Solar Simulator
Solar Simulator Finland Ltd.

Colour Stability

Customer:

Labrox Oy
Pauli Salmelainen

Research contract:

ref.no: LabroxSalmelainen__ta151113AK.pdf

Target:

Cover materials used on the Labrox 5 in 1 multimode plate reader. Black plastic and grey aluminium material samples as shown in Fig. 1.

Fig. 1: *Samples under test. Black plastic material 11.5 cm × 16 cm and grey aluminium material 5 cm × 7 cm.*

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Fig. 2: *Labrox 5 in 1 multimode plate reader, here with grey colouring.*

Testing time:

The start of the test: 18th October, 2013
The end of the test: 12th November, 2013

Purpose of the test:

This test is performed for testing if the UV-radiation from the sunlight through the windows can cause significant degradation of the cover materials and labels used in the Labrox 5 in 1 multimode plate reader.

Test method:

The test method is based on ISO 4892 Plastics – Methods of exposure to laboratory light sources, Part 1: General guidance and Part 3: Fluorescent UV lamps.

UV radiation exposure:

Continuous UVA radiation
Test duration: 500 h
Intensity of UV radiation: 100 W/m²
Total UV-dose during the test: 50 kWh/m²
Air temperature: +30°C

Colour and gloss measurement after 0 h, 72 h, 240 h and 500 h UV radiation exposure

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Validation of the test method:

UV radiation is one of the major cause of the deterioration and color change in polymer materials, e.g., in plastics and paints. The windows do absorb UV light, but still sunlight causes changes in colour also inside.

Performed actions:

The intensity and uniformity of the UV radiation field was measured with a precision pyranometer. The intensity was 100 ± 7 W/m^2.
The spectrum of the UV-radiation used in this test and the UV-spectrum of the sun are presented in Fig. 3.

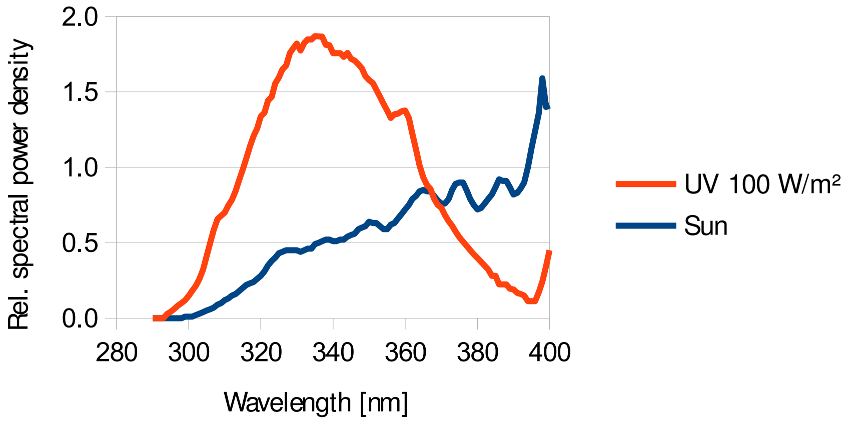

***Fig. 3.** Spectra of solar UV radiation (blue curve) and UV radiation of the lamps used in the test (red curve). Relative spectral power density as a function of wavelength.*

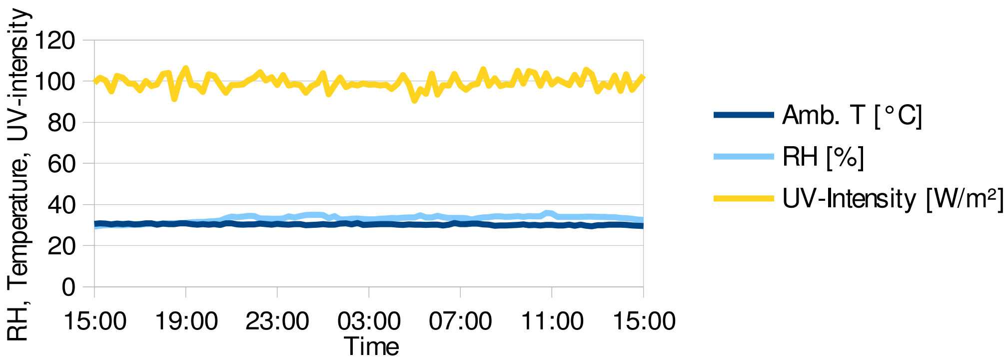

***Fig. 4.** Conditions during one 24-hour test period. Ambient air temperature T, relative humidity RH and intensity of UV radiation are shown. The UV-intensity shown here was recorded with a fast responding UV-photodiode, which was used for control of the machine and the lamps, and thus the curve of UV-intensity is somewhat varying.*

The temperature of the air in the UV-chamber was 30 ± 3°C during the test. One 24 h period of UV-intensity, air temperature and relative humidity in the test chamber are shown in Fig. 4.

The samples were partly protected from UV radiation using Al-foil. The location of the protective film on the samples can be seen in Fig. 5.

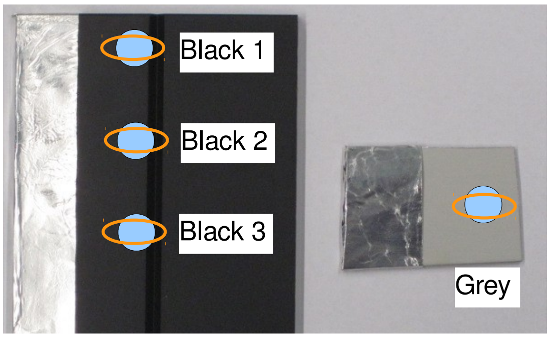

Fig. 5. *Location of the protective Al-foils and measurement points for the colour and gloss measurement on the samples. Blue circle = colour measurement, orange oval = gloss measurement.*

Optical Analysis

The $L^*a^*b^*$ colour coordinate values of the samples were measured. The reflected specular component from the samples is included in the $L^*a^*b^*$ values.

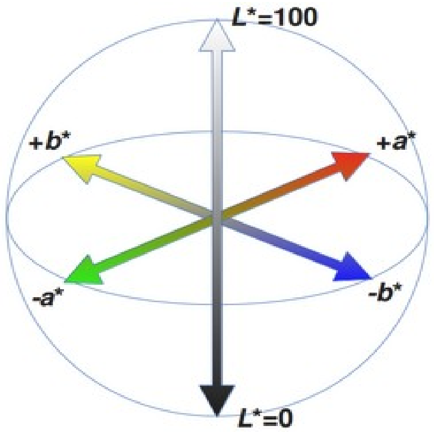

Fig. 6. *CIE L*a*b* colour coordinates.*

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. 6.

Colour difference ΔE represents the Euclidean distance between the $L^*a^*b^*$ values of two colours. Under ideal viewing conditions a ΔE 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.

Gloss is a measure of the proportion of light that has a specular reflection from the surface. The gloss measurement was made at 60°. The gloss value indicates the surface gloss: the glossier the surface, the larger the value. Residual gloss represents the ratio between the current and the original value.

Colour and gloss measurement was performed before the exposure and after 72 h, 240 h and 500 h exposure. The measurement points on the samples are shown in Fig. 5.

Colour difference Δ*E* (SCI, specular component included) and residual gloss as a function of the UV energy are shown in Fig. 7. The colour and gloss of the black plastic cover material was measured at three spots to see how even the material is. The theoretical limit of just perceptible colour difference to human eye, Δ*E*=1, is added to the diagram.

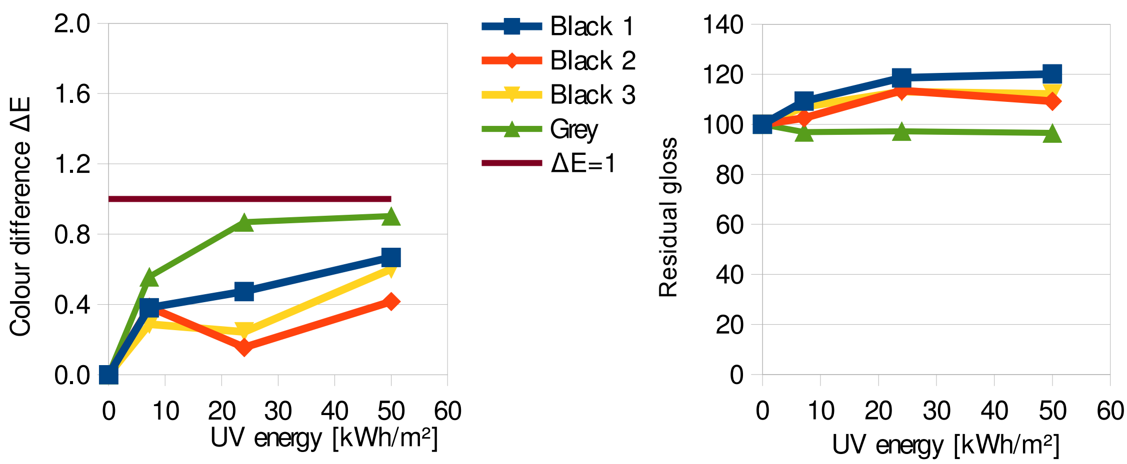

Fig. 7. *Colour difference and residual gloss as a function of UV energy.*

The results of colour and gloss measurements are summarized in Table 1.

Table 1. Colour difference and residual gloss of the sample materials.

Sample	**Δ*E* *(average)***	**Residual gloss**
Black 1,2,3	0.6	110 %
Grey	0.9	97 %

Used equipment:
UV Tester, No. 26
UV-radiation: No. 26 / Photodiode, calibrated 18th October, 2013, calibration is valid
Temperature: No. 51 / Temperature, calibrated 12th October, 2012, calibration is valid
Relative humidity: No. 51 / RH_aux, calibrated 1st July, 2013, calibration is valid
Colour: No. 8, calibration is made before every measurement session, calibration is valid
Gloss: No. 10, calibration is made before every measurement session, calibration is valid

Analysis:

Radiation correspondence:

The mean UV radiation energy outside in Southern Finland during one year is 54 kWh/m² onto a horizontal surface and 47 kWh/m² onto a south facing vertical surface. Thus at this test the total UV-energy of 50 kWh/m² corresponds to 11 months of UV-energy onto a horizontal surface in Southern Finland and nearly 13 months of UV-energy onto a south facing vertical surface in Southern Finland.

The amount of UV-radiation incident to devices or materials in an office environment in Southern Finland has been calculated and approximated from global radiation data and from the colour measurement data of Blue Wool Reference samples. The estimated correspondence of an accelerated UV testing with UV-energy dose ~50 kWh/m² and UV radiation from sun in Southern Finland is shown in Table 2. It was assumed that 65 % of UV radiation is transmitted through the south facing window and, in addition, UV radiation from fluorescent lamps in the office was expected to be 0.2 kWh/m² per one year. Ref. Solar Simulator Finland internal report: UVRadiationInsideOfficeEnvironment__140113TO.pdf.

Table 2. Correspondence of an accelerated UV testing with UV-energy dose ~50 kWh/m² and UV radiation from sun in Southern Finland.

Environment	Correspondence [years]
Outside, south facing surface	1
Behind south facing window	2.5
Inside environment	~ 10

Recommendations:

N/A

Conclusions:

The samples under test were exposed to continuous UV radiation with an intensity of 100 W/m^2 at the ambient temperature of 30°C. The total duration of the exposure was 500 h. The UV-energy falling onto the samples during the test corresponds the UV-energy during one average year outside, during 2.5 average years near south facing window inside, and during more than 10 years away from windows inside in Southern Finland.

Colour difference Δ*E* (SCI, specular component included) during the test was clearly lower than 1 meaning that that there was no noticeable change in colour. The gloss value of both samples changed little, but could be noticed by a trained person in certain lighting. The gloss change of black plastic sample was slightly easier to see than the gloss change of aluminium sample, which was very difficult to see. The exposure caused no visual change in ID marking. The contrast enhanced images of the samples after the test are presented in Fig. 8.

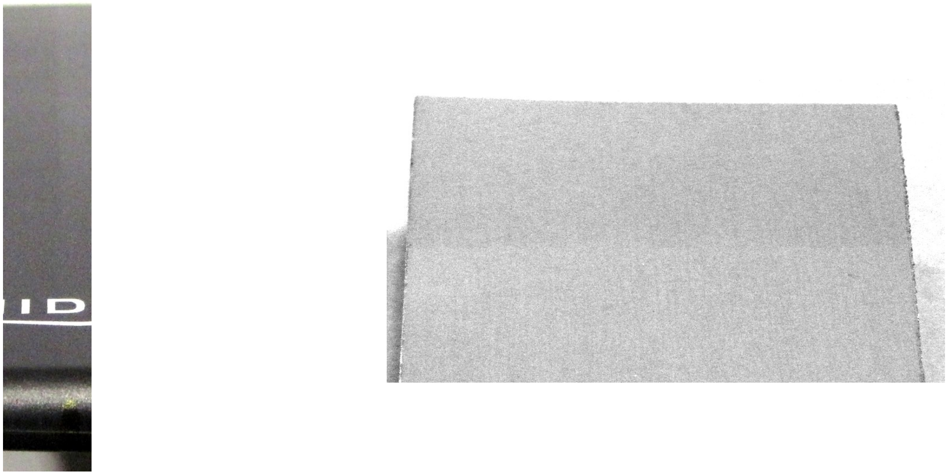

Fig. 8. *The images showing the very slight change in the outlook of the surface. The left side of the black plastic material (left) and the upper part of the Aluminium surface were covered by Aluminium foil during the test. Contrast of the images has to be enhanced to show the change in gloss.*

Remarks:

Actions, operations and reporting are in accordance with IEC/ISO 17025 'General requirements for the competence of testing laboratories'.

Signatures:

Ari Kuusisto
Littoinen, 3rd of December, 2013

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