

Hochschule für Technik Stuttgart

Institute of Applied Sciences
- Acoustics -

Test Report No. 122 001 12P-358

Measurements of sound absorption for ECHOJAZZ Echobards®

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

Applicant: ECHOJAZZ AG
Ringstrasse 25
CH-6010 Kriens

Project-No.: 122 001 12P-358

1 Task

The measurements of the sound absorption were realised on October 16st, 2019 in the reverberation room of the sound technical laboratory of the University of Applied Sciences Stuttgart (HFT Stuttgart), Centre for Building Physics, Pfaffenwaldring 10a, 70569 Stuttgart-Vaihingen.

2 Measurements of sound absorption in the reverberation room

2.1 Sampling

The specimen were delivered by Mr. Bonnard of ECHOJAZZ AG and built up from Mr. Bonnard and the staff of HFT Stuttgart in the reverberation room.

2.2 Measurement

Client: ECHOJAZZ AG, CH-6010 Kriens
Producer: ECHOJAZZ AG, CH-6010 Kriens
Test specimen: 1 Echoboard® 24 mm
2 Echoboard® 12 mm

Test specimen 1.1: Echoboard 24 mm (see picture 1)

- Surface area of test specimen: $3,540 \text{ m} \times 2,850 \text{ m} = 10,1 \text{ m}^2$
- E200 configuration, test specimen 200 mm above the reverberation chamber floor
- Wooden frame around the test specimen

Test specimen 2.1: Echoboard 12 mm (see picture 2)

- Surface area of test specimen: $3,540 \text{ m} \times 2,850 \text{ m} = 10,1 \text{ m}^2$
- E200 configuration, test specimen 200 mm above the reverberation chamber floor
- Wooden frame around the test specimen

Test specimen 1.2: Echoboard 24 mm (see picture 3)

- Surface area of test specimen: $3,540 \text{ m} \times 2,850 \text{ m} = 10,1 \text{ m}^2$
- E50 configuration, test specimen 50 mm above the reverberation chamber floor
- Wooden frame around the test specimen

Test specimen 2.2: Echoboard 12 mm (see picture 4)

- Surface area of test specimen: $3,540 \text{ m} \times 2,850 \text{ m} = 10,1 \text{ m}^2$
- E50 configuration, test specimen 50 mm above the reverberation chamber floor
- Wooden frame around the test specimen

Test specimen 1.3: Echoboard 24 mm (see picture 5)

- Surface area of test specimen: $3,540 \text{ m} \times 2,850 \text{ m} = 10,1 \text{ m}^2$
- Test specimen on the reverberation chamber floor
- No frame around the test specimen

Test specimen 2.3: Echoboard 12 mm (see picture 6)

- Surface area of test specimen: $3,540 \text{ m} \times 2,850 \text{ m} = 10,1 \text{ m}^2$
- Test specimen on the reverberation chamber floor
- No frame around the test specimen

3 Execution of the measurements

The measurements were realised in a reverberation room according to DIN EN ISO 354, issue 12/2003 considering annexes A, B and ZA. The method was applied with disconnected noise. The specimen were observed as laminar absorbers according chapter 6.2.1 and were arranged in the reverberation room according annex B, layout type A and E.

The sound absorption coefficient α_s for laminar absorbers was determined after following relation:

$$\alpha_s = A_T/S$$

With:

$$A_T = A_2 - A_1 = 55.3 V (1/c_2 T_2 - 1/c_1 T_1) - 4 V (m_2 - m_1)$$

That means:

- A_T = equivalent sound absorption area of specimen in m^2 ;
 A_1 = equivalent sound absorption area of the empty reverberation room in m^2 ;
 A_2 = equivalent sound absorption area of the reverberation room incl. specimen in m^2 ;
 S = the area of the specimen in m^2 ;
 V = volume of the empty reverberation room in m^3 ;
 c_1 = sound velocity in the air in m/s at temperature T_1 ;
 c_2 = sound velocity in the air in m/s at temperature T_2 ;
 T_1 = reverberation time of the empty reverberation room in s ;
 T_2 = reverberation time of the reverberation room after positioning the specimen in s ;
 $m_{1/2}$ = air absorption coefficient in $1/m$, calculated with the existing climate terms during the particular measurements.

The evaluation of the sound absorption coefficient is carried out according to DIN EN ISO 11654, issue 7/1997.

The reverberation room has the following dimensions:

$$(L \times W \times H): \quad 7.89 \text{ m} \times 5.54 \text{ m} \times 4.65 \text{ m}; \quad V_{\text{reverberation room}} = 203 \text{ m}^3$$

Following measuring instruments were used:

Analyser:	Manufacturer: Sinus	Type: Soundbook	SN: 07296
Amplifier:	Manufacturer: Falm	Type: PA1000	SN: 280121
Loudspeaker:	Manufacturer: Norsonic	Type: 229	SN: 15013
4 x preamplifier:	Manufacturer: MicroTech	Type: MV210	SN: 13643
	Gefell		SN: 13644
			SN: 13668
			SN: 13674
4 x microphone:	Manufacturer: MicroTech	Type: 1220	SN: 4016
	Gefell		SN: 4017
			SN: 4018
			SN: 4019
Calibrator:	Manufacturer: Larson	Type: Cal200	SN: 7237
Climate measurement:	Manufacturer: Extech Instr.	Type: SD700	SN: 026717

Test sound was pink noise.

The used air sound measuring chain was DAkkS calibrated and bears the calibration mark *2020*.

4 Measuring results

Tables 1 to 3 show the average values of the reverberation time of the test specimen. In annex 1 to 6 the measured sound absorption coefficients α_s for the specimen are represented. The values of the sound absorption coefficients α_s and the practical absorption coefficients α_p are shown next to the diagram.

The report contains:

- 4 pages text
- 3 tables
- 6 pictures
- 6 annexes

To publish this report in extracts has to be allowed in advance by University of Applied Sciences Stuttgart. The mentioned measuring results refer only to the specimen with the described layout.

Stuttgart, the 9th of December 2019

Issuer:



Dipl.-Ing.(FH) Andreas Drechsler

Laboratory Manager:



Prof. Dr.-Ing. Berndt Zeitler

test specimen 1.1

frequency [Hz]	T ₁ [s]	T ₂ [s] specimen 1.1
100	6,92	3,61
125	6,87	3,22
160	6,45	3,15
200	6,49	2,58
250	6,37	2,39
315	6,15	2,37
400	5,62	2,13
500	5,14	2,05
630	5,09	1,90
800	5,18	2,04
1000	5,40	2,21
1250	5,21	2,06
1600	4,82	2,02
2000	4,47	1,96
2500	3,97	1,81
3150	3,46	1,67
4000	2,86	1,51
5000	2,22	1,31
temperature [°C]	22,2	22,0
humidity [%]	44,2	42,4
air pressure [hPa]	970,9	971,0

test specimen 2.1

frequency [Hz]	T ₁ [s]	T ₂ [s] specimen 2.1
100	6,92	3,86
125	6,87	3,23
160	6,37	3,07
200	6,49	2,72
250	6,37	2,46
315	6,15	2,48
400	5,62	2,24
500	5,14	2,06
630	5,09	2,03
800	5,18	2,19
1000	5,40	2,31
1250	5,21	2,22
1600	4,82	2,10
2000	4,47	2,02
2500	3,97	1,84
3150	3,46	1,73
4000	2,86	1,55
5000	2,22	1,32
Temperatur [°C]	22,2	22,2
Feuchte [%]	44,2	43,0
Luftdruck [hPa]	970,9	971,0

Table 1: Climate data at the time of the measurements and the average values of the reverberation time T₁ in the empty reverberation room respectively T₂ in the reverberation room with the specimen 1.1 and 2.1.

test specimen 1.2

frequency [Hz]	T ₁ [s]	T ₂ [s] specimen 1.2
100	7,42	5,61
125	7,87	5,79
160	7,51	5,41
200	7,24	4,73
250	6,99	3,99
315	7,09	3,45
400	6,06	2,84
500	5,43	2,40
630	5,02	2,13
800	5,33	2,07
1000	5,40	1,95
1250	5,18	1,98
1600	5,00	1,97
2000	4,65	1,91
2500	4,10	1,82
3150	3,51	1,72
4000	2,97	1,55
5000	2,29	1,32
temperature [°C]	22,5	22,4
humidity [%]	45,1	43,4
air pressure [hPa]	970,0	970,1

test specimen 2.2

frequency [Hz]	T ₁ [s]	T ₂ [s] specimen 2.2
100	7,42	6,81
125	7,87	6,41
160	7,51	5,70
200	7,24	4,85
250	6,99	4,22
315	7,09	3,87
400	6,06	3,17
500	5,43	2,63
630	5,02	2,40
800	5,33	2,25
1000	5,40	2,09
1250	5,18	2,07
1600	5,00	1,96
2000	4,65	1,91
2500	4,10	1,83
3150	3,51	1,74
4000	2,97	1,59
5000	2,29	1,37
temperature [°C]	22,5	22,5
humidity [%]	45,1	44,6
air pressure [hPa]	970,0	970,1

Table 2: Climate data at the time of the measurements and the average values of the reverberation time T₁ in the empty reverberation room respectively T₂ in the reverberation room with the specimen 1.2 and 2.2.

test specimen 1.3

frequency [Hz]	T ₁ [s]	T ₂ [s] specimen 1.3
100	7,27	6,68
125	7,32	6,79
160	8,24	6,16
200	7,60	5,73
250	6,98	4,90
315	6,91	4,00
400	6,52	3,43
500	5,77	2,76
630	5,40	2,41
800	5,70	2,34
1000	5,64	2,18
1250	5,62	2,07
1600	5,34	1,96
2000	4,98	1,88
2500	4,39	1,75
3150	3,81	1,67
4000	3,15	1,52
5000	2,34	1,33
temperature [°C]	22,5	22,5
humidity [%]	45,0	44,6
air pressure [hPa]	969,8	970,0

test specimen 2.3

frequency [Hz]	T ₁ [s]	T ₂ [s] specimen 2.3
100	7,27	7,28
125	7,32	6,92
160	8,24	7,60
200	7,60	6,37
250	6,98	6,17
315	6,91	5,80
400	6,52	4,92
500	5,77	4,19
630	5,40	3,44
800	5,70	3,18
1000	5,64	2,96
1250	5,62	2,61
1600	5,34	2,31
2000	4,98	2,12
2500	4,39	1,92
3150	3,81	1,73
4000	3,15	1,53
5000	2,34	1,34
temperature [°C]	22,5	22,5
humidity [%]	45,0	44,9
air pressure [hPa]	969,8	969,8

Table 3: Climate data at the time of the measurements and the average values of the reverberation time T₁ in the empty reverberation room respectively T₂ in the reverberation room with the specimen 1.3 and 2.3.



Picture 1: Photography of test specimen 1.1 in the reverberation room.



Picture 2: Photography of test specimen 2.1 in the reverberation room.



Picture 3: Photography of test specimen 1.2 in the reverberation room.



Picture 4: Photography of test specimen 2.2 in the reverberation room.



Picture 5: Photography of test specimen 1.3 in the reverberation room.



Picture 6: Photography of test specimen 2.3 in the reverberation room.

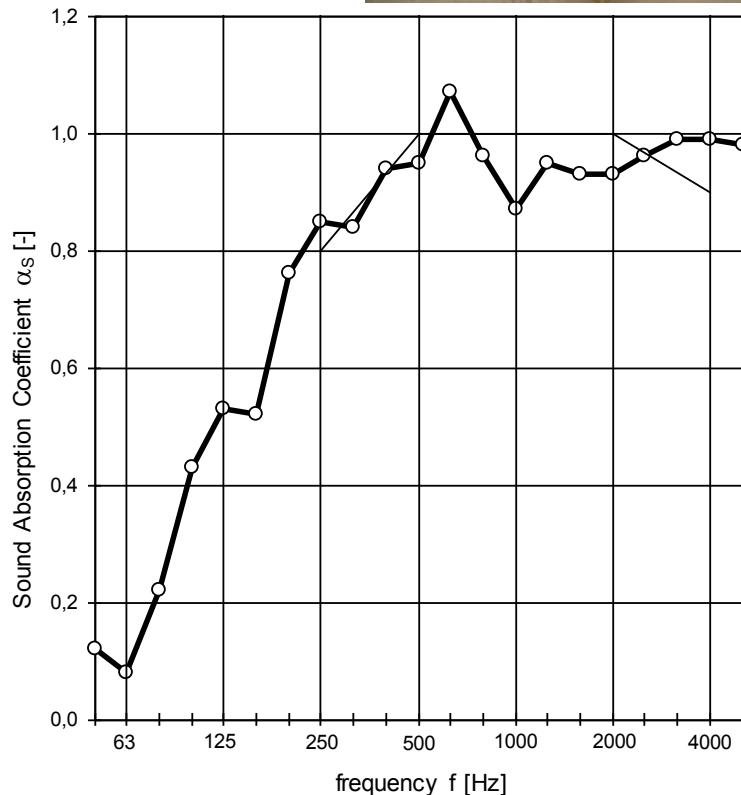
	Sound absorption coefficient α_s according EN ISO 354 Measurement of sound absorption in a reverberation room	Annex 1 122 001 12P - 358
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Client: ECHOJAZZ
 Producer: ECHOJAZZ AG, Ringstrasse 25, CH-6010 Kriens
 Test specimen: **Echoboard® 24 mm**
 Laminar absorber, E200
 Surface area of test specimen: $3,540 \times 2,850 \text{ m} = 10,1 \text{ m}^2$
Wooden frame around the test specimen



Room Volume: $V_s = 203,3 \text{ m}^3$
 Surface of test specimen $S = 10,1 \text{ m}^2$

Frequency [Hz]	α_s [-]	α_p [-]
50	0,12	
63	0,08	
80	0,22	
100	0,43	0,50
125	0,53	
160	0,52	
200	0,76	0,80
250	0,85	
315	0,84	
400	0,94	1,00
500	0,95	
630	1,07	
800	0,96	0,95
1000	0,87	
1250	0,95	
1600	0,93	0,95
2000	0,93	
2500	0,96	
3150	0,99	1,00
4000	0,99	
5000	0,98	



Excitation signal: Pink noise

Filtering: Third octave band filtering

Ratings according EN ISO 11654:	weighted sound absorption value:	$\alpha_w = 1$
	Absorption Class according EN ISO 11654:	A
Rating according ASTM C 423:	Sound Absorption Average:	$SAA = 0,92$
Classification according ASTM E 1264:	Noise Reduction Coefficient:	$NRC = 0,95$

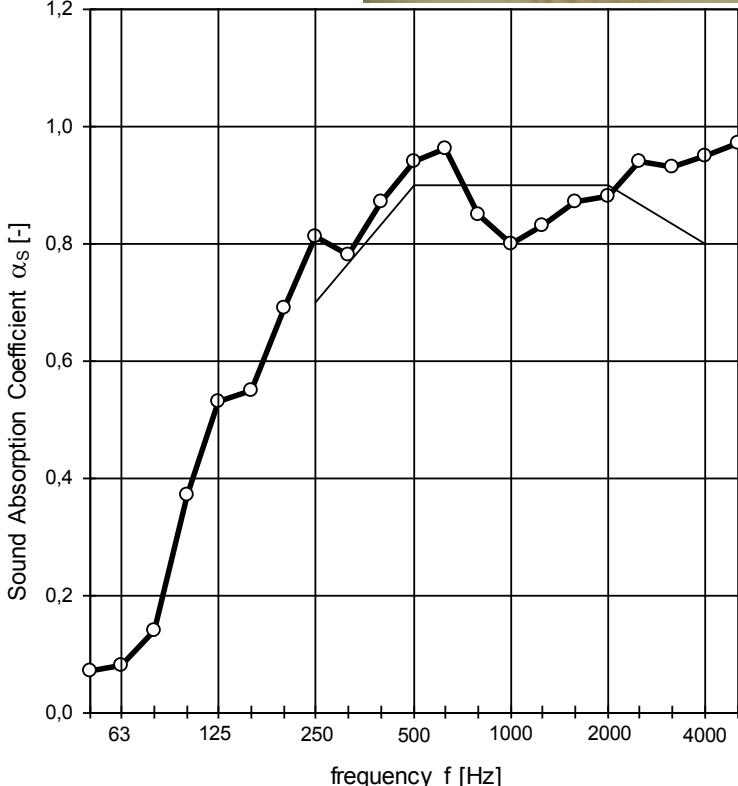
The determination is based on 1/3 octave laboratory measurement results.

Test Report No.: 122 001 12P- 358

Testing date: 16.10.2019

Date: 09.12.2019

Hochschule
für Technik
Stuttgart

Sound absorption coefficient α_s according EN ISO 354 Measurement of sound absorption in a reverberation room			Annex 2 122 001 12P - 358																																																																		
Client: ECHOJAZZ Producer: ECHOJAZZ AG, Ringstrasse 25, CH-6010 Kriens Test specimen: Echoboard® 12 mm Laminar absorber, E200 Surface area of test specimen: 3,540 x 2,850 m = 10,1 m ² Wooden frame around the test specimen																																																																					
																																																																					
Room Volume: $V_s = 203,3 \text{ m}^3$ Surface of test specimen $S = 10,1 \text{ m}^2$																																																																					
<table border="1"> <thead> <tr> <th>Frequency [Hz]</th><th>α_s [-]</th><th>α_p [-]</th></tr> </thead> <tbody> <tr><td>50</td><td>0,07</td><td></td></tr> <tr><td>63</td><td>0,08</td><td></td></tr> <tr><td>80</td><td>0,14</td><td></td></tr> <tr><td>100</td><td>0,37</td><td></td></tr> <tr><td>125</td><td>0,53</td><td>0,50</td></tr> <tr><td>160</td><td>0,55</td><td></td></tr> <tr><td>200</td><td>0,69</td><td></td></tr> <tr><td>250</td><td>0,81</td><td>0,75</td></tr> <tr><td>315</td><td>0,78</td><td></td></tr> <tr><td>400</td><td>0,87</td><td></td></tr> <tr><td>500</td><td>0,94</td><td>0,90</td></tr> <tr><td>630</td><td>0,96</td><td></td></tr> <tr><td>800</td><td>0,85</td><td></td></tr> <tr><td>1000</td><td>0,80</td><td>0,85</td></tr> <tr><td>1250</td><td>0,83</td><td></td></tr> <tr><td>1600</td><td>0,87</td><td></td></tr> <tr><td>2000</td><td>0,88</td><td>0,90</td></tr> <tr><td>2500</td><td>0,94</td><td></td></tr> <tr><td>3150</td><td>0,93</td><td></td></tr> <tr><td>4000</td><td>0,95</td><td>0,95</td></tr> <tr><td>5000</td><td>0,97</td><td></td></tr> </tbody> </table>			Frequency [Hz]	α_s [-]	α_p [-]	50	0,07		63	0,08		80	0,14		100	0,37		125	0,53	0,50	160	0,55		200	0,69		250	0,81	0,75	315	0,78		400	0,87		500	0,94	0,90	630	0,96		800	0,85		1000	0,80	0,85	1250	0,83		1600	0,87		2000	0,88	0,90	2500	0,94		3150	0,93		4000	0,95	0,95	5000	0,97		
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Excitation signal: Pink noise Filtering: Third octave band filtering																																																																					
Ratings according EN ISO 11654: weighted sound absorption value: $\alpha_w = 0,9$ Absorption Class according EN ISO 11654: A Rating according ASTM C 423: Sound Absorption Average: SAA = 0,85 Classification according ASTM E 1264: Noise Reduction Coefficient: NRC = 0,85 The determination is based on 1/3 octave laboratory measurement results.																																																																					
Test Report No.: 122 001 12P - 358 Testing date: 16.10.2019			Hochschule für Technik Stuttgart Date: 09.12.2019																																																																		

		Sound absorption coefficient α_s according EN ISO 354 Measurement of sound absorption in a reverberation room	Annex 3 122 001 12P - 358
Client:	ECHOJAZZ		
Producer:	ECHOJAZZ AG, Ringstrasse 25, CH-6010 Kriens		
Test specimen:	Echoboard® 24 mm Laminar absorber, E50 Surface area of test specimen: 3,540 x 2,850 m =10,1 m ² Wooden frame around the test specimen		
Room Volume:	V _s = 203,3 m ³		
Surface of test specimen	S = 10,1 m ²		
			
Frequency [Hz]	α_s [-]	α_p [-]	
50	0,00		
63	0,07		
80	0,13		
100	0,14		
125	0,15	0,15	
160	0,17		
200	0,24		
250	0,35	0,35	
315	0,48		
400	0,60		
500	0,75	0,75	
630	0,88		
800	0,95		
1000	1,06	1,00	
1250	1,01		
1600	0,99		
2000	0,99	1,00	
2500	0,99		
3150	0,95		
4000	0,98	1,00	
5000	1,01		
Excitation signal:	Pink noise		
Filtering:	Third octave band filtering		
Ratings according EN ISO 11654: weighted sound absorption value: $\alpha_w = 0,65$ (MH) Absorption Class according EN ISO 11654: C Rating according ASTM C 423: Sound Absorption Average: SAA = 0,77 Classification according ASTM E 1264: Noise Reduction Coefficient: NRC = 0,80 The determination is based on 1/3 octave laboratory measurement results.			
Test Report No.:	122 001 12P - 358		
Testing date:	16.10.2019		
Hochschule für Technik Stuttgart			

		Sound absorption coefficient α_s according EN ISO 354 Measurement of sound absorption in a reverberation room	Annex 4 122 001 12P - 358
Client:	ECHOJAZZ		
Producer:	ECHOJAZZ AG, Ringstrasse 25, CH-6010 Kriens		
Test specimen:	Echoboard® 12 mm Laminar absorber, E50 Surface area of test specimen: 3,540 x 2,850 m =10,1 m ² Wooden frame around the test specimen		
Room Volume:	V _s = 203,3 m ³		
Surface of test specimen	S = 10,1 m ²		
			
Frequency [Hz]	α_s [-]	α_p [-]	
50	0,00		
63	0,02		
80	0,11		
100	0,04		
125	0,09	0,10	
160	0,14		
200	0,22		
250	0,30	0,30	
315	0,38		
400	0,49		
500	0,63	0,60	
630	0,70		
800	0,83		
1000	0,95	0,90	
1250	0,93		
1600	1,00		
2000	0,99	1,00	
2500	0,98		
3150	0,94		
4000	0,94	0,95	
5000	0,93		
Excitation signal:	Pink noise		
Filtering:	Third octave band filtering		
Ratings according EN ISO 11654: weighted sound absorption value: $\alpha_w = 0,6$ (MH) Absorption Class according EN ISO 11654: C Rating according ASTM C 423: Sound Absorption Average: SAA = 0,70 Classification according ASTM E 1264: Noise Reduction Coefficient: NRC = 0,70 The determination is based on 1/3 octave laboratory measurement results.			
Test Report No.:	122 001 12P - 358		
Testing date:	16.10.2019		
Hochschule für Technik Stuttgart			

		Sound absorption coefficient α_s according EN ISO 354 Measurement of sound absorption in a reverberation room	Annex 5 122 001 12P - 358
Client:	ECHOJAZZ		
Producer:	ECHOJAZZ AG, Ringstrasse 25, CH-6010 Kriens		
Test specimen:	Echoboard® 24 mm Laminar absorber on the ground Surface area of test specimen: 3,540 x 2,850 m =10,1 m ²		
Room Volume:	V _s = 203,3 m ³		
Surface of test specimen	S = 10,4 m ²		
			
Frequency [Hz]	α_s [-]	α_p [-]	
50	0,04		
63	0,00		
80	0,00		
100	0,04		
125	0,03	0,05	
160	0,13		
200	0,13		
250	0,19	0,20	
315	0,33		
400	0,43		
500	0,59	0,60	
630	0,72		
800	0,79		
1000	0,88	0,90	
1250	0,96		
1600	1,01		
2000	1,04	1,05	
2500	1,08		
3150	1,06		
4000	1,07	1,05	
5000	1,02		
Excitation signal:	Pink noise		
Filtering:	Third octave band filtering		
Ratings according EN ISO 11654: weighted sound absorption value: $\alpha_w = 0,5$ (MH) Absorption Class according EN ISO 11654: D Rating according ASTM C 423: Sound Absorption Average: SAA = 0,68 Classification according ASTM E 1264: Noise Reduction Coefficient: NRC = 0,70 The determination is based on 1/3 octave laboratory measurement results.			
Test Report No.:	122 001 12P - 358		
Testing date:	16.10.2019		
Hochschule für Technik Stuttgart		Date: 09.12.2019	

Sound absorption coefficient α_s according EN ISO 354 Measurement of sound absorption in a reverberation room		Annex 6 122 001 12P - 358
Client: Producer: Test specimen:	ECHOJAZZ ECHOJAZZ AG, Ringstrasse 25, CH-6010 Kriens Echoboard® 12 mm Laminar absorber on the ground Surface area of test specimen: $3,540 \times 2,850 \text{ m}^2 = 10,1 \text{ m}^2$	
Room Volume: Surface of test specimen	$V_s = 203,3 \text{ m}^3$ $S = 10,2 \text{ m}^2$	
Frequency [Hz]	α_s [-]	α_p [-]
50	0,00	
63	0,01	
80	0,04	
100	0,00	
125	0,03	0,00
160	0,03	
200	0,08	
250	0,06	0,10
315	0,09	
400	0,16	
500	0,21	0,25
630	0,34	
800	0,44	
1000	0,51	0,55
1250	0,66	
1600	0,78	
2000	0,86	0,85
2500	0,93	
3150	1,00	
4000	1,07	1,05
5000	1,02	
Excitation signal:	Pink noise	
Filtering:	Third octave band filtering	
Ratings according EN ISO 11654: weighted sound absorption value: $\alpha_w = 0,3 \text{ (MH)}$ Absorption Class according EN ISO 11654: D Rating according ASTM C 423: Sound Absorption Average: SAA = 0,43 Classification according ASTM E 1264: Noise Reduction Coefficient: NRC = 0,45 The determination is based on 1/3 octave laboratory measurement results.		
Test Report No.:	122 001 12P - 358	Date: 09.12.2019
Testing date:	16.10.2019	Hochschule für Technik Stuttgart