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M104146/09 RFD/STY

Fabric “SOUL”
Manufacturer Gabriel A/S

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

Test Report No. M104146/09

Client:	Gabriel A/S Hjulmagervej 55 9000 Aalborg Denmark
Consultant:	Dipl.-Ing. (FH) Dominik Reif Dipl.-Ing. (FH) Eva Müller
Date of report:	2015-02-20
Delivery date of test objects:	2015-01-28
Date of measurements:	2015-02-05
Total number of pages:	In total 13 pages: 6 pages text part, 1 page Appendix A, 1 page Appendix B, and 5 pages Appendix C.

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1 Task

On behalf of the company Gabriel A/S, 9000 Aalborg, Denmark, the sound absorption of the fabric type “SOUL” had to be measured according to EN ISO 354 [1] in the reverberation room. The fabric was tested in a flat arrangement with a distance of 100 mm to the reflective wall. The results are to be evaluated according to EN ISO 11654 and ASTM C 423-09a [3] [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] ISO 9613-1: Acoustics; Attenuation of sound during propagation outdoors; part 1: calculation of the absorption of sound by the atmosphere. 1993-06

[3] EN ISO 11654: Acoustics – Sound absorbers for use in buildings – Rating of sound absorption. 1997-04

[4] ASTM C 423-09a: Standard Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method. Revision: 09a. 2009-10

[5] EN 29053: Acoustics – Materials for acoustical applications – Determination of air flow resistance. 1993-03

3 Test object and test assembly

3.1 Test object

The tested material is described by the manufacturer as follows:

- manufacturer Gabriel A/S
- type SOUL, color 60097
- single layer, material 100 % wool

The testing laboratory has measured as follows:

- area specific mass m = 192 g/m^2
- thickness t = 0.85 mm
- air flow resistance according to EN 29053 [5] R_s = 94 Pa s/m

3.2 Test assembly

The installation of the test object was carried out by employees of the test laboratory in the reverberation room of Müller-BBM. The test object was installed in a flat (G-100) arrangement.

The mounting details 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

The mounting details for the tested arrangement are as follows:

- flat arrangement, mounting type: G-100, according to EN ISO 354 [1], section 6.2.1, and appendix B.5 of EN ISO 354
- arranged in three curtains, overlapping approx. 20 mm
- total dimension of the test surface (starting at the lower border of the metal rail): width x height = 3.48 m x 2.95 m
- total test surface S = 10.27 m^2

The photographs in Appendix B show details of the test arrangement.

4 Execution of the measurements

The measurements of sound absorption in the reverberation room were effected and evaluated according to EN ISO 354 [1].

The test method, the test facility and the test equipment used 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 [3]:

- 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 423-09a [1] 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 certificate in Appendix A.

7 Remarks

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

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DAkkS
Deutsche
Akkreditierungsstelle
D-PL-14119-07-00

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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: Gabriel A/S, Hjulmagervej 55, 9000 Aalborg, Denmark

Test specimen: Fabric "SOUL" - Gabriel A/S,
Mounting type G-100, flat arrangement

Material details

- manufacturer Gabriel A/S
- fabric type "SOUL", colour: 60097
- single layer, material 100% wool
- area specific mass m'' = 192 g/m²
- air flow resistance R_S = 94 Pa s/m
- thickness t = 0.85 mm

Tested construction

-	0.85 mm	fabric "SOUL"
-	100 mm	air gap
-		reflective wall

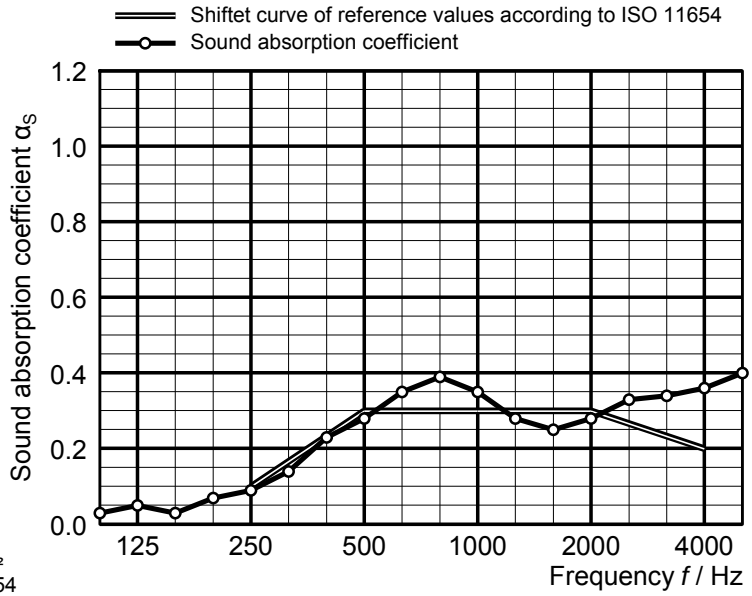
Mounting

- mounting type G-100, distance to the wall 100 mm, arranged without enclosing frame
- arranged flat: 3 curtains, overlap approx. 20 mm
- total dimensions of the test surface: width x height = 3.48 m x 2.95 m

Room: Hallraum E
Volume: 199.60 m³
Size: 10.27 m²
Date of test: 2015-02-05

	θ [°C]	r. h. [%]	*B* [kPa]
without specimen	16.8	36.0	94.7
with specimen	17.0	37.7	94.7

Frequency [Hz]	α_S 1/3 octave	α_p octave
100	∘ 0.03	
125	∘ 0.05	0.05
160	∘ 0.03	
200	∘ 0.07	
250	∘ 0.09	0.10
315	0.14	
400	0.23	
500	0.28	0.30
630	0.35	
800	0.39	
1000	0.35	0.35
1250	0.28	
1600	0.25	
2000	0.28	0.30
2500	0.33	
3150	0.34	
4000	0.36	0.35
5000	0.40	



∘ 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 = 0.30	**Noise Reduction Coefficient *NRC* = 0.25**
Sound absorption class: D	**Sound Absorption Average *SAA* = 0.25**

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Planegg, 2015-02-20
No. of test report M104146/9

Fabric “SOUL”, manufacturer Gabriel A/S

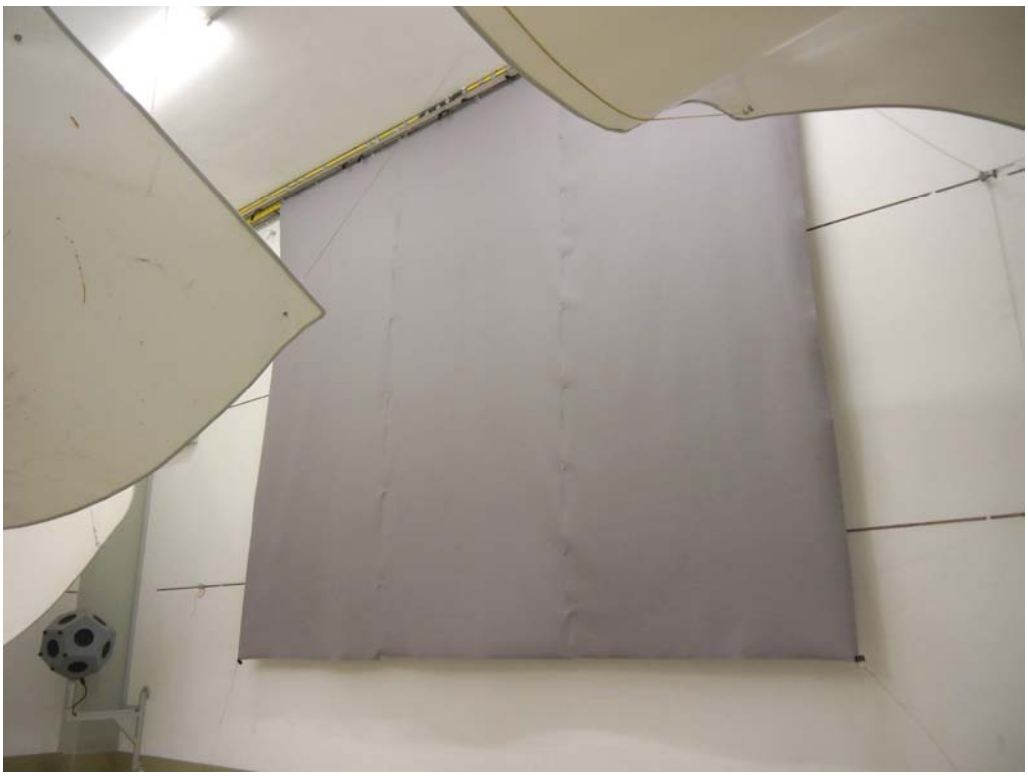

Figure B1. Flat arrangement, test object mounted in the reverberation room.

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 dissipation was calculated according to ISO 9613-1 [2]. 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.

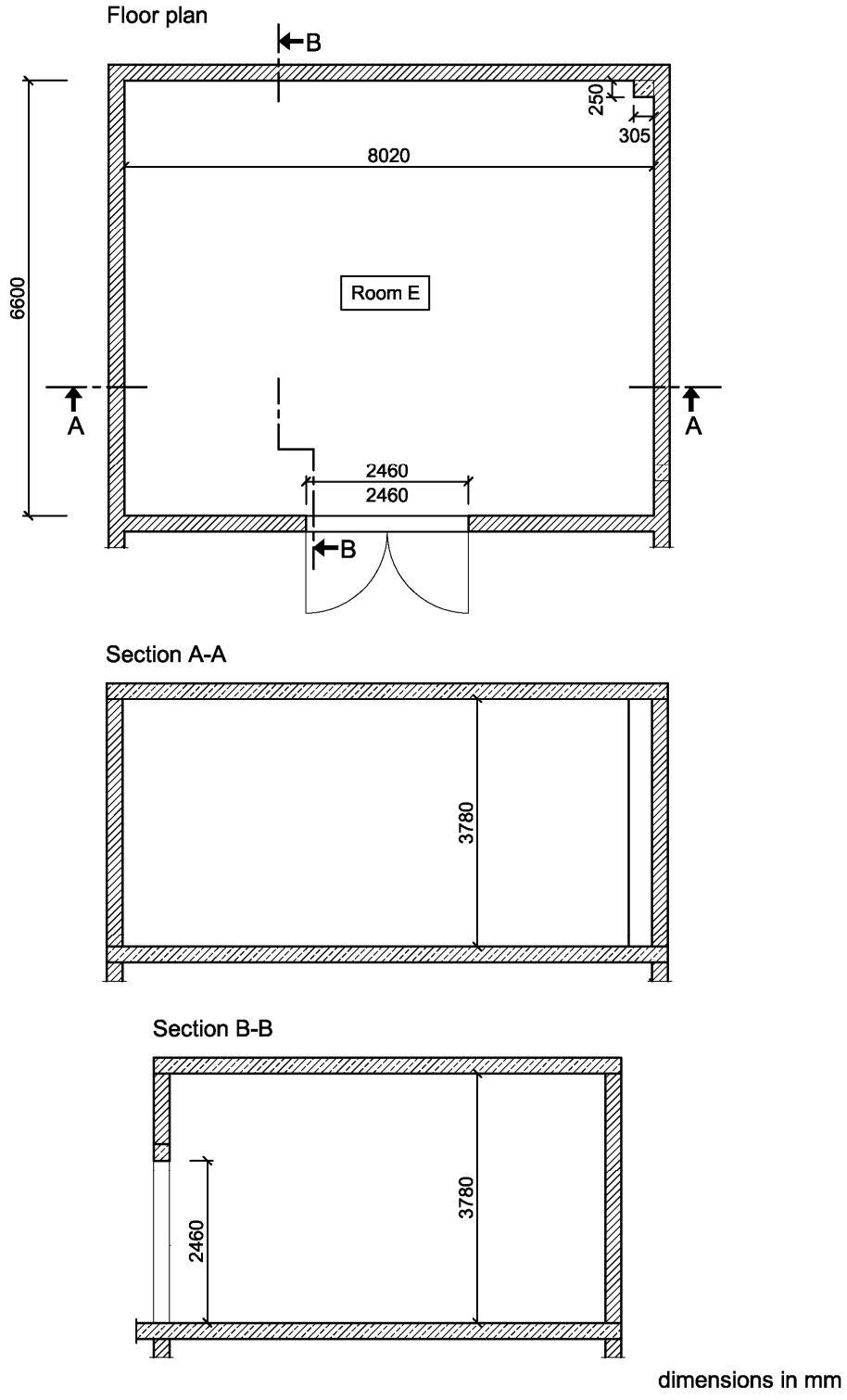

Figure C1. Plan view and sections of the reverberation room.

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 a backward integrated impulse response.

The determined reverberation times in the reverberation room with and without test object are indicated in table C1.

Table C.1. Reverberation times without and with test objects.

Frequency *f* in Hz	**Reverberation time *T* in s**	
	T_1 (without test object)	**T_2 (with test object)**
100	4.94	4.74
125	5.00	4.63
160	5.38	5.08
200	5.47	4.91
250	5.19	4.52
315	5.19	4.19
400	5.56	3.97
500	5.38	3.62
630	5.20	3.29
800	5.04	3.12
1000	5.20	3.31
1250	5.25	3.61
1600	5.06	3.65
2000	4.45	3.21
2500	3.67	2.69
3150	2.88	2.24
4000	2.15	1.77
5000	1.59	1.36

2.3 List of test equipment

The test equipment used is listed in table C2 below.

Table C2. Test equipment.

Name	Manufacturer	Type	Serial-No.
AD-/DA-converter	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
Microphone	Microtech	M360	1783
Microphone	Microtech	M360	1785
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 1.7