Accelerated Weathering Tests of Parking Vignettes

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Abstract

In modern urban life, it has become fairly natural that motor vehicle parking falls under regulations. One frequently applied form of indicating vehicles that carry special permits is the use of vignettes that can be stuck on the windscreen. The largest Hungarian producer of these vignettes used for the regulation of parking has demanded the elaboration of a test method that offers preliminary information in connection with the resistance of the manufactured products to weather conditions. The research order focused on individually numbered vignettes made with flexography on plastic film, and covered the testing of four differently coloured products. In this case, colours carried meanings as to the potentials of use. Our objective was to work out an accelerated weathering test model that simulated use properly, could be appropriately repeated and allowed precise measurements.

Keywords: accelerated weathering tests, flexography, colorimetry, printed vignettes

1. Introduction and background

In modern urban life, it has become fairly natural that motor vehicle parking falls under regulations. One frequently applied form of indicating vehicles that carry special permits is the use of vignettes that can be stuck on the windscreen. These coloured indicators are usually valid for one year. They need to be renewed annually. This is the period of time during which they are required to remain suitable for preserving the correct information. It is also a frequent solution that distinct meanings are associated with the different colours of the vignettes, and therefore their colour fastness can also be an important quality factor.

The largest Hungarian producer of these vignettes used for the regulation of parking has demanded the elaboration of a test method that offers preliminary information in connection with the resistance of the manufactured products to weather conditions.

Such modeling called for a number of special conditions. Vignettes are stuck on car windscreens from the inside. The test needed to take the modifying effects of this special location into account.

2. Methods of research

The research order focused on individually numbered vignettes made with flexography on plastic film, and covered the testing of four differently coloured products. In this case, colours carried meanings as to the potentials of use. The main goal of the test was to find out how the colour fastness of vignettes changes during their term of validity. Our objective was to work out an accelerated weathering test model that simulated use properly, could be appropriately repeated and allowed precise measurements.

2.1 Equipment used for the aging test

To conduct the aging test, SUNTEST XLS+ equipment was used (Figure 1). This equipment is suitable for the performance of indoor, i.e. laboratory weather resistance tests. This accelerated test method is classified to belong to the group of xenon lamp tests.

Figure 1: SUNTEST XLS+ equipment

The sample holder is located in the lower part of the test cabinet, whereas in the upper part there is a 1700 W air-cooled xenon lamp.

For the test, test graphics can be placed into the sample holders horizontally. It has specific significance, because radiation arrives at the sample on car windscreens at an angle of approx. 45°, which needs to be taken into account during the evaluation of the results.

A particular request of the client was that the tests were to be conducted mostly in the UVA radiation range, as the conformity of the products was intended to be reviewed in relation to this weather impact, and for this reason a suitable source of light was used.

The Sun Test parameters used for the measurement were:
- Radiation range: 300–400 nm, using a special auxiliary quartz glass filter for UV
- Irradiation: 45 W/m^2
- 24 hours of irradiation: 1 080 Wh/m^2
- Temperature: 16–50 °C
- Relative humidity: approx. 29 %

This project is continued and extends the earlier investigations from our institute (Borbély, Horváth and Szentgyörgyvölgyi, 2012; 2013).

2.2 Procedure for the measurement of the light fastness of vignettes

Four kinds of samples were tested: red, green, crimson and yellow with four test pieces from each.
The supplied samples were stuck on a 2 mm glass plate (Figure 2) and placed in the sample holder, and then another 2 mm glass plate was placed on them for the duration of illumination, because the thickness of windscreens tends to be larger than 2 mm.

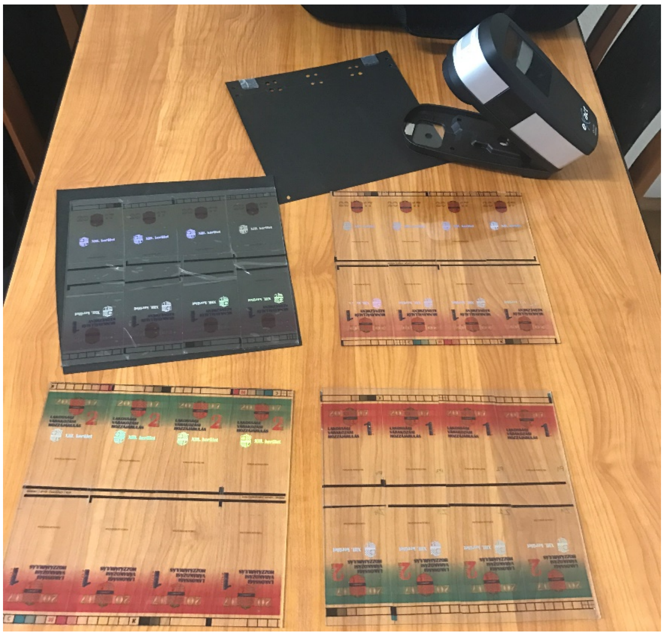

Figure 2: The supplied samples stuck on the glass plate, underplate and gauge

CIELAB values were measured on the samples to calculate the corresponding differences in colour stimulus, and consequently determine the degree of changes. The measurements were carried out on a glass plate, with a black cardboard piece used as the underplate. For the accurate reproducibility of the measurements, a gauge was made. In the gauge, 4 measuring points were defined for every sample, and additionally such registers were applied that allowed the performance of colour measurement during the aging test invariably at the very same points. The extent and possibilities of measurement were restricted by the fact that the tests were carried out on the produced, strictly administered, numbered samples.
The duration of the aging test was restricted by the limited time scales defined by the client. Consequently, the total duration of the aging test was 192 hours. In the first phase of the test, several measurements were made (in 24-hour intervals), because it was presumed that changes were more pronounced in the initial phase. Measuring times are during the entire weathering phase, following 24, 48, 72, 96 and 192 hours. The measurements performed prior to the accelerated weathering test were handled as benchmarks to which the changes were compared. Alterations in the colours of the test samples were measured with an X-rite eXact spectrophotometer (Figure 3), at measuring conditions: D65/2°.

Figure 3: X-rite eXact colorimeter

3. Results and Discussion

During the aging test, the colour values at the designated points of the individual vignettes were measured at 24-hour intervals in the first phase and at the end of the second phase. From these values, colour changes (as per the CIELAB system) and colour differences were calculated against the corresponding values of the prints before the test (International Organization for Standardization, 2007; 2013).

The resulting colour difference values measured on a single vignette (4 testing points) were averaged; the values for the same types of vignettes (4 vignettes) were similarly averaged in order to demonstrate the changes in the colours of the individual types of vignettes in the tables and graphs as a function of time (Figures 4–7).

	Green				
hours	24	48	72	96	192
ΔE^*_{ab} (average)	3.26	5.82	8.56	10.23	11.48

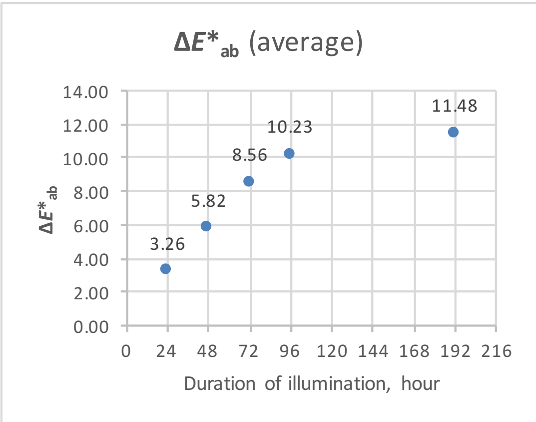

Figure 4: Changes in the colour of the green parking permits as a function of weathering time

	Red				
hours	24	48	72	96	192
ΔE^*_{ab} (average)	1.70	3.05	4.45	6.42	11.13

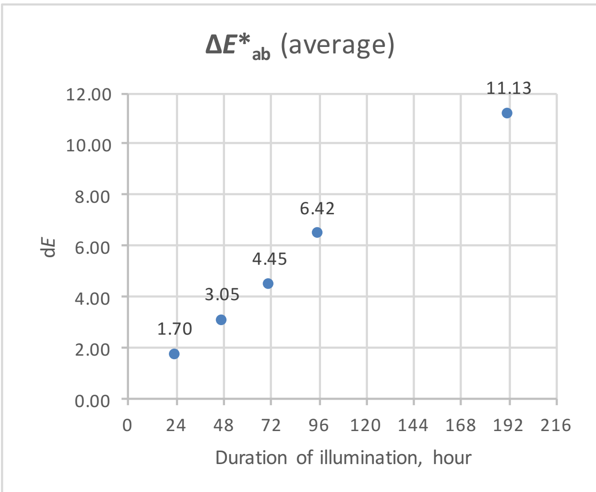

Figure 5: Changes in the colour of the red parking permits as a function of weathering time

	Crimson				
hours	24	48	72	96	192
ΔE^*_{ab} (average)	2.92	2.50	1.72	2.44	2.50

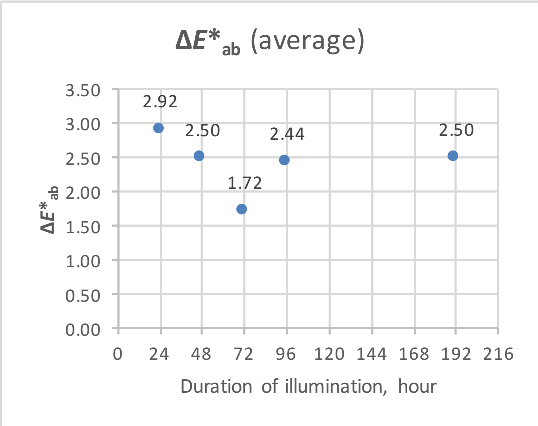

Figure 6: Changes in the colour of the crimson parking permits as a function of weathering time

	Yellow				
hours	24	48	72	96	192
ΔE^*_{ab} (average)	4.60	8.36	10.83	12.46	13.85

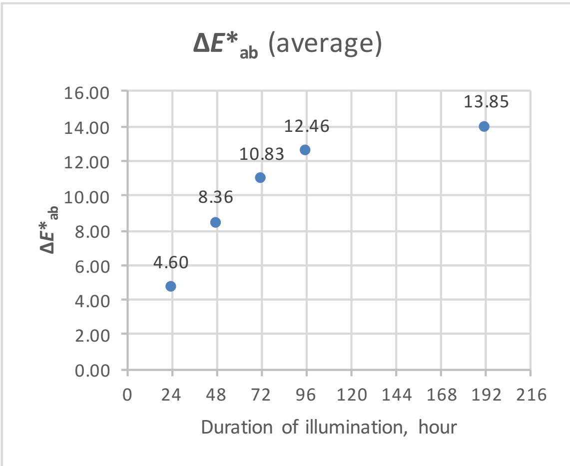

Figure 7: Changes in the colour of the yellow parking permits as a function of weathering time

During the evaluation of the measurement results, the solar radiation data for 2016 was referenced on the basis of Figure 8.

- Annual radiation in total: 1368.6 kWh/m^2
- Average daily radiation: 3750 Wh/m^2
- Ratio of UVA radiation in the total value: 9 %.
- As a result, average daily radiation in the UVA range 337.5 Wh/m^2

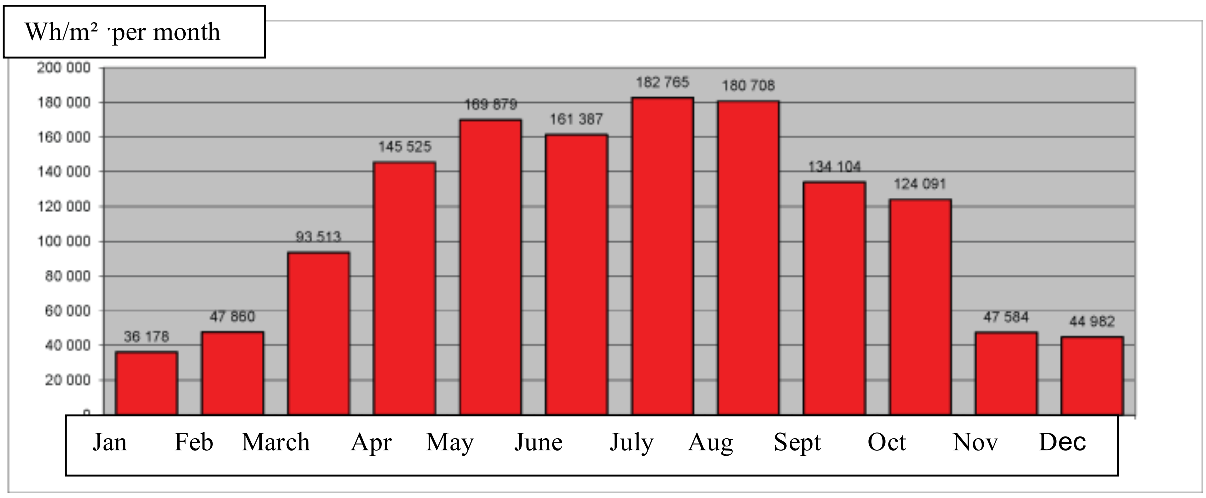

Figure 8: Monthly breakdown of solar radiation

Irradiation value of the source of illumination we use for 24 hours was 1080 Wh/m^2 at the surface area. As a result of the comparison, the 192 hours, that is 8 days we tested in reality correspond to approx. 26 days in the case of the horizontal surface.

4. Conclusions

For the yellow, red and green samples, the measurement results apparently changes almost evenly, and the ΔE^*_{ab} values are around 12. They are clearly perceivable colour differences.

As it is a rising tendency, for these samples it can be expected that as an impact of UVA radiation the colours of the vignettes will alter to an unacceptable extent.

In the case of the crimson sample, the nature of the change is not obvious, but the extent of colour alteration remains acceptable.

Although the result is evident with respect to the non-conformity of the samples, a longer aging test with the addition of the parallel measurement of the impacts of natural sunlight could offer further information in view of the correct selection of vignette materials and colouring agents.

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