Reflector Materials For Marine Applications: Abrasion Resistance

Customer:

Liikennevirasto / Finnish Transport Agency
Yliopistonkatu 38
FI-33100 Tampere

Target:

Five different reflector materials used in navigation marks and in maritime aids to navigation:

3M Diamond Grade
3M Deutchland GmbH

Oralite VC310
Orafol Europe GmbH

Nikkalite ULS 800 and Nikkalite Crystal 92000
Nippon Carbide Industries Netherlands B.V

Omnicube
Avery Dennison Reflective Solutions

3M Diamond grade, Oralite VC310, Nikkalite Crystal 92000 and Omnicube are manufactured using *microprismatic cube corner technology*, but Nikkalite ULS 800 is manufactured using *glass bead technology*.

3M Diamond grade, Oralite VC310, Nikkalite ULS 800 and Omnicube materials were in colours red, blue, green, yellow and white. Nikkalite Crystal 92000 was in colours fluorescent yellow and fluorescent orange, which are not used in maritime marks, since other colours were not available. The colour itself does not affect the results.

Fig. 1. *Reflector materials under test.*

Testing Time:

The start of the test: 28th February, 2017
The end of the test: 1st March, 2017

Purpose of the Test:

To investigate, and compare with each other, the resistance to abrasion of five different reflector materials used in navigation marks and in maritime aids to navigation in fairways.

Test Method:

Exposure
Abrasion with a wheel rotating over the test item with minimum pressure
The wheel covered by sand paper (180)
Rate: 90 times per minute

Measurements
Gloss 85°
Photographing

Feasibility of the Test Method:

The resistance to abrasion of the reflector materials is known to be rather poor in general. Therefore, the abrasion has to carried out carefully in order not to damage the surfaces but to reveal the possible differences between the materials. In addition, it is needed to find out how the materials are affected by the abrasion as a function of exposure duration.

Measurement of Gloss 85° was chosen since it most closely (of the available measurement methods) measures the directly reflected light. In addition, a photograph taken with flash reveals changes in the surface.

The test method is suitable to be used to compare the abrasion resistance of the different reflector materials with each other.

Performed Actions:

The test samples were placed onto a circular substrate, as shown in Fig. 2.

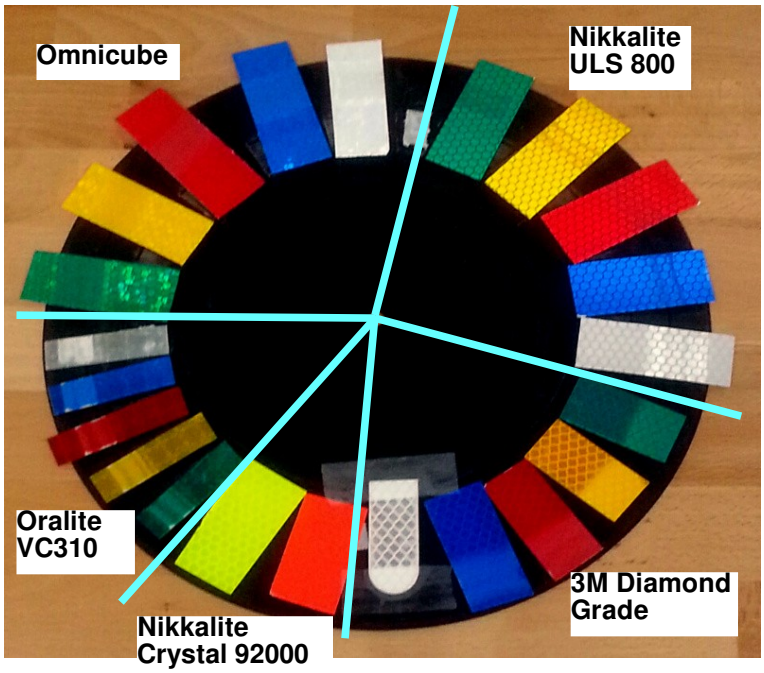

Fig. 2. *Test samples. Omnicube, Nikkalite ULS 800, 3M Diamond Grade and Oralite VC310 reflector materials in colours green, yellow, red, blue and white, and Nikkalite Crystal 92000 reflector material in colours fluorescent yellow and fluorescent orange were tested.*

The abrasion was carried out by two rotating wheels covered by sand paper. The rate of abrasion action was 90 times per minute per sample. The abrasion was performed for 2, 4, 6, 8 and 18 minutes. In addition, an extended period for 45 minutes was performed.

The resulting changes in reflective properties of the materials are best shown in photographs taken with flash from a distance of 5 m from the samples, see Fig. 3. The abrasion marks can be seen as dark areas on the sample surfaces.

The inner dark circle shows how the abrasion affects as a function of time. First image shows the samples before the abrasion. The other images are taken after 2, 4, 6, 8 and 18 minutes of abrasion, as indicated in Fig. 3.

The outer dark circle in Fig. 3 is a result of a longer, 45 minute abrasion (the same in each image). This long-term test was not performed for the Nikkalite Crystal 92000 samples.

The results of Gloss 85° measurements after 2, 6, 8 and 18 minutes of abrasion are shown in Fig. 4. The results are somewhat inconsistent with the photographs shown in Fig. 3. The following reasons may have caused uncertainties in the Gloss 85° measurements:

- The angle of reflected light is 85°, i.e., it is not measure the direct reflection at 90°
- The measurement is done very close to the surface, other reflections may be interfering with the signal
- Oralite VC310 samples were too small for proper focusing of the gloss meter

It can be concluded that the photographs in Fig. 3 give better information about the changes in the reflection properties of the materials than the Gloss 85° measurements.

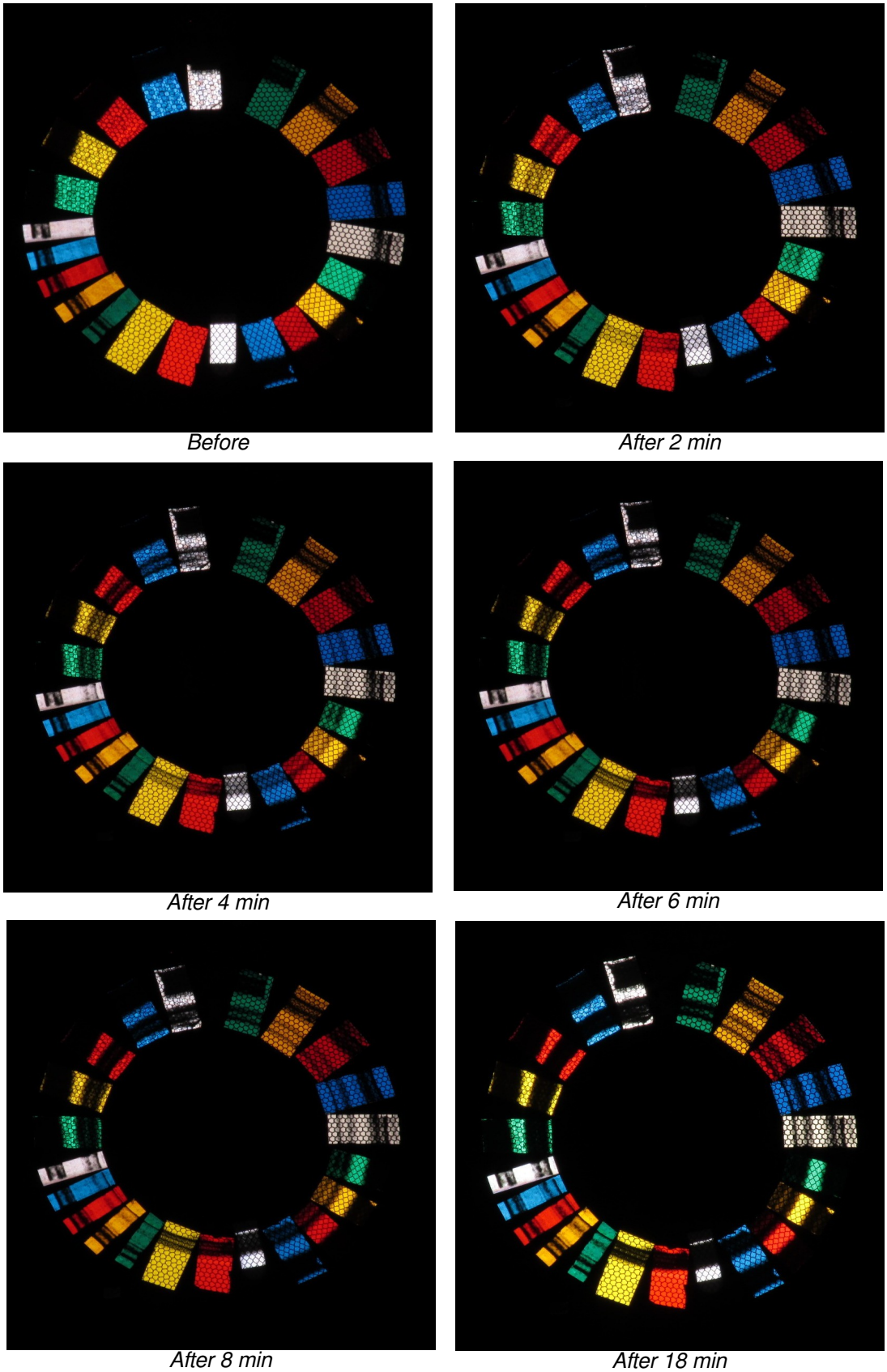

Fig. 3. *Samples photographed before and after abrasion of 2, 4, 6, 8, 18 min (inner circle) and 45 min (outer circle, not for Nikkalite Crystal 92000). The placement of the samples: as in Fig. 2.*

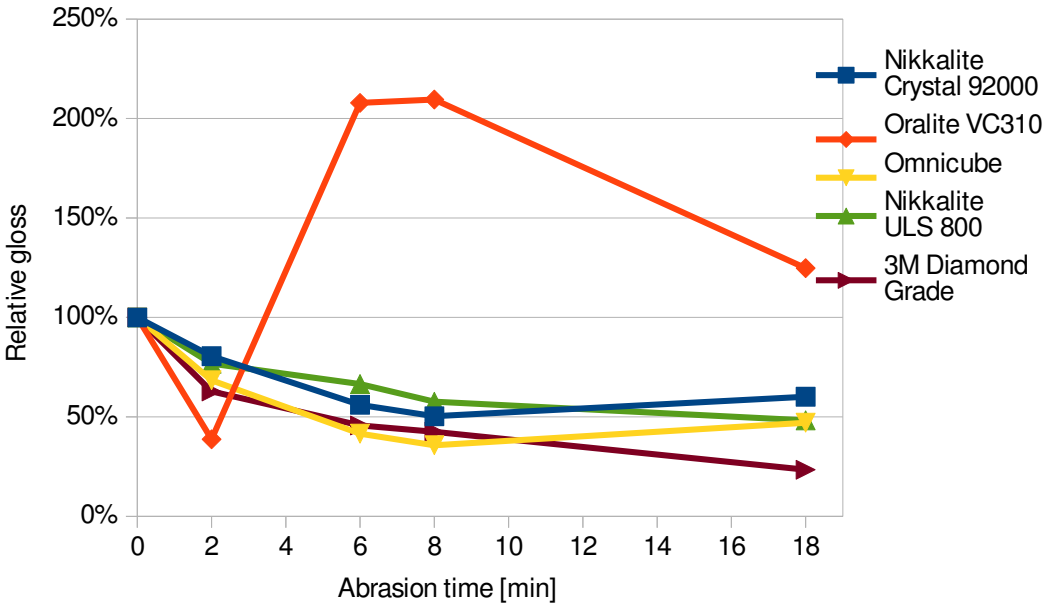

Fig. 4. Residual gloss as a function of abrasion time. The residual gloss is derived from Gloss 85° measurements. A value of 100 % is given to the original gloss before the abrasion.

Used Equipment:
Abrasion device, purpose-built
Gloss Meter No. 71, calibration is made before every measurement session. Calibration is valid.
Optics Laboratory

Analysis:
N/A

Recommendations:
N/A

Conclusions:

The abrasion resistance of five different reflector materials used in navigation marks and in maritime aids to navigation, 3M Diamond grade, Oralite VC310, Nikkalite ULS 800, Nikkalite Crystal 92000 and Omnicube (Avery Dennison), was tested and compared with each other.

The changes in reflective properties of the materials could best be seen in photographs. The tested materials can be put in the following order according to their resistance to abrasion(see Fig. 5):

1. Oralite VC310
   Nikkalite ULS 800
2. Nikkalite Crystal 92000
   3M Diamond Grade
3. Omnicube, Avery Dennison

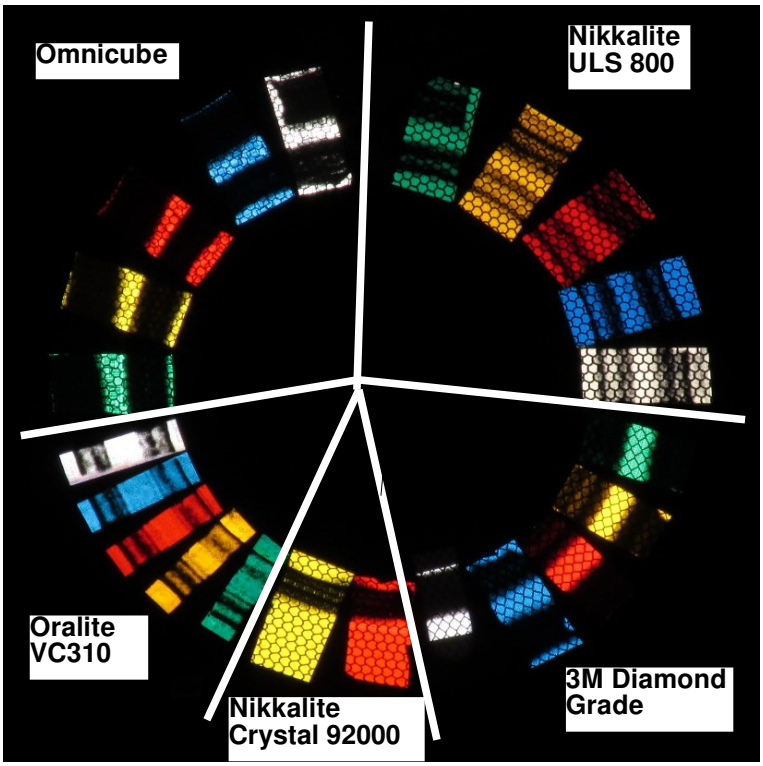

Fig. 5. *Reflector materials photographed after abrasion for 18 min (abrasion marks in the inner circle) and for 45 min (abrasion marks in the outer circle, not shown for Nikkalite Crystal 92000).*

Remarks:

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

Signatures:

Riitta Perälä
Littoinen, 3rd March, 2017
Solar Simulator Finland

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