

Müller-BBM GmbH
Robert-Koch-Str. 11
82152 Planegg bei München

Telephone +49(89)85602 0
Telefax +49(89)85602 111

www.MuellerBBM.de

Dipl.-Ing. (FH) Eva Müller
Telephone +49(89)85602 3206
Eva.Mueller@mbbm.com

2014-03-11
M112214/01 MRE/KRR

Renolit stretch ceilings

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

Test Report No. M112214/01

Client:	Renolit SE Horchheimer Str. 50 67547 Worms
Consultant:	Dipl.-Ing. (FH) Eva Müller
Date of report:	2014-03-11
Delivery date test objects:	2014-03-03
Date of testing:	2014-03-03
Total number of pages:	In total 11 pages, thereof 5 pages text, 1 page Appendix A, 1 page Appendix B and 4 pages Appendix C.

Certified quality management system according to ISO 9001
Accredited testing laboratory according to ISO/IEC 17025

Müller-BBM GmbH
HRB Munich 86143
VAT Reg. No. DE812167190

Managing directors:
Dr. Carl-Christian Hantschk,
Stefan Schierer, Dr. Edwin Schorer,
Elmar Schröder, Norbert Suritsch

Table of contents

1	Task	3
2	Basis	3
3	Test assembly and test objects	3
3.1	Test assembly	3
3.2	Test object	3
4	Execution of the measurements	4
5	Evaluation	4
6	Measurement results	5
7	Remarks	5

Appendix A: Test certificate

Appendix B: Pictures

Appendix C: Description of test method, test facility and test equipment

1 Task

On behalf of the company Renolit SE in 67547 Worms, Germany, the sound absorption coefficient of a stretch ceiling, type „RENOLIT Stretch Ceiling Film PRODECO 10.40.72 M-PERF“ was to be determined by measurements in the reverberation room according to EN ISO 354 [1].

The results are to be evaluated according to EN ISO 11654 [3] and ASTM C 423-09a [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. June 1993
- [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

3 Test assembly and test objects

3.1 Test assembly

The test construction was mounted as type E-100 according to EN ISO 354 [1], Appendix B.4.

The test object was assembled in the reverberation room by the client on the day of measurement.

Information on the test assembly is also included in the test certificate in Appendix A. Appendix B shows photographs of the test assembly.

3.2 Test object

The test object can be described as follows (top down):

- 0.17 mm stretch ceiling film type „RENOLIT Stretch Ceiling Film PRODECO 10.40.72 M-PERF“
- 20 mm air gap
- 80 mm mineral wool
- floor of reverberation room

Details of the materials used are known to the test laboratory.

The test object was enclosed by a circumferential frame which also acted as supporting structure for the stretch ceiling. The enclosing frame was made of 19 mm coated MDF-boards. The joints between the test object and the enclosing frame as well as between the enclosing frame and the floor of the reverberation room were sealed with adhesive tape.

The total dimensions of the test assembly (without frame) were length x width = 3962 mm x 2965 mm.

Dimensions as indicated above were determined on samples by the testing laboratory.

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 D.

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 refer to the conditions on the day of measurements.

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



M.Eng. Philipp Meistring



Dipl.-Ing. (FH) Eva Müller



Durch die DAkkS Deutsche Akkreditierungsstelle GmbH
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: Renolit SE
Horchheimer Str. 50, 67547 Worms, Germany

Test specimen: Renolit stretch ceiling type "RENOLIT Stretch Ceiling Film PRODECO 10.40.72 M-PERF" with 80 mm mineral wool

description of test specimen (top down):

- 0.17 mm stretch ceiling film type „RENOLIT Stretch Ceiling Film PRODECO 10.40.72 M-PERF“
- 20 mm air gap
- 80 mm mineral wool
- floor of reverberation room

Details of the materials used are known to the test laboratory.

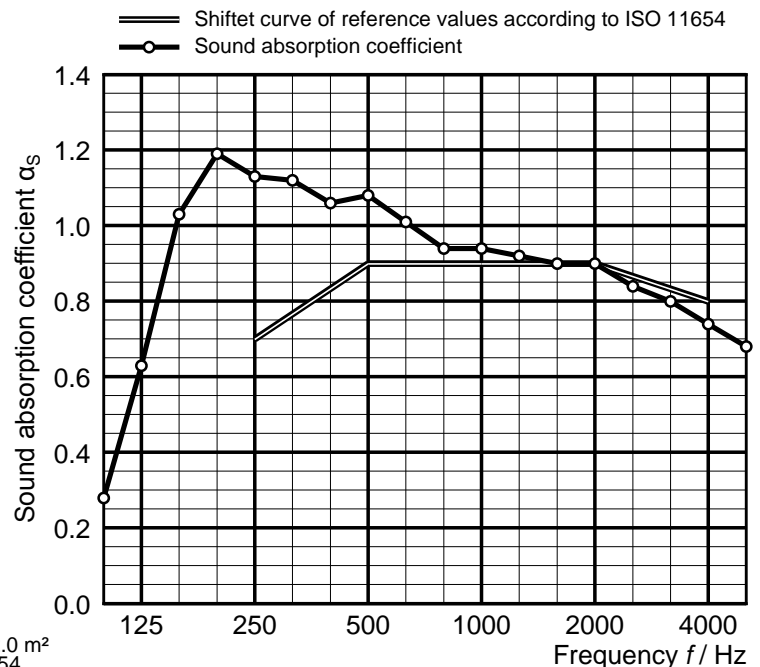
The test object was enclosed by a circumferential frame which also acted as supporting structure for the stretch ceiling. The enclosing frame was made of 19 mm coated MDF-boards. The joints between the test object and the enclosing frame as well as between the enclosing frame and the floor of the reverberation room were sealed with adhesive tape.

The total dimensions of the test assembly (without frame) were length x width = 3962 mm x 2965 mm. Dimensions as indicated above were determined on samples by the testing laboratory.

Room: E
Volume: 199.60 m³
Size: 11.75 m²
Date of test: 2014-03-03

	θ [°C]	r. h. [%]	B [kPa]
without specimen	18.7	56.6	93.1
with specimen	20.9	49.3	93.0

Frequency [Hz]	α_s 1/3 octave	α_p octave
100	0.28	
125	0.63	0.65
160	• 1.03	
200	• 1.19	
250	• 1.13	1.00
315	• 1.12	
400	• 1.06	
500	• 1.08	1.00
630	1.01	
800	0.94	
1000	0.94	0.95
1250	0.92	
1600	0.90	
2000	0.90	0.90
2500	0.84	
3150	0.80	
4000	0.74	0.75
5000	0.68	



• Equivalent sound absorption area greater than 12.0 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 $\alpha_w = 0.90$ (L) Sound absorption class: A	Rating according to ASTM C423: Noise Reduction Coefficient $NRC = 1.00$ Sound Absorption Average $SAA = 1.00$
--	---

Renolit stretch ceiling

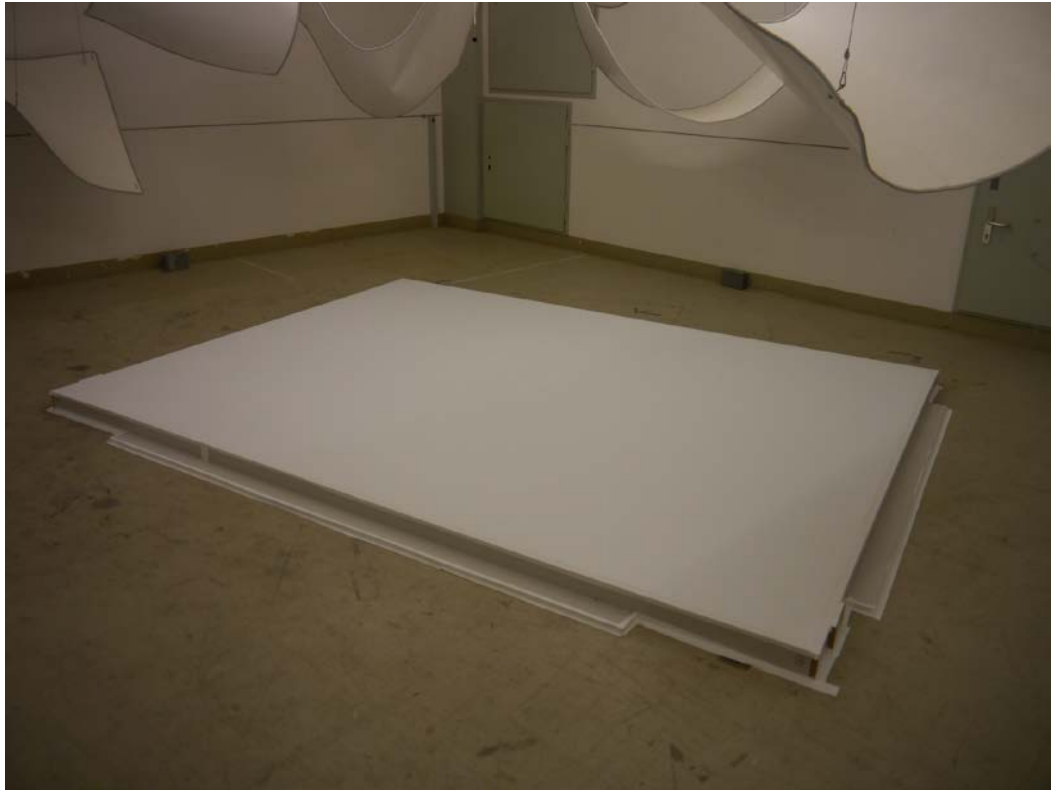


figure B1. test specimen in the reverberation room

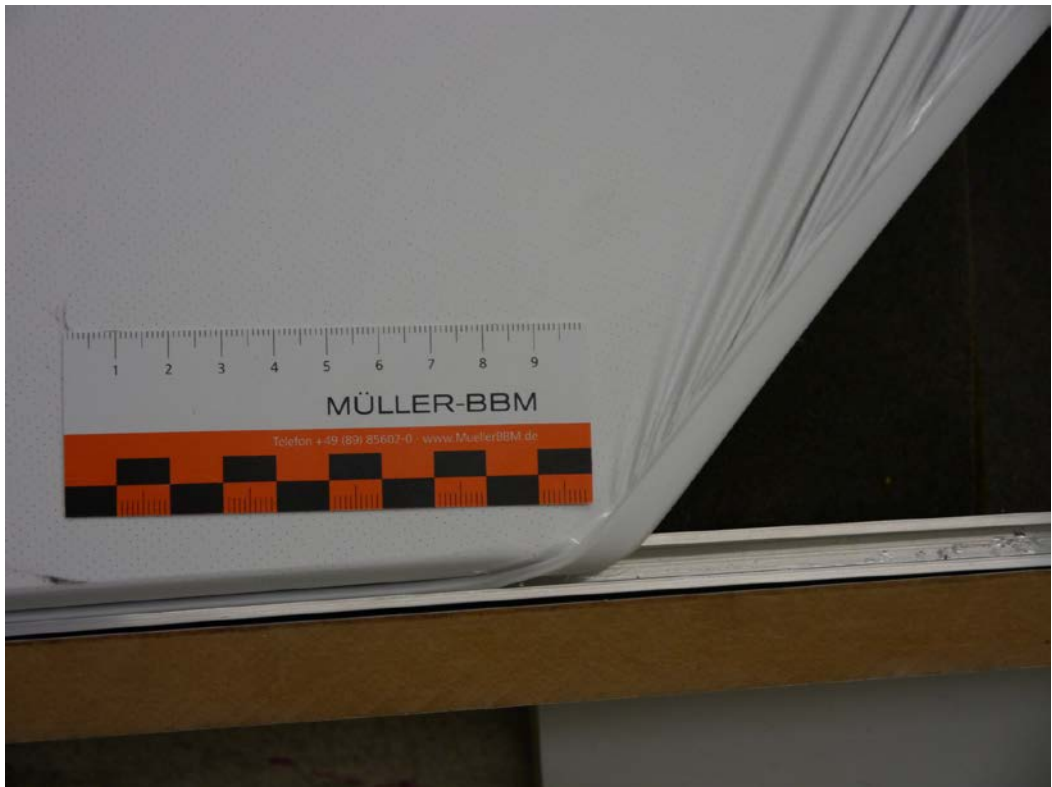


figure B2. detail of stretch ceiling, supporting construction

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 D.1 shows the drawings of the reverberation room.

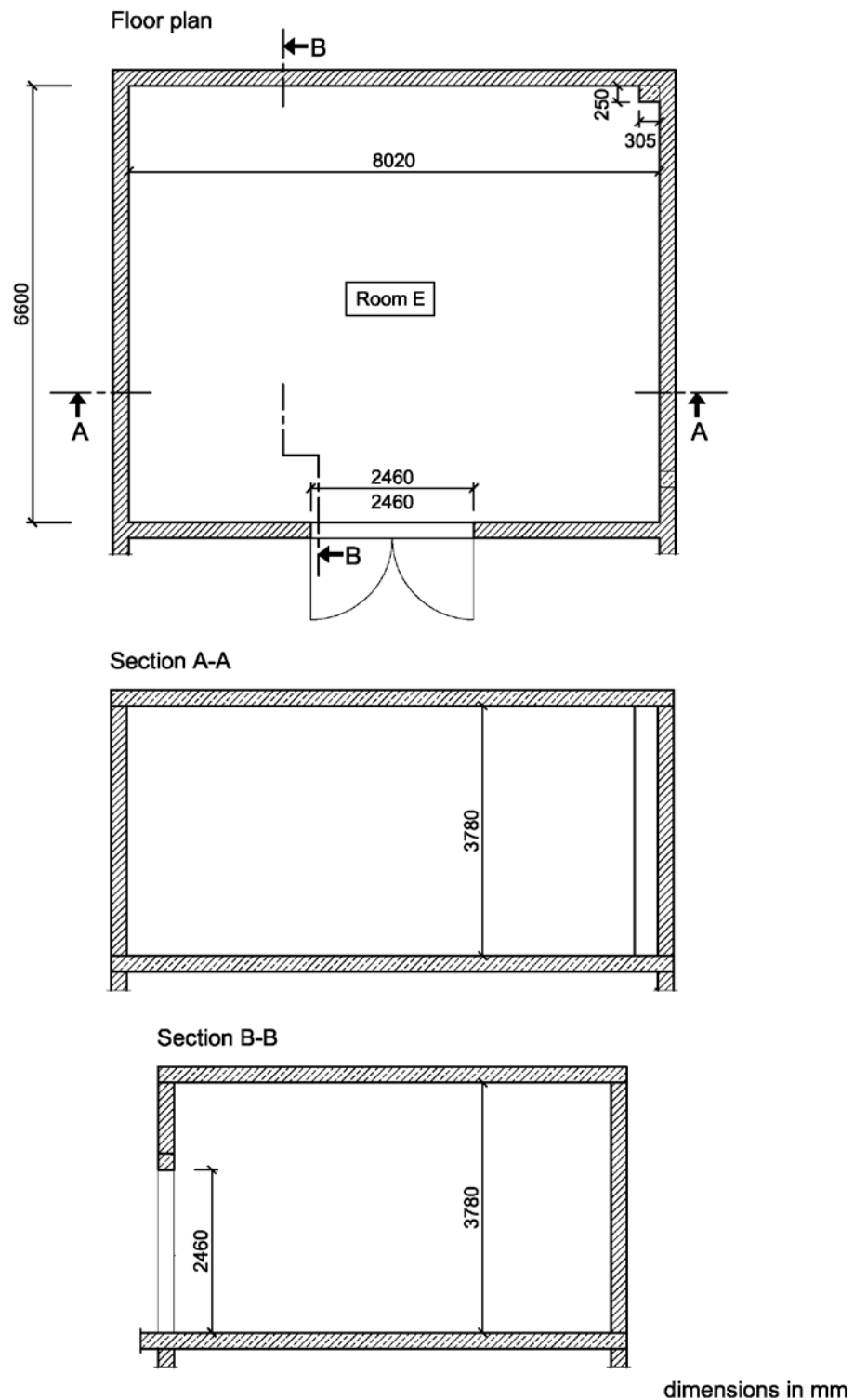


Figure D1. Plan view and sections of the reverberation room.

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 D1.

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

Frequency in Hz	Reverberation time T in s	
	T_1 (without test object)	T_2 (with test object)
100	5.06	3.33
125	5.10	2.34
160	5.20	1.76
200	5.46	1.61
250	5.07	1.63
315	5.04	1.65
400	5.32	1.74
500	5.33	1.71
630	5.21	1.78
800	4.98	1.83
1000	5.23	1.86
1250	5.43	1.91
1600	5.37	1.93
2000	4.93	1.87
2500	4.32	1.84
3150	3.57	1.73
4000	2.82	1.58
5000	2.20	1.40

2.3 List of test equipment

The test equipment used is listed in Table D.2

Table D.2. List of test equipment.

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
Microphone	Microtech	M360	1783
Microphone	Microtech	M360	1785
Microphone	Microtech	M360	1786
Microphone	Microtech	M360	1787
Microphone	Microtech	M360	1788
Microphone	Microtech	M360	1789
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 1.6