MÜLLER-BBM
BUILDING SOLUTIONS

Müller-BBM Building Solutions GmbH
Helmut-A.-Müller-Straße 1 - 5
82152 Planegg

Telephone +49(89)3540486 0
Telefax +49(89)999507 62

www.mbbm-bso.com

M. Eng. Philipp Meistring
Telephone +49(89)3540486 38
philipp.meistring@mbbm-bso.com

2024-06-03
B174328/01 Version 1 MSG/STEG

Whisper® NBO-80-A4

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

Test Report No. B174328/01

Client:	Sealed Air SRL Via Europa 15 20882 Bellusco MB ITALY
Consultant:	M. Eng. Philipp Meistring
Report date:	2024-06-03
Delivery of the test objects:	2024-04-02
Test date:	2024-04-04
Total amount of pages	17 pages, thereof 7 pages text, 1 page Appendix A 3 pages Appendix B 6 pages Appendix C

Müller-BBM Building Solutions GmbH
HRB Munich 278753
VAT No. DE355267779

Managing Directors:
Stefan Schierer, Elmar Schröder

Table of contents

1 Task

On behalf of the company Sealed Air SRL, Italy, the sound absorption coefficient of the panels “Whisper® NBO-80-A4” was to be determined by measurements in the reverberation room according to DIN EN ISO 354 [1].

The results are to be evaluated for room acoustic applications according to DIN EN ISO 11654 [2] and ASTM C 423 [3].

In addition, the measurement results are to be used for an indicative calculation of the single-number values for traffic noise reducing devices at roads and railways according to DIN EN 1793-1 [6][7] and DIN EN 16272-1 [9][10].

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 423-22: Standard Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method. Revision: 22. 2022-03.

[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] DIN EN ISO 12999-2: Acoustics – Determination and application of measurement uncertainties in building acoustics – Part 2: Sound absorption (ISO 12999-2:2020); German version EN ISO 12999-2:2020. 2020-11

[6] DIN EN 1793-1: Road traffic noise reducing devices - Test method for determining the acoustic performance - Part 1: Intrinsic characteristics of sound absorption; German version EN 1793-1:2012. 2013-04.

[7] DIN EN 1793-1: Road traffic noise reducing devices - Test method for determining the acoustic performance - Part 1: Intrinsic characteristics of sound absorption under diffuse sound field conditions; German version EN 1793-1:2017. 2017-07.

[8] DIN EN 1793-3: Road traffic noise reducing devices - Test method for determining the acoustic performance - Part 3: Normalised traffic noise spectrum; German version EN 1793-3:1997. 1997-11

[9] DIN EN 16272-1: Railway applications - Track - Noise barriers and related devices acting on airborne sound propagation - Test method for determining the acoustic performance - Part 1: Intrinsic characteristics - Sound absorption in the laboratory under diffuse sound field conditions; German version EN 16272-1:2012. 2013-01.

[10] DIN EN 16272-1: Railway applications - Infrastructure - Noise barriers and related devices acting on airborne sound propagation - Test method for determining the acoustic performance - Part 1: Intrinsic characteristics – Sound absorption under diffuse sound field conditions; German version EN 16272-1:2023. 2024-02

[11] DIN EN 16272-3-1: Railway applications - Infrastructure - Noise barriers and related devices acting on airborne sound propagation - Test method for determining the acoustic performance - Part 3-1: Normalized railway noise spectrum and single number ratings for diffuse sound field applications; German version EN 16272-3-1:2023. 2024-02.

3 Test assembly and test objects

3.1 Test objects

The tested material is described by the manufacturer as follows:

- designation: Whisper® NBO-80-A4
- material: closed-cell honeycomb-like foam made of low density polyethylene
- format: panels, nominal thickness 80 mm

The following masses and dimensions were determined by the testing laboratory on samples of the test material:

- thickness t = 85 mm
- area specific mass: m'' = 2.07 kg/m²

3.2 Test assembly

The test setup was carried out according to DIN EN ISO 354 [1], section 6.2.1 in mounting type A according to Appendix B.

Test objects were assembled in the reverberation room by the client on the day of measurement.

The panels were jointed bluntly and were placed directly on the concrete floor. The test set-up was made of nine panels (six panels 1220 mm x 1025 mm, three panels 1220 mm x 950 mm).

The test surface had the dimensions length x width = 3.00 m x 3.66 m = 10.98 m² excluding enclosing frame.

The test object was enclosed by a lateral circumferential frame made of 19 mm coated wooden boards. The height of the frame was 85 mm.

The joints between the test objects and the enclosing frame as well as between the enclosing frame and the floor of the reverberation room were sealed with adhesive tape.

Further information on the test assembly is included in the test certificate in Appendix A. Appendix B shows photos of the test assembly.

4 Test method

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

The test method, the test facility and the test equipment used are described in Appendix C.

5 Evaluation

5.1 Room acoustic application

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 to the sound absorption coefficients 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 [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

5.2 Traffic noise reducing devices

On the basis of the test results according to DIN EN ISO 354 [1] the following single-number values were derived for an assessment of the sound absorption characteristics of the material for its application in noise traffic reducing devices in diffuse sound fields at roads and railways:

- Road applications
  using the road traffic noise spectrum according DIN EN 1793-3 [8]:
  1. DL_{α} according to DIN EN 1793-1, issue 2013 [6]
  2. $DL_{\alpha,NRD}$ according to DIN EN 1793-1, issue 2017 [7]

  Railway applications
  using the railway traffic noise spectrum according DIN EN 16272-3-1 [11]:
  3. DL_{α} according to DIN EN 16272-1, issue 2013 [9]
  4. $DL_{\alpha,NRD}$ according to DIN EN 16272-1, issue 2024 [10]

Notes:

- As a basis for determination of the single-numbers $DL_{\alpha,NRD}$ the sound absorption coefficients α_S was transformed into the corresponding values $\alpha_{S,NRD}$ (see Appendix C).
- The material under test was applied without any structural component. The determined single-number values are therefore specific for the material itself but not for any ready-to-use noise traffic reducing device filled with the material.

6 Measurement results

6.1 Room acoustics

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.

6.2 Traffic noise reducing devices

The indicative single-number values for an assessment of the sound absorption characteristics of the material for its application in noise traffic reducing devices in diffuse sound fields at roads and railways railway applications according to DIN EN 1793-1 [6][7] and DIN EN 16272-1 [9][10] are shown in Table 1.

Table 1. Evaluation of the test results for noise barrier applications: single number values.

Test setup	Road application DIN EN 1793-1		Railway application DIN EN 16272-1	
	until issue 2013 [6]	from issue 2017 [7]	until issue 2013 [9]	from issue 2024 [10]
	DL_{α}	$DL_{\alpha,NRD}$	DL_{α}	$DL_{\alpha,NRD}$
Whisper® NBO-80-A4	14 dB	14 dB	16 dB	15 dB

6.3 Measurement uncertainty

Information on the measurement uncertainties (repeatability and reproducibility) are given in Appendix C. Measurement uncertainties were not considered for attribution of the classes of sound absorption according to 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)

Sound absorption coefficient ISO 354

Measurement of sound absorption in reverberation rooms

Client: Sealed Air srl
Via Europa, 15 | 20882 Bellusco (MB) | Italy

Test specimen: Whisper® NBO-80-A4
Mounting type A

Description of the test object

Information provided by the client:

- designation: Whisper® NBO-80-A4
- material: closed-cell honeycomb-like foam made of low density polyethylene
- format: panels, nominal thickness 80 mm

Properties determined by the testing laboratory at samples from test material:

- thickness: t = 85 mm
- area specific mass: m'' = 2.07 kg/m²

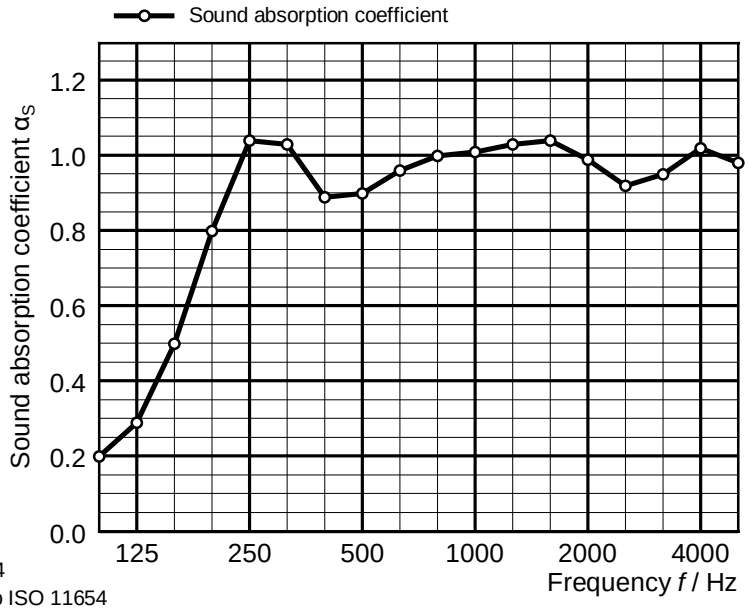
Test set-up:

- ISO 354 mounting type A
- set-up made of 9 panels (6 panels 1220 mm x 1025 mm, 3 panels 1220 mm x 950 mm)
- panels jointed bluntly, placed directly on the concrete floor
- enclosing frame made of 19 mm wooden boards
- joints between frame and floor as well as between frame and test object sealed with adhesive tape
- test surface within the frame w x l = 3.00 m x 3.66 m

Room: E
Volume: 199.60 m³
Size: 10.98 m²
Date of test: 2024-04-04

	θ [°C]	*r. h.* [%]	*B* [kPa]
without specimen	21.1	42.0	94.9
with specimen	21.1	41.5	94.9

Frequency [Hz]	α_S 1/3 octave	α_p octave
100	0.20	
125	0.29	0.35
160	0.50	
200	0.80	
250	1.04	0.95
315	1.03	
400	0.89	
500	0.90	0.90
630	0.96	
800	1.00	
1000	1.01	1.00
1250	1.03	
1600	1.04	
2000	0.99	1.00
2500	0.92	
3150	0.95	
4000	1.02	1.00
5000	0.98	



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 = 1.00	**Noise Reduction Coefficient *NRC* = 1.00**
Sound absorption class: A	**Sound Absorption Average *SAA* = 0.97**

MÜLLER-BBM

Planegg, 2024-06-03
No. of test report B174328/1

Appendix A
Page 1

Whisper® NBO-80-A4

Figure B.1. Surface of the test material.

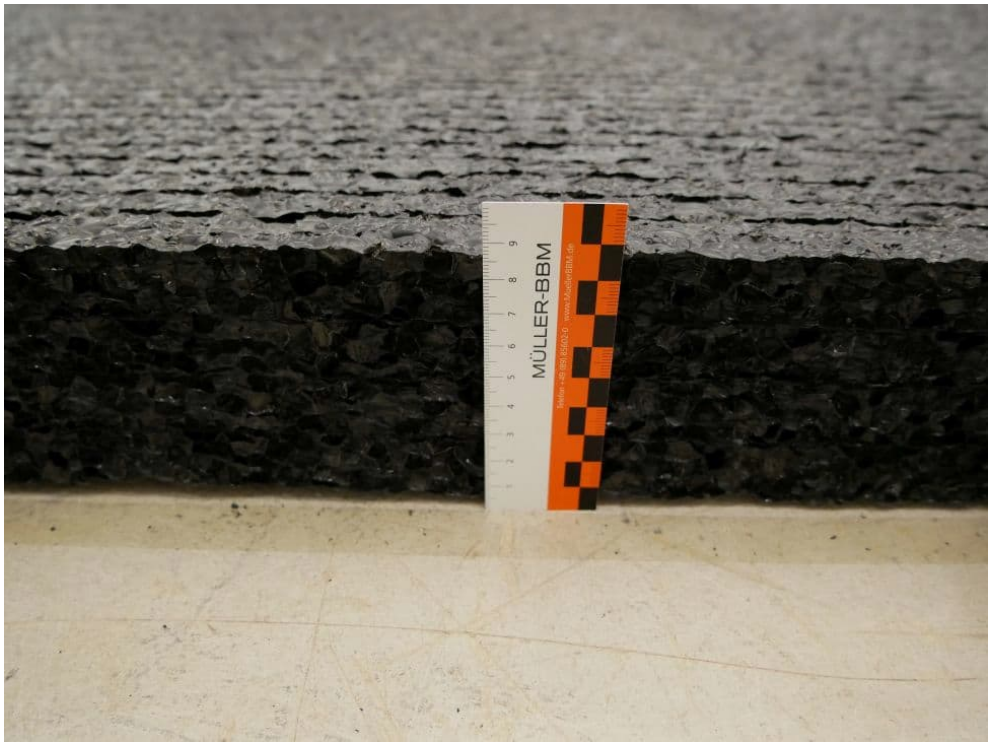


Figure B.2. Section of the test material.

Whisper® NBO-80-A4

Figure B.3. Test set-up: Panels placed directly on the concrete floor, jounted bluntly.

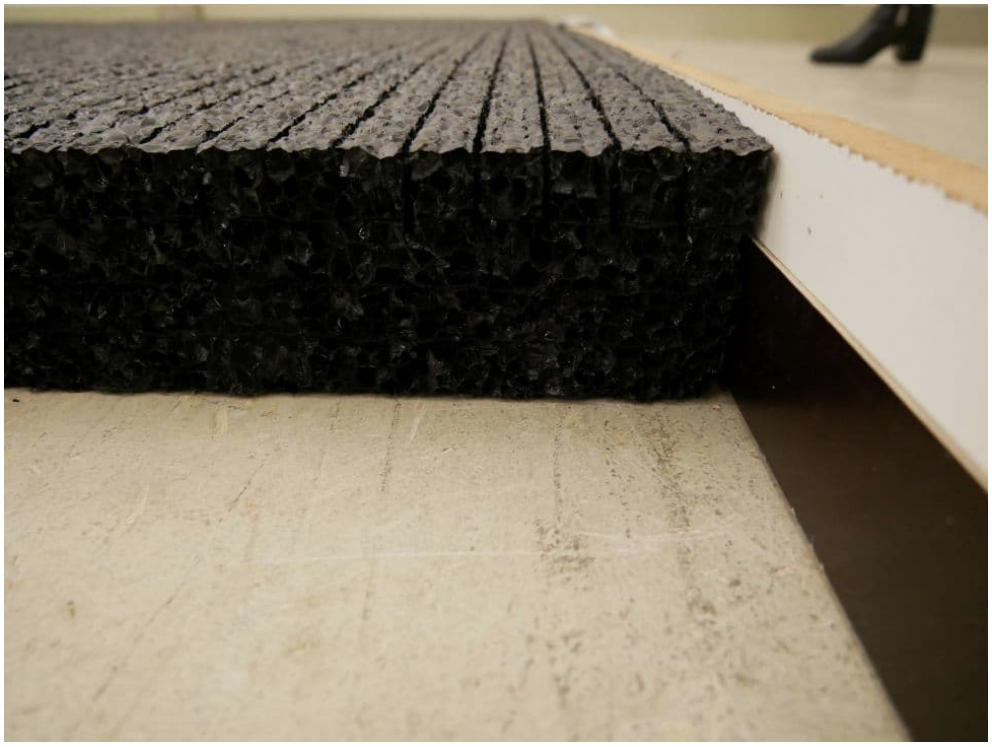


Figure B.4. Test set-up: Panels placed directly on the concrete floor, enclosing frame at lateral edges of the test set-up.

Whisper® NBO-80-A4

Figure B.5. Test set-up: joints to enclosing frame sealed with tape.

Figure B.6. Total view of the test set-up ready-for-test.

Description of the test procedure for the determination of the sound absorption in a reverberation room

1 Measurand

1.1 Sound absorption coefficient α_S

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 of the test object was the area covered by the test object.

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 calculation of the power attenuation coefficients was effected according to ISO 9613-1 [4]. The climatic conditions during the measurements are indicated in the test certificates.

1.2 Sound absorption coefficient α_{NRD}

The sound absorption coefficient α_{NRD} 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:

$$\alpha_{NRD} = \frac{A_T}{S}$$

$$A_T = 55.3\left(\frac{V_2}{c_2 T_2} - \frac{V_1}{c_1 T_1}\right) - 4\,(V_2 m_2 - V_1 m_1)$$

With:

α_{NRD} sound absorption coefficient of a traffic noise reducing device;

A_T equivalent sound absorption area of the test object in m^2;

S area covered by the test object in m^2;

V_1 volume of the empty reverberation room in m^3;

V_2 volume of the reverberation room with test object in m^3; $V_2 = V_1 - V_S$

V_S volume of the test object incl. enclosing frame 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}.

1.3 Uncertainties

Information on the repeatability and reproducibility of the test procedure are given in DIN EN ISO 354 [1] and DIN EN ISO 12999-2 [5]. In [5] for the single-number α_w a standard deviation of reproducibility of $\sigma_R = 0.035$ is indicated. This value was determined from reproducibility data of the test method based on round robin tests and describes the reproducibility of test results that was determined in test laboratories for similar constructions. An aspired confidence level of 95 % results in a coverage factor of $k = 2.0$ and an expanded uncertainty of $U = \pm 0.07$ for the weighted sound absorption coefficient α_w.

For the single value DL_α and $DL_{\alpha,NRD}$ a standard deviation of reproducibility of $\sigma_R = 0{,}1 \cdot DL_\alpha$ is specified in DIN EN ISO 12999-2 [5]. This value corresponds to the standard uncertainty of reproducibility determined in round robin tests and describes the standard uncertainty of test results obtained on the test facility for a component under reproducibility conditions. DIN EN 1793-1 [6][7] and DIN EN 16272-1 [9][10], Appendix A generally specifies a confidence level of 95 % to be aimed for. This results in a coverage factor of $k = 2.0$, and for the measurement result of the reported test, the result is as follows:

Table C.1. Measurement uncertainty for evaluation of the test results for noise barrier applications, $k = 2.0$, both-sided

Test setup	**Road application DIN EN 1793-1**		**Railway application DIN EN 16272-1**	
	until issue 2013 [6]	**from issue 2017 [7]**	**until issue 2013 [9]**	**from issue 2024 [10]**
	$\boldsymbol{DL_\alpha}$	$\boldsymbol{DL_{\alpha,NRD}}$	$\boldsymbol{DL_\alpha}$	$\boldsymbol{DL_{\alpha,NRD}}$
Whisper® NBO-80-A4	(14.4 ± 2.9) dB	(13.5 ± 2.7) dB	(16.4 ± 3.3) dB	(15.0 ± 3.0) dB

According to DIN EN 1793-1 [6][7] and DIN EN 16272-1 [9][10] the single number DL_α / $DL_{\alpha,NRD}$ as indicated in the test report were calculated with one decimal and rounded to whole dBs. For the indication of measurement uncertainty, single numbers were calculated with two decimals and rounded to one decimal.

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.

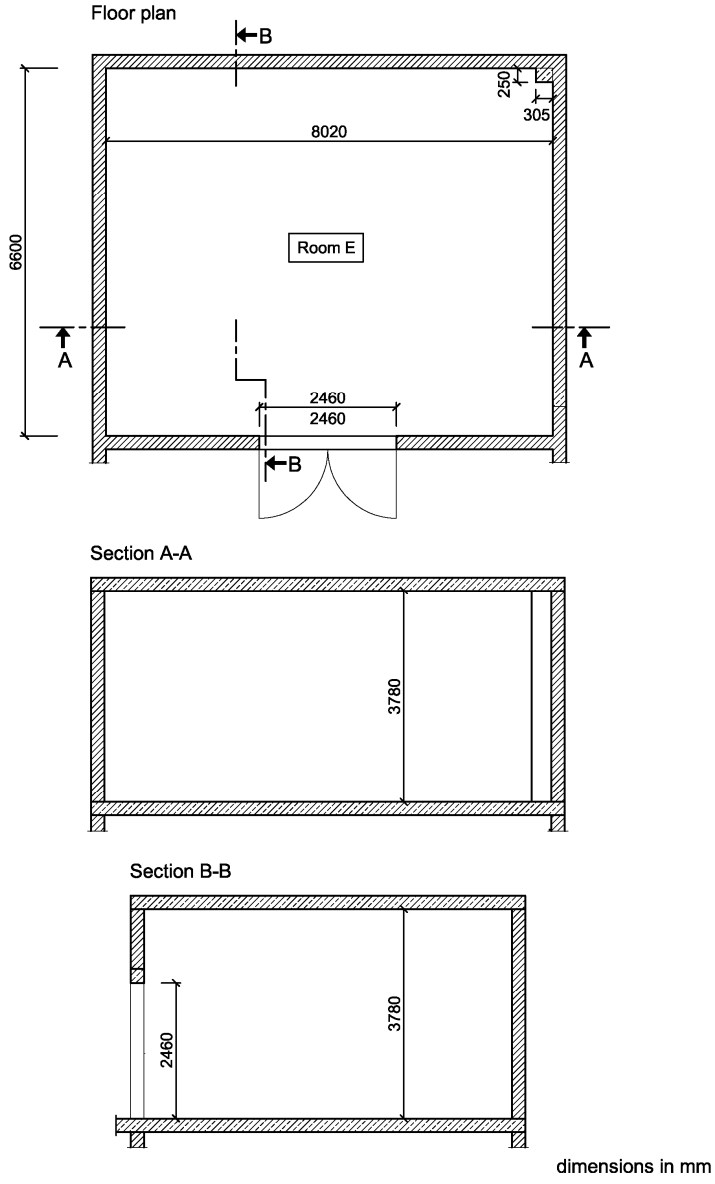


Figure C.1. Plan view and sections of the reverberation room.

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 a backward integrated impulse response.

The determined reverberation times in the reverberation room with and without test object are indicated in table C.2.

Table C.2. 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	5.63	4.09
125	5.92	3.73
160	6.12	2.99
200	5.21	2.14
250	5.63	1.87
315	5.45	1.86
400	5.53	2.07
500	5.50	2.04
630	5.25	1.93
800	5.03	1.85
1000	5.09	1.84
1250	5.16	1.84
1600	5.04	1.81
2000	4.73	1.82
2500	3.96	1.76
3150	3.24	1.57
4000	2.52	1.34
5000	2.00	1.20

2.3 List of test equipment

The test equipment used is listed in Table C.3.

Table C.3. Test equipment.

Name	Manufacturer	Type	Serial-No.
AD-/DA-converter	RME	Fireface 802	23811470
Amplifier	APart	Champ 2	17120171
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	057.0410.0003.9.4.1.30
Software for measurement and evaluation	Müller-BBM	Bau 4	Version 1.11
Electronic balance	Kern	DE120K10N	WD200002751