Colour Stability

Customer:

SeaHow
Porkkalankatu 5
FI-00181 Helsinki
Finland

Purpose of the Test:

Testing of colour stability of polyethylene material used for SeaHow navigation buoys

Target:

18 pcs of polyethylene material used for SeaHow navigation buoys with two different colour materials. The colour materials and colours are (see Annex A):

Plasticolor Sweden AB
- RAL3020 + UV Red; samples: R1, 11, 12
- RAL6037 + UV Green; samples: R4, 14, 15
- RAL1023 + UV Yellow; samples: R7, 17, 18

Brenntag Canada Inc.
- RED8612UV Red; samples: R10, 2, 3
- GRN8712UV Green; samples: R13, 5, 6
- EL8812UV Yellow; samples: R16, 8, 9

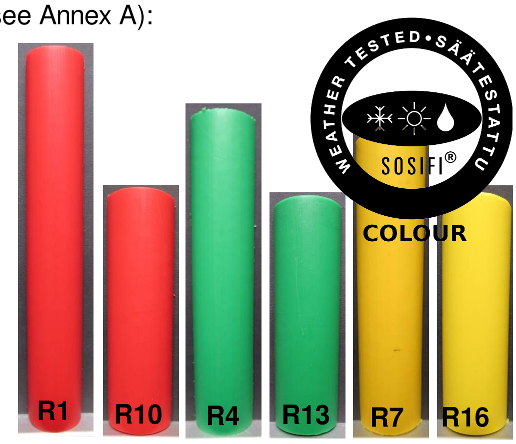


***Fig. 1.** Colour material samples under test.*

Test Method:

Exposure

Exposure to Xenon-arc light
- Cycle: 102 min dry, 18 min water spray
- T(BlackPanel): 63 ± 2°C
- Intensity (300-400 nm): 41.5 ± 2.5 W/m^2

Duration: 1000h (~6 weeks)

Test conditions based on ASTM D2565 "Standard Practice for Xenon-Arc Exposure of Plastics Intended for Outdoor Applications "

Measurements

Colour CIELAB1976 and ΔE (colour change), after 0, 333, 667 and 1000 h exposure
Gloss 60° and Residual gloss, after 0, 333, 667 and 1000 h exposure
Chromaticity coordinate zone analysis, before and after the exposure

Validation of the Test Method:

The test method is according to customer requirements:
"Requirements are based on navigation systems and regulations of Canadian Coast Guard and International Association of marine aids to navigation Lighthouse Authorities (IALA)."

Testing Time:

The start of the test: 10th October, 2014
The end of the test: 1st December, 2014

Performed Actions:

Samples were delivered numbered as shown in Fig. 2. The reference samples that were not exposed to Xenon light, samples No. R1, R4, R7, R10, R13 and R16 can be seen in Fig 2(a). The set of samples exposed to Xenon light is shown in Fig. 2(b).

Notification of the numbering of the samples:
The corresponding reference samples (indicated with letter "R") and exposed samples are as follows

- Plasticolor Sweden AB
  - red: R1 and 11, 12
  - green: R4 and 14, 15
  - yellow: R7 and 17, 18
- Brenntag Canada Inc.
  - red: R10 and 2, 3
  - green: R13 and 5, 6
  - yellow: R16 and 8, 9

(a) (b)

Fig. 2. *(a) Reference samples: Plasticolor Sweden AB No. R1, R4 and R7; Brenntag Canada Inc. No. R10, R13 and R16. (b) Samples exposed to Xenon light: Plasticolor Sweden AB samples (top row) and Brenntag Canada Inc. samples (bottom row).*

The sample plates were placed horizontally into a Xenon lamp weather resistance test chamber. Part of the samples was covered from radiation with a strip of Al-foil. Samples were exposed to a continuous xenon-arc light and simultaneous moisture cycle that consisted of 102 min dry and 18 min water spray. Water consumption during one cycle was about four litres. The purity of the spray water was analytical Grade 2 (ISO 3696). The mutual placement of the samples was changed two-three times a week.

Total intensity of radiation in bright sunlight is 1000 W/m^2 of which the amount of UV radiation is ~ 50 W/m^2. In this test, the intensity of UV radiation in the wavelength range of 300 – 400 nm should be 41.5 W/m^2. Thus the total intensity of xenon light, simulating the spectrum of the sunlight, should be 830 W/m^2.

The intensity of radiation was measured with a precision pyranometer to be (860 ± 90) W/m^2. The spectrum of the incident light on the samples was measured with a spectrometer. The spectrum of the incident light from filtered xenon lamps vs natural sunlight is shown in Fig. 3. The average Black Panel temperature during the dry cycles was 61°C.

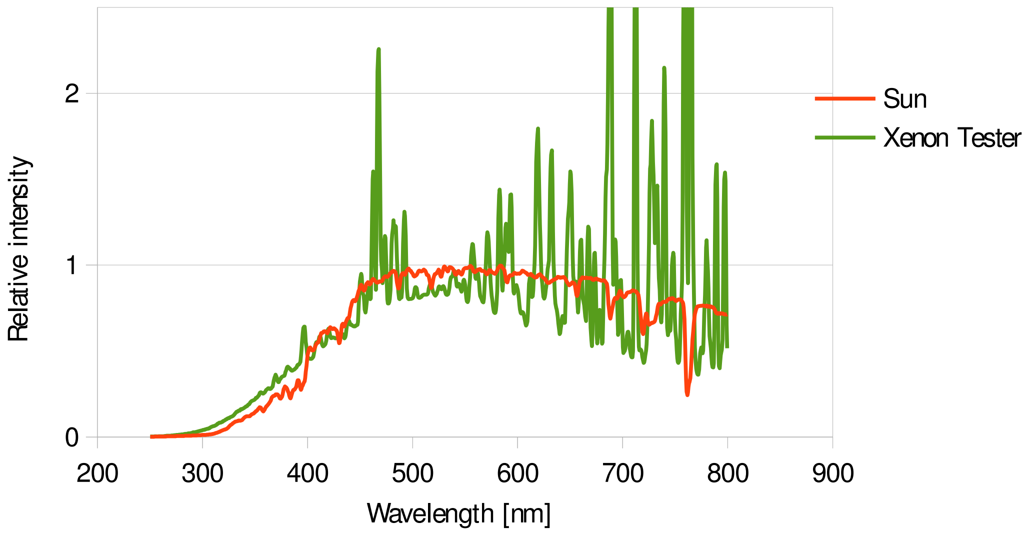


Fig. 3. *Spectrum of the sun and filtered xenon lamps during the testing. Relative intensity as a function of wavelength.*

Panel temperature, ambient temperature and relative intensity of radiation, are shown in Fig. 4. The relative intensity gives the variation in the intensity level as a function of time. Relative humidity (RH) in the test chamber was ~ 30 % during the dry periods and ~ 60 % during the water spray. RH data was not recorded.

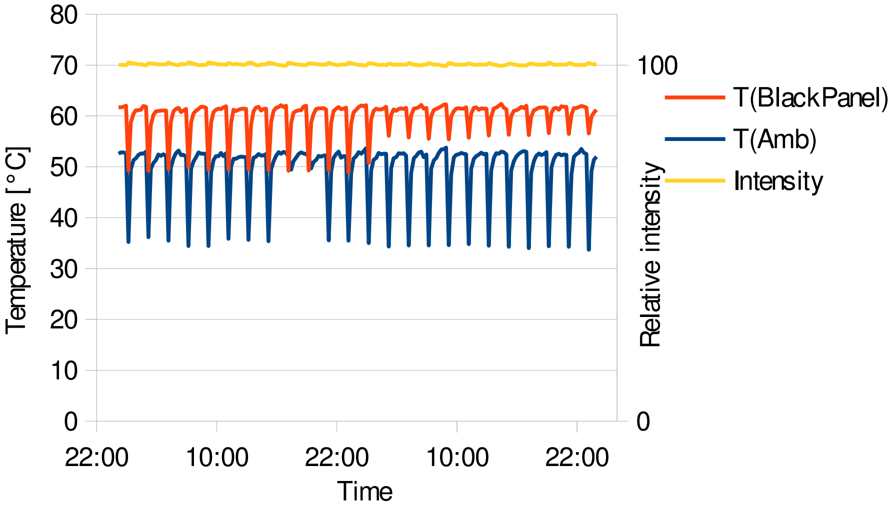


Fig. 4. *Conditions during a 48-hour period of the test. Black Panel temperature, ambient temperature and relative intensity of radiation as a function of time are shown.*

The colour and gloss of the samples was measured at time points 0, 1/3, 2/3 and 3/3 of the test duration. The curved shape of the sample surfaces caused some uncertainty in the because the measuring head of the device, i.e., gloss meter or spectrophotometer, could not be set firmly to the surface.

Blue Wool references No. 5, 6 and 7 were included in the test. Blue Wool references No. 5 – 7 are standardized reference samples (Standard ISO 105-B08). The change in colour of the Blue wools can be seen in Fig. 5. In the photograph, the lower part of the Blue Wools was protected from radiation. Colour difference ΔE is defined in Chapter Optical Analysis below.

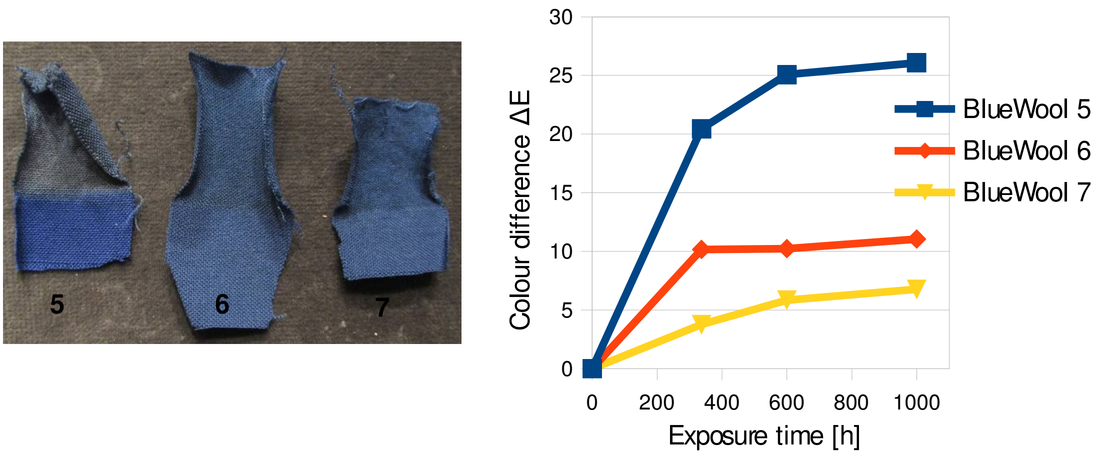


Fig. 5. *Left: Blue Wools No. 5, 6 and 7 photographed after the exposure to xenon light. The lower part of the samples was protected from radiation. Right: Colour difference ΔE as a function of the exposure time.*

Optical Analysis

The CIE *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. Colour difference ΔE represents the Euclidean distance between two colours.

*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.

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.

A colour can be characterized by two parameters: luminance and chromaticity. In the CIE system, a luminance parameter *Y* describes the brightness of the colour, and two colour coordinates *x* and *y* specify the point on the chromaticity diagram. The CIE 1931 chromaticity diagram is shown in Fig. 7.

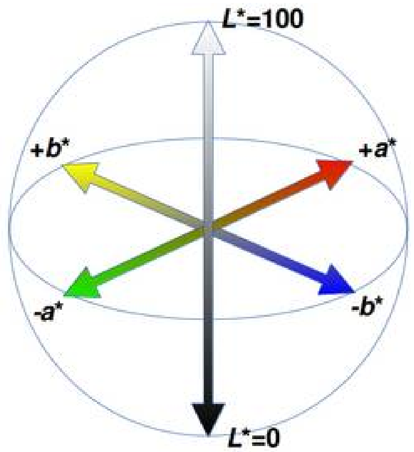


Fig. 6. *CIE L*a*b* colour coordinate system.*

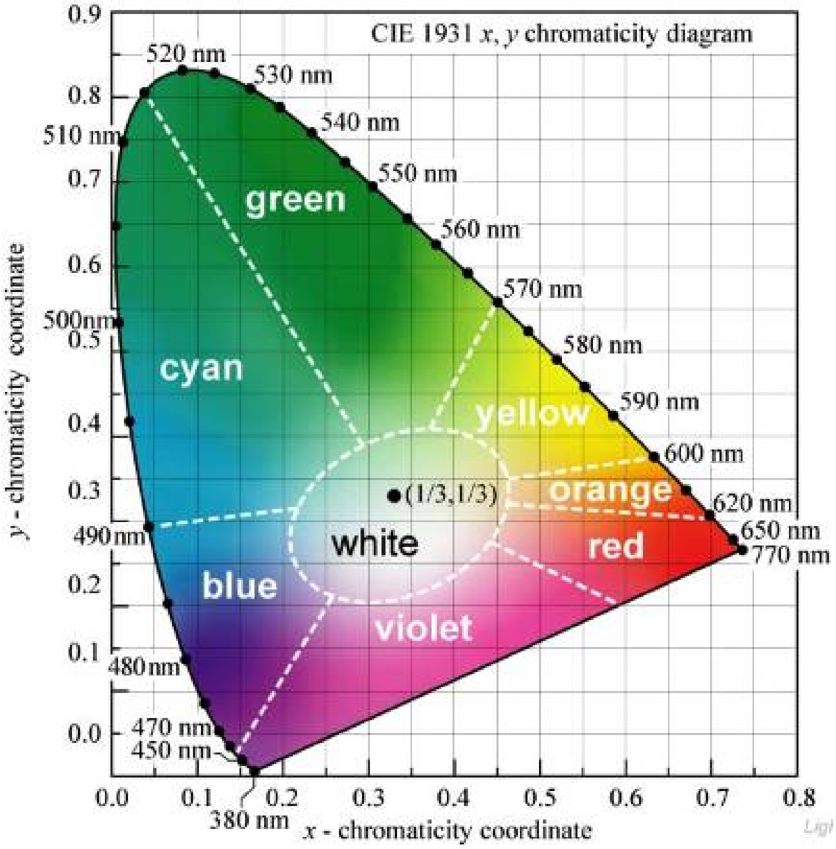


__Fig. 7.__ CIE 1931 x, y chromaticity diagram.

Colour difference Δ*E* (SCI, specular component included) as a function of the exposure time is shown in Figs. 8 and 9. Figure 8 shows the results categorized by colour, i.e., red, green and yellow. Figure 9 shows the results categorized by the colour material, i.e., Brenntag Canada Inc. and Plasticolor Sweden AB.

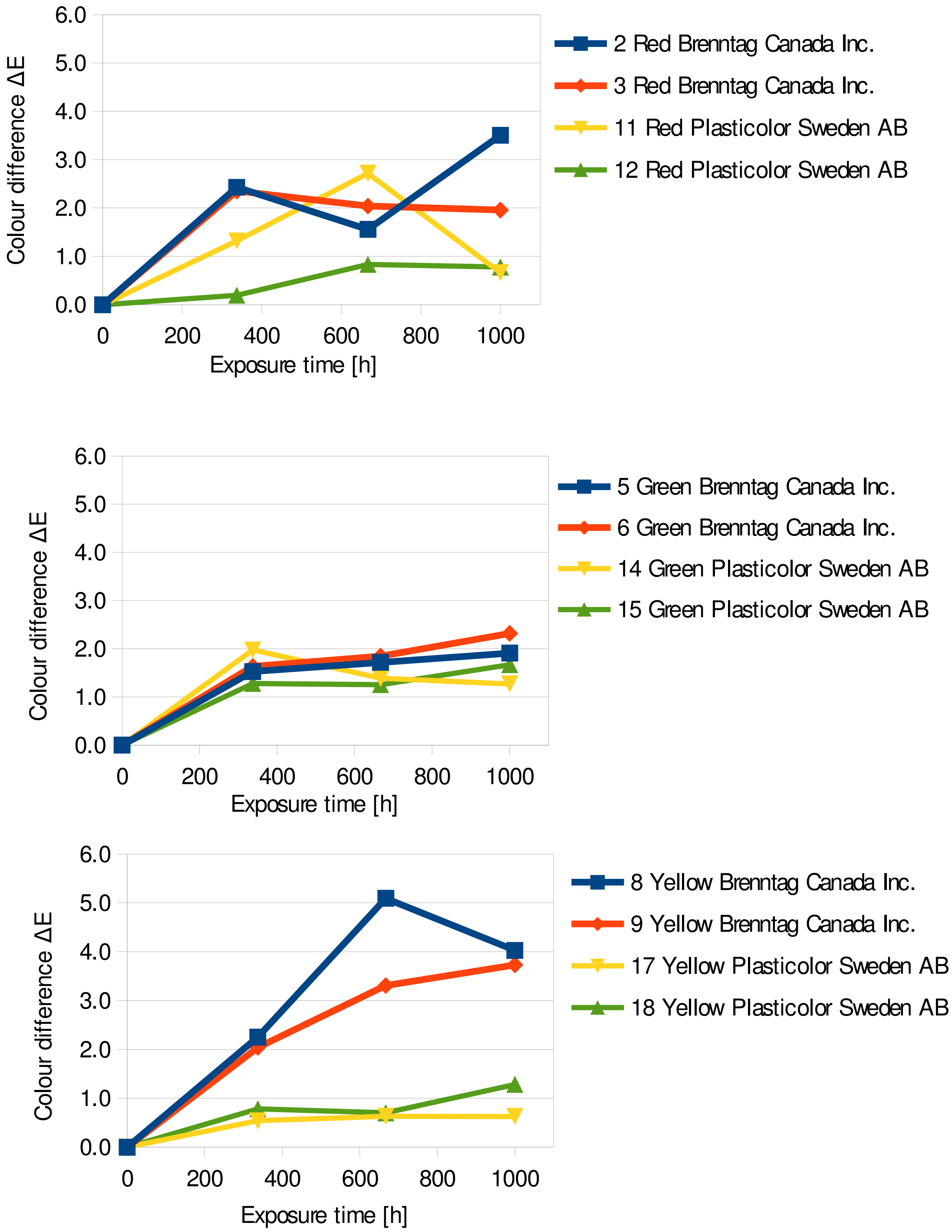


Fig. 8. *Colour difference ΔE as a function of the exposure time. The graphs have been grouped by colour.*

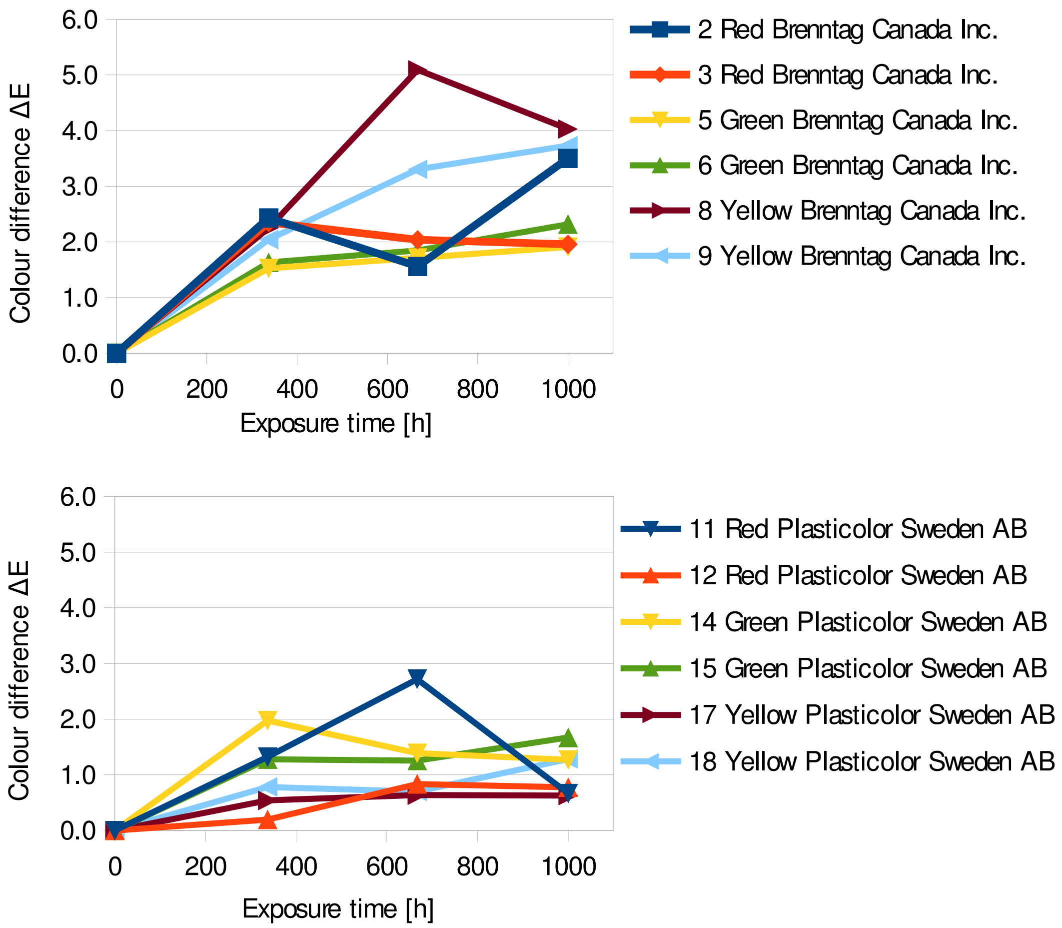


***Fig. 9.** Colour difference ΔE as a function of the exposure time. The graphs have been grouped by the colour material.*

Residual gloss as a function of the exposure time is shown in Figs. 10 and 11. Figure 10 shows the results categorized by colour, i.e., red, green and yellow. Figure 11 shows the results categorized by the colour material, i.e., Brenntag Canada Inc. and Plasticolor Sweden AB. A value of 100 % is given to the original gloss in Figs. 10 and 11.

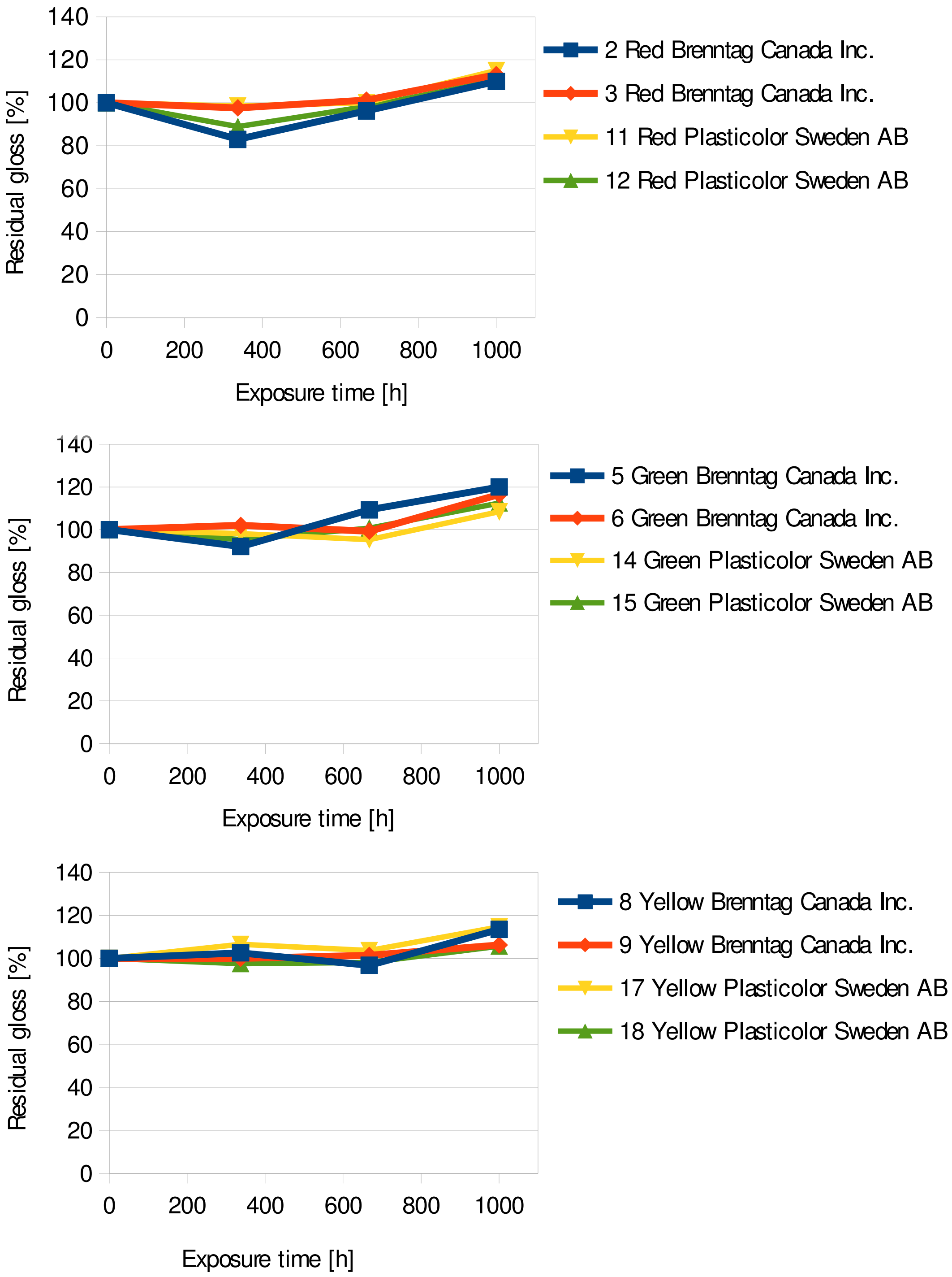
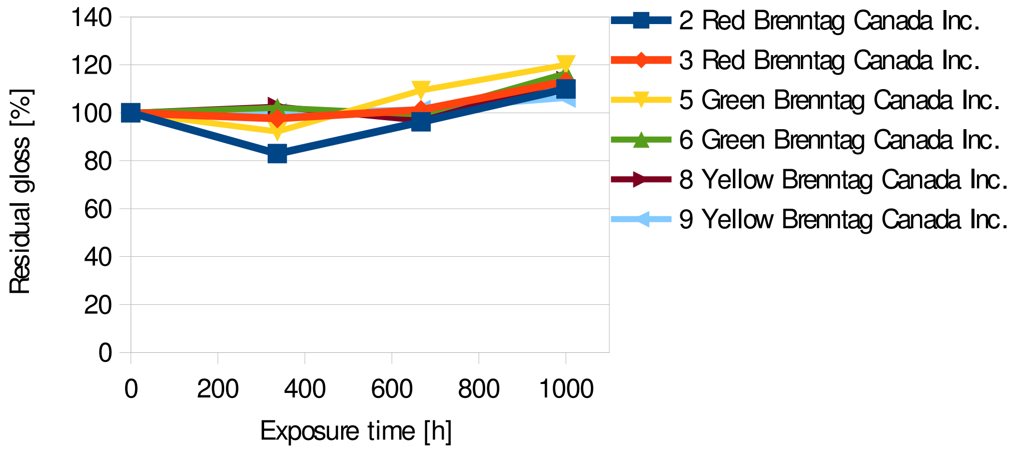


Fig. 10. *Residual gloss as a function of the exposure time. The graphs have been grouped by colour.*



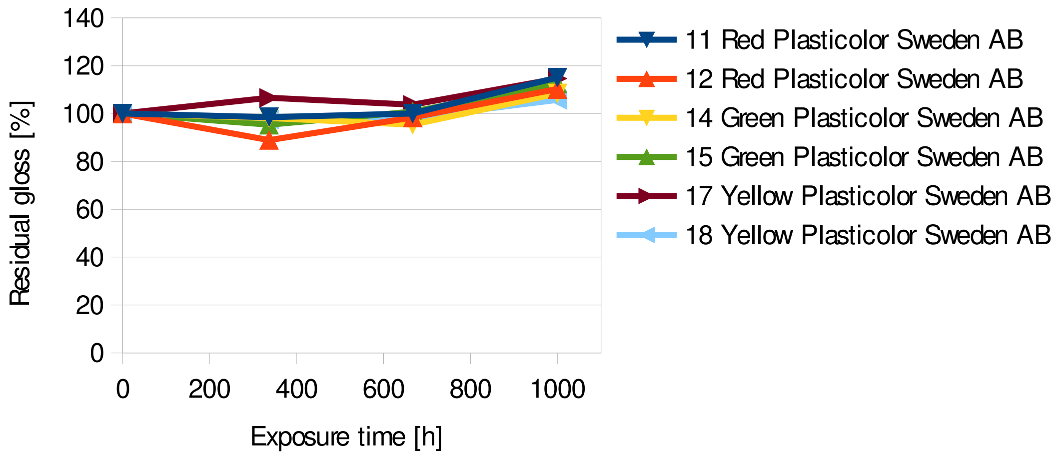


Fig. 11. *Residual gloss as a function of the exposure time. The graphs have been grouped by the colour material.*

Chromaticity diagrams of the red, green and yellow samples are shown in Figs. 12, 13 and 14, respectively. The colour coordinates *x* and *y* were calculated from a reflection spectrum measured from each sample. In the diagrams, the colour coordinates *x* and *y* are given for each sample before and after the exposure. The allowed chromaticity regions according to IALA Recommendation E-108 – Surface colours used as visual signals on aids to navigation, Edition 3, 2013, are shown in the diagrams.

The exposure to xenon light did not cause changes in chromaticity. For both red colour materials, Brenntag Canada Inc. and Plasticolor Sweden AB, the *x* and *y* coordinates were outside of the chromaticity region. The size of the yellow square in Figs. 12 – 14 represents the accuracy of the measurement.

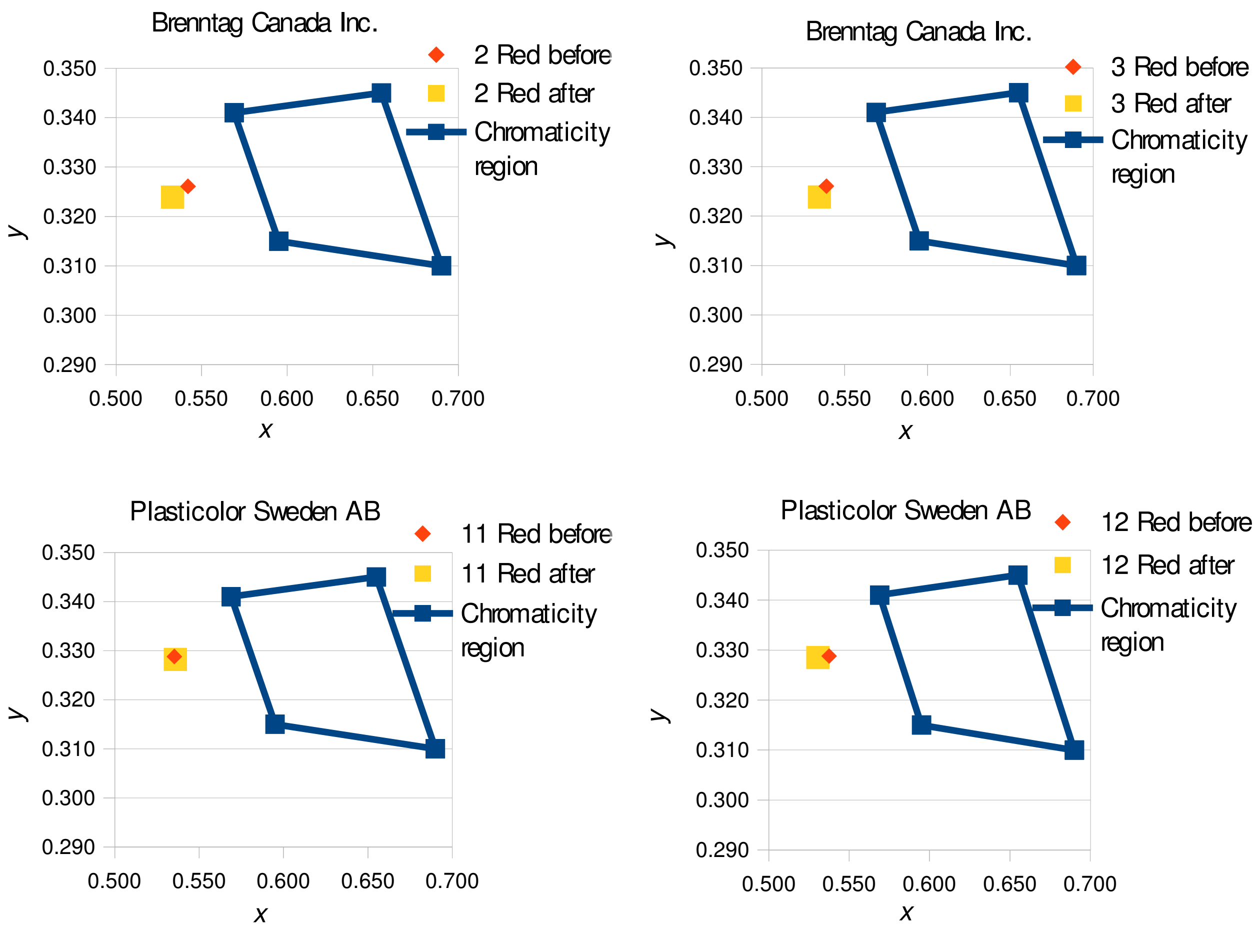


Fig. 12. *Chromaticity diagrams for red samples. The chromaticity region is according to IALA Recommendation E-108. The x and y coordinates for red colour were outside the allowed region.*

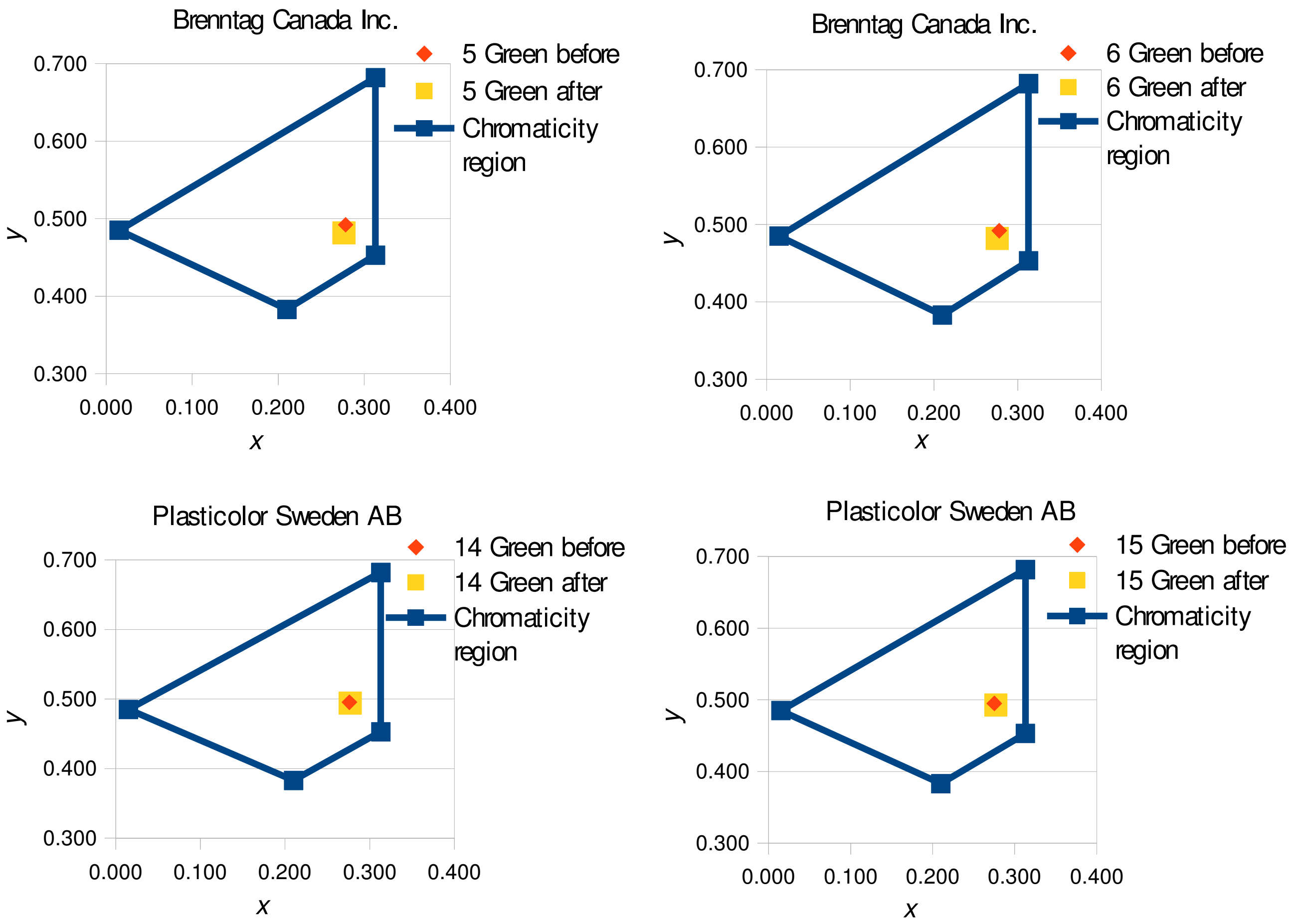


Fig. 13. *Chromaticity diagrams for green samples. The chromaticity region is according to IALA Recommendation E-108.*

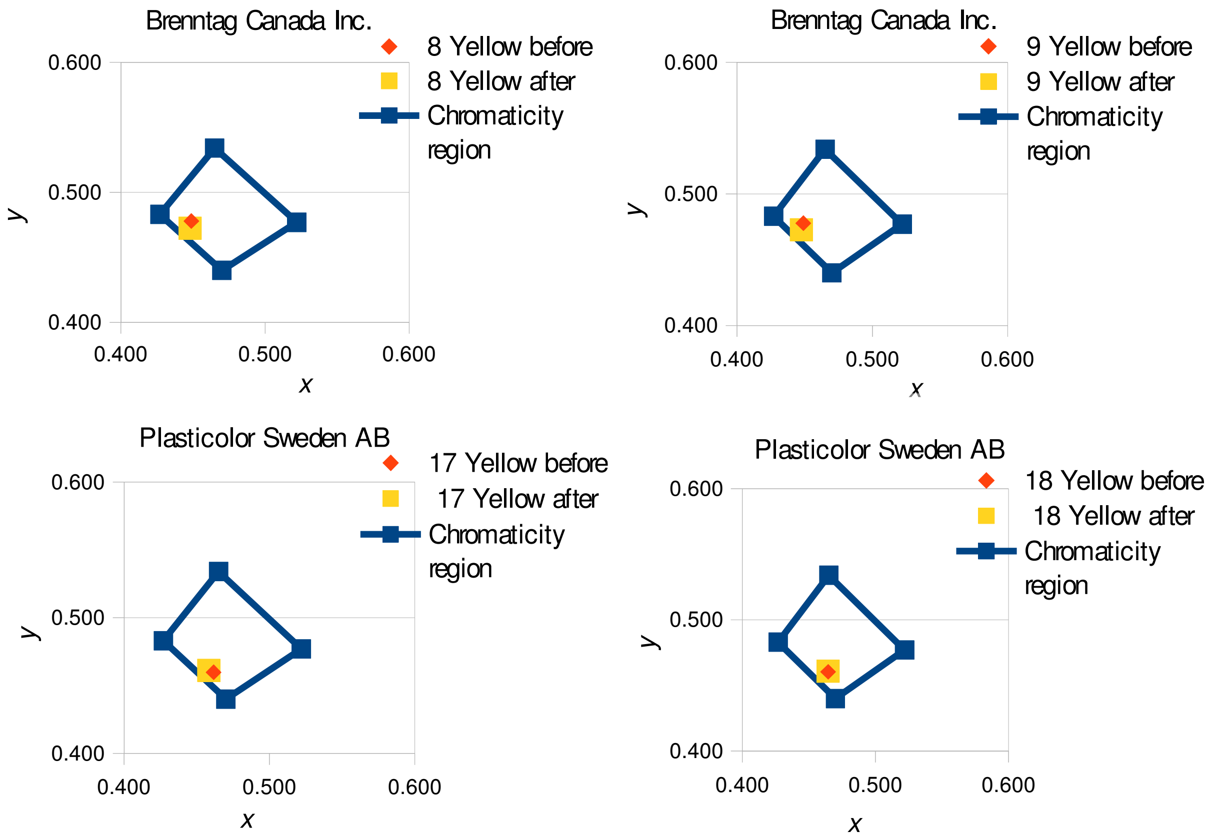


Fig. 14. *Chromaticity diagrams for yellow samples. The chromaticity region is according to IALA Recommendation E-108.*

Used Equipment:
Xenon Tester, No. 62
Spectrometer 1203010U1, calibrated 24th September, 2014, calibration is valid
Radiation intensity: No. 64 / Photodiode, calibrated 10th October, 2014, calibration is valid
Pyranometer No. 25, calibrated 30th May, 2013, calibration is valid
Multimeter No. 24, calibrated 2nd May, 2014, calibration is valid
Temperature: No. 64 / T(BlackPanel)
No. 64 / T(Amb)
Water Purifier, No. 15
Colour: No. 70, calibration is made before every measurement session, calibration is valid
Gloss: No. 10, calibration is made before every measurement session, calibration is valid

Conclusions:

The test specimens, two different colour materials Brenntag Canada Inc. and Plasticolor Sweden AB, in colours red, green and yellow, were exposed to xenon-arc light and moisture for 1000 h.

The effect of radiation on the colour materials was investigated by measuring the CIE *L*a*b** colour coordinate values, CIE 1931 chromaticity and gloss 60°. Changes in colour and gloss were small; colour difference ΔE was 2 – 4 for Brenntag Canada Inc. and ≤ 2 for Plasticolor Sweden AB (Fig. 9) and variation in gloss was within 20 percentage points for both colour materials (Fig. 11). Chromaticity of the colours was not changed. Chromaticity data is summarized in Figs. 15 and 16.

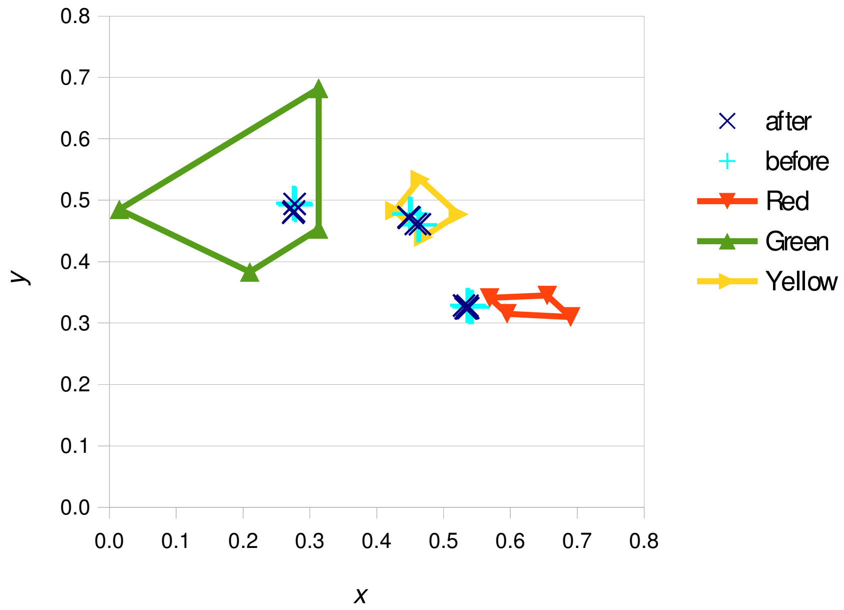


Fig. 15. *Chromaticity of all test specimens summarized in one diagram. The measured x and y coordinates before and after the exposure and the allowed chromaticity regions for red, green and yellow colour according to IALA Recommendation E-108.*

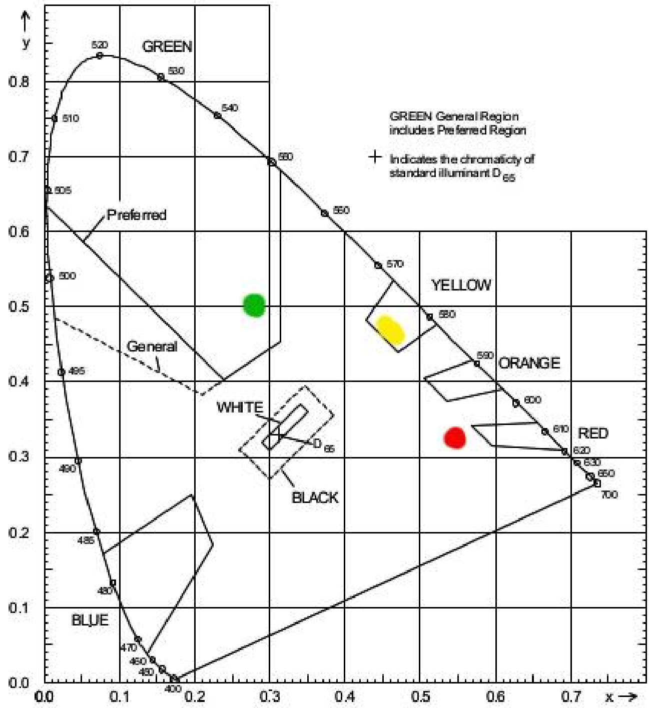


Fig. 16. *Measurement points shown in Fig. 16 (red, green and yellow dots) incorporated in the original figure of chromaticity regions for ordinary colours in IALA Recommendation. [Ref. IALA Recommendation E-108 – Surface colours used as visual signals on aids to navigation , May 1998 - Revised April 2013 , Figure 3.]*

Remarks:

Document history: This report is derived from the previous test report MeritaitoVirtanen__tr121214RP.pdf.

Information of the colour materials was obtained from a document from Haka Plast, September 2014 (Annex A).

Chromaticity of the red colour materials under test is visualized in Annex B.

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

Signatures:

Riitta Perälä
Littoinen, 30th December, 2014
Solar Simulator Finland

TESTED • SÄÄTESTATTU WEATHER SOSIFI®
COLOUR

Annex A (1 / 4)

HAKA Plast

Meritaito Ltd

Utran kanava 5

80910 KUHLO

FINLAND

According to the agreement with Meritaito Ltd test manufacturing of the pipes D32x3,0 yellow, red and green, took place in HAKA Plast Ltd factory, Tööstuse 35, Kadrina 45201, Lääne-Virumaa, Estonia.

The test manufacturing was arranged as it follows:

First manufacturing time was 08.09.2014, with two Meritaito Ltd representative

Test examples Nr.1-9

The used pipes raw material: Tipelin HDPE 7700M Batch nr 430113.

The used colour material: Plasticolor Sweden AB: RAL1023 yellow, RAL6037 green, RAL3020 red. By colour certificate the material has included UV protection.

The second manufacturing time was 24.09.2014

Test examples Nr.10-18

The used pipes raw material: Tipelin HDPE 7700M Batch nr 430113

The used colour material was ordered and send to us by the Meritaito Ltd.: Brenntag Canada Inc: YEL8812UV yellow, GRN8712UV green, and RED8612UV red.

EESTI VABARIIK
HAKA Plast OÜ
LÄÄNE-VIRUMAA

Maarika Adli

Quality Manager

HAKA Plast Ltd

HAKA Plast OÜ:
Tööstuse 35
45201 Kadrina
Lääne- Virumaa
ESTONIA

Tel +372 32 31 990
Fax +372 32 31 991
hakaplast@hakaplast.ee
www.hakaplast.ee

reg. nr 10897652
a/a EE701700017002482693
Nordea Pank
Panga kood: 801

Annex A (2 / 4)

Plasticolor Sweden AB

Färgmatchning

Kund	Haka Plast,Estonia
Attention	Kaul Augasmägi
Vi skickar Er	MB + CHIP
Enligt färgprov	RAL 1023 + UV
Material:	HDPE
Rek konc	3 %
Temperatur	270
Ljusäkthet	8
Livsmedelsgodkänd	Yes
Artikel nr	PE 7A532 L
Benämning	Gul UV PE MB
Kommentar	

Med vänliga hälsningar
Jimmy Holm
+46 40413635
jimmy@plasticolor.se

LOMMA den 27 augusti 2014

Annex A (3 / 4)

Plasticolor Sweden AB

Färgmatchning

Kund	Haka Plast,Estonia
Attention	Kaul Augasmägi
Vi skickar Er	MB + CHIP
Enligt färgprov	RAL 3020 + UV
Material:	HDPE
Rek konc	3 %
Temperatur	300
Ljusäkthet	8
Livsmedelsgodkänd	Yes
Artikel nr	PE 4B424 L
Benämning	Red UV PE MB
Kommentar	

Med vänliga hälsningar
Jimmy Holm
+46 40413635
jimmy@plasticolor.se

LOMMA den 27 augusti 2014

Annex A (4 / 4)

Plasticolor Sweden AB

Färgmatchning

Kund	Haka Plast,Estonia
Attention	Kaul Augasmägi
Vi skickar Er	MB + CHIP
Enligt färgprov	RAL 6037 + UV
Material:	HDPE
Rek konc	3 %
Temperatur	270
Ljusäkthet	8
Livsmedelsgodkänd	Yes
Artikel nr	PE 8B479 L
Benämning	Green UV PE MB
Kommentar	

Med vänliga hälsningar
Jimmy Holm
+46 40413635
jimmy@plasticolor.se

LOMMA den 27 augusti 2014

Annex B (1 / 1)

Comparison of the chromaticity of the red colour materials under test and the chromaticity of the nearest colour that is inside the chromaticity region defined for the red colour in IALA Recommendation E-108 – Surface colours used as visual signals on aids to navigation.