TEST REPORT

Laboratory measurement of sound absorption coefficient of Nature Impact Wall

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Performed for Nature Impact A/S

Project no.: 122-23732

DANAK no. 100/2715

Hørsholm, 7 April 2022

TEST Reg. nr. 100

Acoustics, Noise and Vibrations

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OVERVIEW

Title	Laboratory measurement of sound absorption coefficient of Nature Impact Wall
Project no.	122-23732
DANAK no.	100/2715
Test period	2 March 2022
Client	Nature Impact A/S Sdr. Højrupvejen 130 5750 Ringe Denmark Tel.: +45 65982223
Contact person	Keld Nielsen E-mail: kn@natureimpact.com
Test method	The test is carried out according to EN ISO 354:2003. The uncertainty is calculated according to EN ISO 12999-2:2020. The calculated practical sound absorption coefficient α_p, the weighted absorption coefficient α_w and the associated absorption class are calculated according to ISO 11654:1997
Summary	Laboratory measurements of the equivalent sound absorption area was carried out in a reverberation room according to the test method of EN ISO 354:2003. Product: Nature Impact Wall Depth: 205 mm The test results per one-third octave are shown in tabular form and graphically on Graph Sheet 1. Descriptions of reverberation room and test procedure are found in Appendix 4.
Revisions	Initial version

Test site	DTU, Akustikvej Building 355, 2800 Kongens Lyngby, Denmark
Our ref.	RSHS/LSS/ilk

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1 Introduction

At the request of Nature Impact A/S, measurements of the sound absorption coefficient in a reverberation room have been carried out for the product Nature Impact Wall.

2 Description of the test specimen based on the client's specifications

Nature Impact Wall is a vertical garden. The product consists of aluminium plant modules mounted on guide rail. In the plant modules are plants placed to cover the entire system.

Product: Nature Impact Wall

Plant modules: The plant modules are made of 1 mm thick aluminium.

The dimensions of the boxes: Width: 1200 mm; Height: 190 mm; Depth: 127 mm

Guide Rails: The guide rails are made of 2 mm thick aluminium.

The dimensions of the guide rails: Width: 96 mm; Height: 2380 mm; Depth: 25 mm

The tested construction was 3600 x 3000 mm. 51 plant modules were placed in 3 columns.

Plants: 14 plants were placed in each plant module.

The plant distribution was:

Philodendron Scandens 55 %

Blue Star 5 %

Philodendron Selloum 5 %.

Chlorophytum Variegata 25 %

Cyperus Zumula 10 %

The vertical edges of the product were covered by an aluminium frame. The frame depth was 170 mm.

A principal drawing of the Nature Impact Wall is illustrated in Figure 1 in Appendix 3.

3 Mounting in the laboratory

The test object was placed in the test room in accordance with ISO 354:2003.

The laboratory wall has built in steel plates with fixed mounting grooves. The groove distance is 50 cm which does not fit the product width. In order to mount the guide rails, two wooden boards were fixed horizontal to the wall, whereafter the guide rails were fixed to the wooden boards. The thickness of the wooden boards was 25 mm which increases the total thickness of the test specimen.

The sample was not enclosed by an additional frame, since the mounting in real scenarios are done with the vertical aluminum frame. Thereby, a measurement without a frame will be more representative. For the same reason, covering the joints between the adjacent pieces and concrete floor with tape was not done either, despite the extra distance due to the wooden boards.

Construction height: 205 mm (Type E-210 mounting – without enclosed frame and the use of tape).

The test sample was placed at the wall with the bottom of the construction touching the floor, so that no other parts of the sample was closer than 1 m to any edge of the boundary of the room (other than the floor).

Photo of the specimen in the laboratory can be seen in Appendix 3.

4 Test method

The measurements were carried out according to the test method of ISO 354:2003: "Measurement of Sound Absorption in a Reverberation Room". During the measurements 51 plant modules were put together to form a test area of 10.8 m^2 (3.0 x 3.6 m)

The sound absorption coefficient was calculated from the reverberation times measured with and without the test specimen.

The measurements were performed in Room 005, Building 355 at the Technical University of Denmark. Brief descriptions of the reverberation room and test procedure are found in Appendix 4.

5 Measurement conditions

The reverberation time was recorded in 6 microphone positions, each placed in the range 1.55 m to 2.85 m above the floor. The number of sound source positions was two.
The reverberation time T_1 per third octave of the room without test specimen and the reverberation time T_2 per third octave of the room with test specimen:

Frequency f [Hz]	Reverberation time T_1 [s]	Reverberation time T_2 [s]
100	6.17	5.06
125	7.30	5.46
160	7.84	5.29
200	7.62	4.50
250	7.08	3.78
315	6.85	3.49
400	6.77	2.99
500	6.34	2.84
630	6.21	2.74
800	5.77	2.67
1000	5.17	2.34
1250	4.88	2.37
1600	4.40	2.40
2000	3.83	2.18
2500	3.38	2.13
3150	2.64	1.86
4000	2.09	1.63
5000	1.69	1.41

Temperature and relative humidity in the reverberation room during measurements:

Room without test specimen: 16.6 °C, 41 % RH. Date of test: 2 March 2022

Room with test specimen: 16.7 °C, 47 % RH. Date of test: 2 March 2022.

The correction of the absorption coefficient due to differences in temperature and relative humidity during measurements of T_1 (the reverberation time of the empty room) and T_2 (the reverberation time of the room with test specimen) was 0 at all frequencies.

6 Test results

The test results – the sound absorption coefficient α_s per one-third octave from 100 Hz to 5000 Hz are shown in tabular form and graphically on Graph Sheet 1.

The calculated practical sound absorption coefficient α_p per octave from 125 Hz to 4000 Hz is shown in tabular form and graphically on Graph Sheet 2 together with the weighted absorption coefficient α_w and the associated absorption class. These numbers are calculated according to ISO 11654:1997.

7 Measurement uncertainty

The measurement uncertainty for the sound absorption coefficient α_s per object per one-third octave is calculated according to EN ISO 12999-2:2020. The expanded uncertainty U given as a two-sided 95 % confidence interval (k=2) based on the reproducibility is as follows:

Frequency f [Hz]	U (k = 2, two sided)
100	±0.08
125	±0.08
160	±0.08
200	±0.10
250	±0.10
315	±0.10
400	±0.10
500	±0.10
630	±0.08
800	±0.08
1000	±0.10
1250	±0.08
1600	±0.08
2000	±0.08
2500	±0.08
3150	±0.10
4000	±0.12
5000	±0.14

The uncertainty U (two-sided 95 % confidence interval, k=2) based on reproducibility of the practical sound absorption coefficient α_p per octave is:

Frequency [Hz]	U (k = 2)
250	±0.08
500	±0.08
1000	±0.08
2000	±0.08
4000	±0.10

Uncertainty based on reproducibility based on the weighted absorption coefficient α_w is **±0.07.**

Appendix 1 Graph Sheets

Laboratory measurement of sound absorption according to EN ISO 354:2003

Client: Nature Impact A/S, Sdr. Højrupvejen 130, 5750 Ringe, Denmark

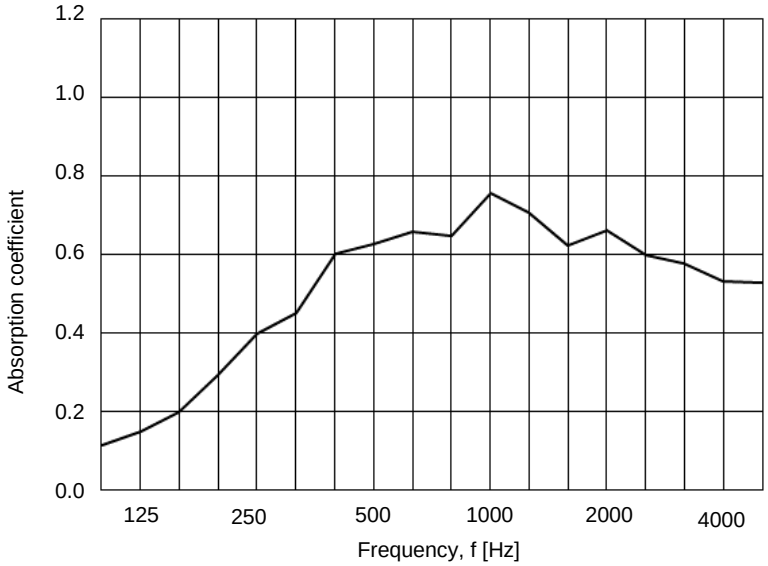
Date of test: 2 March 2022

Test specimen: Nature Impact Wall

Construction height: 205 mm (Type E-210 mounting)

Test area: 10.8 m²
Room volume: 215 m³
Room surface: 305 m²

Frequency f [Hz]	α_s
100	0.11
125	0.15
160	0.20
200	0.29
250	0.40
315	0.45
400	0.60
500	0.63
630	0.66
800	0.65
1000	0.76
1250	0.71
1600	0.63
2000	0.66
2500	0.60
3150	0.58
4000	0.53
5000	0.53



FORCE Technology, 7 April 2022

Rasmus Stahlfest Holck Skov
Acoustics, Noise and Vibrations

Laboratory measurement of sound absorption according to EN ISO 354:2003

Client: Nature Impact A/S, Sdr. Højrupvejen 130, 5750 Ringe, Denmark

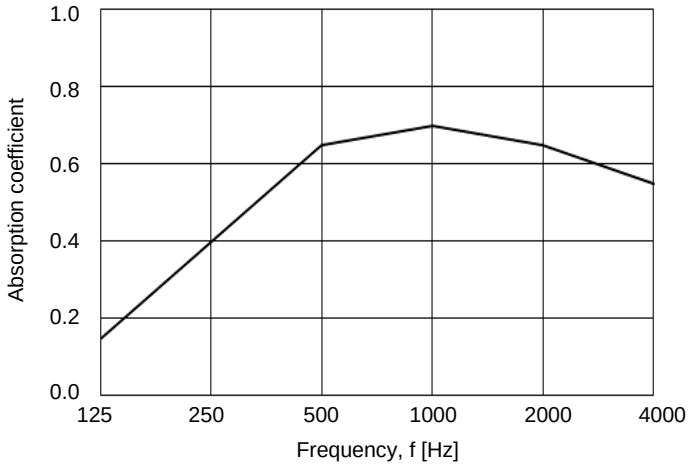
Date of test: 2 March 2022

Test specimen: Nature Impact Wall

Construction height: 205 mm (Type E-210 mounting)

Test area: 10.8 m²
Room volume: 215 m³
Room surface: 305 m²

Frequency f [Hz]	α_p
125	0.15
250	0.40
500	0.65
1000	0.70
2000	0.65
4000	0.55



Practical absorption coefficient, weighted absorption coefficient and absorption class according to EN ISO 11654:1997:

α_w = 0.65 Absorption class: C

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Appendix 2 List of instruments

No.	Equipment	Producer	Model	Calibration	
				Latest	Next
1498L	Sound Level Meter / Analyzer	Brüel & Kjær	2270	2021-09-02	2023-09-02
1256L	Measuring Microphone	Brüel & Kjær	4144	2022-02-25	2024-02-25
1616L	Measuring Microphone	G.R.A.S.	40EN 1"	2020-06-12	2022-06-12
1395L	Microphone Preamplifier	Brüel & Kjær	2619	2020-05-25	2022-05-25
0853L	Microphone Preamplifier	Brüel & Kjær	2619	2022-02-25	2024-02-25
1040L	Microphone Power Supply	Brüel & Kjær	5935	2020-05-26	2022-05-26
1652L	Sensor for Temperature and Humidity	Rotronic	HL-1D-SET	2021-05-18	2022-05-18
1120L	Acoustic calibrator	Brüel & Kjær	4231	2021-10-12	2022-04-12

Appendix 3 Illustrations

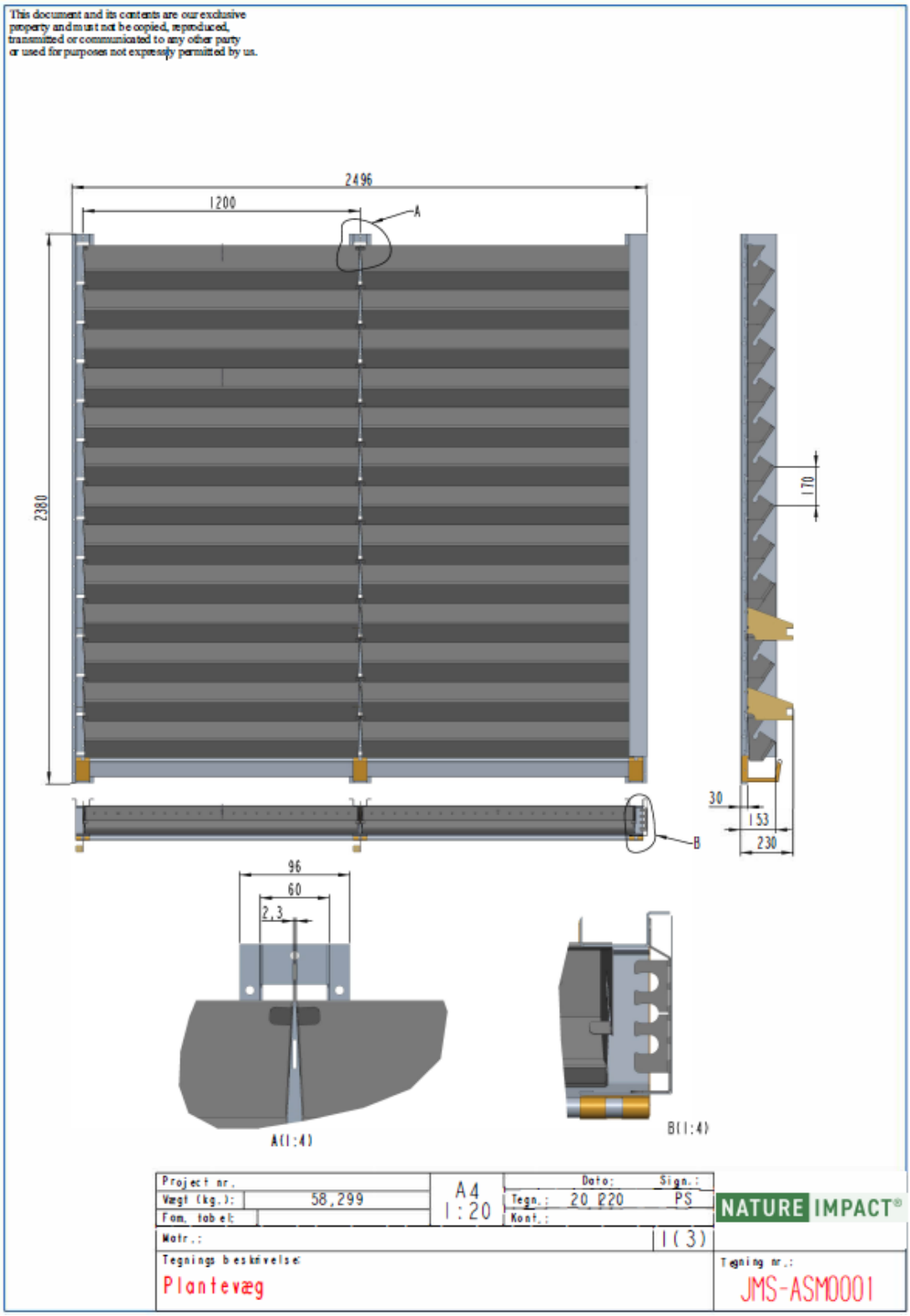

Figure 1 *Principle drawing of the Nature Impact Wall. The drawing does not show the size of the tested wall.*

Figure 2 *Photo of Nature Impact wall mounted in the laboratory.*

Figure 3 *Photo of Nature Impact Wall during mounting in the laboratory.*

Appendix 4 Description of reverberation room and test procedure

Reverberation room

The measurements are performed in a reverberation room (Room 005, Building 355 at the Technical University of Denmark) with walls, ceiling, and floor of 300 mm in situ cast concrete. Length, width, and height of the room are 7.85 m, 6.25 m, and 4.95 m, respectively. The volume of the room is approx. 215 m³, and the total surface area is approx. 305 m². Sound diffusion elements of concrete, of damped steel plate, and of acrylic sheets are placed in the room.

Test procedure

Measurement of sound absorption according to EN ISO 354:2003 is carried out in a reverberation room. The reverberation time is measured with and without the test specimen, and the sound absorption coefficient is evaluated using Sabine's formula.

The test signal used is broad band pink noise emitted successively by two loudspeakers located in two opposite corners of the room. The reverberation time is measured in six microphone positions for each loudspeaker. For each microphone/loudspeaker position three repeated excitations are used. One-third octave filters (100-5000 Hz) are included in the receiving equipment.

The reverberation time is evaluated from the averaged slope of the decay curve over a range from 5 dB to 25 dB below the steady state level.

The sound absorption coefficient α_s is calculated using the following formula:

$$\alpha_s = \frac{55{,}3 \cdot V}{S} \cdot \left(\frac{1}{c_2 \cdot T_2} - \frac{1}{c_1 \cdot T_1} \right) - \frac{4V}{S} \cdot (m_2 - m_1)$$

where

- α_s = Sound absorption coefficient
- V = Volume of the empty reverberation room [m³]
- S = Area of the test specimen
- c_1 = Velocity of sound in air [m/s] without test specimen
- c_2 = Velocity of sound in air [m/s] with test specimen
- T_1 = Reverberation time of the empty reverberation room [s]
- T_2 = Reverberation time of the reverberation room after the test specimen has been introduced [s]
- m_1 = Attenuation coefficients due to air absorption during measurement of T1 (m^{-1})
- m_2 = Attenuation coefficients due to air absorption during measurement of T2 (m^{-1})

The attenuation coefficient of sound in air varies with relative humidity, temperature, and frequency. During a series of measurements of reverberation times T_1 and T_2, the relative humidity and the temperature are held as constant as possible. A correction term as given in the formula above is applied. The correction is based on data from ISO 9613-1:1993.