Durability of soft touch panels in marine conditions

Customer:

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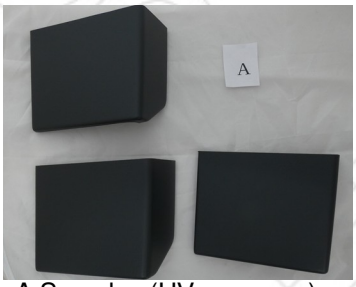
Target:

PVC coated rigid PUR panels (soft touch automoive panels). The samples were divided in three groups: A, B and C as shown in Fig 1.



A Samples (UV exposure)

B Samples (salt water)

C Samples (UV, salt water, heat)

Fig. 1. *All samples by group.*

Testing Time:

The start of the test: 28th April, 2021
The end of the test: 21th July, 2021

Purpose of the Test:

To test how the samples withstand UV radiation, heat and salt water to which they may be exposed to in their actual marine-use environment. UV radiant exposure corresponds to one year in real end-use conditions in Australia.

The test contains three exposures. The purpose of the UV and salt water exposures is to specify possible effects on the samples before exposing the samples to a combination test. The combination test includes UV, salt water and heat exposures.

Test Method:

Exposure

1) UV exposure conditions are derived from ISO 4892-1 and -3 standards
Continuous UV radiation (UVA-340, 60 W/m2 at 300 – 400 nm)
Ambient temperature: 40°C ± 2°C
Duration: 500 h

2) Salt water conditions are derived from MIL810G metod 509.5
Salt solution: NaCl 5%, pH 6.5 – 7.2 (neutral)
Test cycle: 24 hours salt mist spray, 24 hours hour drying, repeated until the total duration of 288h was reached.

3) Combination of UV + salt water + heat, called as marine use conditions
Test cycle:

1. 24 h UV
2. 24h salt spray
3. 24 h heat, Ambient temperature 60°C± 2°C
4. 96 h UV

Repeated until the total uv energy dose 125 kWh/m2 was reached.

Measurements
Visual inspection, colour and gloss measurement.

Calculations
Calculations of the solar UV radiant exposure and its correspondence to the natural solar UV radiant exposure on different locations on earth.

Feasibility of the Test Method:

1) UV exposure
UV-radiation is often the main reason for the degradation of materials and cause of colour and gloss changes. The test temperature was determined to be 40 degrees, that the UV is the cause of any changes not a high temperature.

2) Salt water
The average salinity of sea water is 3.5 %, but may increase to 5%. The test temperature was determined to be 35 degrees, that the salt water is the cause of any changes not a high temperature.

As stated in the MIL810 standard: “Salt is one of the most pervasive chemical compounds in the world. It is found in the oceans and seas, the atmosphere, ground surfaces, and lakes and rivers. It is impossible to avoid exposure to salt.”

Exposure to salt water causes corrosion and, in most cases, cyclic corrosion exposure with drying period accelerates the corrosion and provides more realistic exposure and a higher damage potential than continuous exposure to a salt atmosphere. However the test conditions do not correspond to natural conditions.

3) Marine use conditions
Conditions selected to correspond to marine conditions. Under direct solar radiation the temperature of dark surfaces may reach +60°C. The cooling effect of the wind at sea has been noticed in the temperature.

Performed Actions:

1) UV test

Test Execution
The A samples were exposed to continous UV radiation until the total duration 500 hour was reached. Total energy dose during the test was 52 kWh/m2. Part of the sample was covered with aluminum foil so that any changes are visible to the naked eye. The ambient temperature during the test was 40°C and it is shown on Fig. 4.

More information about the used UV light source, see Appendix 1.

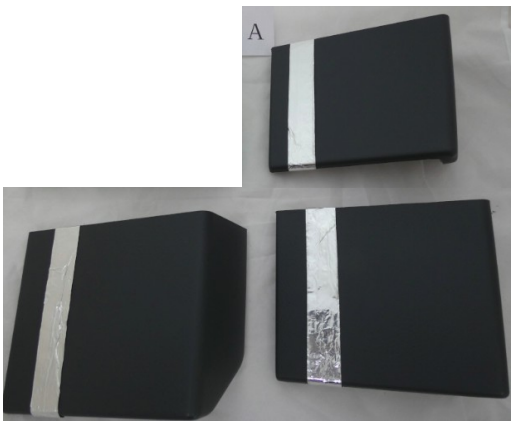


Fig. 3. *Samples with aluminum foil.*

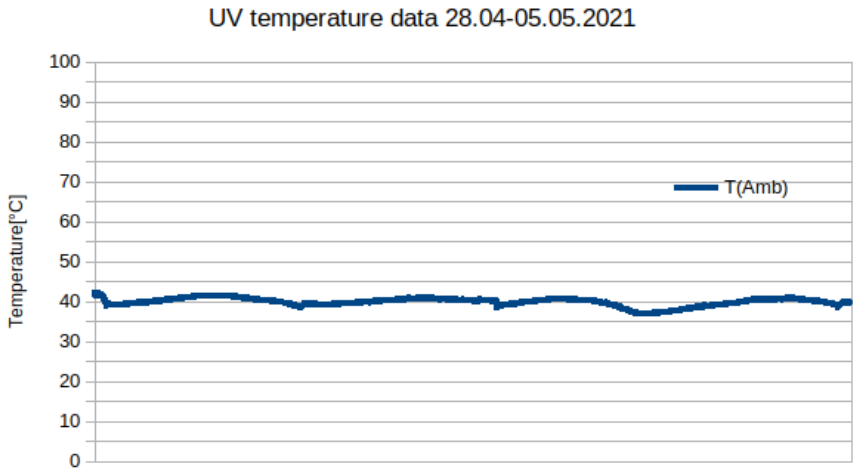


Fig. 4. *Ambient temperature during the test.*

The samples were inspected visually and photographed after the exposure. A small change was observed between the foiled and exposed surface as shown in Fig. 5. The change was so small that the sample had to be held in the right position to see the change.

Fig. 5. *A Samples after the test. Colour and gloss measurement points are indicated by blue spots.*

The colour and gloss measurements were performed before and after exposure. The measurement points are indicated with blue spots in Fig. 5. The results are shown in Table 1.

Table 1. *Colour change and residual gloss of sample group A.*

UV energy [kWh/m2]	**42**	
Samples	Colour change ΔE	Residual gloss
A1	0.11	116.5
A2	0.09	100.9
A3	0.20	109.4

More information about reading the colour and gloss measurement results, see Appendix 2.

Radiation Correspondence:
The correspondence of the UV energies of this test to the natural conditions in selected locations is given in Table 2. The UV energies in Northern Europe, Southern Europe and Australia are estimated average values of these areas.

Table 2. Correspondence of the UV energy of this test vs. natural conditions in different locations on the Earth.

Samples	**UV Energy**	**Correspondence in years**					
		Northern Europe		Southern Europe		Australia**	
	[kWh/m2]	Horizontal	Vertical*	Horizontal	Vertical*	Horizontal	Vertical*
A	52	1	1	0.5	0.7	0.4	0.7

* Vertical surface towards the equator
** Hottest parts excluded
This estimate is based only on the total energy dose and does not take into account the differences in the spectra of the simulated and natural radiation.

2) Salt water
Salt solution oncentration by weight: NaCl 5%
pH of the collected salt solution: 6.4
Spraying rate: 0,82 ± 0.2 ml/h for a horizontal collecting area of 80 cm^2
Test cycle: 24 hours salt mist spray and 24 hours drying,
repeated until the total duration of 288h was reached.

Test execution
The B samples were placed in the test chamber as shown in Fig. 6. Fig. 7 shows the ambient temperature during the test. The total duration of the test was 12 cycles i.e., 288 hours.

Fig. 6. *Samples in the test chamber.*

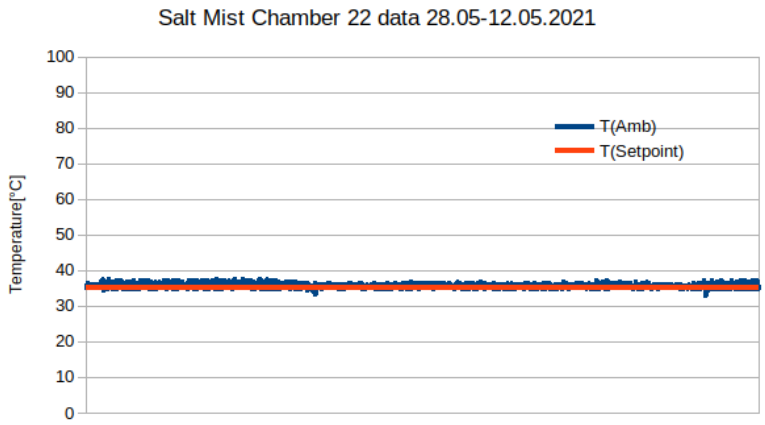
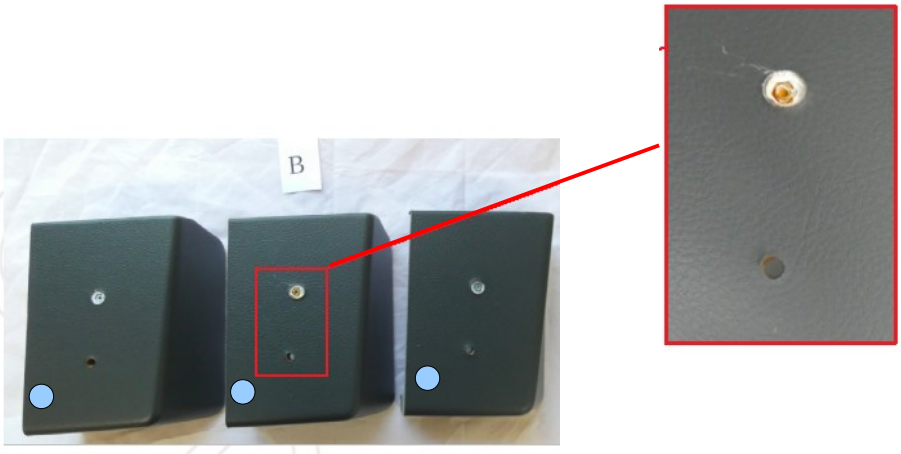


Fig. 7. *Ambient temperature during the test.*

The samples were inspected visually and photographed after the exposure. No changes could be observed in their visual appearance. Only the screws has rusted, but the rust had not spread to the bracket and did not damaged it or the coating of the sample, see Fig. 8.



ss measurement points are indicated by blue spots.

The colour and gloss measurements were performed before and after exposure. The measurement points are indicated with blue spots in Fig. 8. The results are shown in Table 3.

Table 3. *Colour change and residual gloss by sample.*

Sample	Colour change ΔE	Residual gloss
B1	0.27	139.8
B2	0.44	124.1
B3	0.33	127.4

More information about reading the colour and gloss measurement results, see Appendix 2.

3) Marine use conditions
The C samples where exposed to UV, salt water and heat.

More information about the used UV light source, see Appendix 1.

Test execution
The test cycle was as follows:

Samples (C):
- 24 h UV radiation at +40°C
- 24 h salt water exposure at +35°C
- 24 h heat, Ambient temperature 60°C
- 96 h UV radiation at +40°C

The test cycle was repeated until the total uv energy dose 125 kWh/m2 was reached.

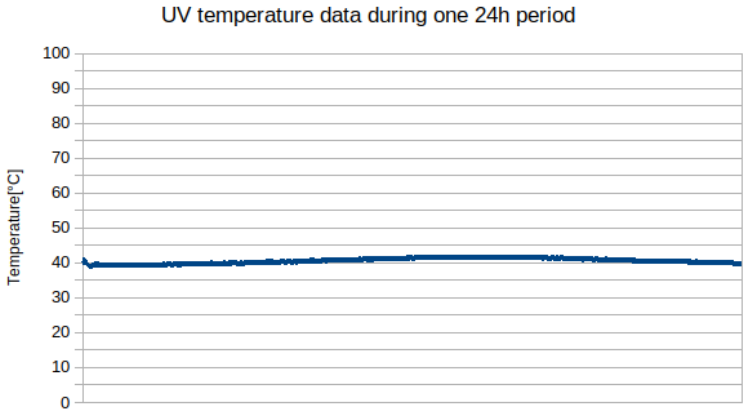


Fig. 9 *Ambient temperature during UV cycle.*

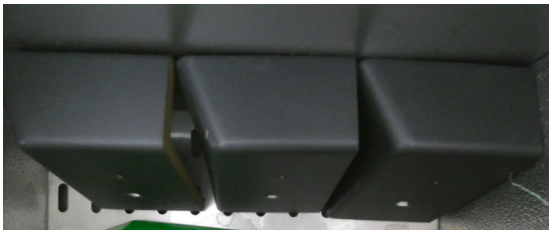


Fig. 10. *Samples at the heat chamber.*

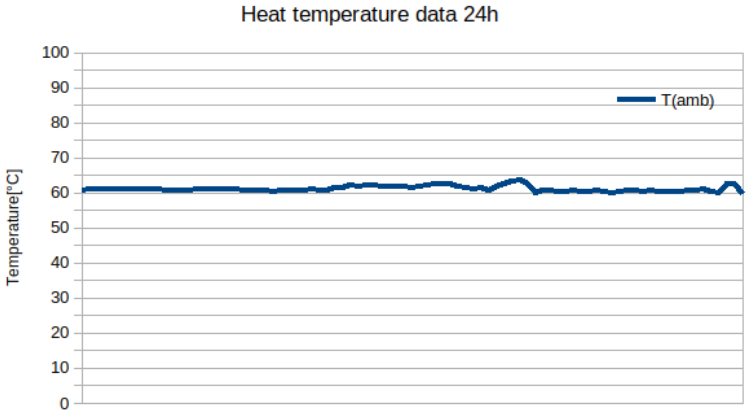


Fig. 11. *Ambient temperature during one 24 hour heat period.*

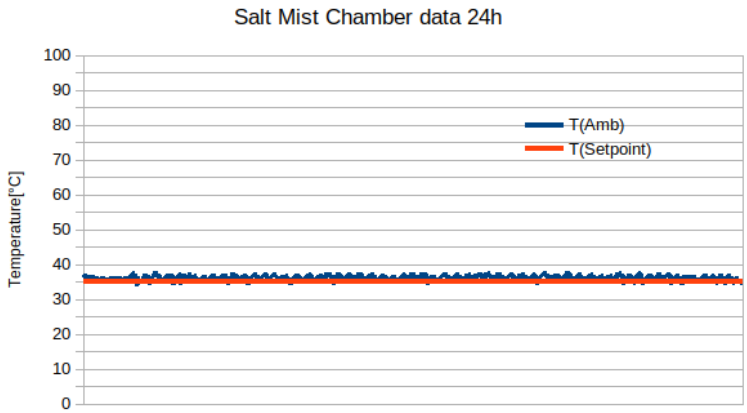


Fig. 12. *Salt water exposure temperature data during one 24 hour period.*

The samples were inspected visually and photographed after the exposure. No changes could be observed in their visual appearance. Part of the samples was not covered with aluminum foil like A samples during the UV exposure, we can assume that a similar small change has occurred also in the C samples.

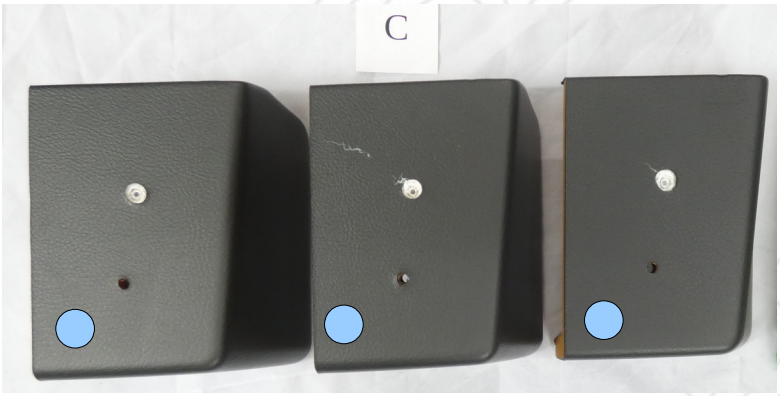


Fig. 13. *C samples after the test. Colour and gloss measurement points are indicated by blue spots.*

The colour and gloss measurements were performed before and after exposure. The measurement points are indicated with blue spots in Fig. 13. The results are shown in Table 4.

Table 4. *Colour change and residual gloss.*

UV energy [kWh/m2]	**32**		**42**		**125**	
Samples	Colour change ΔE	Residual gloss	Colour change ΔE	Residual gloss	Colour change ΔE	Residual gloss
C1	1.25	137.9			0.36	125.2
C2	1.04	122.3			0.69	120.5
C3	0.98	134			0.65	125.5

More information about reading the colour and gloss measurement results, see Appendix 2.

Radiation Correspondence:
The correspondence of the UV energies of this test to the natural conditions in selected locations is given in Table 5. The UV energies in Northern Europe, Southern Europe and Australia are estimated average values of these areas.

Table 5. Correspondence of the UV energy of this test vs. natural conditions in different locations on the Earth.

Samples	**UV Energy**	**Correspondence in years**					
		Northern Europe		Southern Europe		Australia**	
	[kWh/m2]	Horizontal	Vertical*	Horizontal	Vertical*	Horizontal	Vertical*
C	125	2.3	2.3	1.2	1.6	1	1.6

* Vertical surface towards the equator
** Hottest parts excluded

This estimate is based only on the total energy dose and does not take into account the differences in the spectra of the simulated and natural radiation.

Used Equipment:
UV Tester No. 26
Temperature: Datalogger No. 64 + K-type thermocouple, calibrated 1st June, 2020. Calibration is valid.
Colour: Spectrophotometer No. 70, calibration is made before every measurement session. Calibration is valid.
Gloss:Gloss Meter No. 10, calibration is made before every measurement session. Calibration is valid.
Mist Chamber No. 22
Temperature: No. 22_T1, calibrated 28 th July, 2020. Calibration is valid.
Salt solution: Scales No. 78, calibrated 14 th November, 2019. Calibration is valid.
pH Meter No. 77, calibrated 15 th October, 2019. Calibration is valid.
Heat Chamber No. 57
Temperature: Datalogger No. 64 + K-type thermocouple, calibrated 1 st June, 2020. Calibration is valid.

Conclusions:

During the UV exposure the total UV energy dose was 52 kWh/m^2, which corresponds to about one year in Northern Europe. During testing, part of the samples were covered with aluminum foil. Visual inspection after exposure revealed changes between the covered and uncovered surface. The changes were small and the samples had to be viewed from the right angle to see the change. The measured colour and gloss changes were minor.

During salt spray exposure, the samples were exposed to 5% (NaCl) neutral salt spray. After the exposure the samples were visually inspected. No changes were observed on the samples soft touch surface. The screw attached to the sample was rusted, but it did not cause damage to the insert or the soft touch surface. The measured colour and gloss changes were minor.

During marine use condition testing, the samples were exposed to UV radiation, salt and heat. The testing continued until the total UV energy dose during the exposure was 125 kWh/m^2, which corresponds to about one year in Australia. Visual inspection did not reveal any changes. During testing, part of the sample surface was not covered with aluminum foil, as samples during the UV exposure. It can be assumed that similar small changes have also occurred during the marine use condition testing. The measured colour and gloss changes were minor.

The Table 5. below summarizes the color change and residual gloss of all samples.

Table 5. *Colour change and residual gloss by sample.*

UV energy [kWh/m2]	**0**		**32**		**42**		**125**	
Samples/ exposure	Colour change ΔE	Residual gloss	Colour change ΔE	Residual gloss	Colour change ΔE	Residual gloss	Colour change ΔE	Residual gloss
A1/UV					0.11	116.5		
A2/UV					0.09	100.9		
A3/UV					0.20	109.4		
B1/salt water	0.27	139.8						
B2/salt water	0.44	124.1						
B3/salt water	0.33	127.4						
C1/marine use conditions			1.25	137.9			0.36	125.2
C2/marine use conditions			1.04	122.3			0.69	120.5
C3/marine use conditions			0.98	134			0.65	125.5

Remarks:

Document history: This test report is derived from the original test report Novoplastik__tr290421.pdf

This test report contains,
Appendix 1: UV radiation
Appendix 2: Colour and gloss measurements.

Signatures:

Jenna Pesola
Littoinen, 12th August, 2022
Solar Simulator Finland

Appendix 1

UV Radiation
The UV radiation used in this test consists of the same wave lengths as are found in the spectrum of the natural sunlight. The spectrum of the UVA 340 lamps used in the test and that of the sun in the UV-range are shown in Fig. 1.

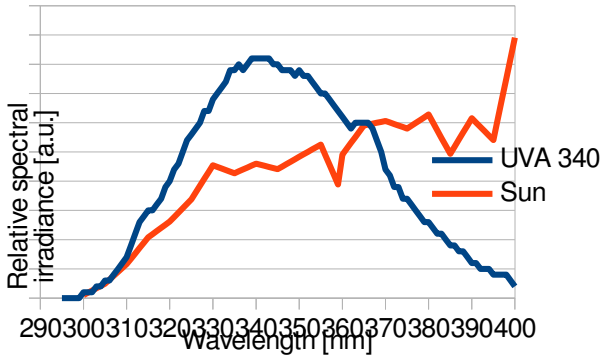


Fig. 1. *Spectrum of the UVA340 lamps used in this test and that of natural sunlight in the UV range. Relative spectral irradiance as a function of wavelength.*
Sun = CIE-85:1989 Table 4 daylight.

The ageing of a product in its conditions of use is the sum of several factors. The radiation strain caused by the sun plays a remarkable role in the ageing of materials outdoors and indoors near the window. Solar radiation consists of ultraviolet, visible, and infrared radiation.

UV radiation specifically is often the component most responsible for ageing materials. Paint factories, for example, largely use equipment producing only uv radiation in their materials testing.

In uv testing, it must be remembered that the ageing produced by visible light and infrared radiation will remain untested. Such a test will serve to remove those samples which have not stood ultraviolet radiation and therefore solar radiation – which is a notable advantage. However, it cannot be stated outright which sample will withstand natural light the best.

Appendix 2

Colour and gloss measurements

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 D*E* represents the Euclidean distance between two colours according to Eq. 1.

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

*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. 1.

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.

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.

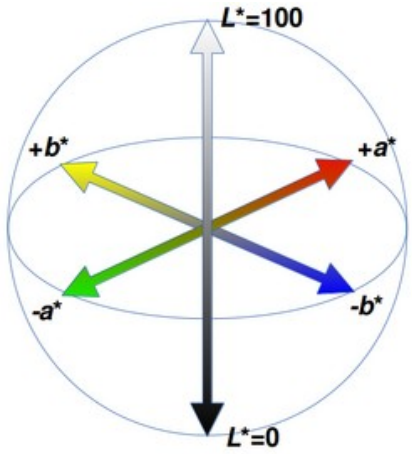


Fig. 1. *CIE L*a*b* colour coordinate system.*