TEST REPORT

Measurement type: Measurement of the equivalent area of acoustic absorption in reverberant chamber
Object of the measure: Silent Field Lamp
Reference technical standard: UNI EN ISO 354:2003
Test Lab: Department of Engineering Reverberant Chamber, University of Ferrara
Measurement date: 29/06/2017
Date of report: 29/06/2017

1. Introduction

At the request of Artemide S.p.A. acoustic absorption measurements were made in the chamber of Silent Field lamps with sound-absorbing function. The measurements were carried out in accordance with the UNI EN ISO 354:2003 Acoustic - Measurement of acoustic absorption in the reverberant chamber by applying it to the case of discrete objects, resulting in the measurement in the absorbent units that a single lamp adds to the environment. At the same time, 4 lamps were measured in accordance with regulations about the maximum measurable absorption and the slightest distance between objects.

2. Experimental apparatus

Test environment

The reverberant chamber at the Acoustic Laboratory of the University of Ferrara's Department of Engineering has a volume of 252.9 m^3 and a total area in the triad of 247.4 m^2. The plant is quadrilateral without right angles with a base surface area of 49.9 m2 and the ceiling, with an average height of 5.14 m, also forms non-right angles with the side walls. On the perimeter there are six full columns that increase the diffusion of the acoustic field and there are 4 large speakers of size 2 m x 2.2 m and 5 m warp radius that, hanging at different heights and in a way that is in line with each other and compared to the pa networks and the ceiling, ensure the diffusion of the acoustic field throughout the range of measurement frequencies.

HW/SW Instrumentation

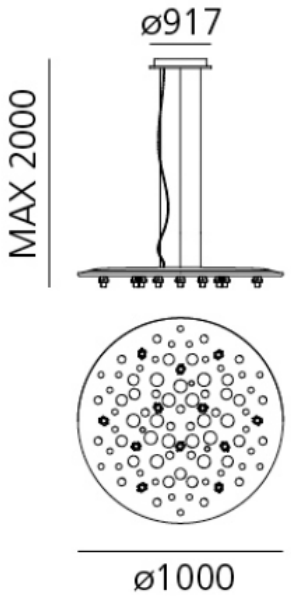
Table 1: HW/SW Resources used in data measurement and analysis

Self Generation	3 dodecahedral sources Marca Lookline Mod. DL304 with digital amplifier
Resumption of Signal	6 multidirectional microphones Class 1 of ½" brand B&K
Acquisition and Analysis System	Sinus sound book with options for impulse response measurement and reverberation calculation

3. Sample tested

Description
The Silent Field lamp consists of two joined discs made of high-density polyester fiber with a diameter of 1000 mm and a total thickness of about 30 mm. The polyester fiber panel at the bottom of the view is shaped with circles of different diameters to create an interplay of full and hollow spaces with maximum depth of about 9 mm. The lamp is then suspended from the ceiling with three steel cables.
In the lower panel, 12 LED spotlights are applied that were not present in the samples used for measurements as they do not affect acoustic absorption.

Figure 1 shows a schematic section of the lamp.



Location
The Silent Field lamp, given how it is assembled, was therefore considered as a "single element" or "discrete element" under the UNI EN ISO 354:2003 standard. The absorbent units (expressed in m2) rather than the acoustic absorption coefficient are therefore assessed, for which the definition would be ambiguous in this case. For the purpose of this measurement, 4 samples were placed in the chamber at a minimum distance of 2 m under the same standard (Figure 2). The lamps were placed on thin floor supports, facing upwards, simulating a typical suspension installation at a distance of 1000 mm from the ceiling.

Figure 2: Arrangement of the 4 Silent Field lamps in reverberant chamber.

4. Measurement procedures

The procedure involves the initial preparation of the reverberant chamber without samples and the execution of impulse response measurements in a minimum of 12, which corresponds to 4 measurement positions for each of the 3 sound sources used. The measurement technique used is the "swept sine" that involves the emission from the dodecahedron of a sine wave with frequency that grows exponentially, and the deconvolution of the signal taken for each microphone. The measurement is repeated 3 times for each sound source. For each of the measured pulse responses, the decay of sound energy is derived through the reverse integration process, and from this the RT1 reverberation time in third-of-eighth bands assessed on a decay of 30 dB. The results are mediated spatially by performing the arithmetic mean of the values obtained for the different combinations of source - receiver. It then corrects the average value obtained due to the absorption of air for the temperature and humidity conditions relative to the empty-room measurements.

A similar procedure is repeated in the same combinations of sources and receivers after placing the test material in the room as described in the previous paragraph. In this case you get an average RT2 reverberation time.

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

$$A_T = A_2 - A_1 = 55{,}3V\left(\frac{1}{c_2 RT_2} - \frac{1}{c_1 RT_1}\right) - 4V(m_2 - m_1) \quad [\mathrm{m}^2]$$

Where:
AT are the absorbent units that characterize the set of 4 lamps
A2 are the absorbent units of the room with lamps
A1 are the absorbent units of the empty chamber
V is the volume of the room
m1 is the corrective coefficient for air absorption in the condition of an empty room
m2 is the corrective coefficient for air absorption in the condition of an occupied room
Measurements took place under the following thermo-hygrometric conditions:

	Temperature	Humidity
Empty Room	25 ° C	30%
Occupied Room	26 °C	30%

Table 2: Thermo-hygrometric conditions during measurements.

The correction of reverberation time data was developed from the regulatory 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 from which you get m using the formula:

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

The required Aobj Value, which represents the absorbent units for each lamp, is finally obtained in the case using the following formula:

$$A_{obj} = \frac{A_T}{4} \qquad [\mathrm{m}^2]$$

5. Results

The results of the equivalent acoustic absorption are provided graphically, as per legislation, in Figure 3 and in numerical form in Table 3 with rounding to 0.1 m2 to absorbing units as indicated by the standard.

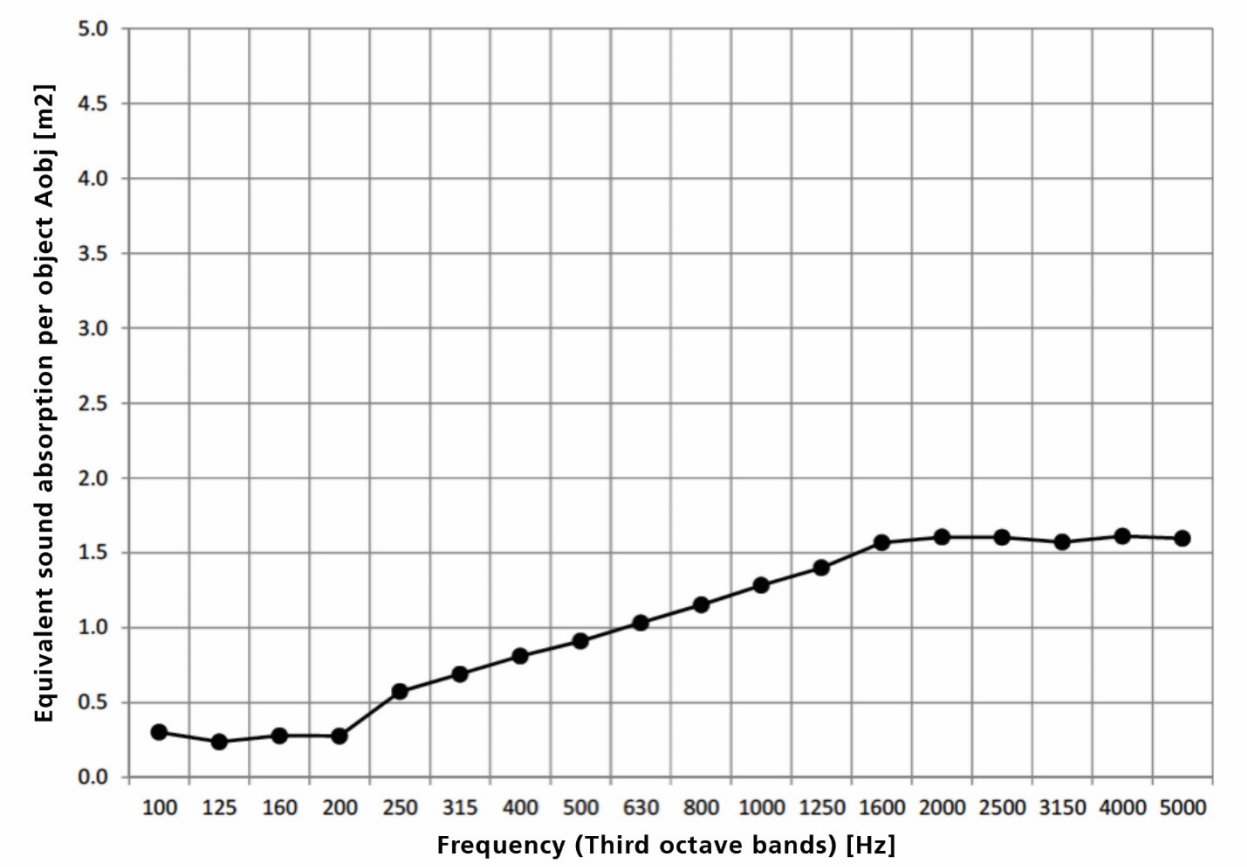


Figure 3: Frequency trend of absorbent units per object A_{obj}

Frequency (Hz)	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000
T1 (s)	6.54	6.12	5.87	5.61	5.38	5.26	5.27	5.36	5.17	5.07	4.78	4.47	4.04	3.48	3.01	2.49	2.14	1.77
T2 (s)	5.46	5.34	5.04	4.85	4.11	3.86	3.69	3.60	3.37	3.20	2.96	2.75	2.48	2.24	2.04	1.81	1.61	1.40
Aobj (m2)	0.3	0.2	0.3	0.3	0.6	0.7	0.8	0.9	1.0	1.2	1.3	1.4	1.6	1.6	1.6	1.6	1.6	1.6

Table 3: Measured reverberation time and absorbent unit data from Silent Field.