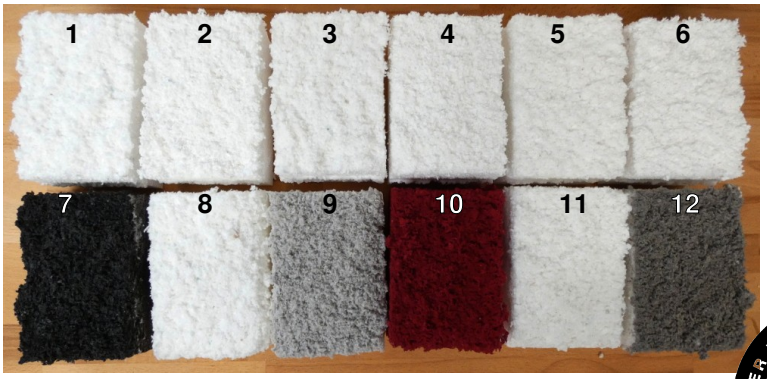
UV and Humidity Test

Customer: Invisible Acoustic Ceilings Scandinavia Oy

Target:

Acoustic plaster finishes for ceilings, as shown in Fig. 1.
UV Test: samples numbered 1 – 12
VISIBLE® Fine, Medium and Texture
VISIBLE® colored and after colored fiber –range
Humidity Test: samples H I and H II, each on three different base materials: VISIBLE® absorber insulation slab, plasterboard and stone



UV test

VISIBLE® Absorber insulation slab | Plasterboard | Stone

Humidity test

Fig. 1. *Acoustic plaster finishes under test.*

Testing Time:

The start of the test: 12th January, 2021
The end of the test: 3rd February, 2021

Purpose of the Test:

To investigate the possible changes in the acoustic ceiling materials when exposed to UV lighting and high relative humidity.

Test Method:

UV Test

Test method based on ISO 4892-1 and ISO 4892-3

Exposure

Exposure to continuous UV irradiation (UVA 340)
Irradiance: ~100 W/m^2
Ambient temperature, *T*(amb): +40°C
Duration: 500 h (3 weeks)

Measurements

Colour measurement weekly (0 h, 168 h, 336 h and 500 h), CIE *L*a*b** and colour change Δ*E*

Humidity Test

Exposure

Continuous exposure to high relative humidity
Relative humidity: 95%RH
Ambient temperature, *T*(amb): +40°C
Duration: 168 h (one week)

Inspections

Visual inspections during and after the test

Performed Actions:

1) Accelerated UV Test

UV Radiation

The UV radiation used in this test consists of the same wavelengths as are found in the spectrum of the natural sunlight. The spectrum of the UV lamps used in the test and that of Sun are shown in Fig. 2. The spectral power density of the UV-lamps (100 W/m^2) is compared to that of Sun (60 W/m^2) in the wavelength scale covering the UV-range.

The intensity of UV radiation was measured with a precision pyranometer and it was 95 W/m^2 in the sample area. The total UV radiant exposure (dose) was thus 48 kWh/m^2.

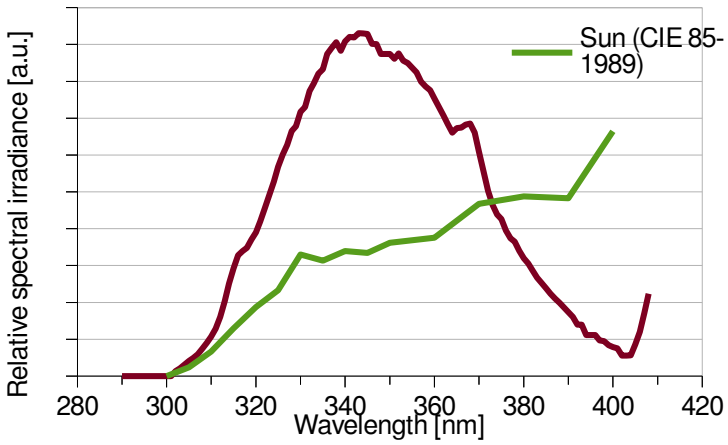


Fig. 2. *Spectrum of the UV lamps used in this test and that of natural sunlight in the UV range. Relative spectral irradiance as a function of wavelength.*

Ambient Temperature

Ambient temperature *T*(Amb) during the test was 40 ± 2°C.

Visual Inspections

Visual inspection was performed in connection with the colour measurements after 0, 168, 336 and 500 h exposure. First visible colour changes were observed in the white samples after 168 h.

The materials were yellowed. In subsequent inspections, the situation appeared to remain the same. No further increase in yellowing could be seen by eye. No visual changes were observed in colored samples 7, 9, 10 and 12.

White samples 1 – 6 are shown in Fig. 3 with their non-exposed references after 168 h and 500 h exposure. Figure 4 shows samples 7 – 12 after 500 h exposure. There was no reference for samples 8 and 11.

After 168 h (1 week):

1 2 3 4 5 6

After 500 h (3 weeks), end of test:

1 2 3 4 5 6

Fig. 3. *Samples 1 – 6 with their non-exposed references after 168 h and 500 h exposure to UV radiation. Top row: references, bottom row: exposed samples.*

After 500 h (3 weeks), end of test:

7 8 9 10 11 12

Fig. 4. *Samples 7 – 12 with their non-exposed references after 500 h exposure to UV radiation. Top row: references, bottom row: exposed samples.*

Optical Analysis

The *L*a*b** colour coordinate values of the samples were measured with a spectrophotometer. The reflected specular component from the samples is included in the *L*a*b** values. Colour difference Δ*E* represents the Euclidean distance between two colours according to Eq. 1.

$$\Delta E = \sqrt{\Delta L^{*^2} + \Delta a^{*^2} + \Delta b^{*^2}} \qquad (1)$$

*L**-coordinate indicates the lightness of the sample. The bigger the value the lighter the sample.
+*a**-coordinate indicates the red direction and -*a** indicates the green direction.
+*b**-coordinate indicates the yellow direction and -*b** indicates the blue direction.
The colour coordinates are shown schematically in Fig. 5.

Under ideal viewing conditions a Δ*E* value of 1 represents a just perceptible colour difference to the human eye. However, the human eye sees differently colour differences in different colours. The differences in darker colours are more perceptible to the eye.

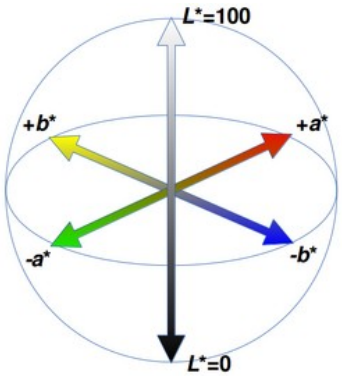


Fig. 5. *CIE L*a*b* colour coordinate system.*

The colour measurements were performed after 0, 168, 336 and 500 h exposure. The results are shown in Fig. 6. The major coulour change in the white samples occurred during the first 168 exposure hours and then stabilized to the level of Δ*E* = 5. For samples 2 and 4, the Δ*E* further increased and was not stabilized. The change was mainly due to increase in coordinate *b**, i.e. change towards the yellow direction (see Fig. 5) in agreement with the visual observations.

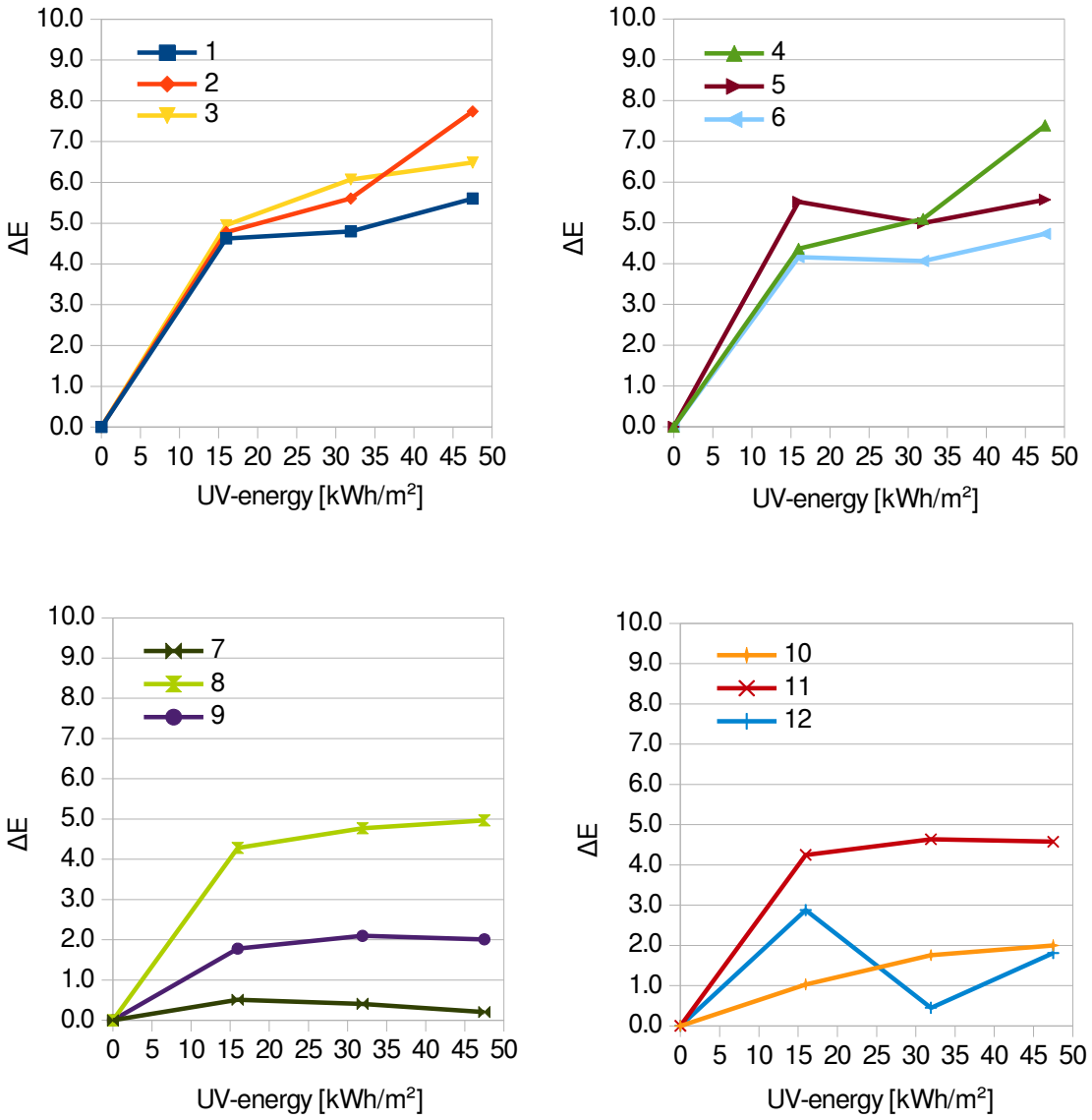
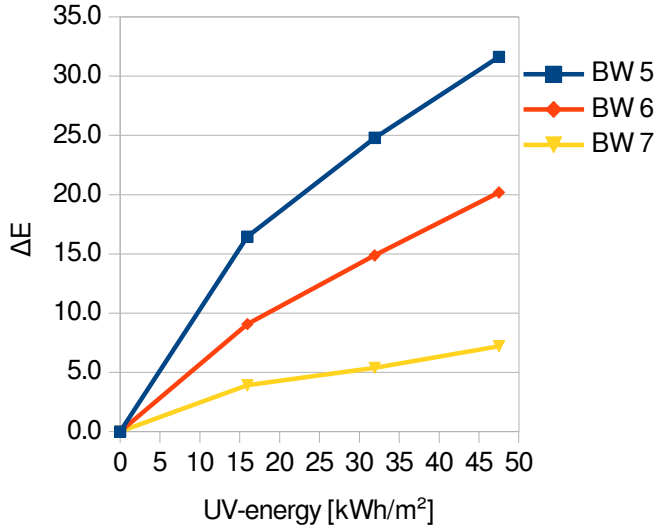


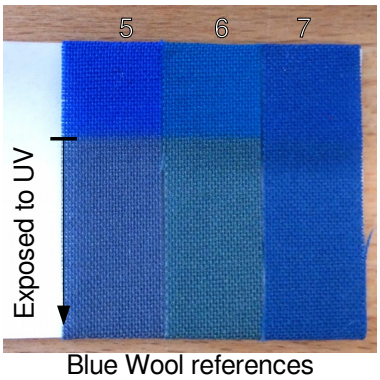
Fig. 6. *Colour change ΔE as a function of UV energy.*

Radiation Correspondence

Blue Wools No. 5, 6 and 7 were used as references in order to evaluate the correspondence of the UV radiant exposure of this test to real indoor environment. The colour change of the Blue Wool references is shown in Fig. 7. It can be compared to a long-term test for the Blue Wools that has been performed in a real office environment with fluorescent lighting and some diffuse sunlight from windows. Based on the long-term study, it can be estimated that this test corresponds to at least 10 years in a real environment.

It should be noted that this comparison is only an estimate.





Blue Wool references

Fig. 7. *Colour change of Blue Wool references in this test.*

2) Humidity Test

The sample plates were placed on supports at their edges with the sample side facing down as if they were on the ceiling (see Fig. 9).

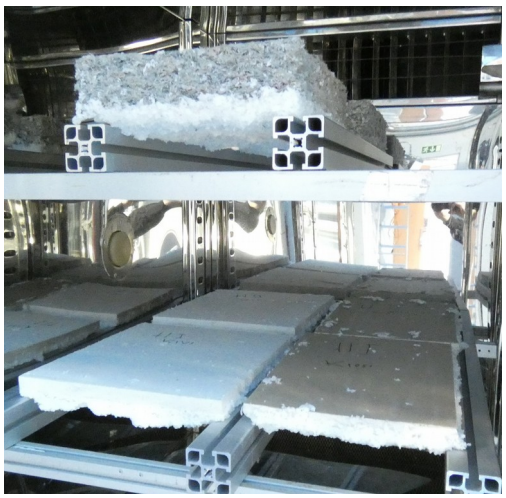


Fig. 9. *Test setup of the humidity test.*

The samples were exposed to high relative humidity at +40°C for 168 h (one week). The ambient temperature and relative humidity during the test are shown in Fig. 10.

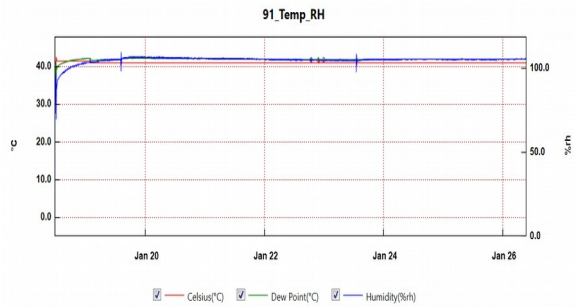
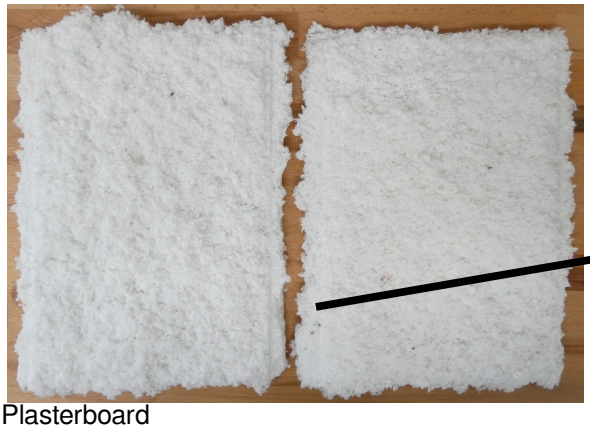


Fig. 10. *Temperature and relative humidity during the humidity test.*

Inspections
The sample plates were inspected after the test. Rapid visual inspections were also carried out during the test at 24 and 120 hours. No changes were observed in the appearance of the plaster finishes. Both the plaster finishes and base materials felt moist. Adhesion of the plaster finishes to the base materials had withstood the exposure. Depressions caused by the supports were seen at the edges of the sample plates.

Figure 11 shows the samples after the humidity test.

VISIBLE Absorber



Plasterboard

Detail

Stone

Fig. 11. *Samples after the exposure to high humidity for 168 h. The inset shows the depressions at the edges of the sample plates caused by the supports used in the test setup.*

Used Equipment:
The calibration is valid for one year from the date given, unless otherwise stated.

UV Tester No. 26
UV irradiation: Pyranometer No. 25, calibrated 21st May, 2019. Calibration is valid due to May 2021.
Multimeter No. 24, calibrated 28th May, 2020. Calibration is valid.
Temperature: No. 26 / Temp
Colour: Spectrophotometer No. 70, calibration is made before every measurement session. Calibration is valid.

Thermal Humidity Chamber No. 72
Temperature: Datalogger No. 91, calibrated 23rd March, 2020. Calibration is valid.
Relative humidity: Datalogger No. 91, calibrated 23rd March, 2020. Calibration is valid.

Conclusions:

Acoustic plaster finishes for ceilings were exposed in separate tests to UV radiation and high relative humidity.

Based on long-term research conducted in an office environment for the Blue Wool references, it can be estimated that this test corresponds to at least 10 years in a real environment.

UV radiation caused some yellowing in the white materials. No other colour changes perceptible to eye were observed. Measured CIE Lab colour change of the white samples occurred during the first third of the exposure and then stabilized to the level of $\Delta E = 5$. For samples 2 and 4, the further increased and was not stabilized.

Exposure to high relative humidity did not cause any changes in the appearance of the plaster finishes or in their adhesion to the different base materials used.

Signatures:

25th February, 2021
Solar Simulator Finland