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2019-03-06 M100827/195 MSG/STEG

Fabric type Still, Manufacturer Kvadrat A/S

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

Test Report No. M100827/195

Client:

Consultant: Date of report: Delivery date of test object: Date of test: Total number of pages: Kvadrat A/S Lundbergsvej 10 8400 Ebeltoft Denmark M. Eng. Philipp Meistring 2019-03-06 2019-02-21 2019-01-23 In total 14 pages, thereof 6 pages text, 2 pages Appendix A, 2 pages Appendix B, and 4 pages Appendix C.

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1 Task

On behalf of the company Kvadrat A/S, 8400 Ebeltoft, Denmark, the sound absorption of the fabric type Still had to be measured according to EN ISO 354 [1] in the reverberation room. The fabric was tested as a curtain 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] Mueller-BBM test report no M100827/194: Fabric Type Still, Manufacturer Kvadrat A/S - Determination of airflow resistance according to EN ISO 9053-1. 2019-01-28

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 Still, color 791
- material 100 % Trevira CS

The testing laboratory has measured as follows:

- area specific mass: $m'' = 456 \text{ g/m}^2$
- thickness: t = 1.4 mm
- air flow resistance acc. to EN ISO 9053-1 [5]: $R_{\rm S}$ = 770 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 and a folded arrangement with a distance to the reflective wall of 100 mm.

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 60 mm
- a) flat arrangement
 - 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 three webs: two webs 1.47 m x 3.00 m and one web 0.60 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 = 3.50 m x 2.94 m
 - total test surface S = 10.29 m²
- b) folded arrangement
 - 100 % fabric addition
 - arranged in five webs: four webs 1.47 m x 3.00 m and one web 1.20 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 = 3.50 m x 2.94 m
 - total test surface S = 10.29 m²

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 onethird 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 onethird 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.

Ph. Mistra

M. Eng. Philipp Meistring (Project Manager)

7- - I- Hal

Jan-Lieven Moll (Responsible)

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Sound absorption coefficient ISO 354

| | M | | ment of sound abso | | |
|---|--|---|---|---|--|
| Client: Test spec | | Kvadrat DK-840 Curtain | A/S 0 Ebeltoft fabric Still by Kvadrat, | | 00 mm distance to reflective wall) |
| Material d • curtain S • material • area spec • airflow re • total thick | till, colo 100% T cific ma sistance | revira Čš ss <i>m"</i> = / e R _s = 7 | S 456 g/m² 70 Pa s/m | | |
| 20 mm ov • hanging o 100 mm o | ip made verlap a on a me clear dis | e of three t curtain etal rail a stance to | webs, two webs 1.47 m x splices t the ceiling of the reverber the wall, arranged without st surface: width x height | ration room in front t enclosing frame | |
| Room: E Volume: 19 Size: 10.29 Date of tes Frequency [Hz] | 9 m² | -03-04 α _p | | without specimen with specimen | θ [°C] r. h. [%] B [kPa] 19.2 33.1 94.0 19.2 33.3 94.0 |
| | 0.02 0.05 0.10 0.17 | 0.05 | 1.2 | Sound absorption | |
| 250 315 400 500 630 | 0.27 0.45 0.64 0.75 0.85 | 0.30 | Sound absorption coefficient α _S 8.0 8.0 8.0 8.0 8.0 8.0 | | |
| 800 1000 1250 | 0.94 0.94 0.89 | 0.90 | 6.0 bsorption 6 | | |
| 1600 2000 2500 3150 | 0.70 0.67 0.76 0.78 | 0.70 | de puno | | |
| 4000 5000 | 0.76 0.76 | 0.75 | 0.0 | 25 250 50 | 00 1000 2000 4000 Frequency f / Hz |
| α _p Practical s | Rating | accordi accordi and ab a _w = 0.6 | ifficient according to ISO 334 ng to ISO 11654: sorption coefficient 60 (<i>MH</i>) otion class: C | Noise Reduct | according to ASTM C423: tion Coefficient <i>NRC</i> = 0.65 rption Average SAA = 0.67 |

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Sound absorption coefficient ISO 354

| lient: | | Kvadrat DK-840 | | oft | | | | | | | | | | | | | | | | |
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| aterial c | letails | | | | | | | | | | | | | | | | | | | |
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| est arrai | ngemen | t | | | | | | | | | | | | | | | | | | |
| | up made | | | | | | | | | | | eb | 1.20 |) m | x 3.0 |)0 n | n, | | | |
| folded wi hanging | | | | | | | | | | | | nt o | far | efle | ctive | e wa | all. | | | |
| 100 mm | clear dis | tance to | the wa | all, arra | anged | withc | ut e | enclo | sing | g fra | ame | | | 00 | | | , | | | |
| total dim | ensions | of the te | st surfa | ace: w | /idth x | heigh | t = : | 3.50 | m > | x 2.9 | 94 m | ı | | | | | | | | |
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Fabric Type Still, 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.



Fabric Type Still, 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
- $A_{\rm T}$ equivalent sound absorption area of the test object in m²
- S area covered by the test object in m²
- V volume of the reverberation room in m³
- *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 $V = 199.6 \text{ m}^3$ and a surface of $S = 216 \text{ m}^2$.

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.

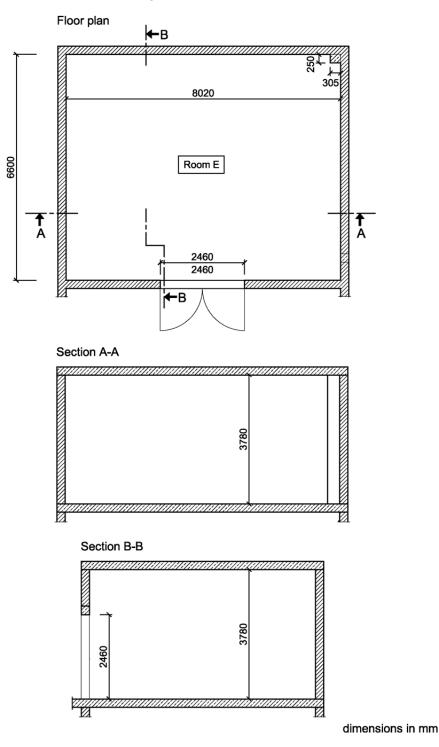


Figure C.1. Plan view and sections of the reverberation room.

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.

| | | Reverberation time <i>T</i> in | S | | | |
|-----------|---|----------------------------------|-------------------------------------|--|--|--|
| Frequency | T /with aut to at | T ₂ (with te | est object) | | | |
| in Hz | T ₁ (without test object) | Appendix A, page 1 G-100 flat | Appendix A, page 2, folded 100 % | | | |
| 100 | 5.09 | 4.95 | 4.62 | | | |
| 125 | 4.96 | 4.61 | 4.19 | | | |
| 160 | 5.29 | 4.51 | 3.83 | | | |
| 200 | 5.14 | 4.02 | 3.22 | | | |
| 250 | 5.24 | 3.62 | 2.83 | | | |
| 315 | 4.99 | 2.91 | 2.23 | | | |
| 400 | 5.36 | 2.55 | 2.06 | | | |
| 500 | 5.40 | 2.36 | 1.96 | | | |
| 630 | 5.28 | 2.18 | 1.89 | | | |
| 800 | 4.88 | 1.98 | 1.87 | | | |
| 1000 | 5.02 | 2.00 | 1.98 | | | |
| 1250 | 4.97 | 2.07 | 1.94 | | | |
| 1600 | 4.81 | 2.32 | 1.88 | | | |
| 2000 | 4.40 | 2.28 | 1.82 | | | |
| 2500 | 3.55 | 1.91 | 1.67 | | | |
| 3150 | 2.79 | 1.65 | 1.47 | | | |
| 4000 | 2.09 | 1.39 | 1.25 | | | |
| 5000 | 1.61 | 1.16 | 1.06 | | | |

Table C.1. Reverberation times.

List of test equipment

The test equipment used is listed in Table C.2.

Table C.2. Test equipment.

| Name | Manufacturer | Туре | 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 1.11 |