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M100827/223 Version 1 MSG/STEG

Curtain fabric Floyd Screen by Kvadrat A/S

Measurement of sound absorption in the reverberation room acc. to DIN EN ISO 354

Test Report No. M100827/223

Client:	Kvadrat A/S Lundbergsvej 10 8400 Ebeltoft DENMARK
Consultant:	M. Eng. Philipp Meistring M. Sc. Paul Siegmüller
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1 Task

On behalf of the company Kvadrat A/S, 8400 Ebeltoft, Denmark, the sound absorption of the curtain fabric type “Floyd Screen” was to be measured according to DIN EN ISO 354 [1] in the reverberation room.

The fabric was tested as a curtain in a flat arrangement with a distance of 100 mm to the reflective wall.

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. February 2017.

[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] Mueller-BBM test report no M100827/224: Fabric Type Floyd Screen, Manufacturer Kvadrat A/S - Determination of airflow resistance according to DIN EN ISO 9053-1. 2020-06-17

3 Test object and test assembly

3.1 Test object

The tested material is described by the client as follows:

- Designation “Floyd Screen 226“
- Material: 50 % polyester / 45 % new wool, worsted / 5 % nylon
- Area specific mass: $m'' = 216$ g/m²

The testing laboratory has measured as follows:

- Thickness: $t = 0.63$ mm
- Specific air flow resistance acc. to DIN EN ISO 9053-1 [6]: $R_s = 150$ Pa·s/m

3.2 Test assembly

The installation of the test object was carried out at the reverberation room by employees of the test laboratory.

The mounting details for the tested arrangement are as follows:

- fixed directly underneath the ceiling of the reverberation room, suspended from a metal rail (height 60 mm), distance to the reflecting back wall 100 mm
- test set-up without enclosing frame
- mounting type G-100 according to DIN EN ISO 354 [1] section 6.2.1 and appendix B.5
- arranged in two webs 1.71 m x 3.00 m
  approx. 20 mm overlap at curtain splices
- total dimensions of the test surface (starting at the lower border of the metal rail): width x height = 3.40 m x 2.94 m
- total test surface S = 10.00 m^2

The test certificates 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 certificate 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)

M. Sc. Paul Siegmüller
(Responsible)

Sound absorption coefficient ISO 354

Measurement of sound absorption in reverberation rooms

Client: Kvadrat A/S
Lundbergsvej 10, 8400 Ebeltoft, Denmark

Test specimen: Fabric Floyd Srceen
arranged as curtain (hanging flat, 100 mm distance to reflective wall)

Material details

Information provided by the client:

- fabric: Floyd Srceen color 226
- material: 50% polyester / 45% new wool, worsted / 5% nylon

Properties determined by the testing laboratory

- area specific mass m'' = 216 g/m²
- airflow resistance R_S = 150 Pa s/m
- thickness t = 0.63 mm

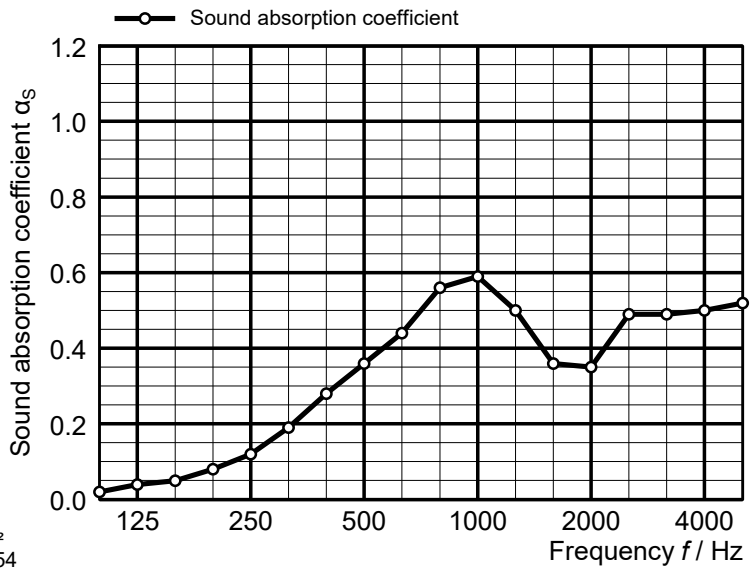
Test arrangement

- curtain arrangement following type G-100 acc. to DIN EN ISO 354, without enclosing frame
- flat arrangement, 100 mm clear distance to the reflective wall
- test set-up made of two webs 1.71 m x 3.00 m, 20 mm overlap at curtain splices
- fixed directly underneath the ceiling on a metal rail (h = 60 mm),
- test surface width x height = 3.40 m x 2.94 m (starting at the lower edge of the metal rail)

Room: E
Volume: 199.60 m³
Size: 10.00 m²
Date of test: 2020-06-15

	θ [°C]	*r. h.* [%]	*B* [kPa]
without specimen	22.4	57.2	95.3
with specimen	22.4	57.2	95.3

Frequency [Hz]	α_S 1/3 octave	α_p octave
100	∘ 0.02	
125	∘ 0.04	0.05
160	∘ 0.05	
200	∘ 0.08	
250	0.12	0.15
315	0.19	
400	0.28	
500	0.36	0.35
630	0.44	
800	0.56	
1000	0.59	0.55
1250	0.50	
1600	0.36	
2000	0.35	0.40
2500	0.49	
3150	0.49	
4000	0.50	0.50
5000	0.52	



∘ 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 = 0.40	**Noise Reduction Coefficient *NRC* = 0.35**
Sound absorption class: D	**Sound Absorption Average *SAA* = 0.36**

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Planegg, 2020-06-17
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Curtain fabric Floyd Screen, by Kvadrat A/S

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.

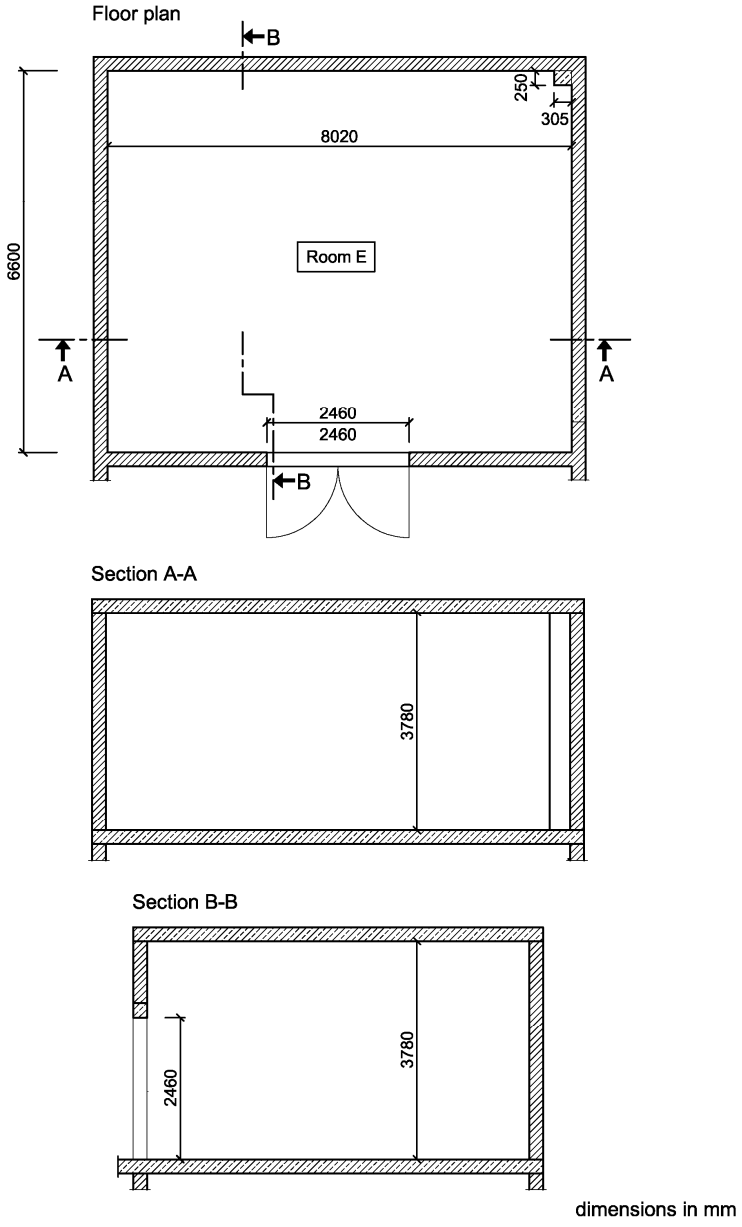

Figure C.1. Plan view and sections of the reverberation room.

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.

Frequency in Hz	**Reverberation time *T* in s**	
	T_1 (without test object)	**T_2 (with test object)**
100	5.39	5.18
125	5.67	5.28
160	6.14	5.56
200	5.65	4.93
250	5.85	4.81
315	5.62	4.23
400	5.56	3.74
500	5.50	3.41
630	5.20	3.05
800	4.84	2.61
1000	4.95	2.59
1250	4.99	2.81
1600	4.99	3.20
2000	4.70	3.12
2500	4.12	2.52
3150	3.49	2.28
4000	2.79	1.94
5000	2.34	1.69

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