LAB N° 0620 L

TEST REPORT No. 21076MAZ-11CA114

Reverberation rooms – Sound test

Amaro, 2021/06/25

Customer:	**TRINITY TREE DESIGN S.r.l.** I – 33076 Pravisdomini (PN) Via Ornedi, 25
Testing location:	Local Unit Udine | HVACR Testing I – 33020 Amaro (UD) | Via J. Linussio, 1
Unit under test:	Wall panel
Manufacturer/Model:	NOISEMONSTER / TRAPEZIUM
Serial number:	n.a
Date of reception of unit:	2021/06/08
Date of test – beginning:	2021/06/25
Date of test – finish:	2021/06/25
Type of test:	Sound power measurement
Dimensions:	L(600) H(30) W(510/600) (mm) for single panel L(1200) H(30) W(1200) (mm) for a whole object
Year of manufacture:	n.a.

Reference documents:

- EN ISO 354: 2003 "Acoustics – Measurement of sound absorption in a reverberation room".

The results presented in this report are valid only for the tested unit.

Executed and Approved by Technical Manager

Andrea Mazzolini – IMQ | Local Unit Udine

The tested unit has been chosen by the customer/manufacturer.
This report consists of 12 pages. Any reproduction of this report must contain all pages.
Any other partial reproduction of this document must be authorised by IMQ.

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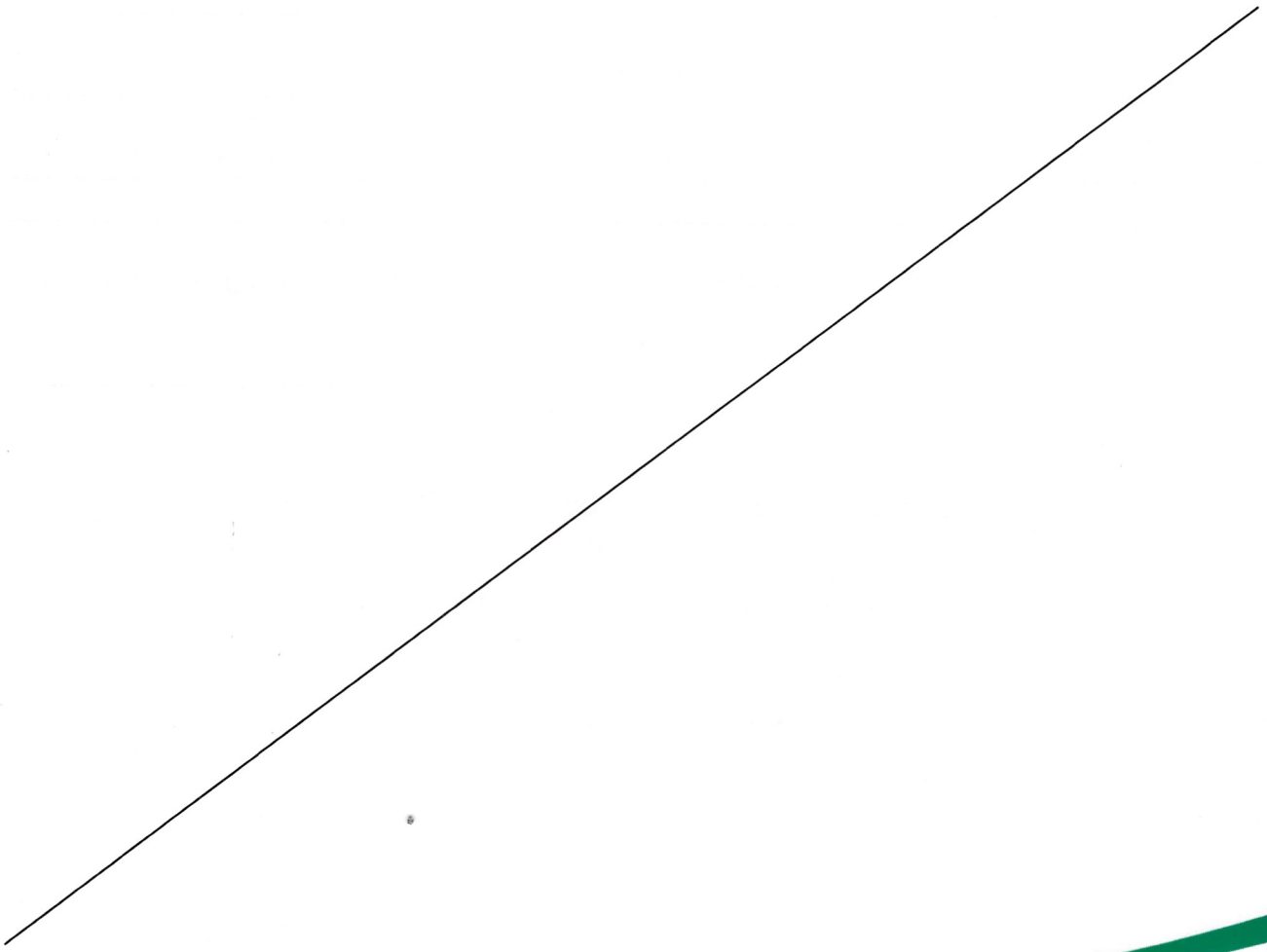


1 PURPOSE OF THE TEST

The purpose of the test is to measure the equivalent sound absorption area of the test specimen using the method defined in *EN ISO 354: 2003 "Acoustics – Measurement of sound absorption in a reverberation* room"
The mean reverberation time is measured for the range of interest of frequencies between 100 to 5000 Hz.

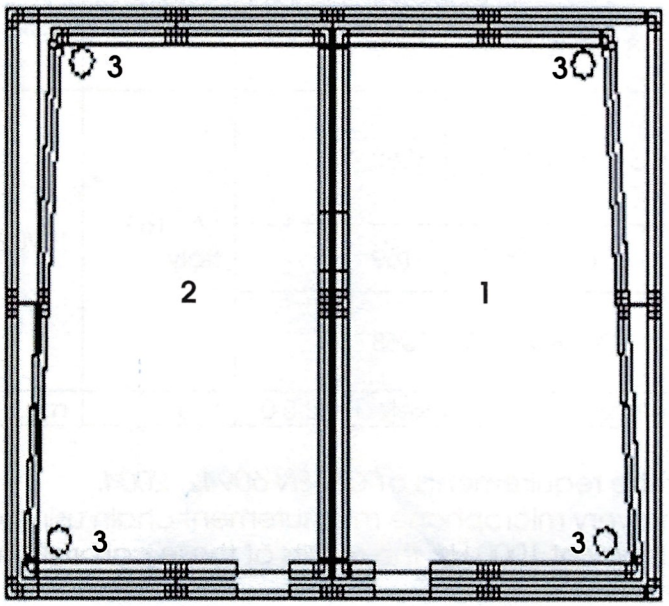
2 TECHNICAL DESCRIPTION

2.1 Reverberation Rooms

The test chambers are two reverberation rooms with symmetrical layout. The nominal volume is approximately of 204 m^3 and the internal surface of 226 m^2 for each room. Detailed dimensions for one room are:

- Length: 9 m
- Width: 5 m
- Height: 4,5 m

To achieve a sound field as much as possible diffuse, rooms are asymmetric with surfaces that are not parallel to each other and painted with primer and polish reflective insulation, the floor is covered with type "clinker" reflective tiles. The soundproofing of the rooms is ensured by a double shell and spring elastic suspension of the inner chambers.



KEY:

1 : Internal Room
2 : External Room
3 : Reconditioning system

Figure 1 - Diagram of the two reverberation rooms

2.2 Test operating conditions

Climatic test conditions (temperature, humidity and pressure) imposed by the following standards:

- *EN ISO 354: 2003 "Acoustics – Measurement of sound absorption in a reverberation room".*

are produced and maintained for all the duration of the test through a soundproof system of ventilation/air conditioning; it consists of a recovery plant enslaved to a central air treatment with heat exchangers equipment that allow quick and fine adjustment with independent software control. To this purpose, the system communicates with the rooms through the ducts represented in Figure 1.

2.3 Instrumentation

Acoustic Instruments					Calibration	
Description		Code	Model	Serial number	Place	Date
Acoustic calibrator		CA02	Bruel & Kjaer 4226	2288479	LAT 163 Italy	27/05/2021
Microphone measurement chain room 1	Diffuse-field microphone class 1 precision	CA06	Larson & Davis 2560	3264	LAT 163 Italy	20/02/2020
	Microphone pre-amplifier	CA08	Larson & Davis 900C	1170		
	Real-time spectrum analyser	CA04	Larson & Davis 2900B	1068		
Microphone measurement chain room 2	Diffuse-field microphone class 1 precision	CA05	Larson & Davis 2560	3262	LAT 163 Italy	20/02/2020
	Microphone pre-amplifier	CA07	Larson & Davis 900C	1169		
	Real-time spectrum analyser	CA04	Larson & Davis 2900B	1068		
Acquisition software		CA55	N&V Works	Release 2.5.0	n.a.	n.a.

Acoustic calibrator is verified to satisfy the requirements of *CEI EN 60942: 2004.*
Acoustic calibrator is used to calibrate every microphone measurement chain using a pure tone with amplitude of 114 dB at frequency of 1000 Hz; the results of these calibration are in compliance to reference documentation.

Both microphone measurement chains are verified to fully satisfy compliance to *CEI 29-30, IEC 651 and IEC 804.*

The one third octave frequency band average value of sound pressure level is determined following criteria described in section 8.3 of *EN*: in every room a rotating boom is used; the microphone path length is 10,3 meters; it is circular and it doesn't lay in a plane that is parallel to room walls/floor (±10°).

Spectrum data are recorded with the real-time spectrum analyzer that is able to carry out frequency analysis of sound pressure levels with one third octave frequency band sampling. Processing of spectrum data for the frequency range of interest (100 Hz to 5000 Hz) is done with N&V Works software that calculates average sound pressure level, sound power level and A-weighted sound power level.

Instrumentation for electrical, climatic and working condition measurements consists of:

Thermoelectrical Instruments				
Measured parameter		Code	Model	Serial number
Air	Dry-bulb temperature	CA29, CA30	Platinum RTD	n.a.
			Thermocouple	n.a.
	Humidity	CA21, CA22	Michel PC52	371709 371707
	Atmospheric pressure	TV_PAMB2500	VAISALA PTB101C	Y4530017

2.4 Uncertainty of measurement

The values of expanded uncertainty of measurement in the frequencies range of interest are obtained in compliance to the internal procedure PR-02/Clima, multiplying the standard uncertainty by a coverage factor k=2, providing a level of confidence of approximately 95%.

The upper limits of measurement uncertainty for thermoelectrical parameters are the following ones:

Measured quantity		Uncertainty of measurement
Air	Dry bulb temperature	± 0,5 K
	Wet bulb temperature	± 0,8 K

3 MEASUREMENT METHOD

The equivalent sound absorption area of the test specimen is calculated measuring the mean reverberation time of the chamber in each frequency band without and with the test specimen in compliance with the standard *EN ISO 354: 2003 "Acoustics – Measurement of sound absorption in a reverberation room"*.

The reverberation times are calculated assessing the sound pressure decay curve with interrupted noise method, using a loudspeaker and several microphone positions.

On conclusion, the equivalent sound absorption of the test specimen, A_T, in square meters, is calculated using the formula:

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

where:

V is the volume, in cubic meters, of the empty reverberation room;

c_1 is the propagation speed of sound air, in meters per second, in air at temperature t_1;

T_1 is the reverberation time, in seconds, of the empty reverberation room;

m_1 is the power attenuation coefficient, in reciprocal meters, calculated according to ISO 9613-1 using the climatic conditions that have been present in the empty reverberation room during the measurement;

c_2 is the propagation speed of sound air, in meters per second, in air at temperature t_2;

T_2 is the reverberation time, in seconds, of the reverberation room after the test specimen has been introduced;

m_2 is the power attenuation coefficient, in reciprocal meters, calculated according to ISO 9613-1 using the climatic conditions that have been present in the reverberation room after the test specimen has been introduced;

Moreover, the sound absorption coefficient, a_{si}, for i-third octave band of a plane absorber or a specified array of the test objects shall be calculated using the formula:

$$\alpha_{Si} = \frac{A_T}{S}$$

S: is the area, in square meters, covered by the test specimen.

When the test specimen comprises several identical objects, the equivalent sound absorption area A_{obj} is defined:

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

n: is the number of objects

4 INSTALLATION OF UNIT UNDER TEST

The test specimen and the microphone are installed in the reverberation room in accordance with *EN ISO 354: 2003*.

In detail:

- The test objects are 4, each consist of 4 panels, each test object is placed on the floor at a distance of more than 1 m from the wall;
- A total of 12 spatially independent measurements are taken (2 loudspeaker position and 6 microphone positions).

Note:
The test objects are set according to the customer/manufacturer instructions.

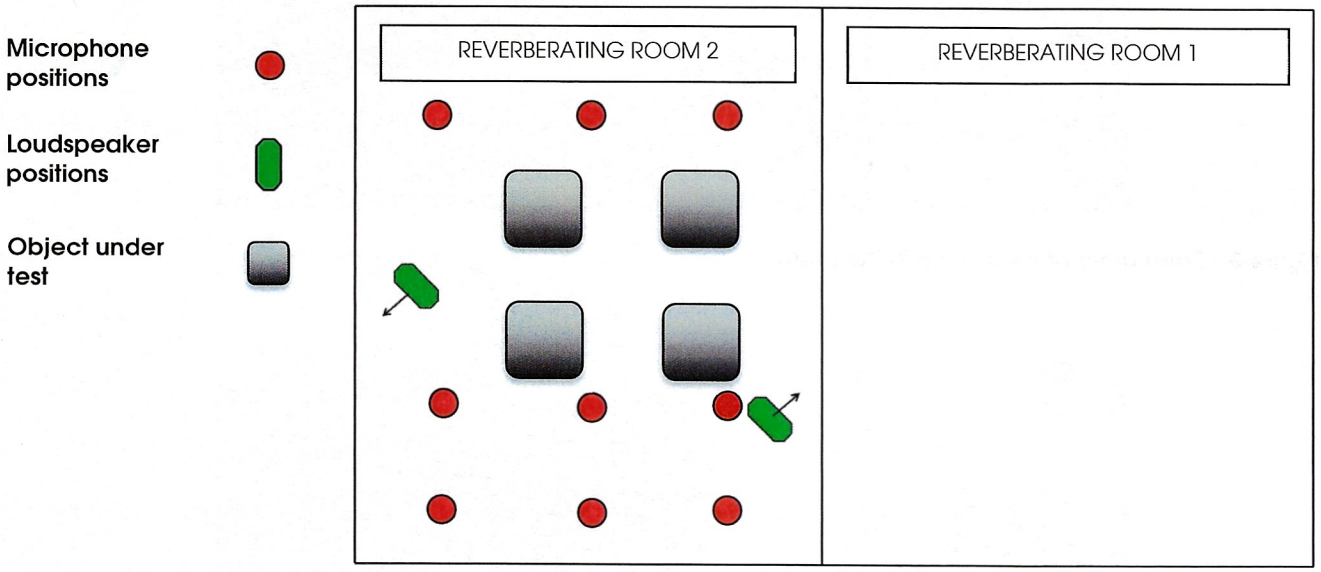


Figure 2 - Schematic installation of the unit.

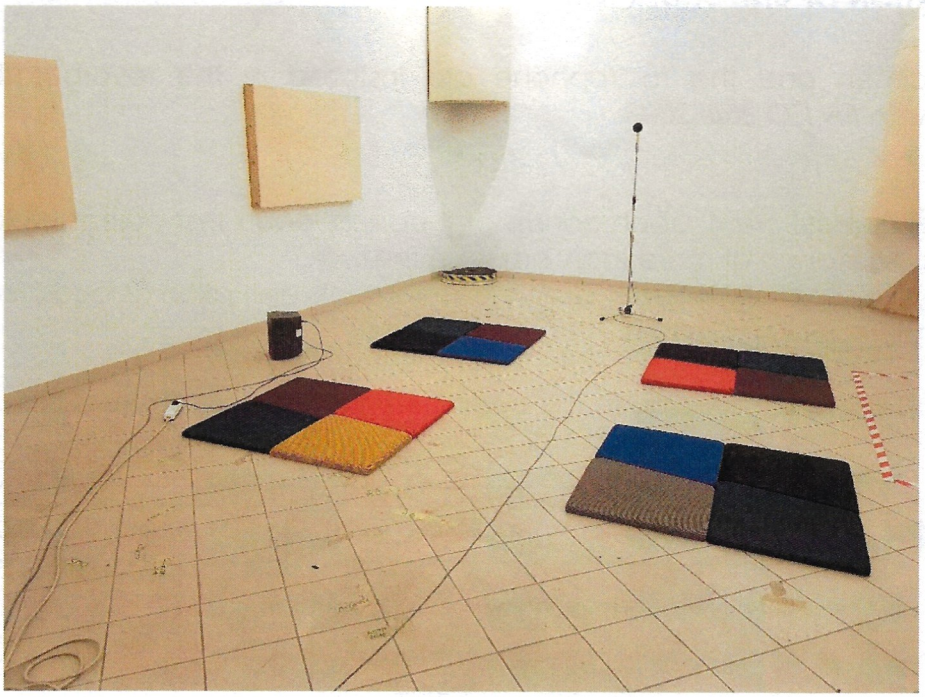


Figure 3 - Panoramic of installation in the room.

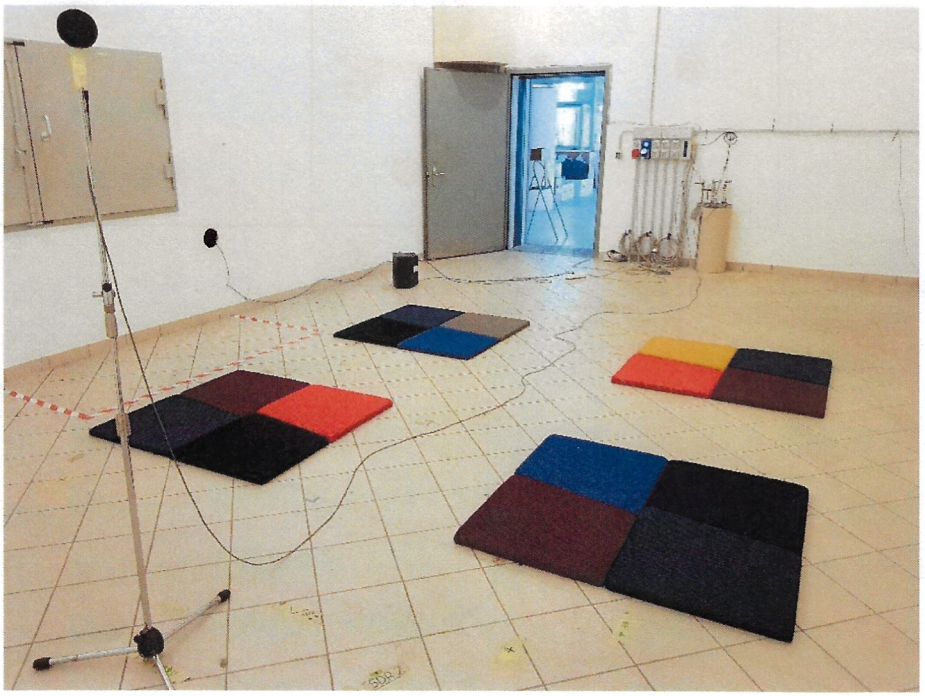


Figure 4 - Panoramic of installation in the room.

Figure 5 - Detail of the whole object, composed by 4 separate panels.

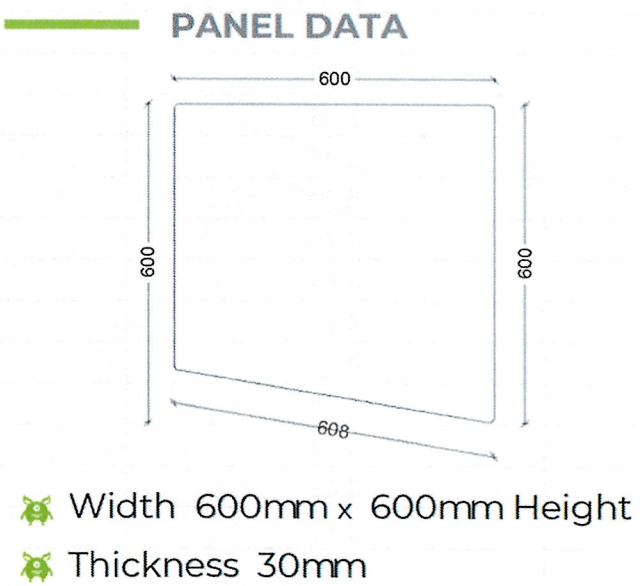


Figure 6 - Dimensional drawing of a single panel.

5 TEST CONDITIONS

Climatic conditions and power supply of unit under test are the following:

TEST CHAMBER	
Dry bulb temperature (°C) – Internal Room	24,44
Relative humidity (RH%) – Internal Room	62
Atmospheric pressure (kPa)	98,47

6 TEST RESULTS: TABLES

6.1 Reverberation time

REVERBERATION TIMES		
Frequency	T_1	T_2
Hz	s	s
100	6,24	5,80
125	6,16	5,84
160	4,99	4,77
200	6,82	6,02
250	5,89	5,00
315	5,88	4,49
400	5,08	3,56
500	5,44	3,68
630	5,20	3,20
800	4,76	2,93
1000	4,64	2,70
1250	4,74	2,59
1600	4,86	2,54
2000	4,66	2,42
2500	4,23	2,33
3150	3,61	2,21
4000	3,11	2,01
5000	2,45	1,76

T_1: reverberation time of the room
T_2: reverberation time of the room with test specimens

6.2 Equivalent sound absorption area and the sound absorption per object

Equivalent sound absorption area and the sound absorption of whole object		
Frequency	A_T	A_{Obj}
Hz	m^2	m^2
100	0,40	0,10
125	0,28	0,07
160	0,30	0,08
200	0,64	0,16
250	0,98	0,25
315	1,71	0,43
400	2,72	0,68
500	2,86	0,71
630	3,92	0,98
800	4,27	1,07
1000	5,02	1,25
1250	5,68	1,42
1600	6,09	1,52
2000	6,46	1,61
2500	6,24	1,56
3150	5,73	1,43
4000	5,71	1,43
5000	5,17	1,29

A_T: Total Equivalent sound absorption area
A_{Obj}: Equivalent sound absorption area of a single object

7 SOUND ABSORPTION LEVELS SPECTRUM

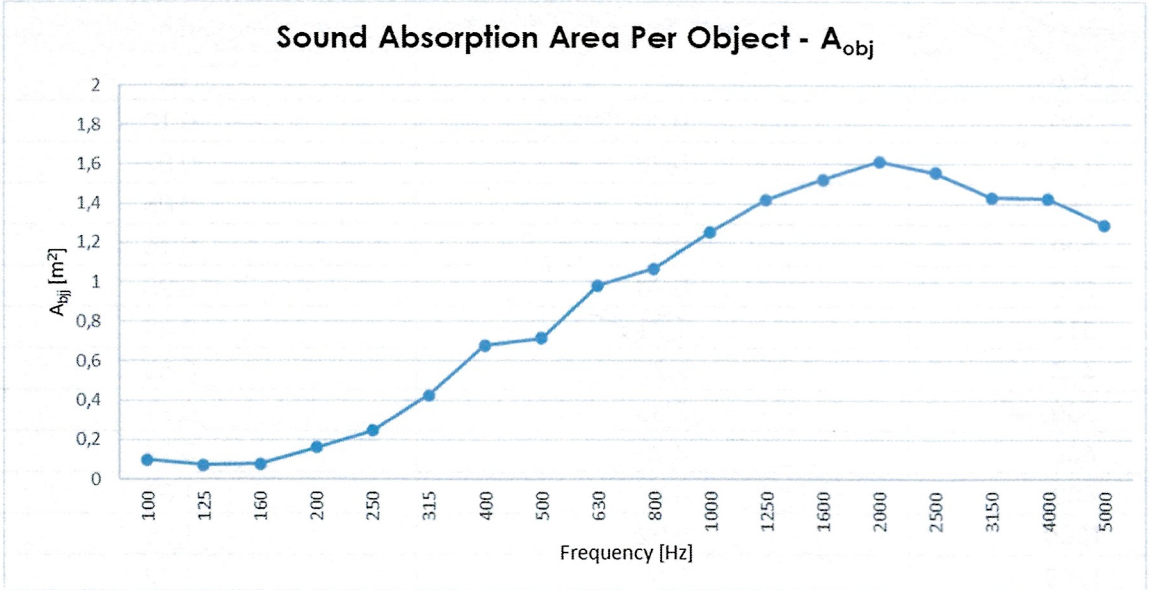


Figure 7 – Sound absorption levels spectrum - whole Object

- End of test report -