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M60 836/6 nm/ftn  
2005-06-27

## **Upholstery fabric Divina 2 973 Manufacturer Kvadrat A/S**

**Measurement of  
sound absorption acc. to EN ISO 354  
and  
air flow resistance acc. to EN 29053**

**Test Report No. M60 836/6**

Client:	Kvadrat A/S Lundbergsvej 10 DK – 8400 Ebeltoft
Date of report	June 27, 2005
Date of measurements	June 6 and 10, 2005
Acoustic consultant:	Dipl.-Ing. (FH) Andreas Niermann
Number of pages :	In total 16 pages: 6 pages of text 2 pages of Appendix A 2 pages of Appendix B 4 pages of Appendix C 1 page of Appendix D 1 page of Appendix E

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## 1 Task

On behalf of the Kvadrat A/S company, DK – 8400 Ebeltoft, the sound absorption according to EN ISO 354 and the air flow resistance according to EN 29053 have to be measured for the upholstery fabric, type Divina 2 973.

## 2 Test object

On June 6, 2005 we received the material to be tested.

The tested material is described by the manufacturer as follows:

- upholstery fabric
- manufacturer Kvadrat A/S
- type Divina 2 973
- material 100 % new wool

Müller-BBM has measured as follows:

- area specific mass  $m'' = 540 \text{ g/m}^2$
- thickness  $t = 1.45 \text{ mm}$

## 3 Sound absorption

### 3.1 Measurement conditions

The fabric was tested in two ways: not folded and folded with an extra fabric quantity of 100 %. The assembly of the test objects was carried out by Müller-BBM. The test constructions were built as G100-constructions according to EN ISO 354.

The fabric was assembled once not folded in 3 curtains and once folded in 6 curtains, each dimensioned width x height = 1510 mm x 2710 mm.

The fabrics were freely suspended. The clear distance between fabric and the wall was 100 mm. The whole construction was built without lateral frame. The curtains were fixed directly without a joint underneath the ceiling by means of a L60 metal beam. The clear distance between the floor and lower border of the curtain was approx. 1010 mm. Between the curtains were no open gaps.

The figures in appendix C show details of the constructions. The test certificates in appendix A give a detailed description.

### 3.2 Execution of the measurements

The measurements were effected and evaluated according to EN ISO 354 “Measurement of sound absorption in a reverberation room”, edition 12-2003.

The measurements were carried out on June 10, 2005 in the reverberation room of the Müller-BBM company in Planegg. The reverberation room has a volume of approx. 200 m<sup>3</sup> and a surface of approx. 216 m<sup>2</sup>.

Six omnidirectional microphones and two loudspeakers were installed in the reverberation room. In order to improve the diffusivity, seven composite sheet metal boards (1.2 m x 1.4 m) and six composite sheet metal boards (1.2 m x 1.2 m) were suspended curved and irregularly.

In all tests, pink noise was used as a test signal.

The climatic conditions during the measurements are stated in the test certificate, appendix A. The different dissipation during the sound propagation in the air was taken into account according to EN ISO 354, chapter 8.1.2.3 regarding ISO 9613-1 “Acoustics – Attenuation of sound during propagation outdoors”, edition 1996-06.

The test equipment listed in appendix D was used for the measurements.

Table 1 in appendix E shows the measured reverberation times in the reverberation room with and without test object.

### 3.3 Measurement results

The measurement results shown in the following table 1 are also described in the test certificates in appendix A.

In addition to the sound absorption coefficients  $\alpha_S$  in single third-octave bands, the practical sound absorption coefficients  $\alpha_p$  in octave bands, which are calculated from these values, are stated. The weighted sound absorption coefficient  $\alpha_w$  is determined as a single number value from the practical sound absorption coefficients  $\alpha_p$  from 250 Hz to 4000 Hz. The practical and weighted sound absorption coefficient were calculated according to DIN EN ISO 11654 “Acoustics – Sound absorber for use in buildings – Rating of Sound absorption”, edition July 1997.

**Table 1.** Practical sound absorption coefficient  $\alpha_p$  according to DIN EN ISO 11654

Construction	Octave centre frequency $f$ / Hz						Test certificate Appendix A, page
	125	250	500	1000	2000	4000	
Upholstery fabric Divina 2 973 Kvadrat A/S 100 mm air gap, not folded	0.05	0.30	0.70	0.90	0.70	0.70	1
Upholstery fabric Divina 2 973 Kvadrat A/S 100 mm air gap folded 100 %	0.15	0.40	0.85	0.95	0.95	1.00	2

## 4 Air flow resistance

### 4.1 Execution of measurements

The measurements were carried out on June 6, 2005 in the laboratory for airflow resistance measurements of the Müller-BBM company in Planegg.

The airflow resistance was determined according to EN 29053: "Acoustics – Materials for acoustical applications – Determination of airflow resistance", 1993-03.

The measurements for the determination of the airflow resistance were performed at different air velocities. The continuous airflow method was applied. The measurement cell (specimen holder) has a diameter of 100 mm. The test specimen was fitted flat over the measurement cell, without stretching the material, sealed at the edges and fixed.

According to the standard, the specific airflow resistance  $R_s$  and the airflow resistivity  $r$  are indicated as measurement results which were determined by extrapolation (linear regression) at an airflow velocity of  $u = 0,0005$  m/s.

## 4.2 Measurement results

The determined airflow resistance values are indicated below. For further information regarding the measurements, see Appendix B.

The results of the measurements are:

$R_S$  = specific airflow resistance perpendicular to the specimen surface  
 $r$  = airflow resistivity

- upholstery fabric Divina 2 973, Kvadrat A/S
  - $R_S = 678 \text{ Pa} \cdot \text{s/m}$
  - $r = 4.68 \times 10^5 \text{ Pa} \cdot \text{s/m}^2$

## 5 Remark

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.



Dipl.-Ing. (FH) Andreas Niermann

MÜLLER-BBM

Accredited Test Laboratory  
according to ISO/IEC 17025



DAP-PL-2465.10

# Sound absorption coefficient ISO 354

## Measurement of sound absorption in a reverberation room

**Client:** Kvadrat A/S  
DK 8400 Ebeltøft

**Test specimen:** Upholstery fabric "Divina" 2 973 Kvadrat A/S  
100 mm air gap, 3 curtains, not folded

### Details about the fabric

- upholstery fabric
- Manufacturer Kvadrat A/S
- Type upholstery fabric "Divina" 2 973
- 100 % new wool
- area specific mass app.  $m'' = 540 \text{ g/m}^2$
- no side of the fabric to be preferred, almost equal
- air flow resistance acc. to EN 29053:  $R_S = 678 \text{ Pa s / m}$

### Mounting details

- Mounting type G100 according to ISO 354
- arranged in 3 curtains, each dimensioned width x height = 1510 mm x 2710 mm
- Test surface  $S = 3 \times 1510 \text{ mm} \times 2710 \text{ mm}$
- freely suspended, not folded
- clear distance to the wall 100 mm
- construction without lateral frame
- fixed directly without joint underneath the ceiling by means of a L60 metal beam
- clear distance between floor and lower border of the curtain app. 1010 mm
- no open gaps between the curtains

Room: Reverberation room E  
Volume: 199.60 m<sup>3</sup>  
Size: 12.28 m<sup>2</sup>  
Date of test: 2005-06-10

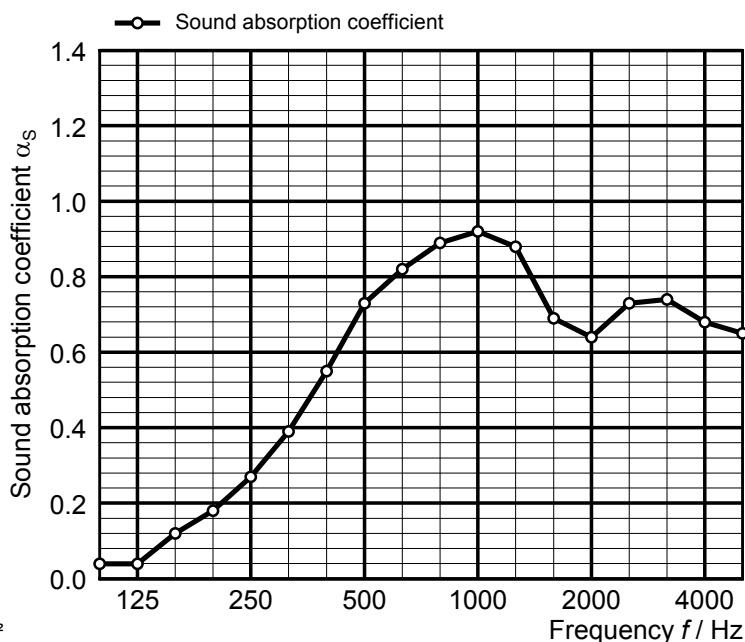
	$\Theta$ [°C]	r. h. [%]	$B$ [kPa]
with specimen	21.2	35	95.7
without specimen	21.2	35	95.7

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according to ISO/IEC 17025



2465.10

Frequency [Hz]	$\alpha_s$ 1/3 octave	$\alpha_p$ oktave
100	0.04	
125	0.04	0.05
160	0.12	
200	0.18	0.30
250	0.27	
315	0.39	
400	0.55	
500	0.73	0.70
630	0.82	
800	0.89	
1000	0.92	0.90
1250	0.88	
1600	0.69	
2000	0.64	0.70
2500	0.73	
3150	0.74	
4000	0.68	0.70
5000	0.65	



◦ Equivalent sound absorption area less than 1.0 m<sup>2</sup>

$\alpha_s$  Sound absorption coefficient according to ISO 354

$\alpha_p$  Practical sound absorption coefficient according to ISO 11654

Rating according to ISO 11654:

**Weighted sound absorption coefficient  $\alpha_w = 0.60$  (M)**

Sound absorption class: C

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Appendix A

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# Sound absorption coefficient ISO 354

## Measurement of sound absorption in a reverberation room

**Client:** Kvadrat A/S  
DK 8400 Ebeltøft

**Test specimen:** Upholstery fabric "Divina" 2 973 Kvadrat A/S  
100 mm air gap, 6 curtains, folded 100 %

**Details about the fabric**

- upholstery fabric
- Manufacturer Kvadrat A/S
- Type upholstery fabric "Divina" 2 973
- 100 % new wool
- area specific mass app.  $m'' = 540 \text{ g/m}^2$
- no side of the fabric to be preferred, almost equal
- air flow resistance acc. to EN 29053:  $R_s = 678 \text{ Pa s / m}$

**Mounting details**

- Mounting type G100 according to ISO 354
- arranged in 6 curtains, each dimensioned width x height = 1510 mm x 2710 mm
- Test surface  $S = 4620 \text{ mm} \times 2710 \text{ mm}$
- freely suspended, folded 100 %
- clear distance to the wall 100 mm
- construction without lateral frame
- fixed directly without joint underneath the ceiling by means of a L60 metal beam
- clear distance between floor and lower border of the curtain app. 1010 mm
- no open gaps between the curtains

Room: Reverberation room E  
Volume: 199.60 m<sup>3</sup>  
Size: 12.52 m<sup>2</sup>  
Date of test: 2005-06-10

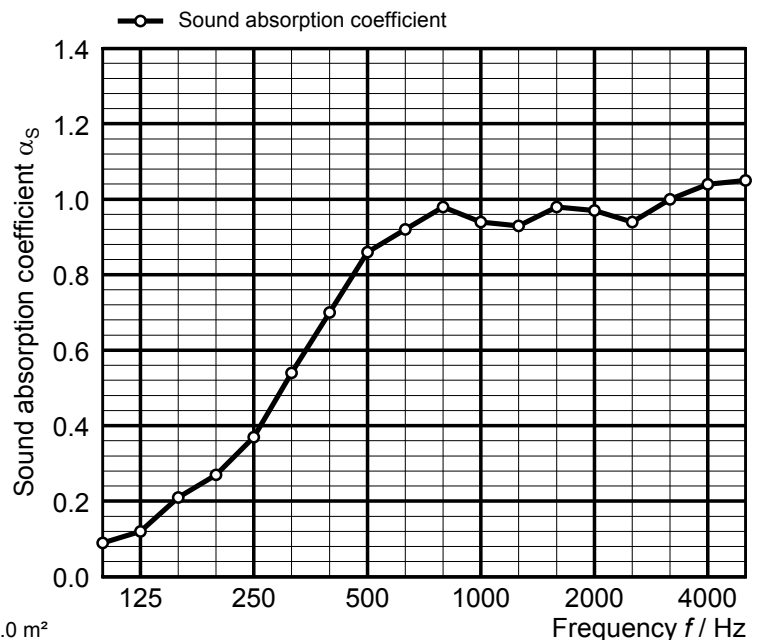
	$\Theta$ [°C]	r. h. [%]	$B$ [kPa]
with specimen	21.2	35	95.7
without specimen	21.2	35	95.7

Accredited testing laboratory  
according to ISO/IEC 17025



2465.10

Frequency [Hz]	$\alpha_s$ 1/3 octave	$\alpha_p$ oktave
100	0.09	
125	0.12	0.15
160	0.21	
200	0.27	
250	0.37	0.40
315	0.54	
400	0.70	
500	0.86	0.85
630	0.92	
800	• 0.98	
1000	• 0.94	0.95
1250	• 0.93	
1600	• 0.98	
2000	• 0.97	0.95
2500	• 0.94	
3150	• 1.00	
4000	• 1.04	1.00
5000	• 1.05	



• Equivalent sound absorption area greater than 12.0 m<sup>2</sup>

$\alpha_s$  Sound absorption coefficient according to ISO 354

$\alpha_p$  Practical sound absorption coefficient according to ISO 11654

Rating according to ISO 11654:

**Weighted sound absorption coefficient  $\alpha_w = 0.70$  (MH)**

Sound absorption class: C

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Appendix A

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## Determination of airflow resistance acc. to EN 29053

<b>Project :</b> Kvadrat
<b>Test report No. :</b> M60836/6
<b>tested by :</b> nm
<b>Date of measurement :</b> 06/06/2005

<b>Details about test specimen</b>		
<b>Number :</b> 3954		
<b>Construction :</b> felt fabric, single layer		
<b>Designation :</b> Divina 2 973 Kvadrat A/S	<b>Mounting details:</b>	
<b>Material :</b> 100 % new wool	both sides equal	
<b>Purpose :</b> upholstery		
<b>Thickness :</b> 1.45 mm	<b>Mass :</b> 21.70 g	
<b>Diameter :</b> 100 mm	<b>Size :</b> 0.040 m <sup>2</sup>	
<b>barom. air pressure :</b> 95.6 kPa	<b>abs. air pressure :</b> 101,3 kPa	<b>area spec. mass:</b> 542.5 g/m <sup>2</sup>

Number of Measurement	Pressure Difference $\Delta p$ / mm H <sub>2</sub> O	Air flow $q_v$ / (cm <sup>3</sup> /min)	Air flow velocity $u$ / (m/s)	spezific air flow resistance $R_s$ / (Pa s/m)	specific air flow resistance rel. Length $r$ / (Pa s/m <sup>2</sup> )
1	8.000	53982	0.10811	726.0	5.01E+05
2	7.600	51543	0.10322	722.0	4.98E+05
3	7.200	48664	0.09746	725.0	5.00E+05
4	6.800	46781	0.09369	712.0	4.91E+05
5	6.400	44016	0.08815	712.0	4.91E+05
6	6.000	40880	0.08187	719.0	4.96E+05
7	5.600	38261	0.07662	717.0	4.94E+05
8	5.200	35698	0.07149	714.0	4.92E+05
9	4.800	33181	0.06645	709.0	4.89E+05
10	4.400	31110	0.0623	693.0	4.78E+05
11	4.000	28650	0.05738	684.0	4.72E+05
12	3.600	25808	0.05168	683.0	4.71E+05
13	3.200	22590	0.04524	694.0	4.79E+05
14	2.800	19406	0.03886	707.0	4.88E+05
15	2.400	16655	0.03335	706.0	4.87E+05

**Extrapolated acc. to EN 29 053:**

<b>0.0005</b>	<b>678</b>	<b>4.68E+05</b>
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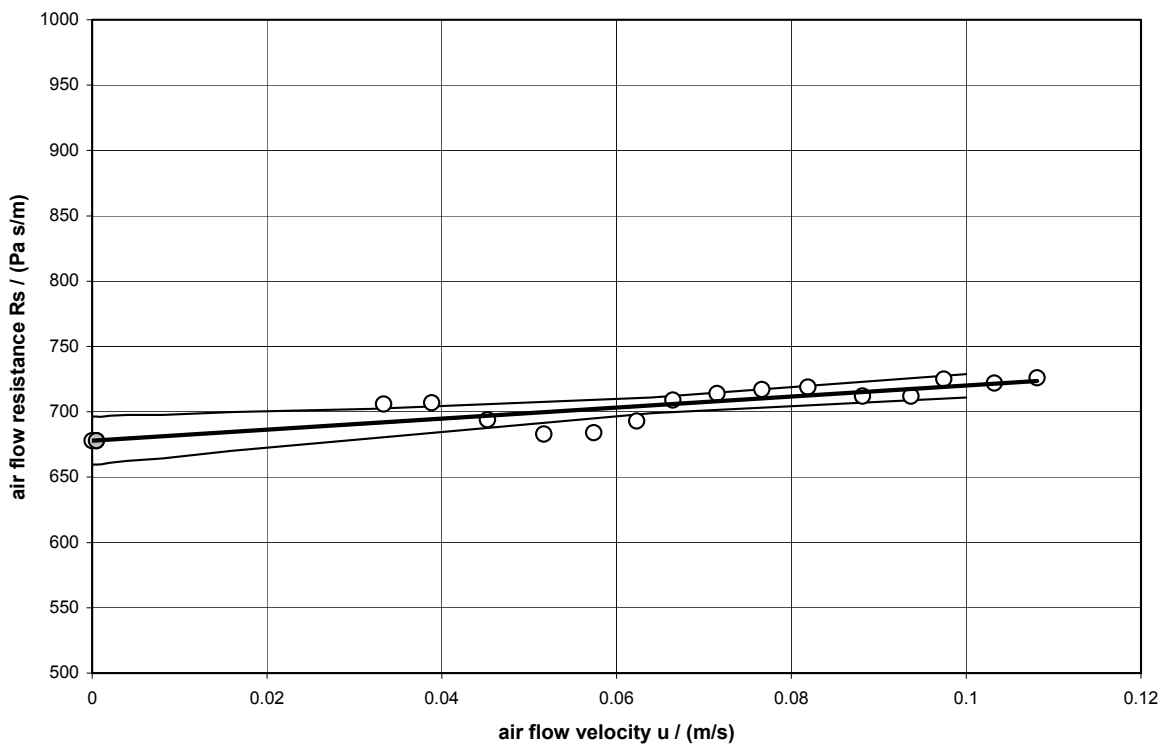
statistical confidence: 95 %

confidence interval at  $u = 0,0005$  m/s:  $\pm 2.7$  %

## Determination of airflow resistance acc. to EN 29053

<b>Project :</b> Kvadrat
<b>Test report No. :</b> M60836/6
<b>tested by :</b> nm
<b>Date of measurement :</b> 06/06/2005

<b>Details about test specimen</b>		
<b>Number :</b> 3954		
<b>Construction :</b> felt fabric, single layer		
<b>Designation :</b> Divina 2 973 Kvadrat A/S	<b>Mounting details:</b>	
<b>Material :</b> 100 % new wool	both sides equal	
<b>Purpose :</b> upholstery		
<b>Thickness :</b> 1.45 mm	<b>Mass :</b> 21.70 g	
<b>Diameter :</b> 100 mm	<b>Size :</b> 0.040 m <sup>2</sup>	
<b>barom. air pressure :</b> 95.6 kPa	<b>abs. air pressure :</b> 101,3 kPa	<b>area spec. mass:</b> 542.5 g/m <sup>2</sup>



**Extrapolated acc. to EN 29 053:**

statistical confidence: 95 %

confidence interval at  $u = 0,0005$  m/s:  $\pm 2.7$  %

Air flow velocity $u$ / (m/s)	Specific air flow resistance $R_s$ / (Pa s/m)	Specific air flow resistance rel. length $r$ / (Pa s/m <sup>2</sup> )
<b>0.0005</b>	<b>678</b>	<b>4.68E+05</b>

Upholstery fabric Divina 2 973 kvadrat A/S

figure 1: test construction made of 3 curtains, not folded  
front view (not scaled)

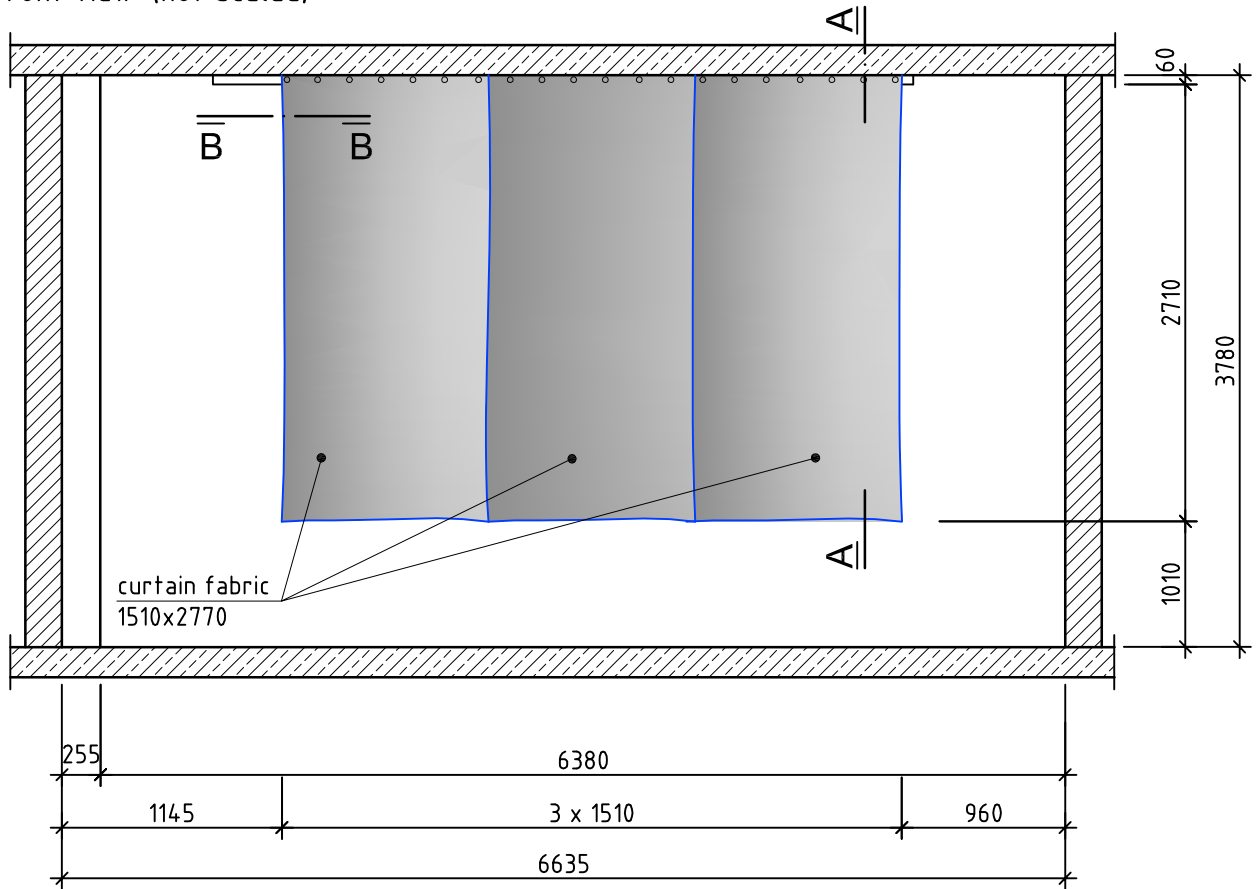
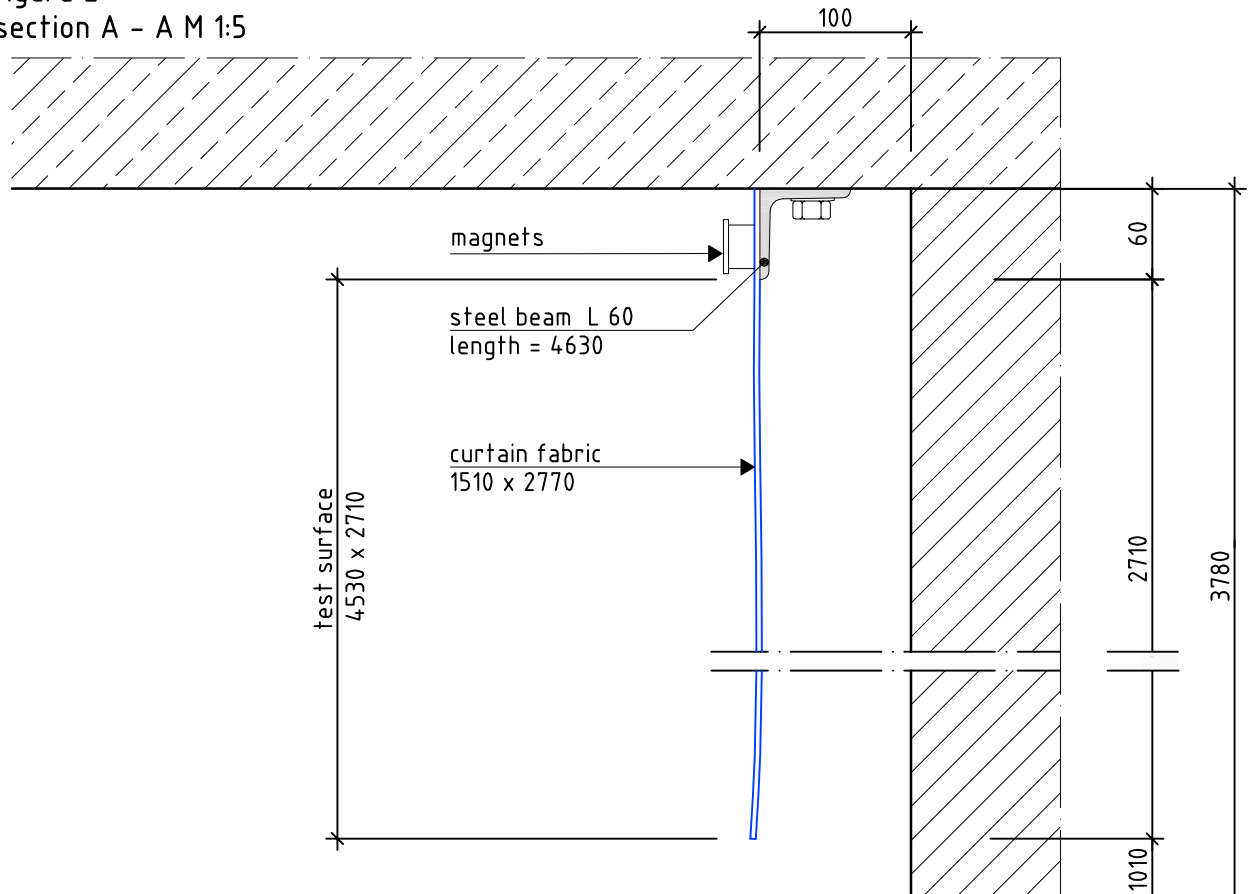


figure 2:  
section A - A M 1:5



Upholstery fabric Divina 2 973 kvadrat A/S

figure 3: test construction made of 6 curtains, folded 100%  
front view (not scaled)

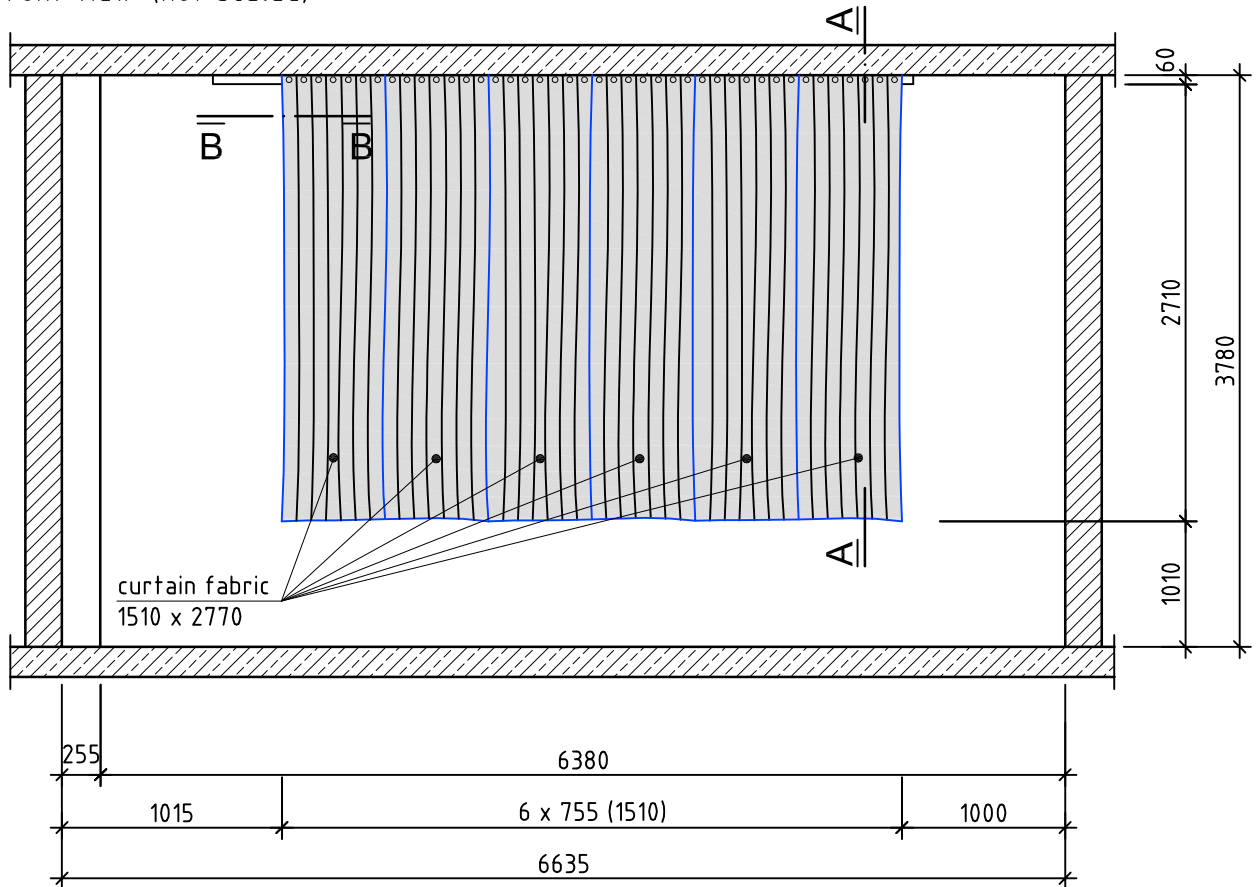


figure 4:  
section B - B M 1:5

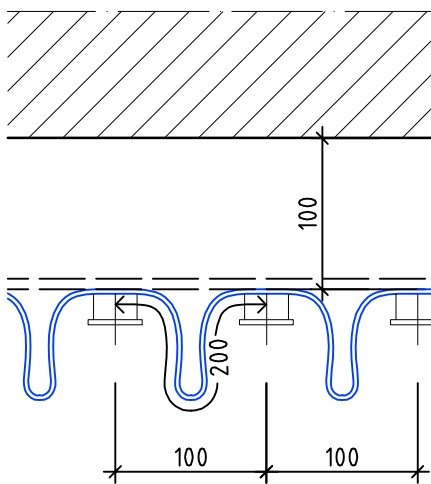
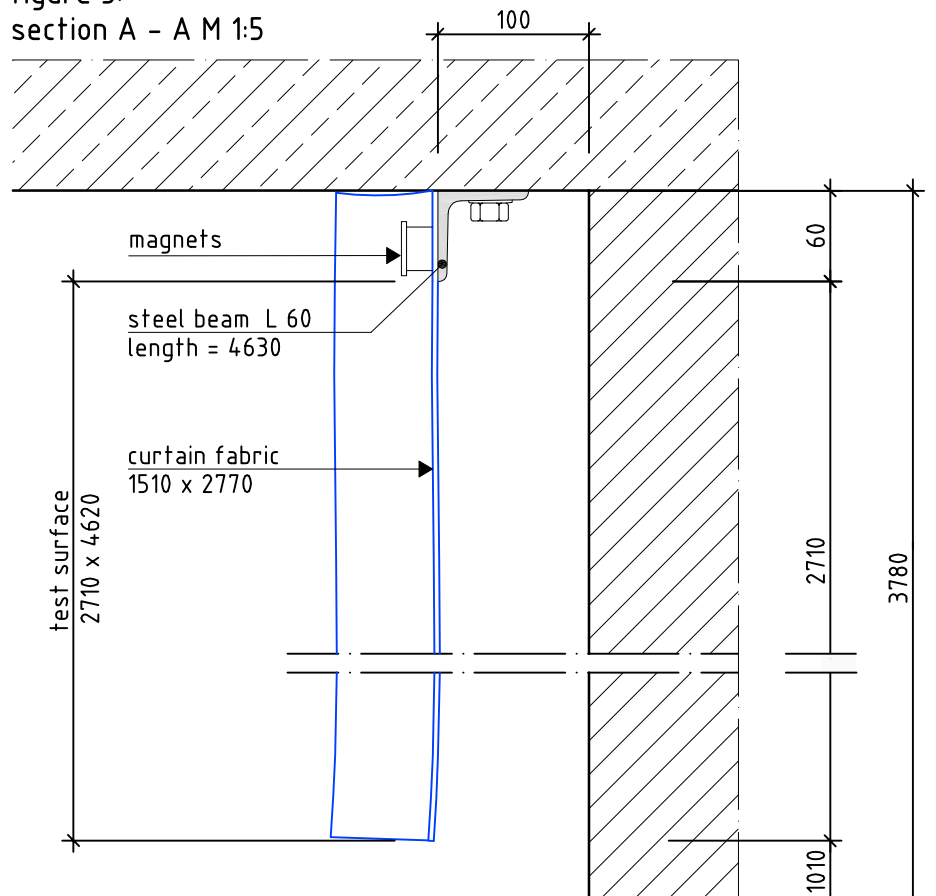


figure 5:  
section A - A M 1:5



Upholstery fabric “Divina” 2 973 Kvadrat A/S



**Figure 6.**

View of the mounted specimen in the reverberation room

Test construction1: 3 curtains, not folded, 100 mm air gap

**Upholstery fabric “Divina” 2 973 Kvadrat A/S**



**Figure 7.**

View of the mounted specimen in the reverberation room

Test construction 2: 6 curtains, folded 100 %, 100 mm air gap

**List of test equipment****Sound absorption**

Name	Manufacturer	Type	Serial-No.
Building acoustics measurement system	Norsonic	121	26342
Amplifier	Norsonic	235	14582
Loudspeakers (2 x in the reverberation room)	Allsound LT	--	--
Microphones (6 x in the reverberation room)	Sennheiser	MD21N	102805
Aspiration psychrometer	Wilh. Lambrecht KG	761	450157
Software for measurement and evaluation	Müller-BBM	Bau 4	Version 1.4

**Air flow resistance**

Name	Manufacturer	Type	Serial-No.
Mikromanometer	Furness Controls	FC O14 - MOS 220	9002407
Flow meter	BROOKS	Tube R-6-15-B	--
Flow meter	BROOKS	Tube R-2-15-C	--
Flow meter	BROOKS	Tube R-2-15-A	--
Flow meter (4 pieces)	Kirchner & Tochter	KD 77/2 (air)	--
Measuring construction for airflow resistance	Müller-BBM	--	--
Computer with programs for evaluation	Müller-BBM	--	--

**Table 1.** Mean values of reverberation time  $T_1$  without and with  $T_2$  specimen

frequency  f / Hz	Mean values of measured reverberation time			
	test construction 1		test construction 2	
	without specimen	with specimen	without specimen	with specimen
100	7.08	6.41	7.08	5.68
125	5.92	5.48	5.92	4.61
160	6.67	5.15	6.67	4.30
200	6.55	4.53	6.55	3.85
250	6.80	4.02	6.80	3.43
315	6.03	3.16	6.03	2.67
400	5.75	2.60	5.75	2.25
500	5.40	2.15	5.40	1.93
630	5.24	1.99	5.24	1.82
800	5.02	1.85	5.02	1.73
1000	5.14	1.84	5.14	1.78
1250	5.34	1.91	5.34	1.82
1600	5.07	2.17	5.07	1.73
2000	4.58	2.16	4.58	1.68
2500	4.02	1.89	4.02	1.62
3150	3.17	1.67	3.17	1.42
4000	2.50	1.52	2.50	1.24
5000	1.89	1.28	1.89	1.07