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TEST REPORT

Measurement type: Measurement of the equivalent area of acoustic absorption in reverberant chamber
Object of the measure: Acoustic Flexia suspension Lamp (120°,150°,180°)
Reference technical standard: UNI EN ISO 354:2003
Test Lab: Department of Engineering Reverberant Chamber, University of Ferrara
Measurement date: 28/06/2022
Date of report: 04/08/2022

1. Introduction

At the request of Artemide S.p.A. sound absorption measurements were taken in a reverberation chamber on the Flexia soundproof lamp with suspension installation. The measurements were taken in accordance with technical standard *UNI EN ISO 354:2003 Acoustics — Measurement of sound absorption in a reverberation chamber* by applying it to the case of discreet objects, obtaining as a result of the measurement the absorbing units that each individual unit adds to the environment.

2. Testing apparatus

Test environment

The reverberation chamber at the Acoustics laboratory in the Engineering Department at the University of Ferrara has a volume of 252.9 m^3 and a total internal surface area of 247.4 m^2. The quadrilateral floor plan has no right angles with a base surface area of 49.9 m^2 and the ceiling, of an average height of 5.14 m, also has no right angles with the side walls. There are six solid pillars along the perimeter which enhance the diffusion of the acoustic field and there are 4 large speakers on the ceiling measuring 2 m x 2.2 m and a radius of curvature of 5 m which, hung at various heights and in a way that they appear crooked with respect to one another and to the walls and ceiling, ensure the diffusion of the acoustic field in the entire range of measuring frequencies.

HW/SW Instrumentation

Signal generation	3 (three) Lookline - DL304 dodecahedral sources with digital amplifier
Recording of signal:	6 (six) Class 1 1/2" B&K 4189 multi-directional microphones + B&K 2671 preamplifier
Acquisition and Analysis System:	Sinus – Soundbook with options for impulse response measurement and reverberation calculation

Table 1: HW/SW resources used for the measurements and data analysis.

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3. Sample tested

Description

The Flexia lamp consists of two different parts, corresponding to half a square split along the diagonal. One part consists of the actual soundproofing panel, comprising a thermoformed fabric panel coupled to polyester wadding, the other part is a transparent surface that generates a diffused emission of uniform light.
The two wings of Flexia can be tilted to form an angle of 180° or 150° replacing the connecting elements between the soundproofing part and the lighting part. Ceiling suspension installation is achieved with 4 cables.
The dimensions of the test lamp are 907 mm (L) x 907 mm (H) x 50 mm (D).

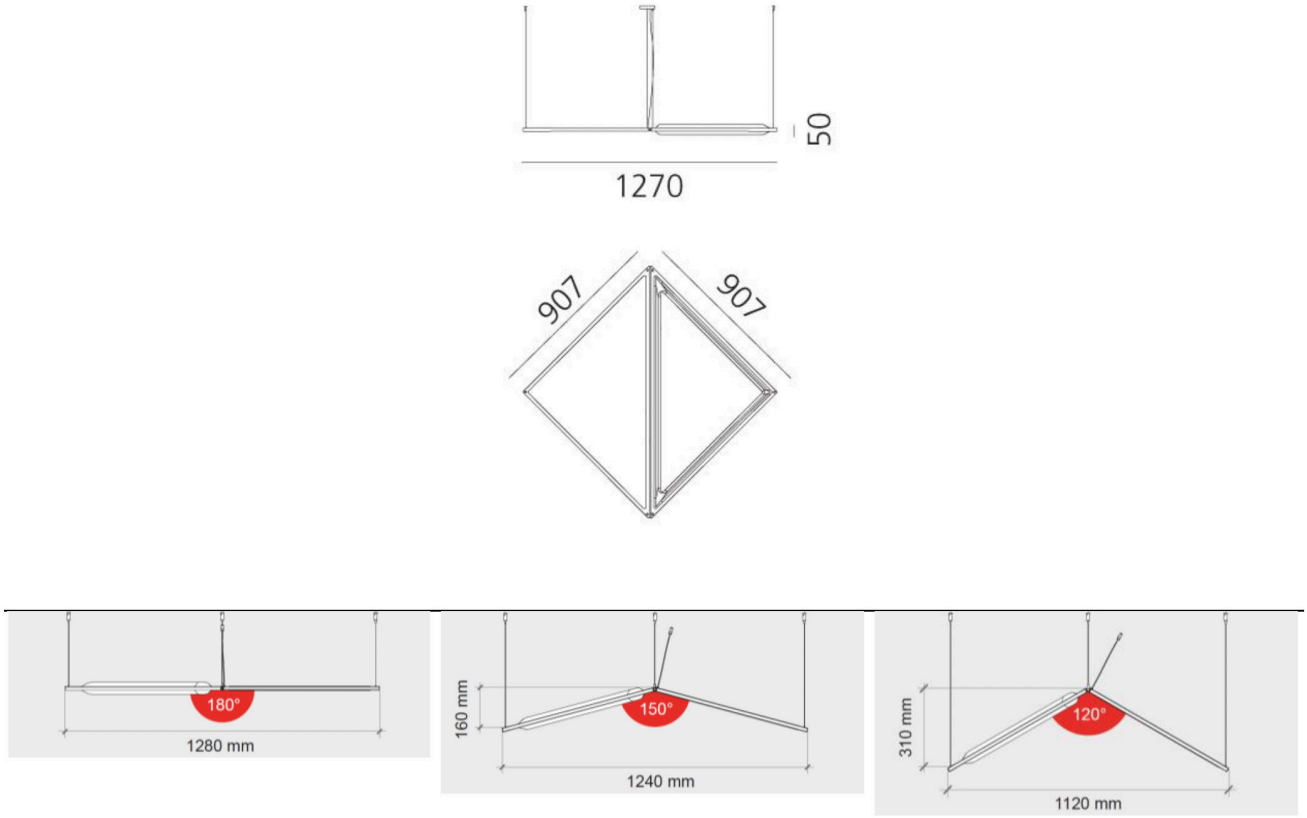

Figure 1: Flexia suspension, dimensions and installation variants.

Positioning

Each Flexia lamp was considered a “discrete element” under the UNI EN ISO 354:2003 standard. The absorbent units (expressed in m^2) rather than the acoustic absorption coefficient were therefore assessed. Considering the dimensions of the test objects and the provisions of the standard about the minimum distances to keep to (i.e. 2 m) 5 objects were used for the measurement.
As regards installation, each lamp was placed on two stands to simulate suspension installation, at a distance of 75 cm from the ceiling.
All Flexia configurations were tested with the three different angles of aperture of the two wings (figure 2).

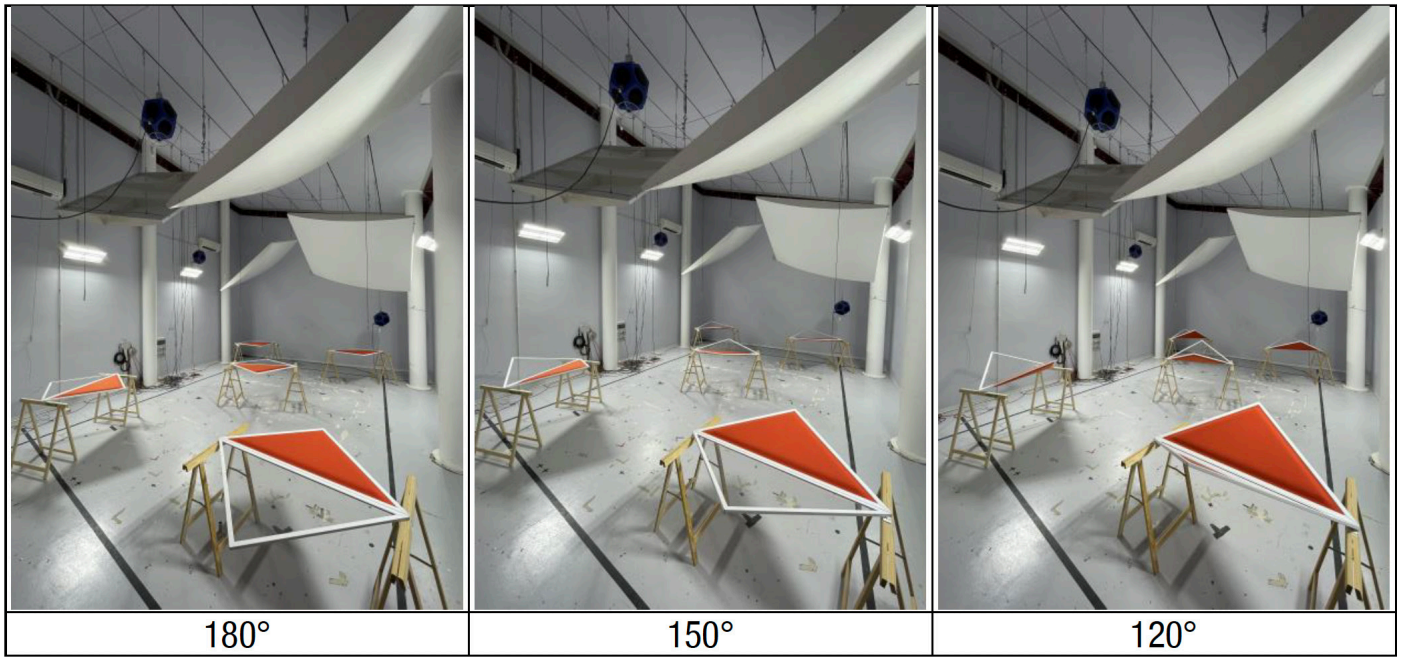

Figure 2: The 5 Flexia in the 2 configurations inside the reverberation chamber.

4. Measurement procedure

The procedure involves the initial preparation of the reverberation chamber without samples and the execution of impulse response measurements in a minimum of 12, in this case specifically 18, which correspond to 6 measurement positions for each of the 3 sound sources used. The measurement technique used is the "sine sweep" that involves the emission from the dodecahedron sound source of a sine wave with a frequency that grows exponentially, and the measurement of the impulse response using the convolution of the signal taken for each microphone. For each of the measured impulse responses, the decay of sound energy is derived through the reverse integration process, and from this the T_1 reverberation time in third-octave bands assessed on a decay of 20 dB. The results are mediated spatially by performing the arithmetic mean of the values obtained for the different combinations of source - receiver. The mean value obtained due to the absorption of air for the temperature and humidity conditions measured is then corrected.

A similar procedure is repeated in the same combinations of sources and receivers after placing the test material in the chamber as described in the previous paragraph. In this case you get an average reverberation time T_2.

Once the reverberation times have been obtained, the total absorbent units A_T are calculated using the following formula:

$$A_T = A_2 - A_1 = 55{,}3V\left(\frac{1}{c_2 T_2} - \frac{1}{c_1 T_1}\right) - 4V(m_2 - m_1) \qquad [m^2]$$

where:

A_1 are the absorbent units of the empty chamber

A_2 are the absorbent units of the chamber with the sample in it

V is the volume of the chamber

m_1 is the corrective coefficient for air absorption in the condition of an empty chamber

m_2 is the corrective coefficient for air absorption in the condition of an occupied chamber

The measurements were taken under the following thermo-hygrometric conditions:

	Temperature	Humidity	Pressure
	[°C]	[%]	[mbar]
Empty room	25.2	31.0	1005
Flexia 180°	24.8	31.0	1005
Flexia 150°	24.8	32.0	1004
Flexia 120°	24.6	34.7	1002

Table 2: measurements during thermo-hygrometric conditions.

The speed of sound as the temperature t varies was calculated using the following formula, applicable to temperatures of between 15 °C and 30 °C:

$$c = (331 + 0{,}6t)\ [m/s]$$

The correction of reverberation time data was developed from the standard ISO 9613-1:1993 *Acoustics - Attenuation of sound during propagation outdoors* - Part 1: Calculation of the absorption of sound by the atmosphere, which provides the attenuation coefficient α from which you get m using the formula:

$$m = \frac{\alpha}{10\mathrm{Log(e)}} \quad [\mathrm{m}^{-1}]$$

The required A_{obj} Value, which represents the absorbent units for each element tested, is finally obtained in this specific case using the following formula:

$$A_{obj} = \frac{A_T}{n} \quad [\mathrm{m}^2]$$

where “n” is the number of objects measured simultaneously and therefore comes to 5 for the Flexia lamp.

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5. Risultati

The results of the equivalent acoustic absorption for the various configurations of Flexia are provided in numerical form in Tables 3, 4 and 5 and in graphic form in Figures 3, 4 and 5.

Frequency [Hz]	T_1 [s]	T_2 [s]	A_{obj} [m^2]
100	6.09	5.14	0.2
125	5.82	5.04	0.2
160	5.41	4.43	0.3
200	5.16	4.36	0.3
250	5.05	4.20	0.3
315	5.15	3.93	0.5
400	5.18	3.87	0.5
500	5.31	3.95	0.5
630	5.13	3.78	0.6
800	4.93	3.58	0.6
1000	4.60	3.34	0.7
1250	4.31	3.15	0.7
1600	3.91	2.86	0.8
2000	3.38	2.58	0.7
2500	2.98	2.33	0.8
3150	2.56	2.09	0.7
4000	2.21	1.88	0.6
5000	1.79	1.57	0.6

Table 3: Measured reverberation time and absorbent unit data from Flexia 180° suspension lamp.

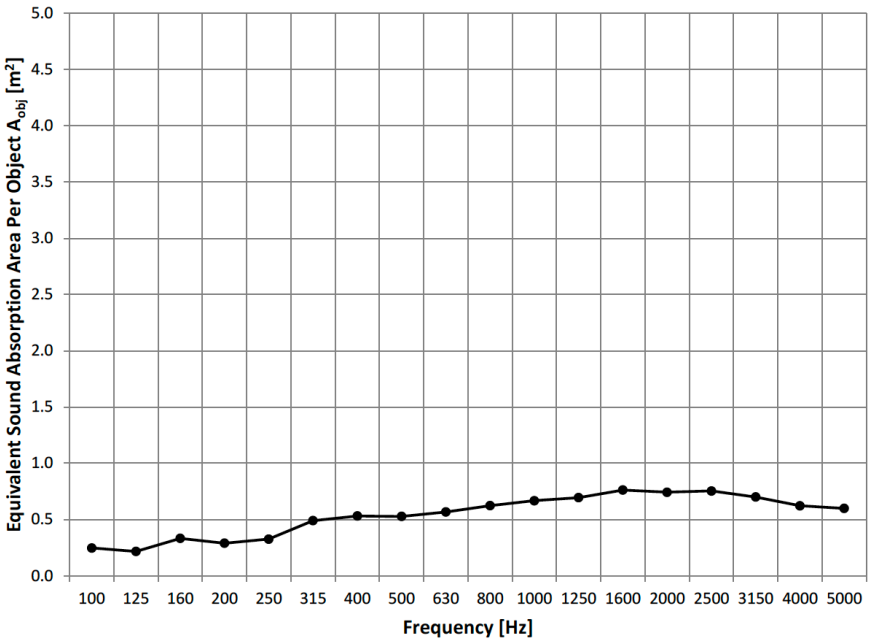

Figure 3: Frequency trend of absorbent units per object A_{obj} – Flexia 180° suspension lamp.

Frequency [Hz]	T_1 [s]	T_2 [s]	A_{obj} [m^2]
100	6.09	5.26	0.2
125	5.82	5.08	0.2
160	5.41	4.59	0.3
200	5.16	4.43	0.3
250	5.05	4.20	0.3
315	5.15	3.93	0.5
400	5.18	3.97	0.5
500	5.31	3.98	0.5
630	5.13	3.82	0.5
800	4.93	3.57	0.6
1000	4.60	3.37	0.6
1250	4.31	3.16	0.7
1600	3.91	2.87	0.8
2000	3.38	2.56	0.8
2500	2.98	2.35	0.7
3150	2.56	2.12	0.7
4000	2.21	1.89	0.6
5000	1.79	1.57	0.7

Table 4: Measured reverberation time and absorbent unit data from Flexia 150° suspension lamp.

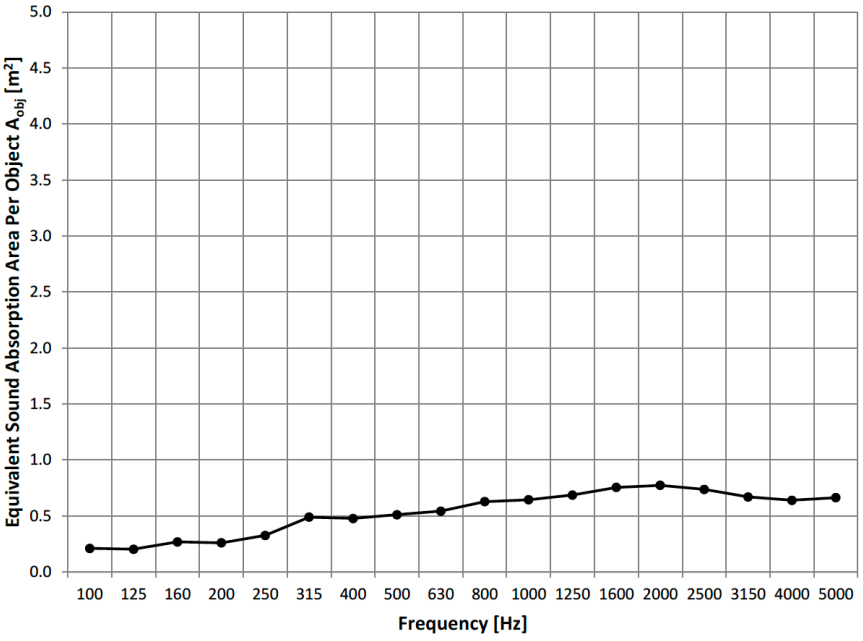

Figure 4: Frequency trend of absorbent units per object A_{obj} – Flexia 150° suspension lamp.

Frequency [Hz]	T_1 [s]	T_2 [s]	A_{obj} [m^2]
100	6.09	5.36	0.2
125	5.82	5.12	0.2
160	5.41	4.70	0.2
200	5.16	4.47	0.2
250	5.05	4.13	0.4
315	5.15	3.88	0.5
400	5.18	4.01	0.5
500	5.31	3.94	0.5
630	5.13	3.78	0.6
800	4.93	3.55	0.6
1000	4.60	3.34	0.7
1250	4.31	3.15	0.7
1600	3.91	2.89	0.7
2000	3.38	2.60	0.7
2500	2.98	2.39	0.7
3150	2.56	2.15	0.7
4000	2.21	1.95	0.6
5000	1.79	1.67	0.5

Table 5: Measured reverberation time and absorbent unit data from Flexia 120° suspension lamp.

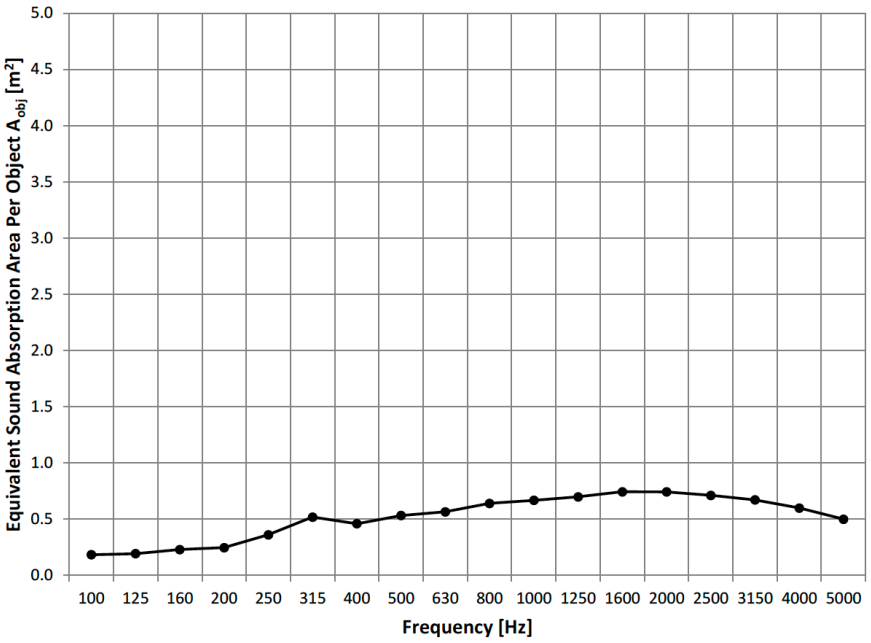

Figure 5: Frequency trend of absorbent units per object A_{obj} – Flexia 120° suspension lamp.

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