UN ECE - GRSG - IGPG
5th Meeting

Update on Taber Abrasion Test as agreed with Dr. Dümmler (MPA) and Dr. Schmitz (KRD)

2012-09-05 Dr. Frank Buckel
ISO 3537 und ISO 15082 both describing the Taber test are currently under revision

- currently **no** technical description for abrasive wheels *
- currently **two** abrasive wheel types with different abrasive particles and binder material in use **

➢ decided to qualify wheels via **reference materials**

- a glass reference alone is not sufficient to define wheels for plastic glazing ***

➢ decided to separate test procedures for glass and plastic glazing materials

**To do:** define a reference material for plastic glazing testing

* modified Taber wheels in contrast to former CS 10F wheels do no longer fulfill “former” technical description (surface hardness)
** CS 10F from Taber & C180 OFX from Daiwa
*** based on the results of the ISO round robin test (revealed different results on plastic using the two available wheel types and a poor reproducibility for both wheels on plastic)
Results ISO Taber Round Robin Test
from 2011 / 2012 with Taber and Daiwa Wheels

**ISO round robin test:**
- two different types but only one lot per type of abrasive wheels*
- ten participating test laboratories
- pre-agreed test protocol **
- two different material types ***
- numbers of cycles: 1000 (glass) 100, 500 (100+400) and 1000 (coated PC)
- using a set of three samples per condition.

<table>
<thead>
<tr>
<th>Material</th>
<th>no. of cycles</th>
<th>average $\bar{x}$</th>
<th>standard deviation $s_x$</th>
<th>repeatability standard deviation $s_r$</th>
<th>reproducibility standard deviation $s_R$</th>
<th>repeatability $r$</th>
<th>reproducibility $R$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glass (Taber)</td>
<td>1000</td>
<td>0,7330</td>
<td>0,2131</td>
<td>0,0892</td>
<td>0,2252</td>
<td>0,25</td>
<td>0,63</td>
</tr>
<tr>
<td>Glass (Daiwa)</td>
<td>1000</td>
<td>0,5570</td>
<td>0,2110</td>
<td>0,0796</td>
<td>0,2207</td>
<td>0,22</td>
<td>0,62</td>
</tr>
<tr>
<td>PC (Taber)</td>
<td>100</td>
<td>1,1623</td>
<td>0,6864</td>
<td>0,2958</td>
<td>0,7277</td>
<td>0,83</td>
<td>2,04</td>
</tr>
<tr>
<td>PC * (Taber)</td>
<td>500 (100+400)</td>
<td>4,2226</td>
<td>1,4213</td>
<td>1,1449</td>
<td>1,7011</td>
<td>3,21</td>
<td>4,76</td>
</tr>
<tr>
<td>PC ** (Taber)</td>
<td>1000</td>
<td>4,1913</td>
<td>1,3638</td>
<td>1,6162</td>
<td>1,8978</td>
<td>4,53</td>
<td>5,31</td>
</tr>
<tr>
<td>PC (Daiwa)</td>
<td>100</td>
<td>0,9871</td>
<td>0,3210</td>
<td>0,2356</td>
<td>0,3742</td>
<td>0,66</td>
<td>1,05</td>
</tr>
<tr>
<td>PC (Daiwa)</td>
<td>500 (100+400)</td>
<td>3,6183</td>
<td>1,0874</td>
<td>0,4535</td>
<td>1,1488</td>
<td>1,27</td>
<td>3,22</td>
</tr>
<tr>
<td>PC (Daiwa)</td>
<td>1000</td>
<td>5,7857</td>
<td>1,6424</td>
<td>0,6772</td>
<td>1,7329</td>
<td>1,90</td>
<td>4,85</td>
</tr>
</tbody>
</table>

* and ** high delta haze results not included in the statistical analysis; including high result would change the values as follows: * repeatability 20,11 and reproducibility 21,46; ** repeatability 10,14 and reproducibility 10,88
Results ISO Taber Round Robin Test
from 2011 / 2012 with Taber and Daiwa Wheels

Summary:

glass

- both wheel types lead to similar average values, as well as repeatability and reproducibility standard deviations

coated PC

- results depend on the used wheel type, even more the “average vs. no. of cycles” function for the two wheel types is completely different *

- the repeatability and reproducibility of both wheel types is quite poor ** and the 95% confidence interval in the case of 1000 cycles covers delta haze values from almost invisible to milky

* linear for the Daiwa wheel and with a limiting value after 500 revolutions for the Taber wheel

** especially under the ideal situation that all wheels of one type came from the same production lot
# Taber Abrasion Test Precision
## ISO vs. IGPG Round Robin Results

<table>
<thead>
<tr>
<th>cycle no.</th>
<th>coated PC</th>
<th>requirement</th>
<th>glass</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Δ haze</td>
<td>max. Δ haze</td>
<td></td>
</tr>
<tr>
<td>ISO best case with only one wheel lot</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Daiwa C180 OFX</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100</td>
<td>0,99</td>
<td>1,74</td>
<td>&lt;4%</td>
</tr>
<tr>
<td>500</td>
<td>3,62</td>
<td>5,92</td>
<td>&lt;10%</td>
</tr>
<tr>
<td>1000</td>
<td>5,79</td>
<td>9,25</td>
<td>&lt;2%</td>
</tr>
<tr>
<td>ISO best case with only one wheel lot</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Taber CS 10F</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100</td>
<td>1,16</td>
<td>2,62 **</td>
<td>&lt;4%</td>
</tr>
<tr>
<td>500</td>
<td>4,22</td>
<td>7,62</td>
<td>&lt;10%</td>
</tr>
<tr>
<td>1000</td>
<td>4,19</td>
<td>7,99 ***</td>
<td>&lt;2%</td>
</tr>
<tr>
<td>IGPG real case (CS 10F different lots)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1000</td>
<td>10,52</td>
<td>37,58</td>
<td>&lt;2%</td>
</tr>
</tbody>
</table>

* max. Δ haze is the upper limit of the 95% confidence interval (average Δ haze + 2 x reproducibility standard deviation)
** even at 1% haze values and only using one Taber wheel lot the test accuracy on plastic is that poor that a 2% limit is not reached reliably
*** even in the unlikely case that all Taber wheel lots are identical the difference between average and max. value for plastics is above the 2% limit, which is therefore not reachable due to test accuracy (EVEN for average values of 0%)
Abrasion Tests
Comparison of Precision of Test Methods

Reproducibility R * allows to compare the precision of different test methods directly (width of distribution independent from the average haze values)

* Definition of reproducibility R: In comparing two results for the same material, obtained by different operators using different equipment, the results should be judged as not equivalent if they differ by more than the R value for that material and condition. $R = 2.8 \times$ reproducibility standard deviation (max. $\Delta$ haze = average $\Delta$ haze + 0.7 x R)
Plastic Windscreens
Haze Values of Plastic Windscreens from KRD*

- plastic windscreens with “on-road” experience are already available (police cars in Germany)
- haze values of these used windscreens are on a low level having only “some” dependency to the mileage
- investigation of the surface deterioration leading to these haze values and comparison to abrasion tests

haze values of plastic windscreens vs. mileage

* data from IGPG-04-02
Plastic Windscreens
Comparison of Microscopic Images with Abrasion Tests

plastic windscreens from KRD (IGPG-04-02)
- mileage: **136452 km**
- haze values: 1.3-1.6% (driver field of vision) and 0.9-1.0% (front-seat passenger side)

abrasion tests on samples from KRD (same coating)
- wiper test - 1000 wipe cycles
- Taber - 1000 cycles
- car wash test
- sand drop test
Plastic Windscreens
Comparison of Microscopic Images with Abrasion Tests

plastic windscreen from KRD with a mileage of 21000 km

abrasion tests on samples from KRD (same coating)

driver field of vision
center of the screen
front-seat passenger side

wiper test - 1000 wipe cycles
Taber - 1000 cycles
car wash test
sand drop test
Glass Windscreens
Comparison of Microscopic Images with Abrasion Tests

<table>
<thead>
<tr>
<th>Laminated glass windscreen with a mileage of 105000 km</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>driver field of vision</strong></td>
</tr>
<tr>
<td><strong>center of the screen</strong></td>
</tr>
<tr>
<td><strong>front-seat passenger side</strong></td>
</tr>
<tr>
<td><strong>in wiper area</strong></td>
</tr>
<tr>
<td><strong>outside wiper area</strong></td>
</tr>
<tr>
<td><strong>amplification 30x</strong></td>
</tr>
</tbody>
</table>

Abrasion tests on glass samples

- **wiper test - 1000 wipe cycles**
- **Taber - 1000 cycles**
- **car wash test**
- **sand drop test**

**amplification 30x**
Windscreens
Summary of Comparison of Microscopic Images

- used plastic windscreens show depending on the location (within the wiper area or not) **scratches and some small pits**
- similar **microscopic images** are created by the car wash test respectively a wiper test and to some extend by the sand drop test
- for plastic windscreens there is **no similarity to the image created by the Taber test**

- most sever surface damage on **glass windscreens** result from **stone chipping**
# Taber Abrasion Tests
## Summary of Test Characteristics

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Consequence</th>
<th>Implication for Plastic Glazing Approval</th>
<th>Possible Adjustment of the Test to Solve Issue</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Real Part Testing</strong></td>
<td>can only be performed on absolutely flat 100mm x 100mm samples</td>
<td>it is not possible to test a finished plastic glazing part due to its shape (only on a reference sample)</td>
<td>the abrasion performance of a finished plastic glazing part will not be checked</td>
</tr>
<tr>
<td><strong>Correlation to On Road Use</strong></td>
<td>two wheels consisting of abrasive particles in a resilient binder are placed with 500g load each on a rotating sample for 1000 cycles</td>
<td>there is no similarity to real &quot;on-road&quot; abrasion actions</td>
<td>no correlation between tested abrasion performance and real &quot;on-road&quot; wear performance</td>
</tr>
<tr>
<td><strong>Technical Description of Abrading Part</strong></td>
<td>no technical details describing the abrasiveness of the wheels</td>
<td>intended or unintended change of the publicly unknown wheel recipe by the manufacturer can change the results</td>
<td>approval depend on pre-delivery quality inspection of the wheel manufacturer</td>
</tr>
<tr>
<td><strong>Precision of the Test Method</strong></td>
<td>round robin test revealed a very low precision for testing plastic samples</td>
<td>haze results for plastics will vary from almost invisible to milky based on test accuracy</td>
<td>approvals not only depend on sample performance</td>
</tr>
</tbody>
</table>

- even if ISO solves these issues it is still not possible to assess the real wear of a finished plastic part
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Thank you!

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