

# TEST REPORT

## Laboratory measurement of sound absorption of Acupanels Upcycled Turf Panels – Type E-60 mounting

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### Performed for Acupanels International ApS

Project no.: 122-30179

DANAK no. 100/2782

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Hørsholm, 12 October 2022



### Acoustics, Noise and Vibrations

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## OVERVIEW

<b>Title</b>	Laboratory measurement of sound absorption of Acupanels Upcycled Turf Panels – Type E-60 mounting
<b>Project no.</b>	122-30179
<b>DANAK no.</b>	100/2782
<b>Test period</b>	7 September 2022
<b>Client</b>	Acupanels International ApS Industrivej 12 7490 Aulum Denmark E-mail: hello@acupanels.dk Tel.: +45 8877 8370
<b>Contact person</b>	Tom Nielsen E-mail: tn@acupanels.dk
<b>Test method</b>	Test method: EN ISO 354:2003 Evaluation: EN ISO 11654:1997 Uncertainty: EN ISO 12999-2:2020
<b>Summary</b>	Laboratory measurements of sound absorption coefficients were carried out in a reverberation room according to the test method of EN ISO 354:2003. Product: Acupanels Upcycled Turf Panels Mounting: Type E-60 with mineral wool 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.
<b>Revisions</b>	Initial version
<b>Test site</b>	DTU, Akademivej, Bygning 355, 2800 Kongens Lyngby, Denmark

**Our ref.**

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## 1 Introduction

At the request of Acupanels International ApS, measurements of sound absorption coefficients in a reverberation room have been carried out for Acupanels Upcycled Turf Panel product.

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

Acupanels Upcycled Turf Panel is a felt panel covered with MDF lamellas that are coated in veneer. The felt is made from upcycled turf.

Product:	Acupanels Upcycled Turf Panel
Lamellas:	27 x 10 mm MDF lamellas covered with veneer, 40 mm spacing, cc 13 mm
Felt:	7 mm felt from upcycled turf, density 150 kg/m <sup>3</sup>
Thickness:	7 mm of felt / 17 mm felt with lamellas
Insulation:	45 mm mineral wool, density 16 kg/m <sup>3</sup> , placed between 45 x 45 mm wooden battens of 600 mm spacing
Construction height:	62 mm
Module size:	Different sizes

## 3 Mounting in the laboratory

The panels were placed as a plane on a concrete floor in a frame with the size 3.60 m × 3.00 m on top of a 45 mm mineral wool layer. The mineral wool was placed between 45 x 45 mm wooden battens of 600 mm spacing.

Mounting depth: 62 mm (Type E-60 mounting).

Both the mineral wool layer and the edges of the test specimen were enclosed by a wooden frame.

All joints between the test specimen and the frame as well as between the frame and the concrete floor were sealed with tape.

The test sample was placed so that no part of them was closer than 1 m to any edge of the boundary of the room other than the floor.

The photo and drawing of the test 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".

The test specimen was put together of 6 Upcycled Turf Panels of size 2400 x 600 mm and 6 Upcycled Turf Panels of size 600 x 600 mm to form a test area of 10.8 m<sup>2</sup> (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	6.60	4.90
125	7.48	4.65
160	8.13	4.16
200	7.35	3.33
250	6.88	3.14
315	7.17	2.73
400	6.60	2.39
500	6.18	2.06
630	5.91	2.19
800	5.51	2.14
1000	5.02	2.07
1250	4.68	2.09
1600	4.44	2.04
2000	4.03	1.99
2500	3.68	1.92
3150	2.97	1.70
4000	2.53	1.52
5000	2.14	1.40

Temperature and relative humidity in the reverberation room during measurements:

Room without test specimen: 21.6 °C, 58.8 % RH. Date of test: 07 September 2022

Room with test specimen: 21.8 °C, 59.7 % RH. Date of test: 07 September 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  $\alpha_s$  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  $\alpha_p$  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  $\alpha_w$  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  $\alpha_s$  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	±0.12
125	±0.12
160	±0.14
200	±0.14
250	±0.12
315	±0.14
400	±0.14
500	±0.14
630	±0.12
800	±0.10
1000	±0.10
1250	±0.10
1600	±0.10
2000	±0.10
2500	±0.10
3150	±0.12
4000	±0.14
5000	±0.16

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

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

Uncertainty based on reproducibility based on the weighted absorption coefficient  $\alpha_w$  is **±0.07**.

## **Appendix 1**

## **Graph Sheets**



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

Client: Acupanels International ApS, Industrivej 12, 7490 Aulum, Denmark

Date of test: 7 September 2022

Test specimen: Product: Acupanels Upcycled Turf Panel  
Thickness: 17 mm

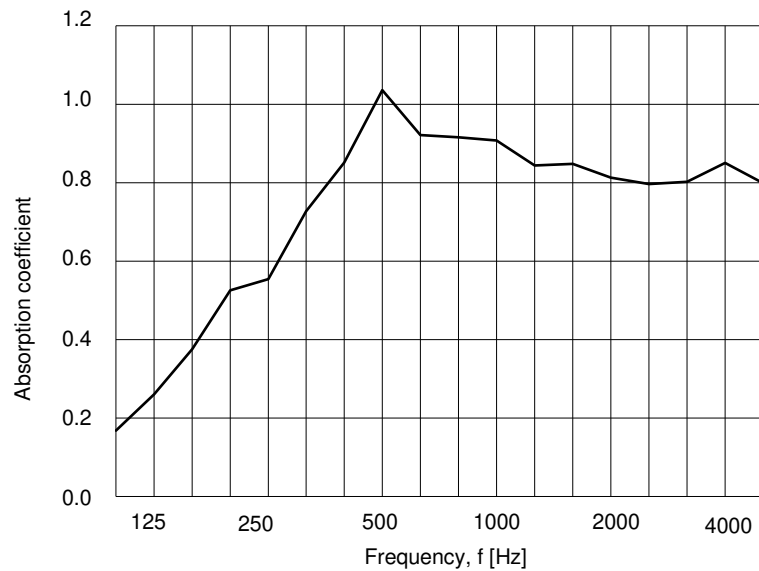
Construction height: 62 mm (Type E-60 mounting with mineral wool)

Test area: 10.8 m<sup>2</sup>

Room volume: 215 m<sup>3</sup>

Room surface: 305 m<sup>2</sup>

Frequency f [Hz]	$\alpha_s$
100	0.17
125	0.26
160	0.38
200	0.53
250	0.55
315	0.73
400	0.85
500	1.04
630	0.92
800	0.92
1000	0.91
1250	0.84
1600	0.85
2000	0.81
2500	0.80
3150	0.80
4000	0.85
5000	0.80



FORCE Technology, 12 October 2022

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

Client: Acupanels International ApS, Industrivej 12, 7490 Aulum, Denmark

Date of test: 7 September 2022

Test specimen: Product: Acupanels Upcycled Turf Panel  
Thickness: 17 mm

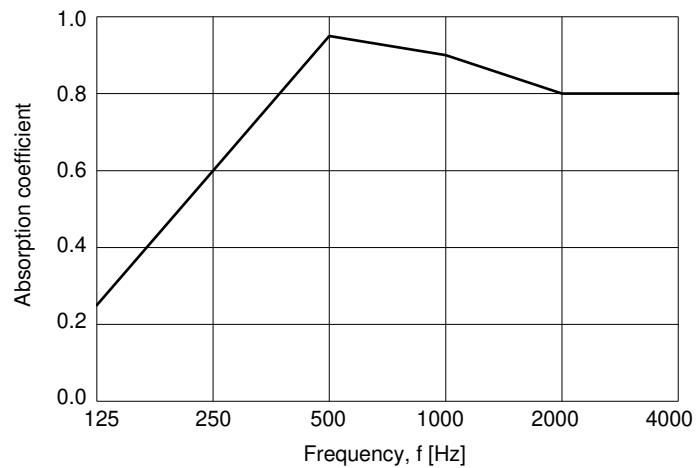
Construction height: 62 mm (Type E-60 mounting with mineral wool)

Test area: 10.8 m<sup>2</sup>

Room volume: 215 m<sup>3</sup>

Room surface: 305 m<sup>2</sup>

Frequency f [Hz]	$\alpha_p$
125	0.25
250	0.60
500	0.95
1000	0.90
2000	0.80
4000	0.80



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

$\alpha_w = 0.85$

Absorption class: B

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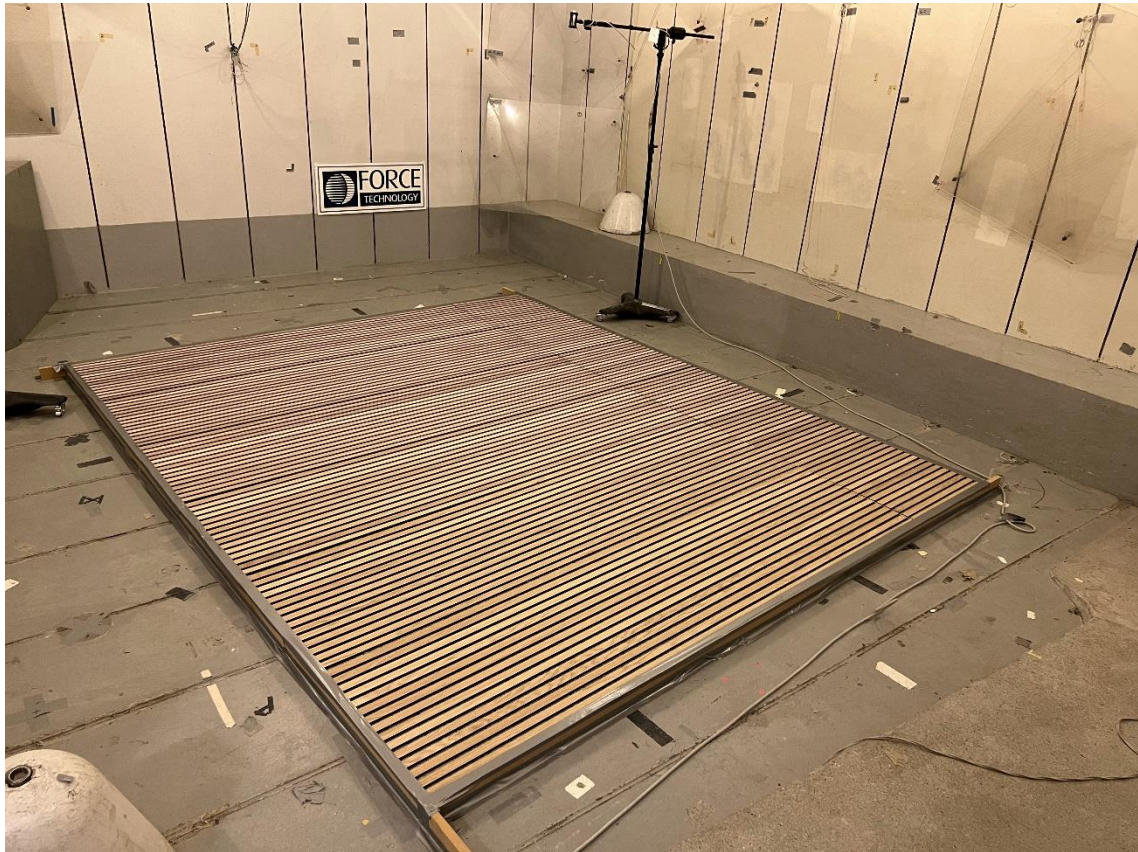
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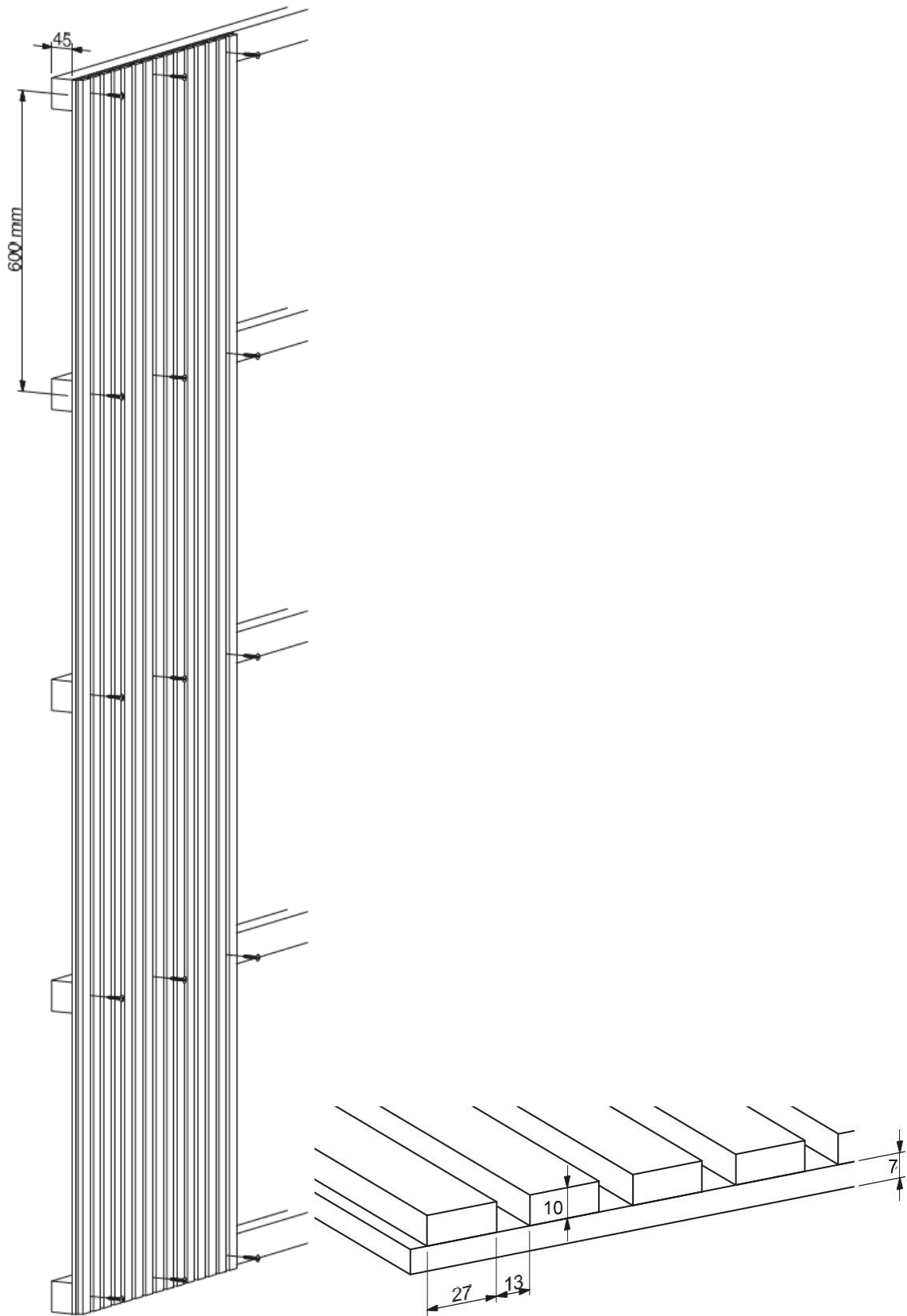
## Appendix 2 List of instruments

No.	Equipment	Producer	Model	Calibration Latest	Calibration 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
0716L	Measuring microphone	Brüel & Kjær	4144	2022-06-20	2023-06-20
853L	Microphone preamplifier	Brüel & Kjær	2619	2022-02-25	2024-02-25
1395L	Microphone preamplifier	Brüel & Kjær	2619	2022-07-08	2024-07-08
1040L	Microphone power supply	Brüel & Kjær	5935	2022-07-12	2024-07-12
1654L	Sensor for tempera- ture and humidity	Rotronic Instruments	BL-1D-SET	2021-05-18	2023-01-01
1158L	Acoustic calibrator	Brüel & Kjær	4231	2022-06-07	2022-12-07

## Appendix 3 Photo and drawing



**Figure 1** *Acupanel Upcycled Turf Panels mounted in the laboratory (type E-60 mounting).*



**Figure 2** Drawing of Acupanel Upcycled Turf Panels.

## 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 m<sup>3</sup>, and the total surface area is approx. 305 m<sup>2</sup>. 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  $\alpha_s$  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

- $\alpha_s$  = Sound absorption coefficient
- V = Volume of the empty reverberation room [m<sup>3</sup>]
- 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  $T_1$  (m<sup>-1</sup>)
- $m_2$  = Attenuation coefficients due to air absorption during measurement of  $T_2$  (m<sup>-1</sup>)

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.