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

Background

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

❑ **18/01/2011:** 1st 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

Background

❑ **14/06/2011:** Presentation of the Taber Round Robin Test results
by BAYER

	Glass	coated PMMA	coated PC
	Δ haze [%]		
Lowest measured value	0,58	3,46	1,70
Highest measured value	2,00	39,94	40,90
Arithmetic mean of all values	1,18	15,44	10,52
Standard deviation	0,37	10,59	13,11
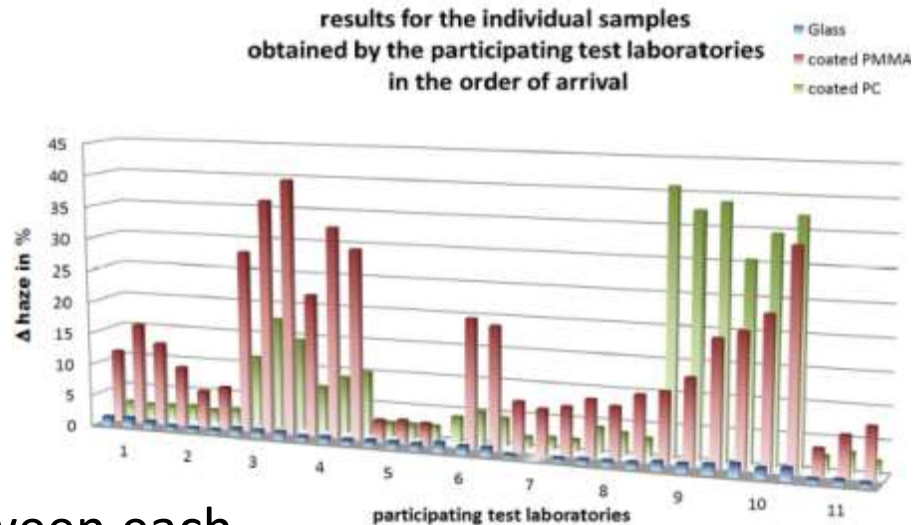
- Important variation between each

  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

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Background

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

IGPG 03-11

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**

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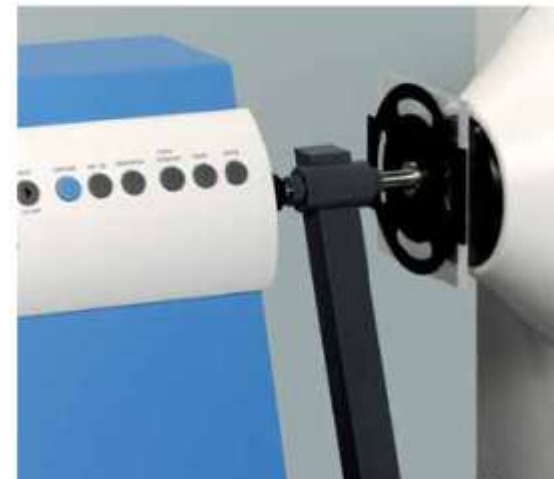
Set up of an inter-laboratory tests
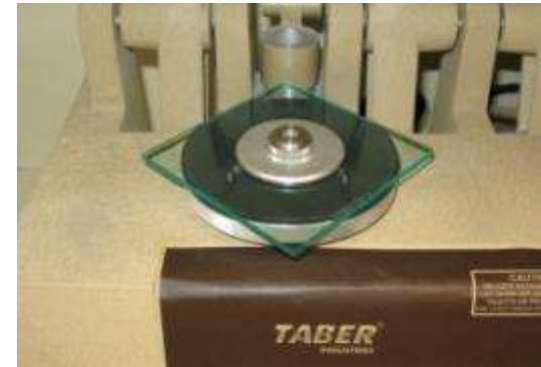
- Measurements done on each of 4 points located in each window of the support as shown in the figure. Hence, in total 16 measurements are carried out.
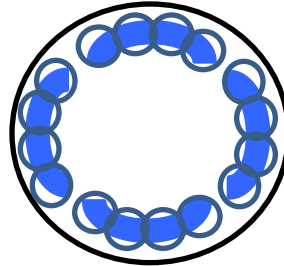
- Initial positioning of the sample with the abrasive grinding stones located in a zone where no measurement is done

❖ **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

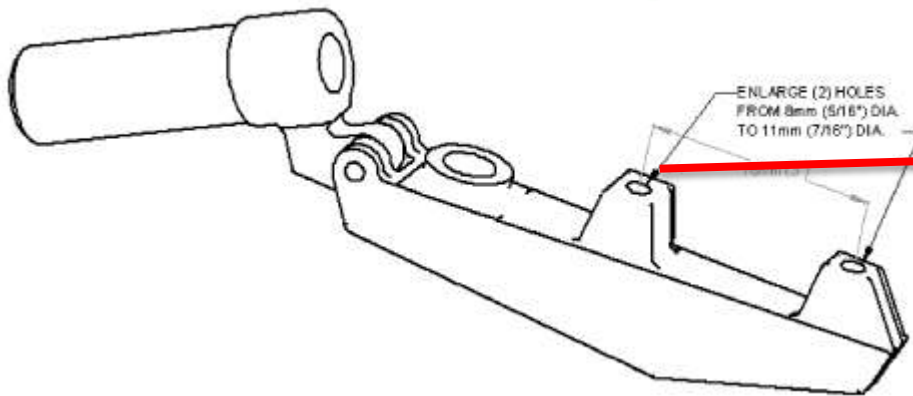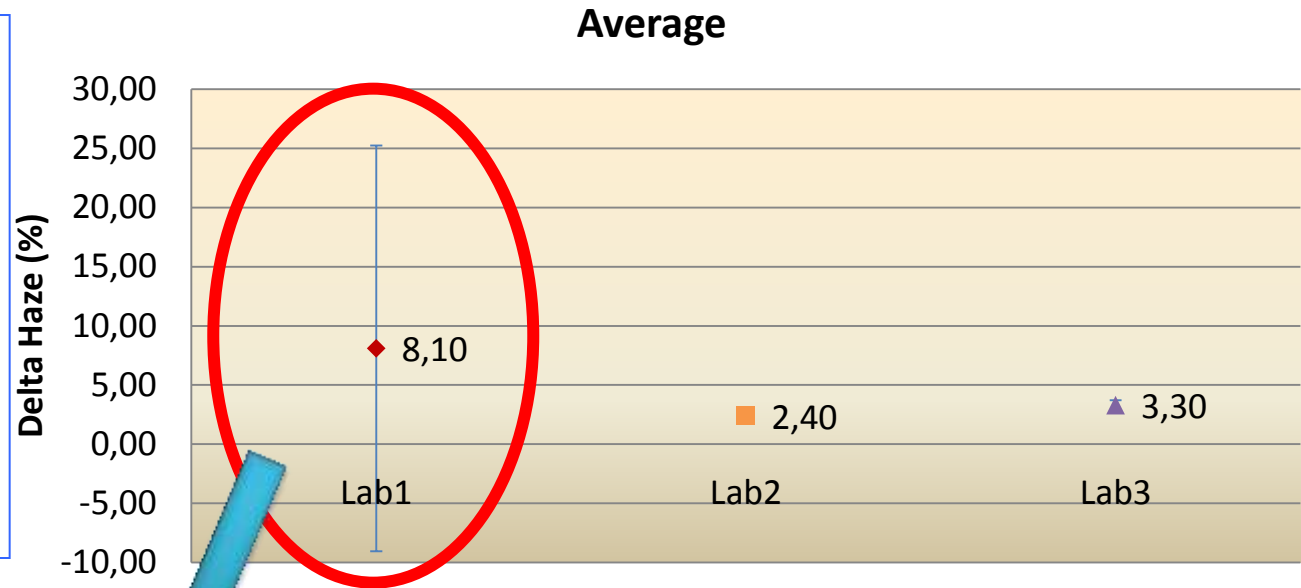❑ Information with regard to each laboratory Taber test

Test laboratory	Laboratory 1	Laboratory 2	Laboratory 3
Test method	Common test method		
Wheel type and lot number	CS 10F ER23D2	CS 10F (type IV) EH19D2	CS 10F (type IV) EH19D2
Wheel - Expiration date	01/01/2014	01/05/2013	01/05/2013
Wheel - Hardness (DIDC)	91 DIDC	90 DIDC	L-85 DIDC / R-84 DIDC
Refacing medium	ST 11 DX 25 ST2	ST 11 38A180-MU	ST 11 38A180-MU ST-11
Vacuum nozzle (orifice size)	11 mm	11 mm	11 mm
Distance nozzle / sample	1 mm	1 mm	1 mm
Instrument Taber reference and serial number and date of last calibration	5131 N° série : 9732 Date de dernière calibration : Janvier 2012	5131 N° série : 20031221 Date de dernière calibration : 17/04/2012	5130 - SCU0005 N° série : 904865 Date de dernière calibration : 07/09/2011
Instrument Haze-gard reference and serial number and date of last calibration	Gardner Haze-Gard "Plus" N° série : 991703	Gardner Haze-Gard "Plus" N° série : 190031 Date de dernière calibration Août 2011	Pacific Instrument-HazeGard XL-211 N° série : BAN0017 Date de dernière calibration : 27/04/2012

Results of the inter-laboratory tests

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

Average

Delta Haze (%)

30,00	
25,00	
20,00	
15,00	
10,00	
5,00	◆ 8,10
0,00	■ 2,40 ▲ 3,30
-5,00	Lab1 Lab2 Lab3
-10,00	

ENLARGE (2) HOLES FROM 8mm (5/16") DIA. TO 11mm (7/16") DIA.

Results of the inter-laboratory tests

❑ 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

Delta Haze Average (without abberante values)
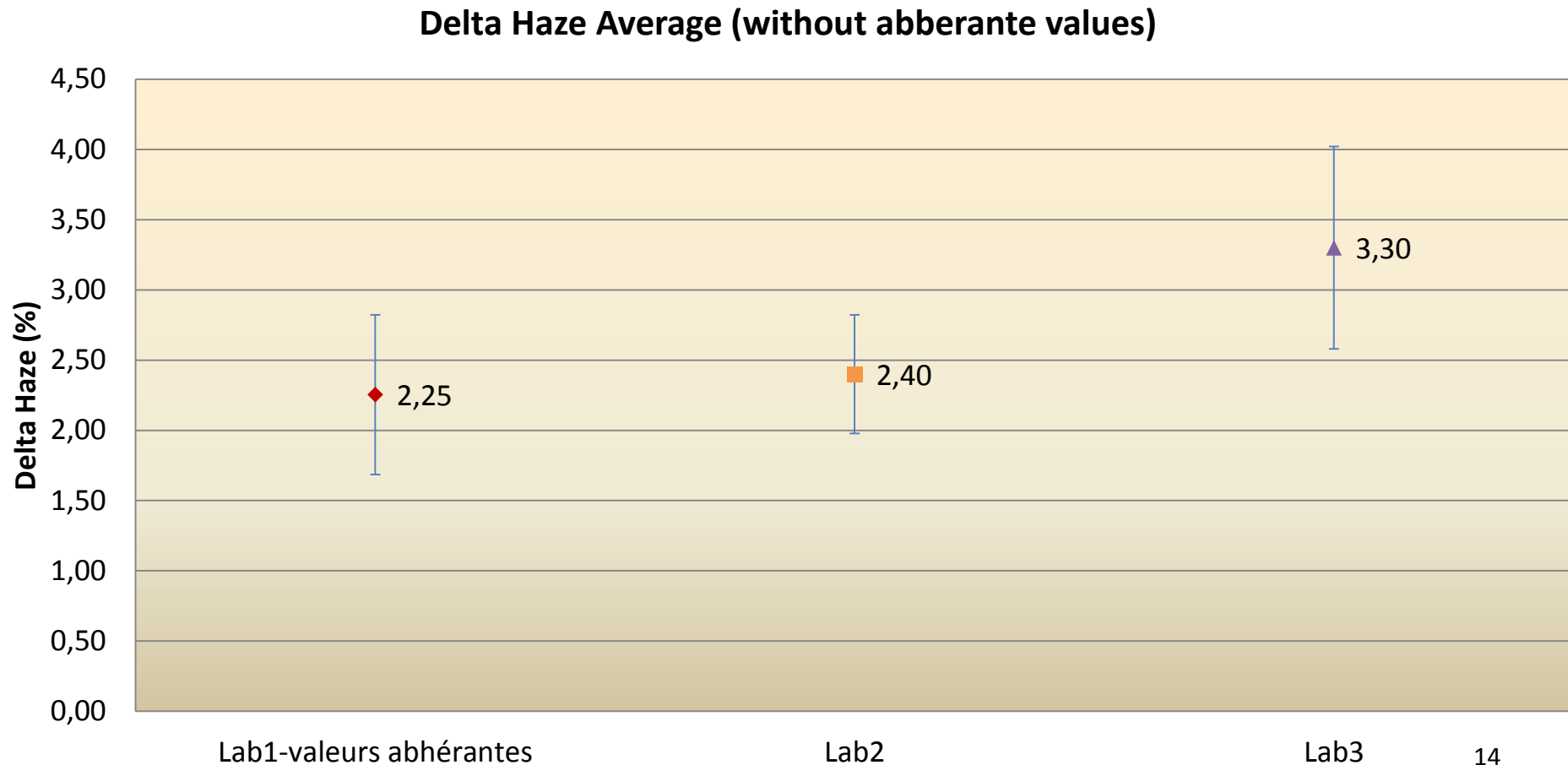
Results of the inter-laboratory tests

❑ Statistical results analysis with Cochran and Grubbs Test for the 3 laboratories for final Haze
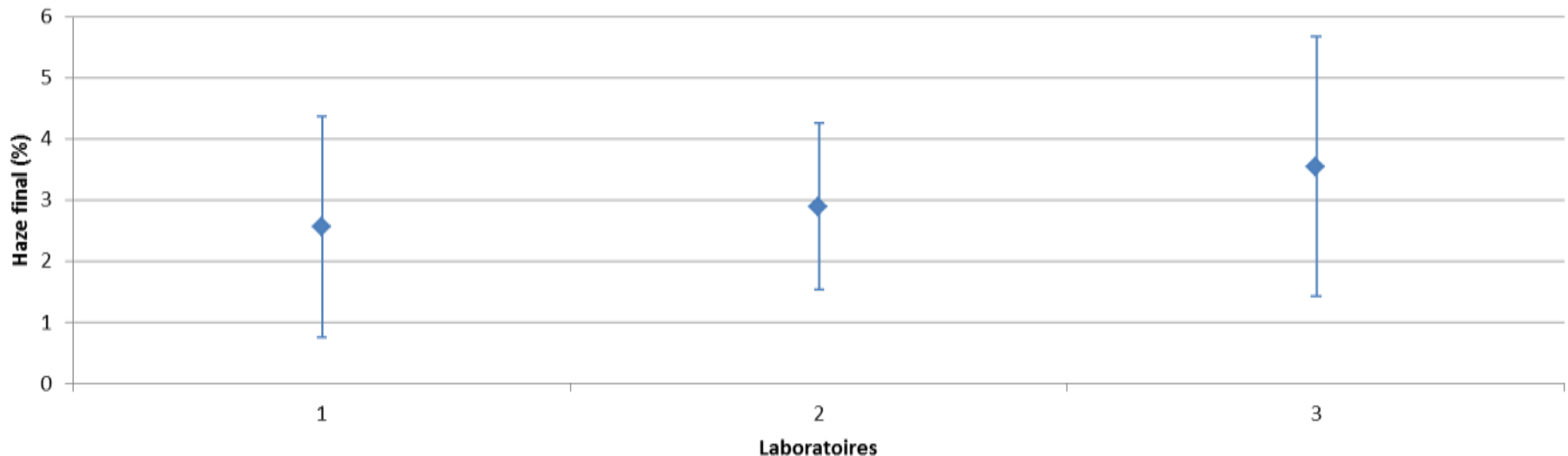
❖ **The laboratory 1 is considered statistically as the reference laboratory. All laboratories have in the same range uncertainties regarding their own results.**

❖ **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.**

# Results of the inter-laboratory tests

Average inter-opérators (without aberrante values)
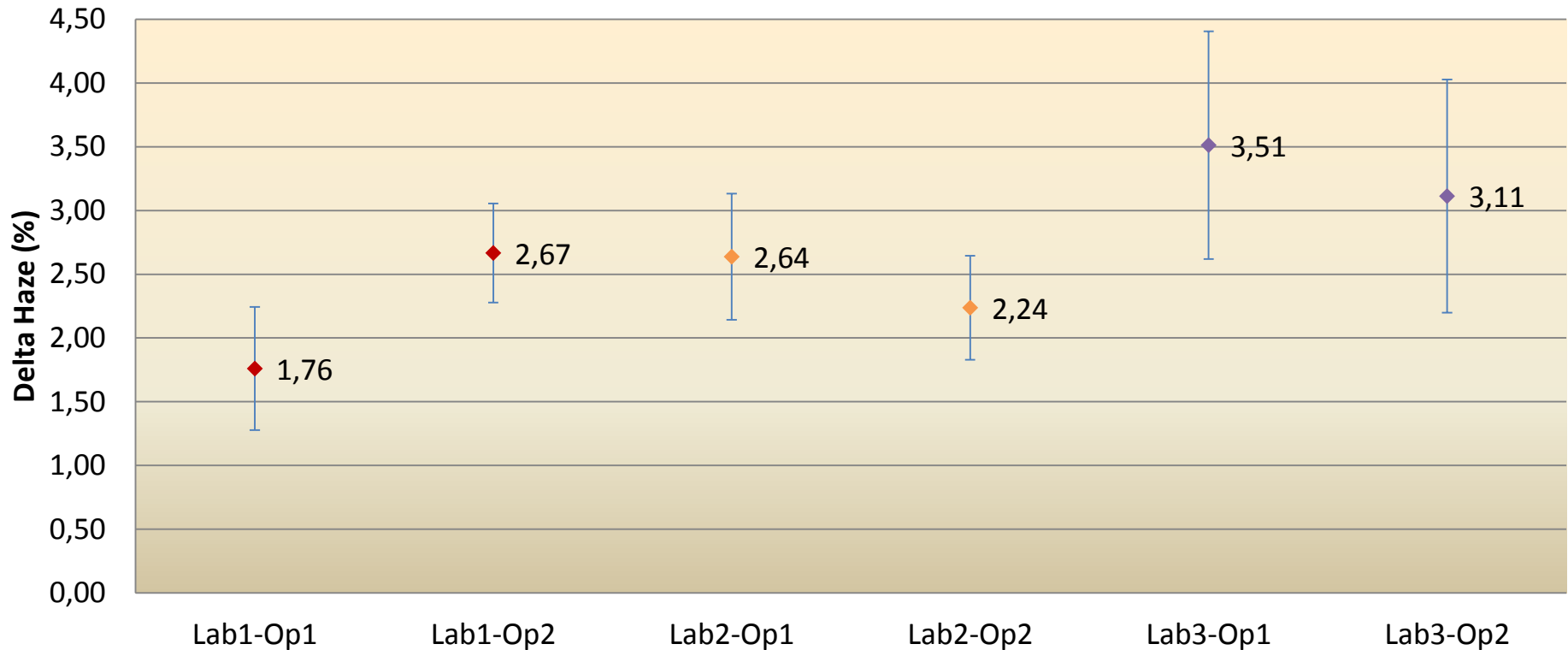
❖ **For a same laboratory, the means are in the same range of the uncertainties**

❖ **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**

Influence of parameters on the final Haze

❖ **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)**

Influence Haze means of measurement
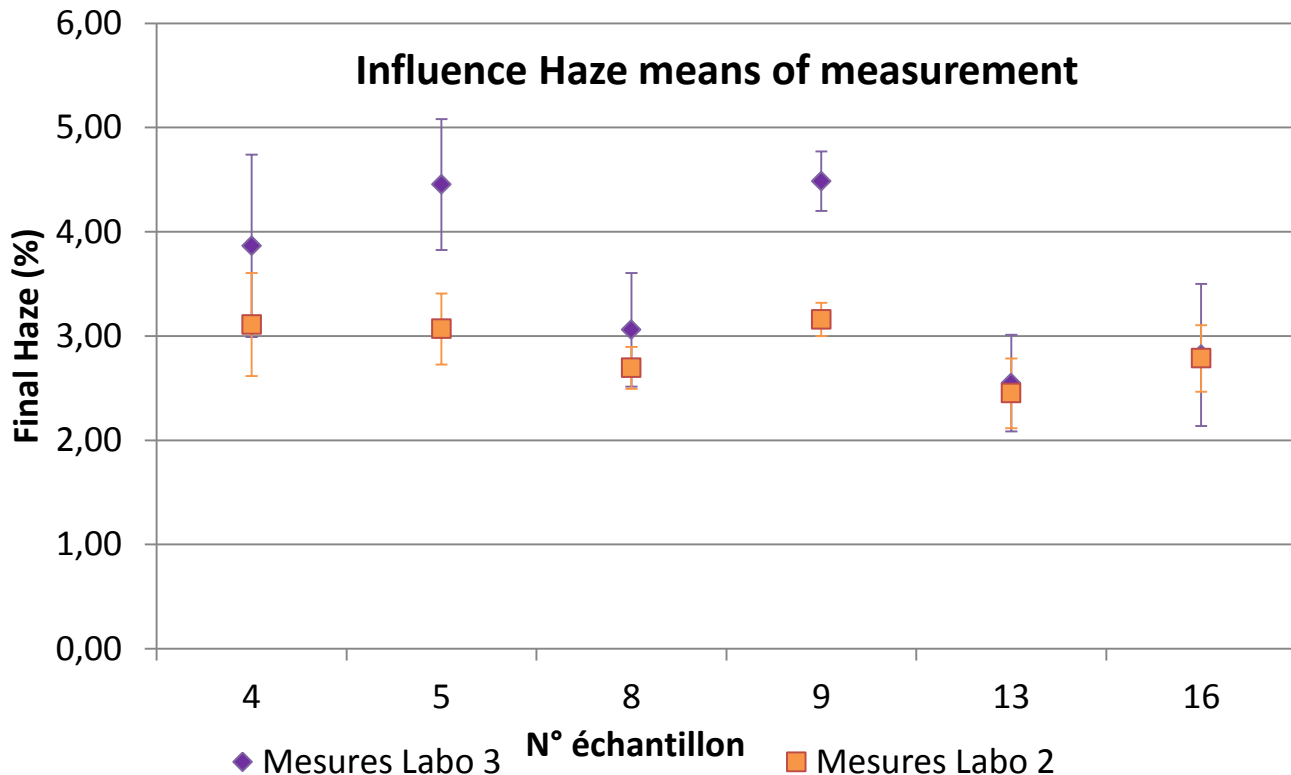
	Labo 2	Labo 3
Average	2,9	3,5
Std deviation	*0,4*	*1,0*

Labo 2	Labo 3
Gardner Haze-Gard "Plus" N° série : 190031	Pacific Instrument-HazeGard XL-211 N° série : BAN0017

■ 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).**
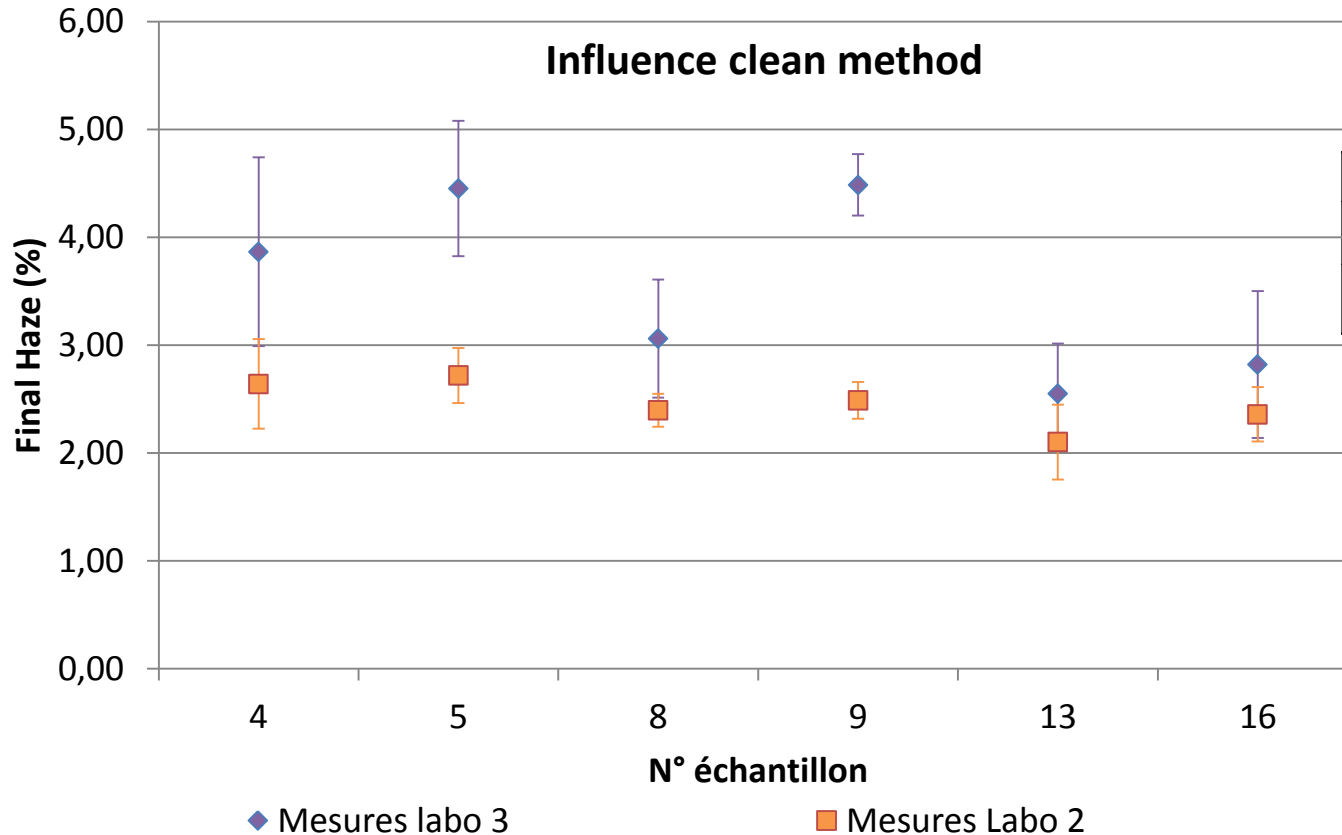
	Labo 2	Labo 3
Average	2,4	3,5
Std deviation	*0,3*	*1,0*

■ <u>**The cleaning has an impact on the final values**</u>

Influence of parameters on the final Haze

❖ **Measurement of the Final Haze with the cleaning of the Labo1 samples by Labo2**

Influence Haze means
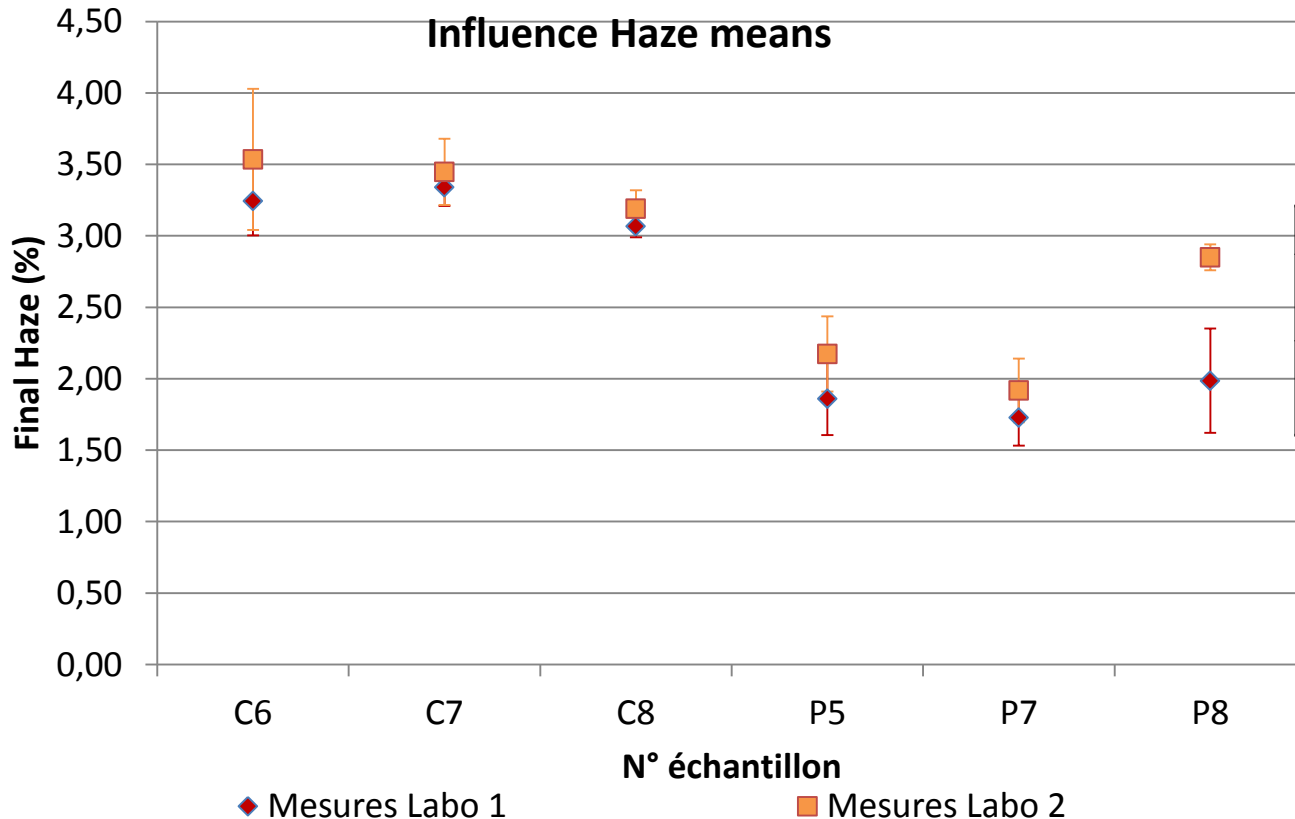
	Labo 1	Labo 2
Average	2,5	2,9
Std deviation	*0,7*	*0,7*

Final Haze (%) — axis from 0,00 to 4,50

N° échantillon — C6, C7, C8, P5, P7, P8

◆ Mesures Labo 1   ■ Mesures Labo 2

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

Final conclusion

❏ 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

TABLE 1 Precision Statement Based on Three Replicate Observations

Material	Number of Cycles	Mean	Values in Units of Percent Haze				
			S_r	S_r	S_R	r	R
Glass	1000	0.69	0.19	0.16	0.25	0.46	0.70
Polycarbonate—Coating 1	501	2.52	0.76	0.95	1.19	2.65	3.36
Polycarbonate—Plasma Coating	1000	2.62	0.83	0.93	1.22	2.61	3.42
Polycarbonate—Coating 2	500	8.96	1.25	1.64	1.96	4.58	5.57
Polycarbonate—Coating 3	500	11.66	2.96	4.82	5.48	13.48	15.33

S_r = pooled within-laboratories standard deviation of the mean for three or ten specimens,
S_R = total among-laboratories standard deviation of the mean for three or ten specimens,
$r = 2.83\ S_r$ (see 13.2), and
$R = 2.83\ S_R$ (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

equipment, the averages should be judged not equivalent if they differ by more than the R value for that material and condition.
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.
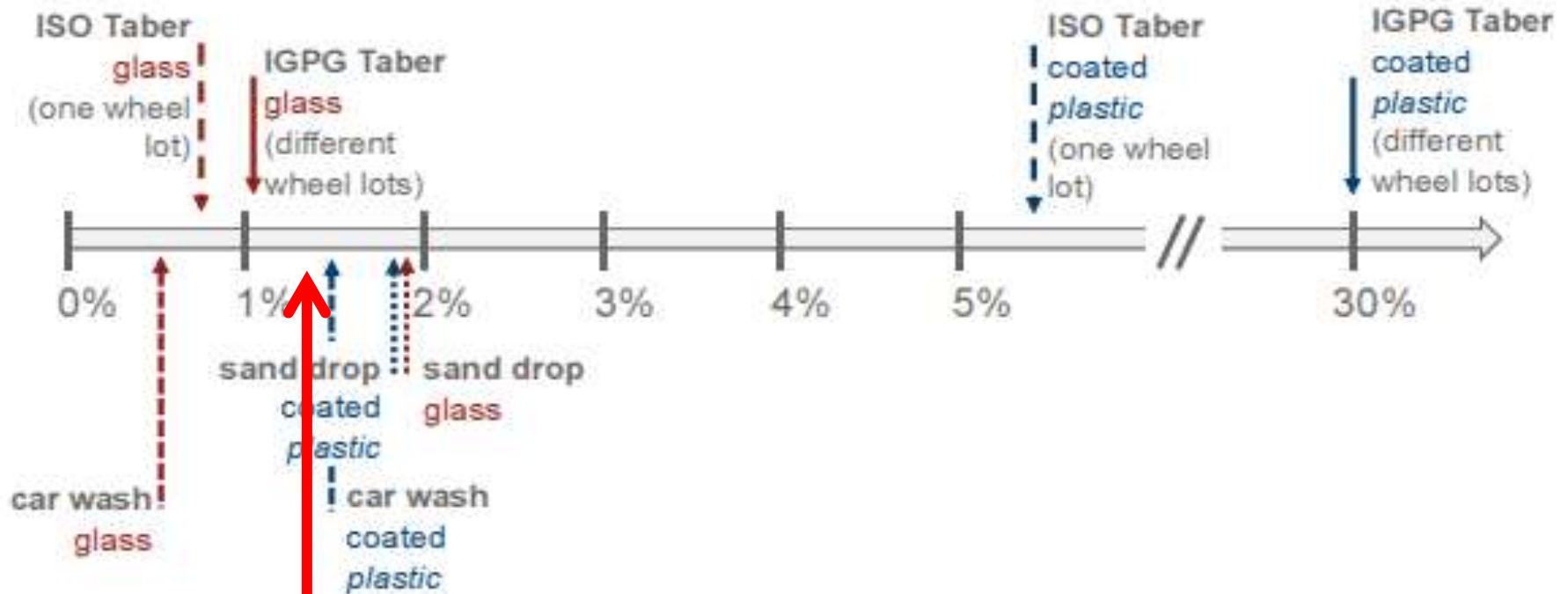
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Final conclusion

❑ 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

Final conclusion

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

ISO Taber
glass
(one wheel lot)

IGPG Taber
glass
(different wheel lots)

ISO Taber
coated
plastic
(one wheel lot)

IGPG Taber
coated
plastic
(different wheel lots)

0%   1%   2%   3%   4%   5%   30%

sand drop
coated
plastic

sand drop
glass

car wash
glass

car wash
coated
plastic

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. $R = 2.8 \times$ reproducibility standard deviation (max. Δ haze = average Δ 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