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B169497/02 Version 2 MSG/STEG

## **Fabric WHISPER air**

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

**Test Report No. B169497/02**

Client:	Annette Douglas Textiles AG Klosterstrasse 42 5430 Wettingen Switzerland
Consultant:	M. Eng. Philipp Meistring
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## 1 Task

On behalf of the company Annette Douglas Textiles AG, 5430 Wettingen, Switzerland, the sound absorption of the fabric WHISPER air had to be measured according to EN ISO 354 [1] in the reverberation room. The fabric was tested in a flat and a folded arrangement with a distance of 150 mm to the reflective wall.

## 2 Basis

This test report is based on the following documents (issue at the date of measurement):

- [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] ASTM C 423-09a: Standard Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method. Revision: 09a
- [4] ISO 9613-1: Acoustics; Attenuation of sound during propagation outdoors; part 1: calculation of the absorption of sound by the atmosphere. June 1993
- [5] EN 29053: Acoustics – Materials for acoustical applications – Determination of airflow resistance. March 1993

## 3 Test object and test assembly

### 3.1 Test object

The tested material is described by the manufacturer as follows:

- curtain fabric WHISPER air
- material 100 % PES-FR

The testing laboratory has measured as follows:

- thickness:  $t = 0.30 \text{ mm}$
- air flow resistance acc. to EN 29053 [5]:  $R_s = 158 \text{ Pa}\cdot\text{s/m}$
- area specific mass:  $m'' = 88 \text{ g/m}^2$

### 3.2 Test assembly

The installation of the test objects was carried out by employees of the test laboratory in the reverberation room of Müller-BBM. The test objects were installed in a flat and a folded arrangement.

Both arrangements were mounted as follows:

- clear distance to the reflective wall 150 mm
- fixed directly underneath the ceiling on a metal rail ( $h = 50$  mm)
- measurement without enclosing frame
- visible side corresponding to marking by the manufacturer faced to the reverberation room

The mounting details for the tested arrangements are as follows:

#### a) flat arrangement

- mounting type G-150 acc. to EN ISO 354 [1], section 6.2.1 and Appendix B of EN ISO 354 [1]
- one curtain width x height = 3500 mm x 3000 mm
- total dimensions of the test surface (starting at the lower edge of the metal rail) width x height = 3500 mm x 2950 mm

#### b) folded arrangement

- mounting type following G-150 acc. to EN ISO 354 [1]
- 100 % folded
- two curtains with each width x height = 3500 mm x 3000 mm
- total dimensions of the test surface (starting at the lower edge of the metal rail) width x height = 3500 mm x 2950 mm

Appendix B contains photos of the tested arrangements.

## 4 Execution of the measurements

The measurements were executed and evaluated according to 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  $\alpha_S$  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  $\alpha_p$  in octave bands
- weighted sound absorption coefficient  $\alpha_w$  as single value:

The weighted sound absorption coefficient  $\alpha_w$  is determined from the practical sound absorption coefficients  $\alpha_p$  in the octave bands of 250 Hz to 4000 Hz.

According to ASTM C 423-09a [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  $\alpha_S$  in one third-octave bands, the practical sound absorption coefficients  $\alpha_p$  in octave bands and the single values  $\alpha_w$ , *NRC* and *SAA* are indicated in the test certificates in Appendix A.

## 7 Remarks

The determined test results only refer to the test specimens and prevailing conditions on the day of measurements.



M. Eng. Philipp Meistring  
(Project manager)

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# Sound absorption coefficient ISO 354

## Measurement of sound absorption in reverberation rooms

**Client:** Annette Douglas Textiles AG  
Klosterstrasse 42, 5430 Wettingen, Switzerland

**Test specimen:** Fabric WHISPER air  
Mounting type G-150, flat arrangement

**Curtain fabric:**

- curtain fabric WHISPER air
- material 100 % PES-FR
- area specific mass  $m'' = 88 \text{ g/m}^2$
- air flow resistance  $R_S = 158 \text{ Pa s/m}$
- thickness  $t = 0.30 \text{ mm}$

**Tested arrangement:**

- mounting type G-150 acc. to EN ISO 354, without enclosing frame
- one curtain width x height = 3500 mm x 3000 mm
- fixed directly underneath the ceiling on a 50 mm high metal rail
- wall distance 150 mm
- test surface width x height = 3500 mm x 2950 mm (starting at the lower edge of the metal rail)

Room: E

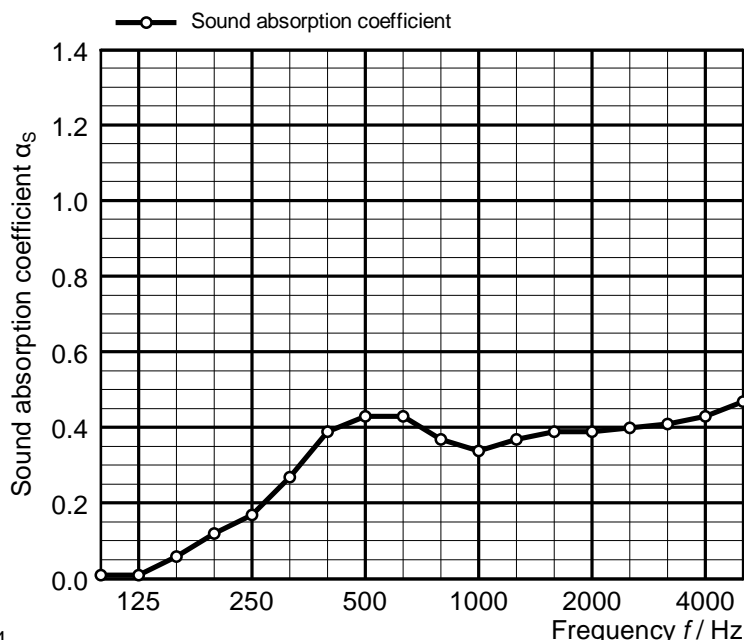
Volume: 199.60 m<sup>3</sup>

Size: 10.33 m<sup>2</sup>

Date of test: 2014-02-07

	$\theta$ [°C]	r. h. [%]	B [kPa]
without specimen	18.3	34.2	94.1
with specimen	18.5	35.2	94.1

Frequency [Hz]	$\alpha_s$ 1/3 octave	$\alpha_p$ octave
100	0.01	
125	0.01	0.05
160	0.06	
200	0.12	
250	0.17	0.20
315	0.27	
400	0.39	
500	0.43	0.40
630	0.43	
800	0.37	
1000	0.34	0.35
1250	0.37	
1600	0.39	
2000	0.39	0.40
2500	0.40	
3150	0.41	
4000	0.43	0.45
5000	0.47	



◦ Equivalent sound absorption area less than 1.0 m<sup>2</sup>  
 $\alpha_s$  Sound absorption coefficient according to ISO 354  
 $\alpha_p$  Practical sound absorption coefficient according to ISO 11654

<p>Rating according to ISO 11654:  <b>Weighted sound absorption coefficient</b>  <math>\alpha_w = 0.40</math>                  Sound absorption class: D</p>	<p>Rating according to ASTM C423:  <b>Noise Reduction Coefficient NRC = 0.35</b>  <b>Sound Absorption Average SAA = 0.34</b></p>
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Appendix A

Page 1

# Sound absorption coefficient ISO 354

## Measurement of sound absorption in reverberation rooms

**Client:** Annette Douglas Textiles AG  
Klosterstrasse 42, 5430 Wettingen, Switzerland

**Test specimen:** Fabric WHISPER air  
Wall distance 150 mm, folded arrangement

**Curtain fabric:**

- curtain fabric WHISPER air
- material 100 % PES-FR
- area specific mass  $m'' = 88 \text{ g/m}^2$
- air flow resistance  $R_S = 158 \text{ Pa s/m}$
- thickness  $t = 0.30 \text{ mm}$

**Tested arrangement:**

- mounting type following G-150 acc. to EN ISO 354, without enclosing frame
- two curtains with each width x height = 3500 mm x 3000 mm
- fixed directly underneath the ceiling on a 50 mm high metal rail
- wall distance 150 mm
- test surface width x height = 3500 mm x 2950 mm (starting at the lower edge of the metal rail)

Room: E

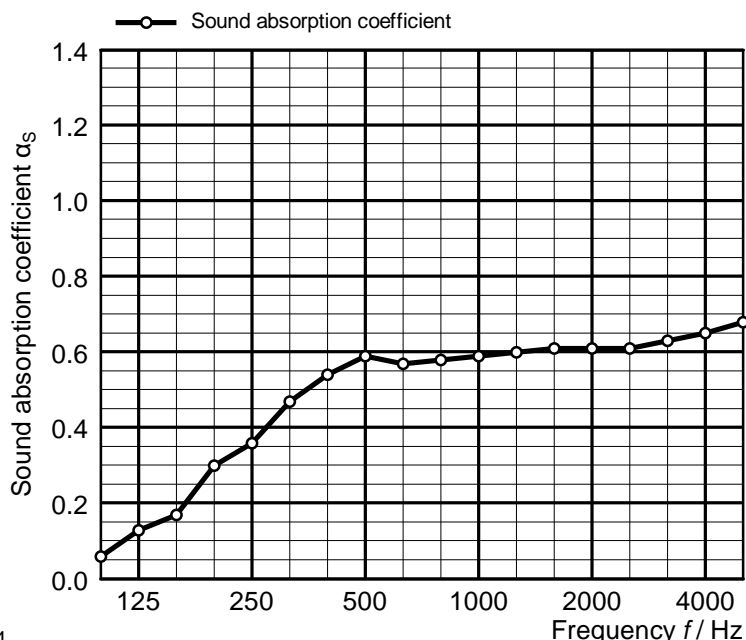
Volume: 199.60 m<sup>3</sup>

Size: 10.33 m<sup>2</sup>

Date of test: 2014-02-07

	$\theta$ [°C]	r. h. [%]	B [kPa]
without specimen	18.3	34.2	94.1
with specimen	18.7	36.6	94.1

Frequency [Hz]	$\alpha_s$ 1/3 octave	$\alpha_p$ octave
100	0.06	0.10
125	0.13	
160	0.17	
200	0.30	
250	0.36	0.40
315	0.47	
400	0.54	
500	0.59	0.55
630	0.57	
800	0.58	
1000	0.59	0.60
1250	0.60	
1600	0.61	
2000	0.61	0.60
2500	0.61	
3150	0.63	
4000	0.65	0.65
5000	0.68	



◦ Equivalent sound absorption area less than 1.0 m<sup>2</sup>  
 $\alpha_s$  Sound absorption coefficient according to ISO 354  
 $\alpha_p$  Practical sound absorption coefficient according to ISO 11654

<p>Rating according to ISO 11654:  <b>Weighted sound absorption coefficient</b>  <math>\alpha_w = 0.60</math>                  Sound absorption class: C</p>	<p>Rating according to ASTM C423:  <b>Noise Reduction Coefficient NRC = 0.55</b>  <b>Sound Absorption Average SAA = 0.54</b></p>
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Appendix A

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**Fabric WHISPER air**



Figure B.1. Flat arrangement, test object mounted in the reverberation room.



Figure B.2. Folded arrangement, test object mounted in the reverberation room.

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

### 1 Measurand

The sound absorption coefficient  $\alpha$  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:

- $\alpha_s$  sound absorption coefficient;
- $A_T$  equivalent sound absorption area of the test object in  $\text{m}^2$ ;
- $S$  area covered by the test object in  $\text{m}^2$ ;
- $V$  volume of the reverberation room in  $\text{m}^3$ ;
- $c_1$  propagation speed of sound in air in the reverberation room without test object in  $\text{m/s}$ ;
- $c_2$  propagation speed of sound in air in the reverberation room with test object in  $\text{m/s}$ ;
- $T_1$  reverberation time in the reverberation room without test object in  $\text{s}$ ;
- $T_2$  reverberation time in the reverberation room with test object in  $\text{s}$ ;
- $m_1$  power attenuation coefficient in the reverberation room without test object in  $\text{m}^{-1}$ ;
- $m_2$  power attenuation coefficient in the reverberation room with test object in  $\text{m}^{-1}$ .

The area covered by the test object was used as area of the test object.

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 [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 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  $S = 216 \text{ m}^2$ .

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.

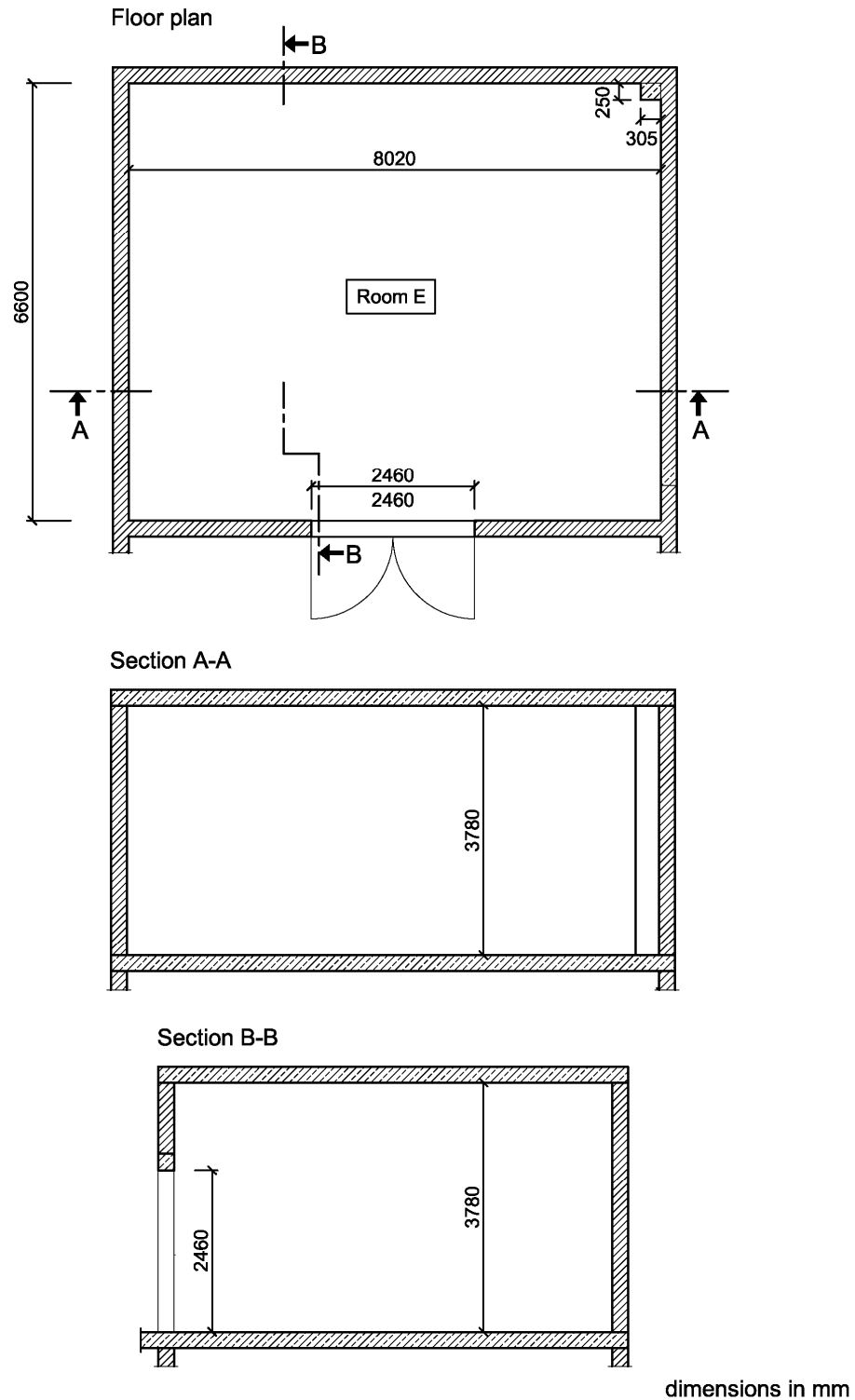


Figure C.1. Plan view and sections of the reverberation room.

## 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 are indicated in Table C.1.

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

Frequenz $f$ / Hz	Nachhallzeit $T$ / s		
	$T_1$ (ohne Prüfobjekt)	$T_2$ (mit Prüfobjekt)	
		Anhang A Seite 1	Anhang A Seite 2
100	4.84	4.77	4.41
125	4.68	4.61	3.90
160	4.93	4.49	3.86
200	5.48	4.53	3.57
250	5.28	4.08	3.29
315	5.08	3.54	2.87
400	5.54	3.29	2.82
500	5.47	3.13	2.69
630	5.26	3.06	2.68
800	4.94	3.13	2.57
1000	5.07	3.28	2.59
1250	5.21	3.24	2.62
1600	5.00	3.08	2.55
2000	4.45	2.87	2.41
2500	3.74	2.56	2.20
3150	2.92	2.13	1.88
4000	2.18	1.71	1.55
5000	1.62	1.33	1.25

### 2.3 List of test equipment

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

Table C.2. Test equipment.

<b>Name</b>	<b>Manufacturer</b>	<b>Type</b>	<b>Serial-No.</b>
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 1.7