

Bellaterra: 16th of October, 2015
Report Number: 15/11041-2642
Petitioner Reference: **ASCÉNDER, S.L.**
Ctra. Santo Domingo, nº 69
26280 Ezcaray (La Rioja)

TEST REPORT

Requested test: Measurement of the sound absorption in a reverberation room, in conformity with the standard UNE-EN ISO 354:2004, of a set of 12 seats referenced **DAFNE WOOD**. Seat and back upholstered in *Steelcut Trio 2* by Kvadrat.

Date of test: 5th of October, 2015

Test carried out by: Xavier Molins (Acoustics Laboratory – LGAI Technological Center)

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1.- SCOPE OF THE TEST

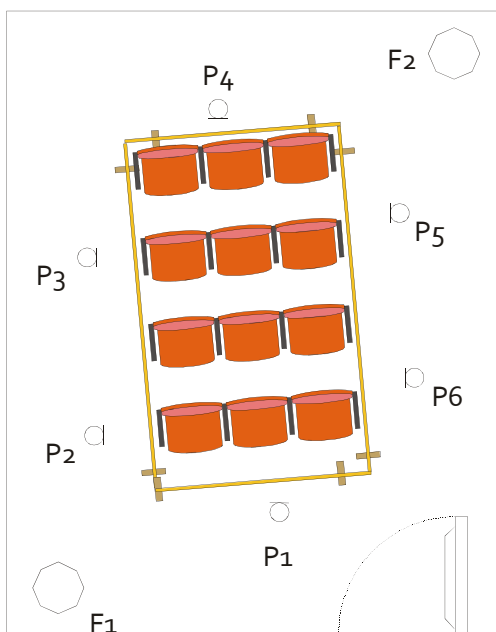
The scope of this test is to determinate the sound absorption, in conformity with the standard UNE-EN ISO 354:2004, of a set of 12 seats referenced **DAFNE WOOD** with *Fabric Steelcut Trio 2* by Kvadrat upholstery in seats and backs. The distance between backrests is 1040 mm.

2.- MEASUREMENT EQUIPMENT

The equipment used in the test is the following:

- Spectrum analyser id. number: 103099 (Bruel&Kjaer mod. Pulse)
- Microphone calibrator id. number: 103032 (Bruel&Kjaer mod. 4231)
- Microphones id. numbers: 103128, 103131, 170093 and 170108 (Bruel&Kjaer mod. 4943) and 170374 and 170375 (G.R.A.S. mod. 40AR)
- Sound sources id. numbers: 103098 (AVM mod. DO12) and 103124 (CESVA mod. BP012)
- Noise generator id. number: 103195 (Bruel&Kjaer mod. 1049)
- Power amplifier id. number: 103097 (INTER mod. M700)
- Graphic equalizer id. number: 170092 (INTER mod. EQ-9231)
- Thermo-hygrometer id. number: 170539 (Oregon Scientific mod. WMR88)
- Tape measurer id. number: 103095 (Stanley mod. Powerlock)

3.- TEST PROCEDURE



The test is carried out in accordance with the standard UNE-EN ISO 354:2004, 'Measurement of sound absorption in a reverberation room'; reverberation times of the room with and without test specimen are compared. The evaluation and rating is done in accordance with the standard UNE-EN ISO 11654:1998.

Around the room 6 microphones positions (P1 to P6, in figure) and 2 sound sources (F1 and F2) positions are defined. Measurements are carried out exciting the room with pink noise and calculated from the measured reverberation times as specified in part 4.3.

4.- DEFINITIONS AND CLASSIFICATION

4.1. **Reverberation time.** Time, in seconds, that would be required for the sound pressure level to decrease by 60 dB after the sound source has stopped.

4.2. **Equivalent sound absorption area of a room.** Hypothetical area of a totally absorbing surface without diffraction effects which, if it were the only absorbing element in the room, would give the same reverberation time as the room under consideration.

4.3. **Equivalent sound absorption area of the test specimen.** Difference between the equivalent sound absorption area of the reverberation room with and without the test specimen. To calculate this parameter the average reverberation time in the reverberation room is measured with and without the test specimen. From these reverberation times the equivalent sound absorption area, A_T , shall be calculated using the Sabine formula:

$$A_T = A_2 - A_1 = 55.3 V \left(\frac{1}{c_2 T_2} - \frac{1}{c_1 T_1} \right) - 4 V (m_2 - m_1)$$

where:

- c_1 and c_2 are the propagation speed of sound in air temperatures t_1 and t_2 ,
- V is the volume, in cubic metres, of the empty reverberation room,
- T_1 is the reverberation time, in seconds, of the empty reverberation room,
- T_2 is the reverberation time, in seconds, of the empty reverberation room after the test specimen has been introduced,
- m_1 and m_2 are the power attenuation coefficients, in reciprocal metres, of the empty reverberation room and with the test specimen, respectively. The value of m is calculated according to the International Standard ISO 9613-1 using the climatic conditions that have been present during the measurement.

The value of m can be calculated from the attenuation coefficient, α , which is used in International Standard ISO 9613-1 according to the formula:

$$m = \frac{\alpha}{10 \log(e)}$$

4.4. Sound Absorption Coefficient. The sound absorption coefficient, α_s , of a plane absorber (or an array of identical objects), shall be calculated using the formula:

$$\alpha_s = \frac{A_T}{S}$$

where:

- A_T is the equivalent sound absorption area of the test specimen, in square meters,
- S is the area, in square meters, of the test specimen.

For discrete absorbers, the result should be expressed as equivalent sound absorption area per object, which is determined by dividing A_T by the number of objects tested, n :

$$A_{obj} = \frac{A_T}{n}$$

For a specified array of objects, the result should be given as equivalent sound absorption area of the whole configuration.

4.5. Practical sound absorption coefficient, α_p . Value of sound absorption coefficient depending of frequency, based upon measurements of sound absorption according standard ISO 354, and calculated using the formula:

$$\alpha_{pi} = \frac{\alpha_{i1} + \alpha_{i2} + \alpha_{i3}}{3}$$

where:

- α_{pi} is the practical sound absorption coefficient for the i^{th} octave band,
- α_{i1} , α_{i2} and α_{i3} , are the sound absorption coefficients of the corresponding third-octave band within the i^{th} octave band.

Values are given with 2 decimal and rounded in steps of 0,05 until a maximum value of $\alpha_{pi} = 1.00$ in case of rounded average values > 1.00 .

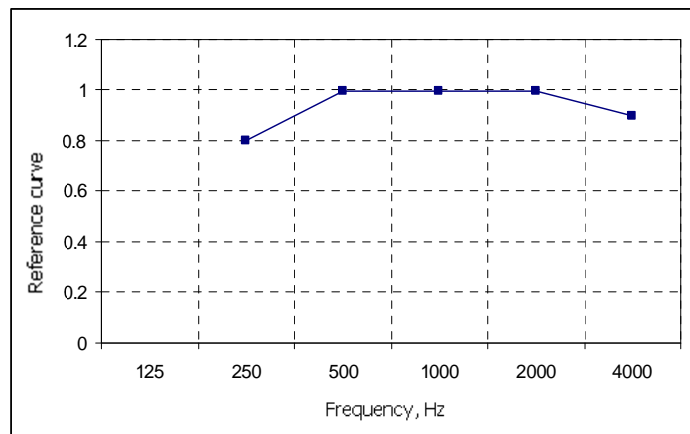
4.6. Weighted sound absorption coefficient, α_w . Single-number defined as the value of the reference curve, at the frequency of 500 Hz, after shifting it according to the method laid down.

To evaluate the results of a measurement, the reference curve is shifted in steps of 0.05 towards the curve of practical sound absorption, α_p , until the sum of the unfavourable deviations is as large

as possible but no more than 0.10. An unfavourable deviation at a particular frequency occurs when the result of measurement is less than the reference curve.

The set of reference values used for comparison with measurement results (reference curve) is specified in table below:

Frequency (Hz)	Reference curve value
250	0.80
500	1.00
1000	1.00
2000	1.00
4000	0.90



4.7. Shape indicators, L. M. H. If a practical sound absorption coefficient, α_{pi} , exceeds the shifted reference curve value on 0.25 or more, a shape indicator will be added.

When excess happens at 250 Hz, indicator L is used. For 500 and 1000 Hz octave bands, indicator M is used. For 2000 Hz and 4000 Hz octave bands, indicator H is used.

4.8. Absorption Classes. Absorption classes A to E are another classification method described in the International Standard ISO 11654 and it is used in wide band applications. The single-number, α_w , is compared with values given in the table below:

Absorption class	α_w
A	0.90; 0.95; 1.00
B	0.80; 0.85
C	0.60; 0.65; 0.70; 0.75
D	0.30; 0.35; 0.40; 0.45; 0.50; 0.55
E	0.15; 0.20; 0.25
Not classified	0.00; 0.05; 0.10

5.- UNCERTAINTY OF TEST

The uncertainty associated to the test has been calculated and is available to the petitioner.

6.- TEST ELEMENT DESCRIPTION

The test specimen consists of 12 seats referenced **DAFNE WOOD** with side panels, arms, seats and back shells in oak wood. Seats and backs are upholstered in *Steelcut Trio 2* by Kvadrat (information provided by test petitioner).

The seats are placed into the reverberation room in 4 rows of 3 seats each. The distance between backrests is 1040 mm.

The test specimen is provided by the petitioner and received within Applus Laboratories – LGAI Technological Center on the 5th of October, 2015.



Images 1 to 4 DAFNE WOOD seats

The perimeter of the seats is closed with 800 mm height and 19 mm thick MDF wooden boards. The area bounded by the boards is 1.89 x 4.16 m; therefore the sample surface is 7.86 m².

The test is carried out with the empty seats and with the seats occupied by a person.

The installation of the test element into the reverberation room is done with the petitioner resources on the 5th of October, 2015.

Images 5 and 6 show the seats configuration tested, installed into the reverberation room with the measurement set-up.



Images 5 and 6 Measurement of the sound absorption of the seats

7.- TEST CONDITIONS

Reverberation room characteristics			
Shape:	Parallelepiped	Total area (A_T):	238.2 m ²
Dimensions:	7.84 × 4.96 × 6.27 m	Number of diffusers:	14
Volume (V):	243.6 m ³	Size of diffuser:	1.5 m ²

Environmental conditions of reverberation room			
Room state:	Empty (without seats)	With empty seats	With occupied seats
Temperature:	22.8 °C	23.0 °C	23.1 °C
Humidity:	59 %	63 %	63 %
Atmospheric Pressure:	1011 hPa	1009 hPa	1009 hPa

8.- REVERBERATION TIMES AND EQUIVALENT SOUND ABSORPTION AREA

In sections 8.1 and 8.2, the reverberation time values of the test room with and without the test element are given, as well as the calculated equivalent sound absorption area of an individual seat.

8.1. **Test 1:** Empty seats.

Frequency (Hz)	Reverberation time of the empty room, T_1 (s)	Reverberation time of the room with the test specimen, T_2 (s)	Equivalent sound absorption area, A_T (m ²)	Equivalent sound absorption area, of an individual object, A_{obj} (m ²)
100	13.50	9.53	1.21	0.10
125	12.07	7.91	1.70	0.14
160	11.56	6.73	2.43	0.20
200	12.21	5.75	3.60	0.30
250	11.94	5.50	3.85	0.32
315	11.33	5.06	4.28	0.36
400	10.44	4.61	4.74	0.39
500	10.30	4.51	4.87	0.41
630	9.70	4.43	4.78	0.40
800	8.91	4.26	4.77	0.40
1000	8.45	4.10	4.87	0.41
1250	7.57	3.80	5.08	0.42
1600	6.71	3.44	5.49	0.46
2000	5.78	3.14	5.66	0.47
2500	5.00	2.91	5.63	0.47
3150	4.25	2.65	5.63	0.47
4000	3.32	2.27	5.66	0.47
5000	2.62	1.94	5.63	0.47

8.2. **Test 2:** Occupied seats.

Frequency (Hz)	Reverberation time of the empty room, T_1 (s)	Reverberation time of the room with the test specimen, T_2 (s)	Equivalent sound absorption area, A_T (m ²)	Equivalent sound absorption area, of an individual object, A_{obj} (m ²)
100	13.50	8.43	1.74	0.15
125	12.07	6.52	2.76	0.23
160	11.56	5.69	3.49	0.29
200	12.21	5.12	4.44	0.37
250	11.94	5.20	4.26	0.35
315	11.33	4.35	5.55	0.46
400	10.44	4.07	5.86	0.49
500	10.30	3.92	6.17	0.51
630	9.70	3.80	6.24	0.52
800	8.91	3.61	6.41	0.53
1000	8.45	3.52	6.44	0.54
1250	7.57	3.34	6.50	0.54
1600	6.71	3.10	6.73	0.56
2000	5.78	2.83	7.01	0.58
2500	5.00	2.61	7.20	0.60
3150	4.25	2.38	7.29	0.61
4000	3.32	2.05	7.46	0.62
5000	2.62	1.78	7.48	0.62

9.- RESULTS

In sections 9.1 and 9.2 the sound absorption coefficients for the seats empty and occupied are given.

9.1. Empty seats

Sound absorption according to UNE-EN ISO 354:2004



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Test specimen:

Set of 12 seats referenced **DAFNE WOOD** with seats and backs upholstered in *Steelcut Trio 2*. The distance between backrests is 1040 mm. Test specimen area of 7.86 m².

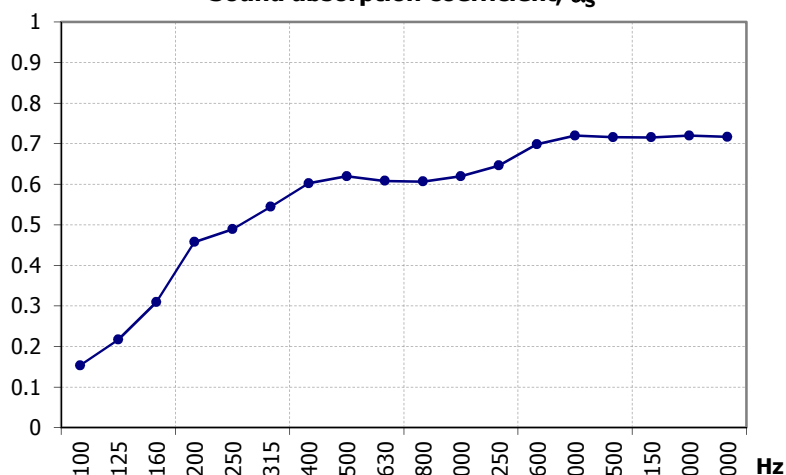
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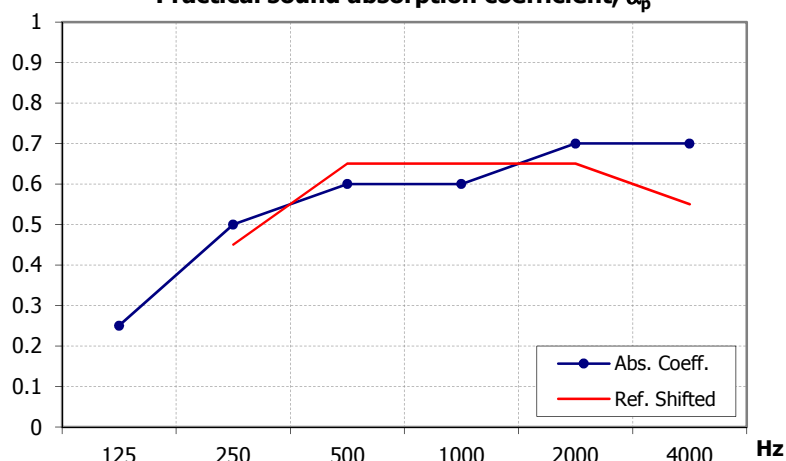
Sound abs. coefficient, α_s

Freq. (Hz)	α_s
100	0.15
125	0.22
160	0.31
200	0.46
250	0.49
315	0.54
400	0.60
500	0.62
630	0.61
800	0.61
1000	0.62
1250	0.65
1600	0.70
2000	0.72
2500	0.72
3150	0.72
4000	0.72
5000	0.72

Sound absorption coefficient, α_s



Practical sound absorption coefficient, α_p



Practical sound abs. coefficient, α_p

Freq. (Hz)	α_p
125	0.25
250	0.50
500	0.60
1000	0.60
2000	0.70
4000	0.70

Weighted sound absorption coefficient, $\alpha_w = 0.65$ (-)

Absorption class: **C**

It is highly recommended to use the single number "weighted sound absorption coefficient (α_w)" together with frequency-dependent values of sound absorption coefficient.

The results reported in this document relate only to the sample, product or item delivered to LGAI Technological Center the appointed day having been tested under the conditions established in this document.

9.2. Occupied seats

Sound absorption according to UNE-EN ISO 354:2004



ASCÉNDER, S.L.

Test specimen:

Set of 12 seats referenced **DAFNE WOOD** with seats and backs upholstered in *Steelcut Trio 2*. The distance between backrests is 1040 mm. Test specimen area of 7.86 m².

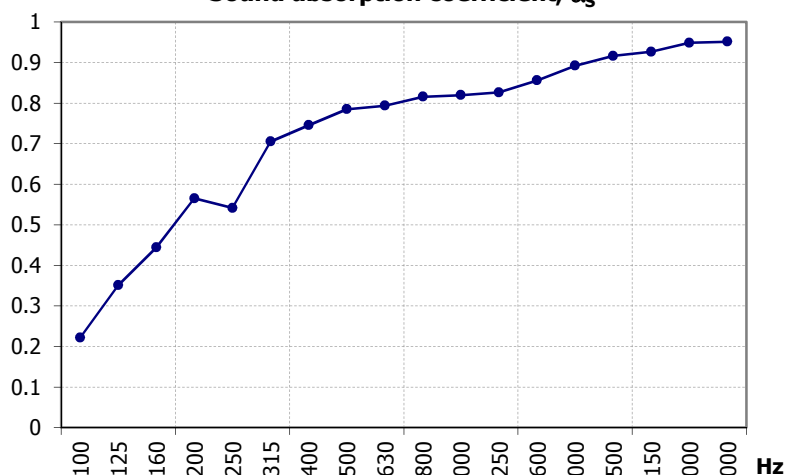
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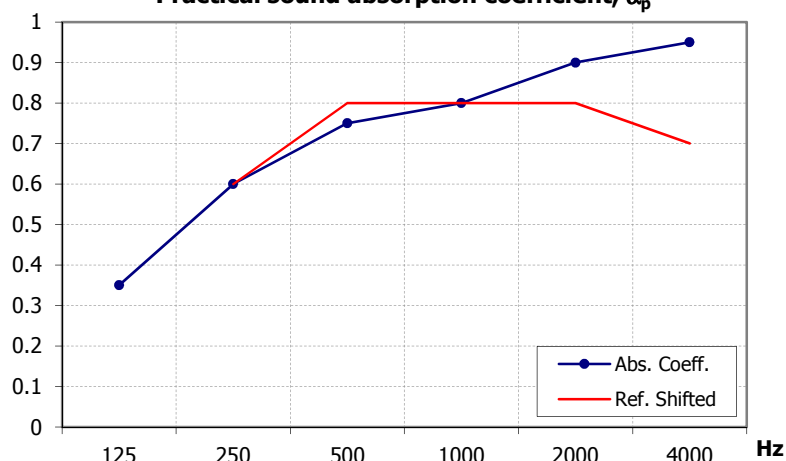
Sound abs. coefficient, α_s

Freq. (Hz)	α_s
100	0.22
125	0.35
160	0.44
200	0.57
250	0.54
315	0.71
400	0.75
500	0.79
630	0.79
800	0.82
1000	0.82
1250	0.83
1600	0.86
2000	0.89
2500	0.92
3150	0.93
4000	0.95
5000	0.95

Sound absorption coefficient, α_s



Practical sound absorption coefficient, α_p



Practical sound abs. coefficient, α_p

Freq. (Hz)	α_p
125	0.35
250	0.60
500	0.75
1000	0.80
2000	0.90
4000	0.95

Weighted sound absorption coefficient, $\alpha_w = 0.80$ (H)

Absorption class: **B**

It is highly recommended to use the single number "weighted sound absorption coefficient (α_w)" together with frequency-dependent values of sound absorption coefficient.

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