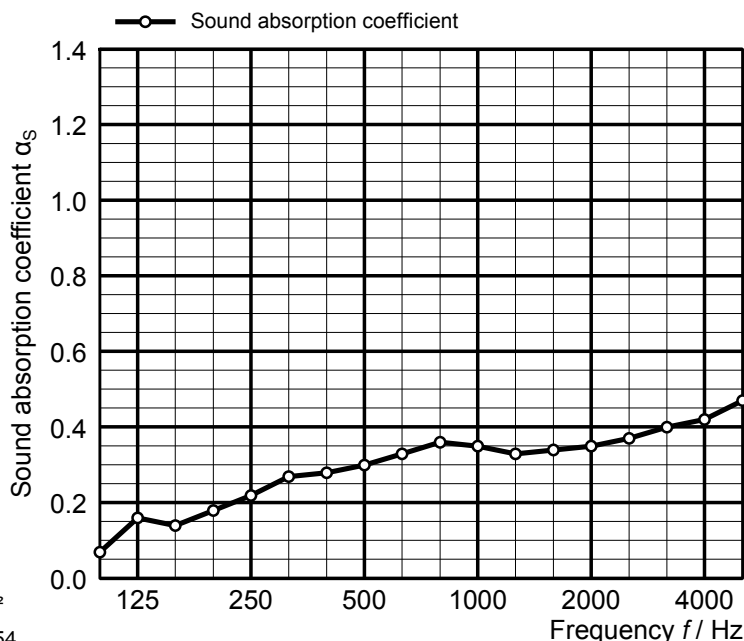Volume: 199.60 m³
Size: 10.32 m²
Date of test: 2011-06-23

	θ [°C]	r. h. [%]	B [kPa]
without specimen	22.6	62.2	95.5
with specimen	22.8	61.5	95.5

Accredited testing laboratory according to ISO/IEC 17025
Deutscher Akkreditierungs Rat
DAP-PL-2465.10

Frequency [Hz]	α_S 1/3 octave	α_p octave
100	∘ 0.07	
125	0.16	0.10
160	0.14	
200	0.18	
250	0.22	0.20
315	0.27	
400	0.28	
500	0.30	0.30
630	0.33	
800	0.36	
1000	0.35	0.35
1250	0.33	
1600	0.34	
2000	0.35	0.35
2500	0.37	
3150	0.40	
4000	0.42	0.45
5000	0.47	

∘ 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 $\alpha_w = 0.35$
Sound absorption class: D

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Curtain fabric Ginger; Manufacturer Kvadrat A/S

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

Figure B.2   Folded arrangement: test object mounted in the reverberation room

Curtain fabric Ginger; Manufacturer Kvadrat A/S

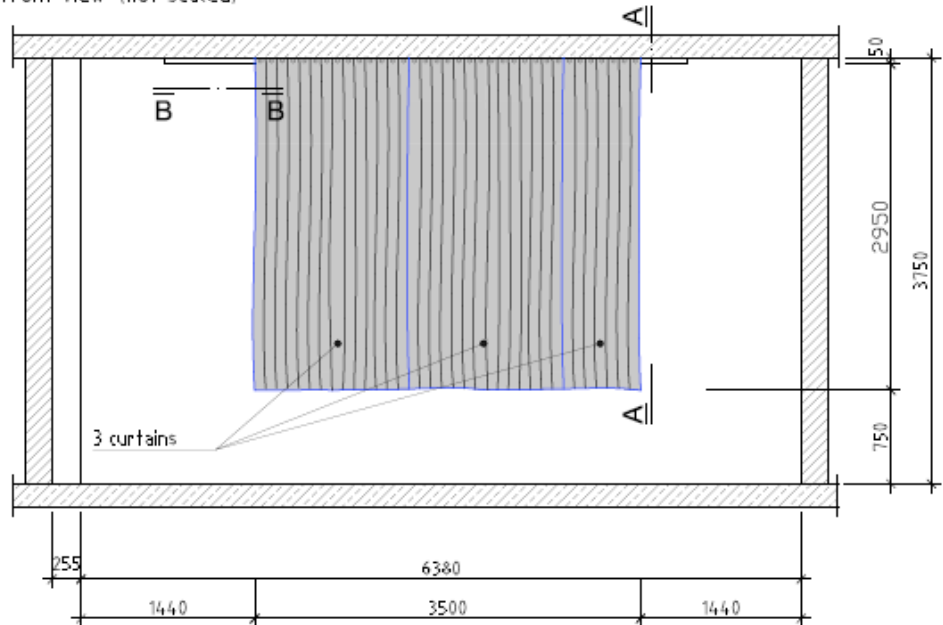figure C1: test construction made of 3 curtains, folded 100%
front view (not scaled)

3 curtains

255
1440
6380
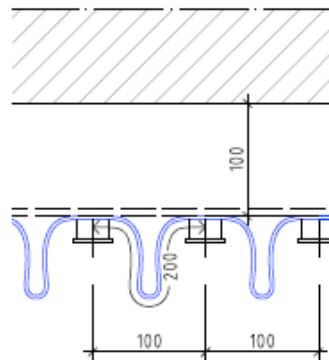3500
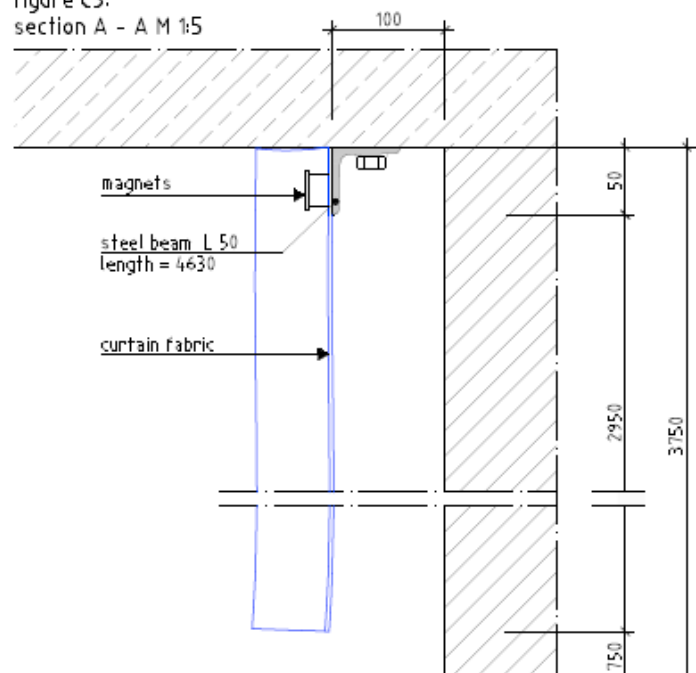1440
50
2950
3750
750

figure C2:
section B – B M 1:5

100
200
100
100

figure C3:
section A – A M 1:5

100

magnets

steel beam L 50
length = 4630

curtain fabric

50
2950
3750
750

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

1 Quantity to be measured

The sound absorption coefficient α 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 results by 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;

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 dissipation was effected according to ISO 9613-1 [3] . The climatic conditions during the measurements are stated in the test certificates.

Designations to the repeatability and to the precision of the test procedure are given in EN ISO 354 [1] .

2 Test procedure

2.1 Description of the reverberation room

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.
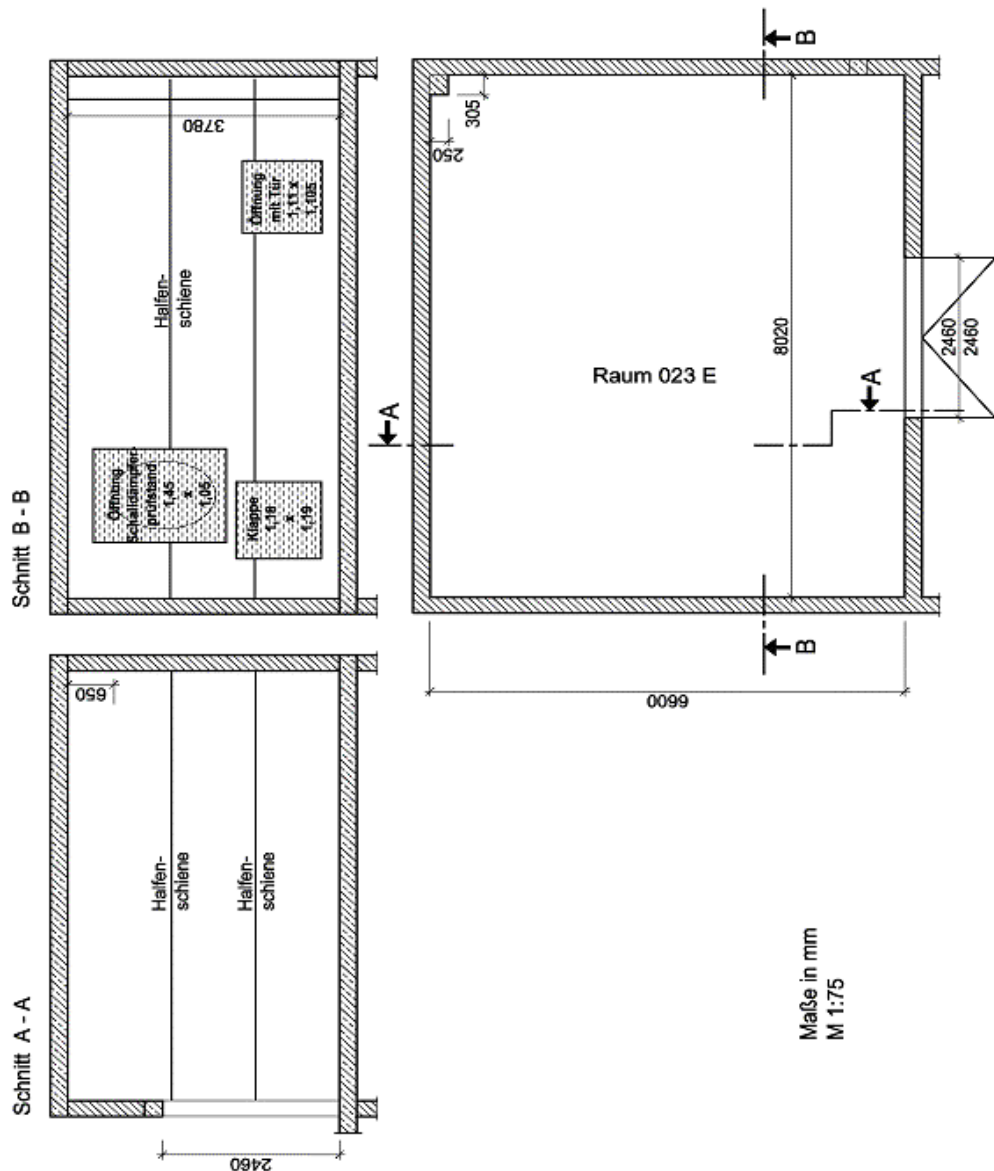
Figure D.1. Drawings of the test stand

2.2 Measurement of the 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 the following table D.1.

Reverberation time T in s			
frequency in Hz	T_1 (without test object)	T_2 (with test object)	
		Appendix A, page 1 G-100 flat	Appendix A, page 2 G-100 folded
100	4.57	4.46	4.15
125	4.49	4.35	3.64
160	4.70	4.48	3,.87
200	4.83	4.58	3.76
250	5.02	4.67	3.68
315	5.07	4.52	3.53
400	5.25	4.40	3.57
500	5.26	4.15	3.48
630	5.25	3.87	3.39
800	5.19	3.57	3.24
1000	5.24	3.49	3.28
1250	5.09	3.60	3.31
1600	4.90	3.78	3.20
2000	4.66	3.71	3.05
2500	4.31	3.21	2.84
3150	3.70	2.83	2.49
4000	3.03	2.40	2.14
5000	2.50	2.00	1.81

Table D.1 Reverberation times without and with test objects

2.3 List of test equipment

Table D.2 shows the test equipment used for the measurements.

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
Dynamic microphone	Microtech	M360	1783
Dynamic microphone	Microtech	M360	1785
Dynamic microphone	Microtech	M360	1786
Dynamic microphone	Microtech	M360	1787
Dynamic microphone	Microtech	M360	1788
Dynamic microphone	Microtech	M360	1789
Barometer	Lufft	Opus 10	030.0910.0003. 9.4.1.30
Thermo-/Hygrometer	Testo	Saveris H1E	01554624
Software for measurement and evaluation	Müller-BBM	Bau 4	Version 1.6

Table D.2 List of test equipment