RESULTS AND ANALYSIS
TABER ROUND ROBIN TEST
(RENAULT / UTAC / PSA)

IGPG Fifth meeting at OICA – 5 & 6 September 2012
Background
Background

- **End of 2010:** Project of an amendment of the ECE 43 Regulation for an usage of plastic glazing for windscreen

- **18/01/2011:** 1\(^{st}\) meeting in the framework of the « Informal Group on Plastic Glazing » (IGPG) in which we defined the way in the evaluation of the Taber Test via a Round Robin test
  - with the support of 11 laboratories
  - on 3 types of support: monolithic glass, PMMA coating, PC coating
  - without defining at the beginning of the test campaign a common procedure of the test
14/06/2011: Presentation of the Taber Round Robin Test results by BAYER

- Important variation between each laboratories, with a value of 40% of the Haze: reproducibility of plastic parts > 30%
- The origin of the source of the Haze measurement is not due to the variation but solely by the abrasion itself
- No linear relation according to the type of samples
- The characteristic of the wheels are not sufficiently informed
Background

- **21/11/2011**: Comprehension of the sources of variation (BAYER)

Possible reasons for high standard deviation when testing plastics:

- **different test procedure used**
  - two procedures are used (only ASTM D1044 is updated since generation IV wheels are used)
  - review of according to Taber crucial differences

- **calibration and age of the instrument (including suction force)**
  - results of the calibration verification using a special kit from Taber

- **consistency of CS-10F wheels**
  - results of Taber’s inspection of two used wheels lots
  - additional investigation from lab no. 9/10

- **haze measurement**
  - haze cross check for PC samples done by PC sample manufacturer confirm that there is no significant deviation in haze measurement between the participating test labs

- **sample inhomogeneity**
  - since the repeatability is good compared to the reproducibility the samples are not the source
Conclusion

- Taking into account the very dispersive results in the first campaign, the French manufacturers proposed at the 4th meeting held in Germany to carry out a new study by taking into account the preceding analyses done by BAYER.

- This new study will be done by RENAULT, UTAC and PSA.
Set up of an inter-laboratory tests
Set up of an inter-laboratory tests

- Taking into account the conclusions of the Round Robin Test done by BAYER in 2011
  - Application of the ASTM D1044-08 standard by taking into account experiences from diverse laboratories
    - Cleaning with Water-Ethanol (50/50) applied to soft rag nonfluffy woven cotton + rinsing under the demineralized water + drying air before and after test
    - Height of the arm of aspiration adjusted with a **hold of 1mm thickness** or a wire of 1mm of diameter between the front of the vacuum nozzle and the stone of patching
    - Use of protective gloves for the handling of the sample
    - **Calibration and measurement of Haze** realized using the specific support of the Taber test provided with Haze-Gard
Set up of an inter-laboratory tests

- Measurements done on each of 4 points located in each window of the support as shown in the figure. Hence, in total 16 measurements are carried out.

- Initial positioning of the sample with the abrasive grinding stones located in a zone where no measurement is done

- Maintenance of the TABER test tool according to the recommendations of TABER carried out before the study
Set up of an inter-laboratory tests

- Condition of the experimental study carried out in the weeks 29 and 30 of August 2012
  - 3 laboratories
  - 2 operators per laboratory
  - 1 type of sample tested given by BAYER (PC with coating)
    - Thickness of the samples are homogeneous
      - Topcoat: 7.7 -> 8.5 µm / Basecoat: 1.8 -> 2µm
  - 16 samples per laboratory, hence 8 samples per operator
  - Alternation of the abrasion tests between each operator (except laboratory number three)
  - Abrasion carried out under the load 500g and 1000 cycles
  - Use of several lots of abrasion wheels, with the characterization of their DIDC hardness
## Set up of an inter-laboratory tests

### Information with regard to each laboratory Taber test

<table>
<thead>
<tr>
<th>Test laboratory</th>
<th>Laboratory 1</th>
<th>Laboratory 2</th>
<th>Laboratory 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test method</td>
<td>Common test method</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wheel type and lot number</td>
<td>CS 10F ER23D2</td>
<td>CS 10F (type IV) EH19D2</td>
<td>CS 10F (type IV) EH19D2</td>
</tr>
<tr>
<td>Wheel - Expiration date</td>
<td>01/01/2014</td>
<td>01/05/2013</td>
<td>01/05/2013</td>
</tr>
<tr>
<td>Wheel - Hardness (DIDC)</td>
<td>91 DIDC</td>
<td>90 DIDC</td>
<td>L-85 DIDC / R-84 DIDC</td>
</tr>
<tr>
<td>Refacing medium</td>
<td>ST 11 DX 25 ST2</td>
<td>ST 11 38A180-MU</td>
<td>ST 11 38A180-MU ST-11</td>
</tr>
<tr>
<td>Vacuum nozzle (orifice size)</td>
<td>11 mm</td>
<td>11 mm</td>
<td>11 mm</td>
</tr>
<tr>
<td>Distance nozzle / sample</td>
<td>1 mm</td>
<td>1 mm</td>
<td>1 mm</td>
</tr>
<tr>
<td>Instrument Taber reference and serial number and date of last calibration</td>
<td>5131 N° série : 9732 Date de dernière calibration : Janvier 2012</td>
<td>5131 N° série : 20031221 Date de dernière calibration : 17/04/2012</td>
<td>5130 - SCU0005 N° série : 904865 Date de dernière calibration : 07/09/2011</td>
</tr>
</tbody>
</table>
Results of the inter-laboratory tests
5 aberrant values have been detected in the results of Lab 1 following handling error:
- Vacuum nozzle in contact with the sample at the rear
- Height of the vacuum nozzle non respected

<table>
<thead>
<tr>
<th>Lab</th>
<th>Delta Haze (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lab 1</td>
<td>8.10</td>
</tr>
<tr>
<td>Lab 2</td>
<td>2.40</td>
</tr>
<tr>
<td>Lab 3</td>
<td>3.30</td>
</tr>
</tbody>
</table>

**Average**
After withdrawal of the aberrant values, the results show that the arithmetic mean inter-laboratory are in the same of the range of the uncertainties measurement.
Results of the inter-laboratory tests

- Statistical results analysis with Cochran and Grubbs Test for the 3 laboratories for final Haze

- The laboratory 1 is considered statistically as the reference laboratory. All laboratories have in the same range uncertainties regarding their own results.

- The standard deviation of the reproducibility corresponding to 95% of the population (all results) is of 1,2% of Haze

- The laboratory 3 presents a high standard deviation compared to the reference laboratory. It is necessary to identify the origin of this variation.
For a same laboratory, the means are in the same range of the uncertainties

Laboratories 1 and 2 have the same range uncertainties regarding the results

Laboratory 3 seems badly control the process of the Haze measurement → the results have to be studied further
In order to define the influence factors, 6 samples per laboratories were chosen, corresponding to the max, the min and the average of the series of the measure for each operators.

Measurement of the Final Haze **without cleaning** of the Labo3 samples by Labo2 (Reference laboratory).

- The use of 2 generations of Hazegard has an influence on the final results and on the standard deviation.
Influence of parameters on the final Haze

- Measurement of the Final Haze with the cleaning of the Labo3 samples by the Labo2 (Reference laboratory).

<table>
<thead>
<tr>
<th></th>
<th>Labo 2</th>
<th>Labo 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>2.4</td>
<td>3.5</td>
</tr>
<tr>
<td>Std deviation</td>
<td>0.3</td>
<td>1.0</td>
</tr>
</tbody>
</table>

- The cleaning has an impact on the final values
Influence of parameters on the final Haze

- Measurement of the Final Haze with the cleaning of the Labo1 samples by Labo2

- When the same cleaning method is used, the correlation between 2 laboratories is good.

<table>
<thead>
<tr>
<th></th>
<th>Labo 1</th>
<th>Labo 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Average</strong></td>
<td>2.5</td>
<td>2.9</td>
</tr>
<tr>
<td><strong>Std deviation</strong></td>
<td>0.7</td>
<td>0.7</td>
</tr>
</tbody>
</table>
The Taber test has a good repeatability and reproducibility for organic glazing with the ASTM D1044-8 standard more refined

The more influent factors are:

- The device of the Haze measurement
- The cleaning methodology

With our procedure, our reproducibility value (1.2%) is under the target (3.42%) given by ASTM D1044-8 standard after 1000 cycles

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**Final conclusion**

<table>
<thead>
<tr>
<th>Material</th>
<th>Number of Cycles</th>
<th>Mean (0.69)</th>
<th>S_e</th>
<th>S_a</th>
<th>S_m</th>
<th>r</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glass</td>
<td>1000</td>
<td>2.12</td>
<td>0.19</td>
<td>0.16</td>
<td>1.25</td>
<td>2.56</td>
<td>3.70</td>
</tr>
<tr>
<td>Polycarbonate—Coating 1</td>
<td>1000</td>
<td>2.62</td>
<td>0.76</td>
<td>0.85</td>
<td>2.86</td>
<td>3.42</td>
<td></td>
</tr>
<tr>
<td>Polycarbonate—Plasma</td>
<td>1000</td>
<td>0.96</td>
<td>0.83</td>
<td>0.83</td>
<td>1.22</td>
<td>2.01</td>
<td></td>
</tr>
<tr>
<td>Polycarbonate—Coating 2</td>
<td>500</td>
<td>3.05</td>
<td>1.23</td>
<td>1.64</td>
<td>1.90</td>
<td>4.56</td>
<td></td>
</tr>
<tr>
<td>Polycarbonate—Coating 3</td>
<td>500</td>
<td>3.95</td>
<td>2.95</td>
<td>4.82</td>
<td>5.48</td>
<td>13.49</td>
<td>15.33</td>
</tr>
</tbody>
</table>

*S_e* = pooled within-laboratories standard deviation of the mean for three or ten specimens.

*S_m* = total among-laboratories standard deviation of the mean for three or ten specimens.

\[ r = 2.83 \, S_e \text{ (see 13.2), and} \]

\[ R = 2.83 \, S_m \text{ (see 13.3).} \]

Other materials may give somewhat different results.

**13.2 Repeatability**—In comparing two averages for the same material, obtained by the same operator using the same equipment on the same day, the average should be judged not

**13.4 The judgments in accordance with 13.2 and 13.3 will be correct in approximately 95% of such comparisons.**

**13.5 For further information on the methodology used in this section, see Practice E 691.**

**13.6 Bias**—No statement is made about bias of this test method, as there is no absolute method available as a referee method.
Final conclusion

- Why should we keep the Taber test for the abrasion?
  - In majority, OEM and suppliers have got the Taber test equipment
  - The Taber test is representative of the depths of the abrasion which can meet on plastic parts (20 to 100 nm)
  - Taber Test is an equipment which can permit to evaluate the best coating
Repeatability R * allows to compare the precision of different test methods directly (width of distribution independent from the average haze values).

French results in PC

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. \( R = 2.8 \times \text{repeatability standard deviation} \) (max. \( \Delta \text{haze} = \text{average } \Delta \text{haze} + 0.7 \times R \)).
Open discussion

- Use of a reference sample allowing each laboratory to calibrate itself

- The control of the wheels, the disc of refacing and the homogeneity of the surface quality have to be studied