Solar Simulator
Solar Simulator Finland Ltd.

Uranus Comparative UV Radiation Analysis

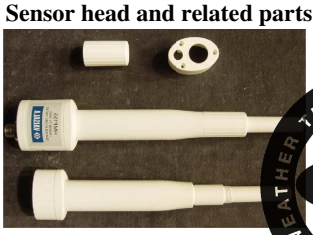
Customer: VAISALA

Vaisala Oyj
Helsinki, Finland

Target:

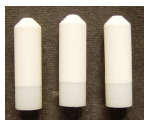
Sensor head: HMP 155 Relative humidity and temperature probe
3 pcs of sintered teflon filter
8 pcs of gaskets
3*10 pcs of white and grey 'dogbones', 170*20/10*4.4 mm²

Sensor head and related parts



Grey and white 'dogbones'

Sintered teflon filter



Gaskets

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Purpose of the test:

The tested samples consist of materials which are used in outdoors situated products of the customer. However, they are used inside the radiation shields. They are in their normal use subjected to solar radiation but not nearly as much as if they were used under bare sky. The purpose of this test is to clarify the mechanical and visual withstand of the samples to UV-radiation.

Test method:

Test cycle consisted of continuous UV-radiation of 120 W/m² and of water spray cycles of 4 hours made twice a week. Total test time was 1000 hours. The Standard ISO 4892-3 was followed. Mechanical tensile strength and elongation tests together with colour measurements revealed the effects of the strains.

Validation of test method:

The produced UV-radiation resembles the UV-radiation of the real sun. On a sunny day there is about 60 W/m² of UV-radiation within the solar radiation. By increasing the amount of UV-radiation the test can be accelerated. The special study concerning radiation energy inside the radiation shield was made in May, 2007. Ref.no.: *VaisalaPitkanentr170407TO.pdf.*

The mechanical tensile strength test and elongation test give results of the mechanical effects of the strains.

Solar Simulator Finland Ltd.
Keskiläntie 5
FIN-20660 Littoinen

Tel. +358 (0)2 474 1600
Fax +358 (0)2 474 1629
www.solarsimulator.com

Research Contract:

VaisalaPitkanenta040407HS.pdf

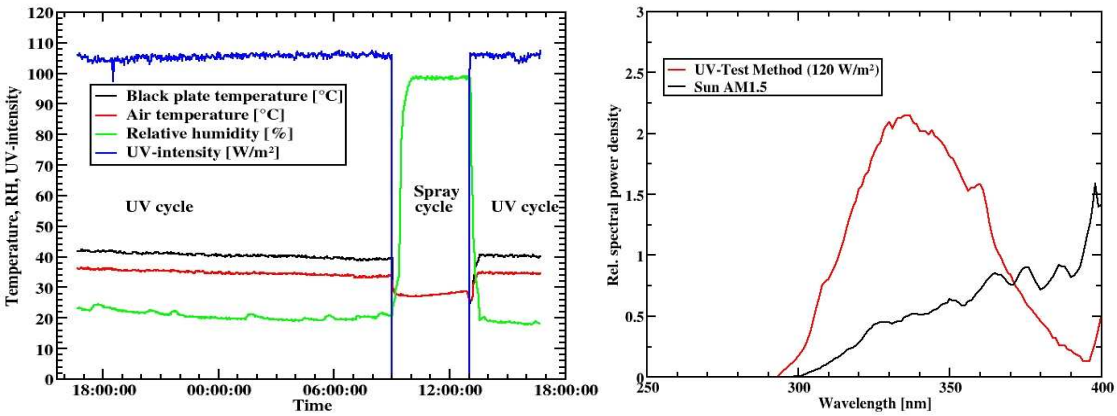
Testing time:

Test started 3rd of October, 2007
Test ended 23rd of November, 2007

Actions done:

The samples were situated horizontally during the test on a grid so some reflected UV-radiation has reached also the other side of the samples.

The test lasted for 1000 hours. There were totally 952 UV-radiation hours and 48 water spray hours. The amount of UV-radiation on the surface of the samples was P = (110 ± 8) W/m². The total amount of UV-energy onto the samples was thus E = 105 kWh/m². The uniformity of the radiation was ±5 %. The UV-radiation was produced with lamps which spectrum is figured below togehther with UV part of the Sun.



The temperature of the black plate reference sample was 41 ± 2 °C during the test. In the figure above there are the amounts of UV-radiation, black plate temperature, air temperature and relative humidity in the test chamber during a cycle of 24 hours. This cycle included also a spray cycle.

● Luna Optical Analysis

The ***Grey Scale values*** of the samples were determined on a visual checking board in every 200 test hours. The samples were illuminated with a D65 light. The light was incident upon the surface at an angle of 45º and the direction of viewing was perpendicular to the surfaces. The fastness grade (the Grey Scale value) was observed by comparing the radiated part of the sample to the unradiated part of the sample or to a reference sample. Grey Scale value 5 means that there is no contrast between the radiated and unradiated parts of the sample and 1 indicate a very large contrast difference. Acceptable Grey Scale values are 5, 4/5 and 4.

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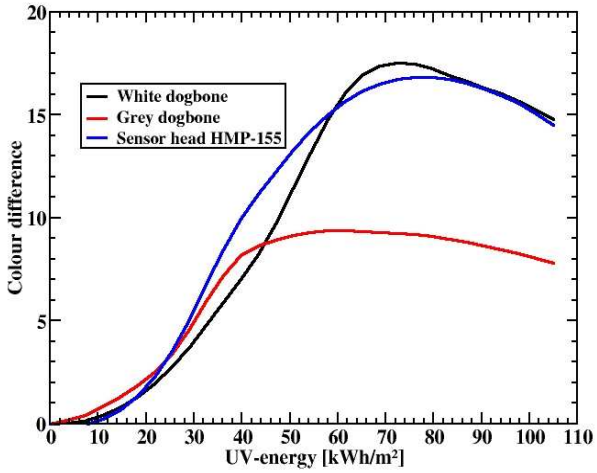
The ***colour coordinates*** L*, a*, and b* were measured at the test hours of 0, 200, 400, 600, 800 and 1000 test hours. The measurements were done before the spray cycle. The last measurements at the end of the test were done after two hours of water spray letting the samples to dry before the measurements. The coordinate values are SCI-values (Specular Component Included).

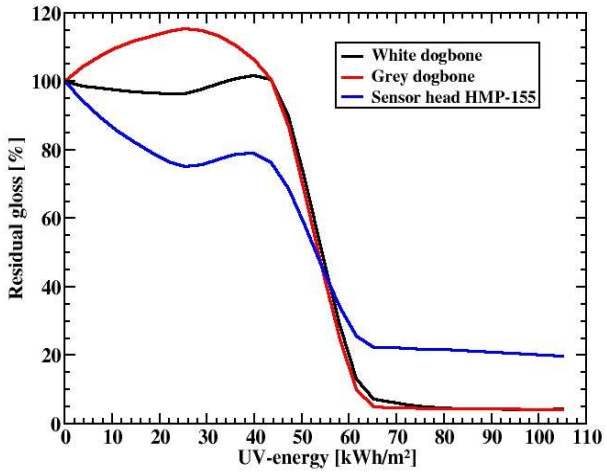
The L*-coordinate indicates the lightness. The bigger the value the lighter the sample.
The +a*-coordinate indicates the red direction and -a* indicates the green direction.
The +b*-coordinate indicates the yellow direction and -b* indicates the blue direction.

Under ideal viewing conditions a DE 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.

At 180 test hours (20 kWh/m²) first signs of colour changes were observed in the dogbones. The sensor head was also a little yellow.



At the colour measurement of 400 test hours (42 kWh/m²) the ***Sensor head*** had a quite brownish yellow tone. The colour difference did not change very much anymore after 500 test hours. The gloss of the Sensor head diminished abruptly at the middle of the test to about 20 % of the original value and stayed at that level to the end of the test.



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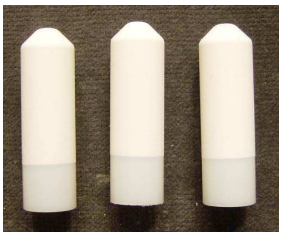
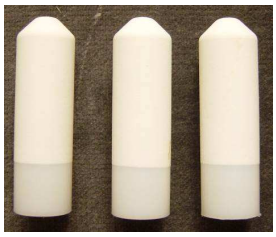
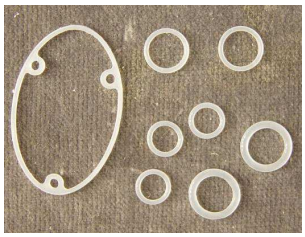
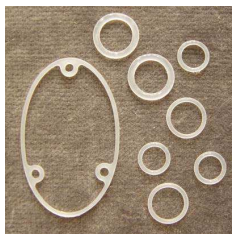
Sample 3 ***Sintered teflon filter*** seems to be the same looking as before the test. The picture on the left is taken before the test and picture on the right is taken after the test.



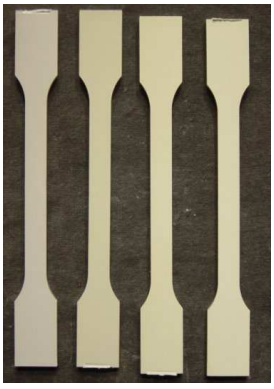


Also the ***gaskets*** seem to be the same looking after the test as before the test. The picture on the left is taken before the test and picture on the right is taken after the test.

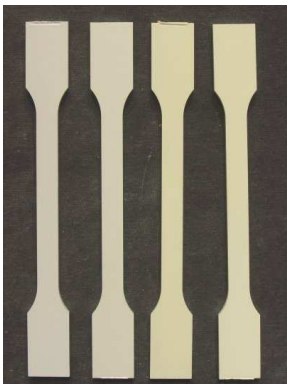




The colour difference of the grey ***dogbones*** increased up till 400 test hours (42 kWh/m² of UV-energy) but after that it stayed nearly constant. The colour difference of the white dogbones increased up till 600 test hours (65 kWh/m²) and after that it stayed nearly constant. The glosses of both dogbones changed quite abruptly between the 400 test hours and 600 test hours. The gloss values of grey and white dogbones were changed to about 5 % from their original gloss values. The grey and white reference dogbones, dogbones after 333 test hours, dogbones after 675 test hours and dogbones after 1000 test hours are shown in the photographs.



Grey dogbones, from left: Ref., 333 h, 675 h and 1000 h.



White dogbones, from left: Ref., 333 h, 675 h and 1000 h.

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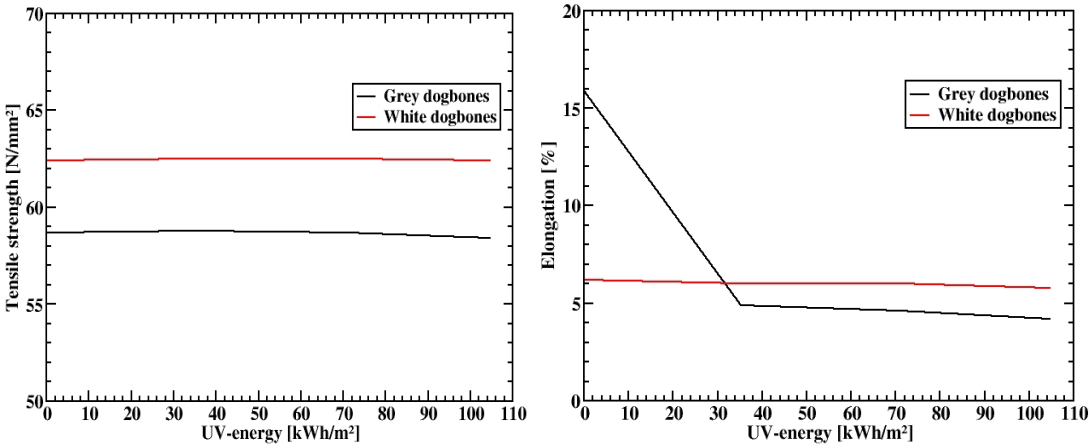
● Luna Mechanical Analysis

Five samples of each dogbones were removed from the test after 333 h, 675 h and 1000 h. For these samples and Reference samples (0 h) were made tensile strength and elongation tests. The tension speed during the measurements was 250 mm/min and the throat depth was 100 mm.

The mean tensile strengths of the grey and white dogbones did not change as a function of test hours.



The mean elongation of the white dogbones as a function of test hours did not change at all. However, the elongation of the grey dogbones changed from 16 % to 5 % for the samples of 333 test hours and stayed after that at that level.

Radiation correspondence

The tested products are to be used inside the Vaisala radiation shields. According to the study *VaisalaPitkanentr170407TO.pdf* the amount of solar energy inside the radiation shield corresponding to 1.0 kWh/m² of UV energy in Southern Finland. The reasonable maximum time according to the customer for this kind of instrument is 20 - 30 years corresponding accordingly to 20 - 30 kWh/m² of UV-energy.

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Conclusions:

The strain onto the samples was UV-radiation and water spray.

The colour differences ΔE, Grey Scale values and approval of the colour and mechanical tests of the samples at the 22 kWh/m² of UV-energy measurement are tabulated.

Sample	*ΔE*	*Grey Scale*	*Approval of colour, '20 years'*	*Approval of mechanical tests*
Sensor head	2.41	4/5	Passed	-
Dogbone, white	2.05	4/5	Passed	Passed
Dogbone, grey	2.60	4/5	Passed	Passed

Remarks:

The reference according to which the Grey Scale value was determined was the reference dogbone or the radiation shielded part of the sample. The shielded part of the sample was however at an elevated temperature during the test which could cause some changes to the shielded parts of the samples.

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

Signatures:

Littoinen, 10th of December, 2007

Timo Oksa

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Solar Simulator Finland Ltd.
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FIN-20660 Littoinen

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