WET GRIP TEST METHOD IMPROVEMENT for Passenger Car Tyres (C1)

Overview of Tyre Industry and ISO activities

GRBP - 70th session

Geneva
September, 2019
• BACKGROUND / RECAP

• TRAILER method revision – RECAP and UPDATE

• VEHICLE method revision

• TIMELINE
• BACKGROUND / RECAP

• TRAILER method revision – RECAP and UPDATE

• VEHICLE method revision

• TIMELINE
ISO test method for PSR wet grip is the reference for several regulations (EU, UN and worldwide).

**ISO 23671:2015**
Passenger car tyres — Method for measuring relative wet grip performance -- Loaded new tyres

**UNDER REVISION**

**TYPE approval - UN R117.02**
Test method in Annex 5(A)  
(minimum requirement on WET grip for homologation)

**TYRE LABELLING**
Europe EC 1222/2009* - Test method in Annex V (Reg. 228/2011)
... but also Brazil, Korea, Japan, ...

*Note: revision of EU label will directly refer to UN R117 for wet grip test

**GTR16**
Global Technical regulation

This standard is under revision: the experience accumulated so far by the Industry and by the EU Member States Authorities indicated an opportunity for developing further improvements on the accuracy of the test method.
The current wet grip test method allows the \textit{NECESSARY FLEXIBILITY} in terms of testing conditions \textbf{worldwide}: possibility to test using different tools (vehicle/trailer), on different tracks (wide friction range for tracks), and in different periods of the year (wide temperature range).

When the test was firstly developed, it appeared to grant both a \textit{good repeatability} (same test conditions = same test results) and a good reproducibility (different test conditions = same grade).

Anyhow the \textit{reproducibility of the test is not in line with the initial evaluations}.

\textbf{In other words, when different set of testing conditions (within the allowed ranges) are adopted to test the same tyre, the same wet grid index might not be always granted.}

\textbf{Note}

This problem was identified in the \textit{Final Report on the Review study on the Regulation (EC) No 1222/2009 on the labelling of tyres (March 2016)}.

Following the experience accumulated after the implementation of EU label Reg. 1222, \textit{Tyre Industry progressively recognized the problem and indicated opportunities for improvements} in the same Review Study.
Following preliminary collaboration among EUROPE, USA and JAPAN Tyre Industry, the revision of the existing ISO 23671:2015 for PSR was launched last Sept 14th, 2017;

An ISO (global) “technical table” is currently in place:
The WET GRIP Working Group (TC31/WG12) was established with the aim to

By priority

1. Improve the reproducibility of the current ISO,

2. Try to keep on average similar wet grip indexes values and ratings as current test procedure

3. Drive the global standardization & promote harmonization worldwide

Status update (2018, August)
Draft International Standard registered
Step 1 – Identification of the parameters affecting the dispersion of the test

✓ completed

Step 2 - 3 Round Robin Tests using TRAILER methodology

✓ Completed
Total of 37 tires - 1163 results!
16 different test sites/trailer in EU (ETRTO), Japan (JATMA) and USA (USTMA)

Step 3 – 1 Round Robin Tests Using VEHICLE methodology

✓ Completed
tests In EU (ETRTO)
Step 1 – Identification of the parameters affecting the dispersion

The parameters having an influence on the variability of test method were listed exhaustively. The most impacting the reproducibility of the test were identified:

1. Methodologies (TRAILER / VEHICLE)

2. Conditioning (stabilization) of tyre prior testing

3. Wet Track - Friction & Temperature

4. Tyre typologies & corresponding correction equations
• BACKGROUND / RECAP

• TRAILER method revision – RECAP and UPDATE

• VEHICLE method revision

• TIMELINE
TYRE BREAK-IN (CONDITIONING)

Tyre Break-In (conditioning) was identified as an important source of variability

Current standard

For tyre break-in, two braking runs shall be performed under the load, pressure and speed as specified

Not enough!

New proposed approach:

The tyres should be stabilized in performance prior to testing, which means that no evolution of the $\mu_{peak}/BFC$ values in test runs should be detectable; in any case there will be an ex-post verification according to clauses specified in [the test procedure]*

In all cases, tyre designed tread depth and designed tread block or rib integrity shall not change significantly with break-in, which means the pace and “severity” of the break-in needs to be carefully controlled to avoid such changes.

[*paragraph “Validation of tests results” – improved requirements on the Coefficient of Variation (CoV) of the $\mu_{peak}/BFC$ values of both reference and candidate tyres and on the evolution of the reference tyre (SRTT) during the test cycles]

Note: “how” operationally stabilizing the tyre (on road driving, drum,...)is left to each company, being also dependent on internal practices and tyre constructions.
In the current method, the grip of the track can be controlled with one of two criteria: BPN [42-60] or $\mu_{SRTT14''}$ [0.6-0.8].

Anyhow there is no correlation between the 2 criteria → this point is an important source of variability between different test centers.

Also the reference tyre SRTT14'' will be discontinued.

SRTT 16” will be used NOT ONLY AS REFERENCE TYRE, BUT ALSO FOR TRACK VALIDATION IN PLACE OF [SRTT 14 or BPN]

✓ Replacement of SRTT14 and discontinuation of BPN measurement
✓ A source of variability eliminated

agreement for friction range $\mu_{SRTT16''}$ [0.65 ; 0.90]
# TYRE TYPOLOGIES / Track Temperature

3 different typologies of tyres should be treated differently within the wet grip test procedure.

<table>
<thead>
<tr>
<th>R117 category of use / markings</th>
<th>Normal</th>
<th>Snow M+S - not 3PMSF</th>
<th>Snow for use in severe snow conditions M+S and 3PMSF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial name</td>
<td>SUMMER</td>
<td>USA ALL SEASON</td>
<td>WINTER</td>
</tr>
<tr>
<td></td>
<td>Normal -</td>
<td></td>
<td>Severe Snow tires are designed to perform best in severe cold weather conditions and are not typically used during extended warm weather conditions. They guarantee the minimum snow traction of a Severe Snow (Winter) tire. They are also designed to operate at higher temperatures, without the typical traction limitations of Severe Snow (Winter) tires.</td>
</tr>
<tr>
<td></td>
<td>T ref = 20</td>
<td>T ref = 15</td>
<td>T ref = 10</td>
</tr>
<tr>
<td></td>
<td>12-35 °C</td>
<td>5-35 °C</td>
<td>5-20 °C</td>
</tr>
</tbody>
</table>

Each tyre typology has its own behavior vs friction & temperature. Specific/different correction formulas and coefficients shall be applied.
The grip of the track has a strong influence

The MTD (Mean Texture Depth) has also a minor influence

\[ \Delta \mu \] 

\[ \Delta \text{MTD} \]

The temperature (especially the low temperature for normal tyres) has also an influence (even if lower than the grip)

\[ \Delta T = T_{\text{test}} - T_{\text{ref}} \]

\[ \Delta \mu = \mu_{\text{SRTT16}} - 0.85 \]

\[ \Delta \text{MTD} = \text{MTD} - 0.8 \]

\[ a, b, c, d : \text{different depending on tyres typologies} \]

K-trailer: minimizes the difference in average current vs future procedure for TRAILER
Correction coefficients [a, b, c, d] minimize the dispersion of the tests results for each tyre typology.

<table>
<thead>
<tr>
<th>Tyre sidewall marking</th>
<th>t₀</th>
<th>a</th>
<th>b</th>
<th>c</th>
<th>d</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neither M+S marking nor 3PMSF marking</td>
<td>20</td>
<td>0.99757</td>
<td>0.00251</td>
<td>-0.00028</td>
<td>0.07759</td>
</tr>
<tr>
<td>M+S marking without 3PMSF marking</td>
<td>15</td>
<td>0.87084</td>
<td>-0.00025</td>
<td>0.00004</td>
<td>-0.01635</td>
</tr>
<tr>
<td>3PMSF marking</td>
<td>10</td>
<td>0.67929</td>
<td>0.00115</td>
<td>-0.00005</td>
<td>0.03963</td>
</tr>
</tbody>
</table>

K-trailer: minimize the difference in average current vs future procedure for TRAILER

Method: Least Squares

Calculation

\[ S = \Sigma (WGI \text{ proposed} – WGI \text{ current})^2 \]  \rightarrow S minimization: K trailer = 1.502

K trailer = 1.50
ADDITIONAL CONSIDERATIONS

On average:
• All points (Current WGI / new WGI) well distributed across the bisector line (= overall gap is minimized)

On average, for each tyre typology (Normal, M+S only, 3PMSF)
• similar WGI values as current procedure

On the single tests results
• The proposed procedure grants more stability (vs tests conditions) than current procedure: consequently possible differences in WGI (new vs current) on single tests results depend on the specific test conditions
• BACKGROUND / RECAP

• TRAILER method revision – RECAP and UPDATE

• VEHICLE method revision

• TIMELINE
Some of - **but not all** - the technical findings on trailer can be automatically transposed to vehicle methodology.

ETRTO (EU only) performed dedicated test campaign on vehicle:

1. to **compare the variability of both TRAILER and VEHICLE methodologies**

2. to check the **correlation between the two modified** methods (both methods should give same Index)

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**Step 3 – Round Robin Tests Using VEHICLE methodology**

- **Technical findings on trailer directly applicable also to vehicle method**
  - Tyres typologies and permitted **temperature range**
  - Stabilization of tyre performance prior testing

- **Dedicated technical analysis for vehicle method**
  - Usage of two vehicles with a “control” tyre (**Bridge test**)
  - Track friction description
  - Corrections formulas (tailored for vehicle)
  - ...other... e.g. Vehicle, Tyres Inflation Pressure adjusted depending on actual axle load
**VEHICLE – “BRIDGE TEST”**

Currently used when size of the candidate tyre differs significantly from SRTT

**VEHICLE 1**
- Control
- Vs
- SRTT

**VEHICLE 2**
- Candidate
- Vs
- Control

**Candidate**
- Vs
- SRTT

*Bridge test increases significantly the dispersion*

**Possibility of bridge test is ELIMINATED**
Even if it is recognized that it will be not possible to test on vehicle the full range of existing sizes (Load indexes).

For the “extreme” sizes trailer method shall be used.
VEHICLE – “FRICTION RANGE”

- **IN CASE OF TRAILER** → Elimination of BPN and \( \mu_{SRTT14''} \)
  
  Friction Range \( \mu_{SRTT16''} \) [0.65 ; 0.90 ]

- **IN CASE OF VEHICLE**
  
  - Not possible to measure the \( \mu_{SRTT16''} \) [on trailer]
  
  → agreed to use the corresponding parameter on vehicle: BFC (SRTT16’’)

  correlation \( \mu_{SRTT16''} \) [on trailer] <-> BFC(SRTT16’’) [on vehicle]
  
  depends on both vehicle and trailer used

On average

\( \mu_{SRTT16''} \) [on trailer] = (0.65-0.90) corresponds to BFC(SRTT16’’) [on vehicle] = (0.57-0.79)
VEHICLE – “CORRECTION FORMULAS”

Same formulas as trailer: 4 “optimized terms but tailored for vehicle

\[ G(T) = K_{vehicle} \times [BFC_{test} - (a' \Delta BFC + b' \Delta T + c' \Delta T^2 + d' \Delta MTD)] \]

Correction coefficients \([a, b, c, d]\) minimize the dispersion of the tests results for each tyre typology

<table>
<thead>
<tr>
<th>Tyre sidewall marking</th>
<th>(t_0)</th>
<th>(a')</th>
<th>(b')</th>
<th>(c')</th>
<th>(d')</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neither M+S marking nor 3PMSF marking</td>
<td>20</td>
<td>0.99382</td>
<td>0.00269</td>
<td>-0.00028</td>
<td>-0.02472</td>
</tr>
<tr>
<td>M+S marking without 3PMSF marking</td>
<td>15</td>
<td>0.92654</td>
<td>-0.00121</td>
<td>-0.00007</td>
<td>-0.04279</td>
</tr>
<tr>
<td>3PMSF marking</td>
<td>10</td>
<td>0.72029</td>
<td>-0.00539</td>
<td>0.00022</td>
<td>-0.03037</td>
</tr>
</tbody>
</table>

K-vehicle: minimize the difference new procedure for TRAILER vs new procedure for VEHICLE.

Using ETRTO dataset of the tyres tested on both vehicle and trailer

\[ S = \text{Sum of Diff} = \sum_{i=1}^{13} (WGI_{\text{SkidTrailer}} - WGI_{\text{Vehicle}})^2 \]

\( \Rightarrow K\text{-vehicle} = 1.87 \)
For the evaluation of the wet grip index (G) of a candidate tyre, the wet grip braking performance of the candidate tyre is compared to the wet grip braking performance of the reference tyre on a straight, wet, paved surface. It is measured with one of the following methods:

- vehicle method consisting of testing a set of tyres mounted on a commercialized vehicle;
- test method using a trailer or a tyre test vehicle equipped with the test tyres.

In case of verification of the wet grip index (G) the same test method [i.e. Trailer / Vehicle] used for its declaration shall be used.

Proposed amendment of paragraph 4 of ISO 23671:2015

- The possible gap between trailer and method is minimized.
- No method (trailer or vehicle) provides systematically higher or lower WGI results.
## TRAILER & VEHICLE – IMPROVEMENT BY THE NEW FORMULAS

<table>
<thead>
<tr>
<th></th>
<th>TRAILER RRT</th>
<th>VEHICLE RRT BRIDGE excluded</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number of data</td>
<td>1163</td>
<td>319</td>
</tr>
<tr>
<td>Number of candidate tyres</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal</td>
<td>18</td>
<td>9 (7 same as trailer)</td>
</tr>
<tr>
<td>M+S</td>
<td>9</td>
<td>2 (2 same as trailer)</td>
</tr>
<tr>
<td>3PMSF</td>
<td>10</td>
<td>7 (4 same as trailer)</td>
</tr>
<tr>
<td>Number of testing companies</td>
<td>17</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>EU + USA + JPN</td>
<td>EU</td>
</tr>
<tr>
<td>Weighted Standard deviation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CURRENT formula</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal</td>
<td>0.083</td>
<td>0.103</td>
</tr>
<tr>
<td>M+S</td>
<td>0.077</td>
<td>0.047</td>
</tr>
<tr>
<td>3PMSF</td>
<td>0.088</td>
<td>0.059</td>
</tr>
<tr>
<td>NEW formula</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal</td>
<td>0.065 (-22%)</td>
<td>0.089 (-14%)</td>
</tr>
<tr>
<td>M+S</td>
<td>0.060 (-22%)</td>
<td>0.025 (-46%*)</td>
</tr>
<tr>
<td>3PMSF</td>
<td>0.060 (-32%)</td>
<td>0.051 (-13%)</td>
</tr>
</tbody>
</table>

* Improvement to be considered jointly with the number of candidate tyres
• BACKGROUND / RECAP

• TRAILER method revision – RECAP and UPDATE

• VEHICLE method revision

• TIMELINE
### TIMELINE

**ACTIVITIES ENLARGED AT ISO level**
- Robust technical approach
- Worldwide Harmonization

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<tbody>
<tr>
<td></td>
<td>3Q</td>
<td>4Q</td>
<td>1Q</td>
<td>2Q</td>
<td>3Q</td>
<td>4Q</td>
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<td>4Q</td>
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<td>2Q</td>
</tr>
</tbody>
</table>

#### TRAILER activities
ETRTO (EU) & JATMA (Jap)

**EC 1222** Review study
Reproducibility to be improved!

#### VEHICLE testing activities
ETRTO (EU)

Completion of data analysis

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**FROM PREVIOUS INDUSTRY MEETING / GRBP INFORMAL DOC**

- Working doc. GRBP (tbc)
- Informal doc. GRBP
- CD approved
- DIS registration
- NWIP
- DIS validation
APPENDIX
For the calculation of the wet grip index of a candidate tyre, the wet grip performance of the candidate tyre is compared to the reference tyre ASTM SRTT 16” (Standard Reference Tyre Test).

Thus it is a COMPARISON TEST.

The wet grip index can be measured with one of the 2 following methodologies (today considered as equivalent):

**TRAILER**
- using a trailer towed by a vehicle
  - **1 tyre** mounted on a specific tool
  - **OUTPUT**
    - peak braking force coefficient (μ peak)
    - highest value of the ratio braking force / vertical load

**VEHICLE**
- using an instrumented passenger car
  - **1 set of 4 tyres** mounted on a commercialized vehicle
  - **OUTPUT**
    - Average Deceleration (AD)
    - measured during braking
TRAILER METHODOLOGY

The tyre to be tested is fitted on a specific position for measurements (test position)

The brake in the test position is applied maintaining the specified speed (65 km/h) and the specified Load (depending on the Load Index of the tyre) until test-tyre lock-up

The ratio braking force / vertical load is acquired in real time: the highest value of this ratio provide the wet grip performance of the tyre.
It is called tyre peak braking force coefficient (μ peak )
VEHICLE METHODOLOGY

An instrumented passenger car, equipped with an Antilock Braking System (ABS).

Starting with a defined initial speed, the brakes are applied on four wheels at the same time to activate the ABS.

The average deceleration $AD$ is calculated between two pre-defined speeds ($80\rightarrow 20\text{km/h}$).

$$\text{Braking Force Coefficient } \rightarrow \text{BFC} = \frac{AD}{g}$$

VEHICLE METHODOLOGY USING CONTROL TYRE SET (BRIDGE TEST)

Where the candidate tyre size is significantly different from that of the reference tyre (SRTT), a direct comparison on the same instrumented passenger car may not be possible.

In that case the comparison between a candidate tyre and a reference tyre is obtained through the use of a control tyre set (so called “bridge”) and two different instrumented passenger cars.
CURRENT WET GRIP TEST - APPLICABLE REFERENCE TYRES (ASTM)

SRTT 16”

ASTM F2493 P225/60R16

Must be used as reference tyre to determine the relative wet grip performance of the candidate tyre

SRTT 14”

ASTM E1136 P195/75R14

It can be used to verify / certify track friction properties (one of the 2 possible methods)

Will be discontinued
Mathematical corrections are applied to align the results when the tests are performed in different conditions: i.e. different test locations (tracks) or different weather conditions (temperatures).

\[ G(T) = \frac{\mu_{\text{candidate tyre}}}{\mu_{\text{SRTT16}}} \times 1.25 + A \cdot (\text{Temp} - T_0) + B \cdot (\mu_{\text{SRTT16}} - \mu_0) \]

This ratio is a raw index of the measured friction of the candidate tyre vs the SRTT16" at the tests conditions (Temp, \( \mu_{\text{SRTT16}} \)).

**Linear correction in temperature** to estimate the value of the index at the reference temperature \( T_0 \)

**Linear correction in friction** to estimate the value of the index at the reference friction (track) \( \mu_0 \)

The mathematical corrections (coefficient A and B) depend on category of use of the candidate tyre:

- Normal Tyres

- Snow Tyres (all tyres marked M+S, including the tyres marked also 3PMSF)
CORRECTION FORMULAS – BASIC IDEA

WGI raw = \frac{\mu_{\text{candidate tyre}}}{\mu_{SRTT16}}

No relation between Ratio WGI raw and \( \mu \)-SRTT16

Correction should NOT be applied to WGI raw (as done today)

Evident linear relation between \( \mu \)-cand and \( \mu \)-SRTT16 (track friction)

Correction should be applied directly to \( \mu \)-cand tyre
Reference $\mu = 0.85$ (ref. conditions) unchanged vs current ISO / R117 test method

- keep consistency between this revised edition and previous edition of this standard

- Method: for $\mu_{\text{Ref}}$ in $\{0.75, 0.80, 0.85\}$, re-optimize $a, b, c, d$ coefficients and re-evaluate dispersion

Conclusion: NO significant evolution of coefficients (< 1.0E-05), neither on dispersion or WStdDev
Vehicle
- Age of the car < 5 years
- mechanical conditions according to car manufacturer recommendations
- no alert from ABS (e.g. lights warnings).
- No substantial modification of the vehicle & specifically no modification of the braking system

Tyres Inflation Pressure (front axle tyres)
- differentiation standard load and XL (same as trailer)
- adjusted by a formula:
  based on actual load of the vehicle + load transfer during braking (+ 30%~)
ISO 23671:201x - TIMELINE

✓ New Project approved (TC31 plenary meeting) 2017, May
✓ WG12 - Kick-off meeting, Working Draft 2017, Sept
✓ ISO WG12 WebEx’s 2017, Oct → March
✓ ISO WG12 meeting (Washington), CD agreed 2018, April
✓ CD submittal for ballot 2018, June
✓ CD approved with technical comments 2018, August

✓ DIS registered (submittal for ballot) 2019, June

✓ DIS validation - Text publicly available
✓ IS publication 2020, May [Deadline]

DIS registration should be prior working document at UN to grant alignment ISO – R117
ISO CD 23671:201x – BALLOTS RESULTS

No disapprovals,
12 approval votes
5 approval votes with comments.
3 abstention

| Answers to Q.1: "Do you approve the circulation of the draft as a DIS?" |
|---|---|
| 13 x Approval | Belgium (NBN)  
Canada (SCC)  
China (SAC)  
Finland (SFS)  
France (AFNOR)  
Germany (DIN)  
Korea, Republic of (KATS)  
Netherlands (NEN)  
Russian Federation (GOST R)  
Spain (UNE)  
Ukraine (DSTU)  
United Arab Emirates (ESMA)  
United Kingdom (BSI) |
| 4 x Approval with comments | Italy (UNI)  
Japan (JISC)  
Thailand (TISI)  
United States (ANSI) |
| 0 x Disapproval |  |
| 3 x Abstention | Austria (ASI)  
India (BIS)  
Sweden (SIS) |