

TEST REPORT

Laboratory measurement of sound absorption of Acupanels Træ Panels – Type E-65 mounting

Performed for Fog & Venø A/S

Project no.: 122-32087

DANAK no. 100/2800 Revision 1

Page 1 of 14

Hørsholm, 11 November 2022



Acoustics, Noise and Vibrations

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OVERVIEW

| | |
|-----------------------|---|
| Title | Laboratory measurement of sound absorption of Acupanels Træ Panels – Type E-65 mounting |
| Project no. | 122-32087 |
| DANAK no. | 100/2800 Revision 1 |
| Test period | 13 October 2022 |
| Client | Fog & Venø A/S Buntmagervej 5 7490 Aulum Denmark E-mail: hello@fog-veno.com Tel.: +45 88 77 83 70 |
| Contact person | Anders Dahlgaard E-mail: ad@fog-veno.com |
| Test method | Test method: EN ISO 354:2003 Evaluation: EN ISO 11654:1997 Uncertainty: EN ISO 12999-2:2020 |
| Summary | 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 Træ Panels Mounting: Type E-65 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. |

Revisions

This test report replaces previously issued DANAK test report 100-2800 dated 8 November 2022. The changes in this revision are: The client name and address has been changed from Acupanel International ApS to Fog & Venø A/S.

Test site

DTU, Akademivej, Bygning 355, 2800 Kongens Lyngby, Denmark

Our ref.

LISL/RSHS/ilk

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TABLE OF CONTENTS

| | | |
|-------------------|--|-----------|
| 1 | Introduction | 5 |
| 2 | Description of the test specimen based on the client's specifications | 5 |
| 3 | Mounting in the laboratory | 5 |
| 4 | Test method | 5 |
| 5 | Measurement conditions | 6 |
| 6 | Test results | 6 |
| 7 | Measurement uncertainty | 7 |
| Appendix 1 | Graph Sheets..... | 8 |
| Appendix 2 | List of instruments | 11 |
| Appendix 3 | Photo and drawing..... | 12 |
| Appendix 4 | Description of reverberation room and test procedure | 14 |

1 Introduction

At the request of Fog & Venø A/S, measurements of sound absorption coefficients in a reverberation room have been carried out for Acupanels Træ Panel product.

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

Acupanels Træ Panel is an acoustic panel of polyester felt that is covered with plywood lamellas.

| | |
|----------------------|---|
| Product: | Acupanels Træ Panel |
| Lamellas: | 27 x 11 mm plywood from MDF and wood veneer, 12 mm spacing between lamellas |
| Felt: | 9 mm polyester felt |
| Thickness: | 9 mm polyester felt / 20 mm felt with lamellas |
| Insulation: | 45 mm mineral wool, density 16 kg/m ³ , placed between 45 x 45 mm wooden battens of 600 mm spacing |
| Construction height: | 65 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: 65 mm (Type E-65 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 5 Træ panels of size 2400 x 600 mm and 5 Træ panels of size 1200 x 600 mm to form a test area of 10.8 m² (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 [Hz] | Reverberation Time T_1 [sec] | Reverberation Time T_2 [sec] |
|----------------|--------------------------------|--------------------------------|
| 100 | 6.30 | 5.31 |
| 125 | 7.63 | 5.05 |
| 160 | 7.73 | 4.47 |
| 200 | 7.43 | 3.35 |
| 250 | 7.02 | 3.17 |
| 315 | 7.40 | 2.46 |
| 400 | 6.68 | 2.19 |
| 500 | 6.22 | 2.16 |
| 630 | 6.24 | 2.16 |
| 800 | 5.80 | 2.04 |
| 1000 | 5.22 | 1.97 |
| 1250 | 4.95 | 2.06 |
| 1600 | 4.63 | 2.01 |
| 2000 | 4.16 | 1.96 |
| 2500 | 3.76 | 1.95 |
| 3150 | 2.96 | 1.70 |
| 4000 | 2.42 | 1.54 |
| 5000 | 2.06 | 1.43 |

Temperature and relative humidity in the reverberation room during measurements:

| Measurement | Date | Temperature, °C | RH, % |
|------------------|-----------------|-----------------|-------|
| Without specimen | 13 October 2022 | 18.2 | 57.0 |
| With specimen | 13 October 2022 | 18.3 | 58.7 |

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, α_p per octave and the weighted absorption coefficient α_w 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:

| α_s | |
|----------------|---------|
| Frequency [Hz] | U (k=2) |
| 100 | ±0.08 |
| 125 | ±0.10 |
| 160 | ±0.12 |
| 200 | ±0.14 |
| 250 | ±0.14 |
| 315 | ±0.16 |
| 400 | ±0.14 |
| 500 | ±0.12 |
| 630 | ±0.12 |
| 800 | ±0.12 |
| 1000 | ±0.12 |
| 1250 | ±0.10 |
| 1600 | ±0.10 |
| 2000 | ±0.10 |
| 2500 | ±0.10 |
| 3150 | ±0.12 |
| 4000 | ±0.12 |
| 5000 | ±0.16 |

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

| α_w |
|------------|
| U (k=2) |
| ±0.07 |

Appendix 1

Graph Sheets



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

Client: Fog & Venø A/S, Buntmagervej 5, 7490 Aulum, Denmark

Date of test: 13 October 2022

Test specimen: Product: Acupanels Træ Panel

Thickness: 20 mm

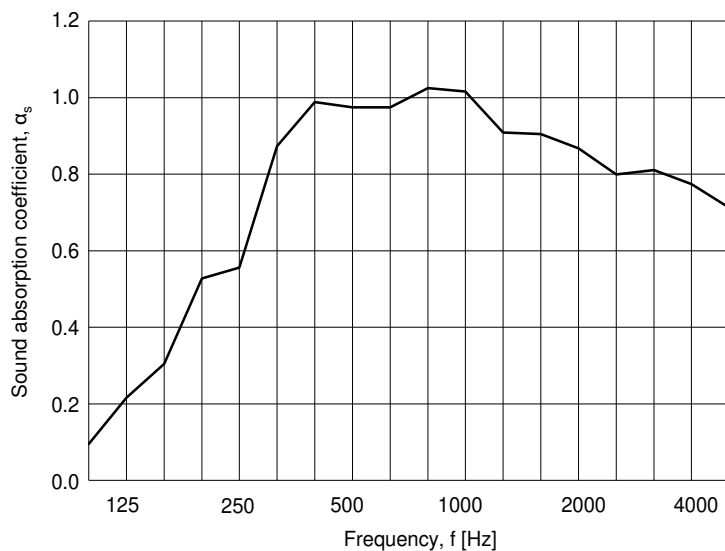
Construction height: 65 mm (Type E-65 mounting with mineral wool)

Test area: 10.8 m²

Room volume: 215 m³

Room surface: 305 m²

| Frequency f [Hz] | α_s |
|------------------------|------------|
| 100 | 0.09 |
| 125 | 0.22 |
| 160 | 0.30 |
| 200 | 0.53 |
| 250 | 0.56 |
| 315 | 0.87 |
| 400 | 0.99 |
| 500 | 0.97 |
| 630 | 0.97 |
| 800 | 1.02 |
| 1000 | 1.02 |
| 1250 | 0.91 |
| 1600 | 0.90 |
| 2000 | 0.87 |
| 2500 | 0.80 |
| 3150 | 0.81 |
| 4000 | 0.77 |
| 5000 | 0.71 |



FORCE Technology, 10 November 2022

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

Client: Fog & Venø A/S, Buntmagervej 5, 7490 Aulum, Denmark

Date of test: 13 October 2022

Test specimen: Product: Acupanels Træ Panel

Thickness: 20 mm

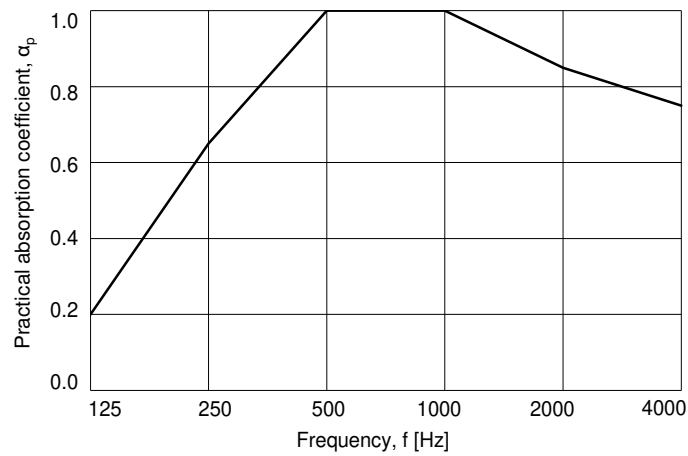
Construction height: 65 mm (Type E-65 mounting with mineral wool)

Test area: 10.8 m²

Room volume: 215 m³

Room surface: 305 m²

| Frequency f [Hz] | α_p |
|------------------------|------------|
| 125 | 0.20 |
| 250 | 0.65 |
| 500 | 1.00 |
| 1000 | 1.00 |
| 2000 | 0.85 |
| 4000 | 0.75 |



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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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 |
| 1616L | Measuring microphone | GRAS | 40EN | 2022-07-13 | 2024-07-13 |
| 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 *Acupanels Træ Panels mounted in the laboratory (Type E-65 mounting).*

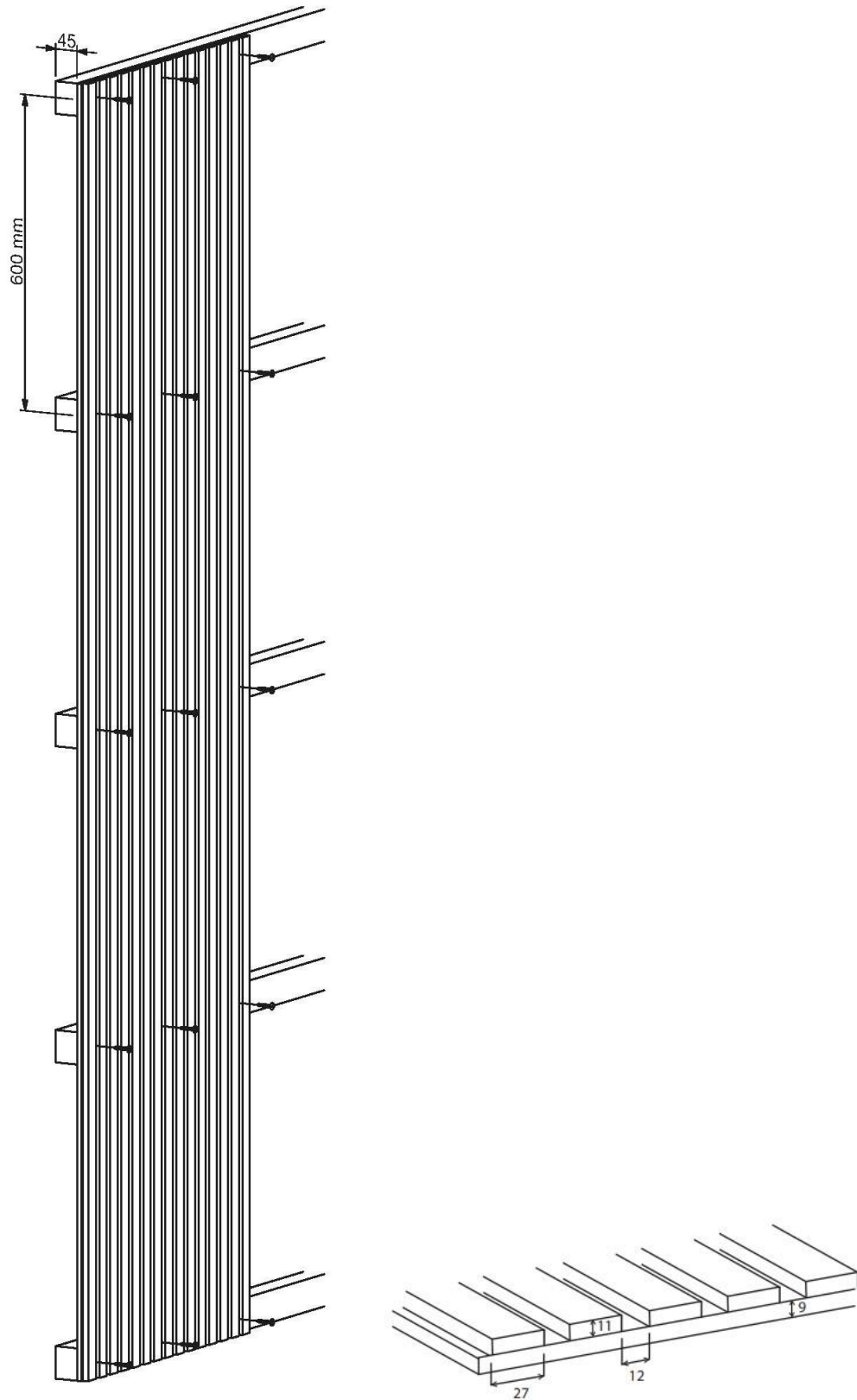


Figure 2 Drawing of Acupanel Træ Panels.

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 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 T_1 (m⁻¹)
- m_2 = Attenuation coefficients due to air absorption during measurement of T_2 (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.