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

Overview of Tyre Industry / ISO activities

GRBP 68th session

Geneva
September 12-14th, 2018
• CURRENT REGULATORY FRAMEWORK

• CURRENT WET GRIP PROCEDURE - TECHNICAL PRINCIPLES

• ISO ACTIVITIES - TECHNICAL DIRECTIONS

• TIMELINE
• CURRENT REGULATORY FRAMEWORK

• CURRENT WET GRIP PROCEDURE - TECHNICAL PRINCIPLES

• ISO ACTIVITIES - TECHNICAL DIRECTIONS

• TIMELINE
CURRENT REGULATORY FRAMEWORK

TYRE LABELLING

Europe EC 1222/2009 - Test method in Annex V (Reg. 228/2011) *
... but also Brazil, Korea, Japan, ...
*UNDER REVISION
direct reference to UN R117 will be made for wet grip test method

ISO 23671:2015
Passenger car tyres — Method for measuring relative wet grip performance
UNDER REVISION

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

GTR16
Global Technical regulation

- ISO test method for PSR wet grip is currently a key reference for several regulations in Europe and worldwide

- 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 (see slide #10).
• CURRENT REGULATORY FRAMEWORK

• CURRENT WET GRIP PROCEDURE - TECHNICAL PRINCIPLES

• ISO ACTIVITIES - TECHNICAL DIRECTIONS

• TIMELINE
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 ($\mu$ 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
CURRENT WET GRIP TEST - APPLICABLE REFERENCE TYRES
(ASTM)

**SRTT 16”**

ASTM F2493  
P225/60R16

**SRTT 14”**

ASTM E1136  
P195/75R14

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

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, \(\mu_{\text{SRTT16}}\)).

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)
The current wet grip test method **allows the necessary flexibility** in terms of testing conditions: 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 **good repeatability** (same test conditions = same test results) and a good reproducibility (different test conditions = same grade).

Anyhow the **reproducibility of the test is not in line with the initial evaluations**.

**In other words, when different set of testing conditions (within the allowed ranges) are adopted to test the same tyre, the same grade might not be always granted.**
REPRODUCIBILITY OF THE CURRENT WET GRIP TEST

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

8.4 Improvement of test standards and conditions
Several sources, including independent consumer organizations, indicate that there is incoherence between the labelled performance and the measured performance of a tyre. Tests performed by Member States Authorities (“MSAs”) confirm the lack of reproducibility of the tests, hinted by third parties. This also implies that in disputes, MSAs might have difficulties to prove incorrect labelling due to the low reproducibility of results.
According to MSAs, a large part of this problem is due to different conditions for the tests
 [...] Especially the braking test on wet surface for measuring wet grip gives rise to large differences in test results.

Following the experience accumulated after the implementation of EU label Reg. 1222, Tyre Industry progressively recognized the problem and indicated opportunities for improvements in the same Review Study

8.4.1 Wet grip test standard
The experience accumulated so far by the Industry and by the MSAs on wet grip test standards is indicating an opportunity for developing further improvements on the accuracy of the test method.
 [...] Due to the wide intervals of allowed test conditions, a number of correction factors were adopted for calculating the wet grip. Examples of this are the correction factors for the surface friction coefficient (‘b’ = μ/grip) and temperature (‘a’) that are not working as intended and have a large influence on the result. Hence, there is a large difference in results if a tyre is tested at different conditions and correction factors are used to make results comparable.
• CURRENT REGULATORY FRAMEWORK

• CURRENT WET GRIP PROCEDURE - TECHNICAL PRINCIPLES

• ISO ACTIVITIES - TECHNICAL DIRECTIONS

• TIMELINE
Following preliminary collaboration among EUROPE, USA and JAPAN, 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 (minimize gaps with the current worldwide regulations)

3. Drive the global standardization & promote harmonization worldwide
Step 1 – Identification of the parameters affecting the dispersion of the test

✓ ✓ completed

Step 2 - three Round Robin Tests using TRAILER methodology

✓ tests activities completed
... analysis almost finalized
(ref. ETRTO / ISO)

Step 3 – 1 Round Robin Tests Using VEHICLE methodology

... tests activities completed
Analysis ongoing
The **parameters having an influence on the variability of test method** were listed exhaustively. The ones to be analyzed to be better controlled in the future test method were identified:

<table>
<thead>
<tr>
<th>Tyre typologies</th>
<th>CURRENT ISO TEST METHOD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal tyres</td>
<td>Snow tyres (M+S)</td>
</tr>
<tr>
<td></td>
<td>Including severe snow (M+S &amp; 3PMSF)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Methodologies</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicle method</td>
<td></td>
</tr>
<tr>
<td>Trailer method</td>
<td></td>
</tr>
</tbody>
</table>

| Conditioning of test tyres       | break-in = 2 braking runs                   |

| Wet Track Grip                   | MTD = 0,7 ± 0,3 mm                          |
|                                  | BPN = 42-60 or µSRTT14 = 0,7 ± 0,1          |

| Wet Track Temperature            | 5-35 °C                                      |
|                                  | 2-20 °C                                      |

| Correction equation & coefficients | TRAILER: $G(T) = \frac{\mu_{\text{test}}}{\mu_{\text{SRTT16}}} 1.25 + a \cdot \Delta T + b \cdot \Delta \mu$  
|                                  | $\mu_{0-\text{SRTT16}} = 0.85$              |
|                                  | VEHICLE: $G(T) = \frac{BFC_{\text{test}}}{BFC_{\text{SRTT16}}} 1.25 + a \cdot \Delta T + b \cdot \Delta \mu$  
|                                  | $BFC_{0-\text{SRTT16}} = 0.68$              |
|                                  | $a = -0.4232$                                |
|                                  | $b = -8.297$                                 |
|                                  | $a = 0.7721$                                 |
|                                  | $b = 31.18$                                  |
Step 2 - Two Round Robin Tests using TRAILER methodology

Three huge tire testing plans were carried out for a total of 37 tires - 1163 results!

Tyres were tested on different tracks, using the trailer of each participant, in different periods of the years, for a total of 16 different test sites/trailer in EU (ETRTO), Japan (JATMA) and USA (USTMA).

Agreed direction

- Stabilization of the tyre performance prior testing
- Better definition of the track surface (one method)
- Consider the specificity of tyre typologies for the temperature conditions and the corrections formulas
Proposed approach:

The tyres should be stabilized in performance prior testing. 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.
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

Recent EU-USA agreement for friction range $\mu_{SRTT16''}$ [0.65 ; 0.90]
**TYRE TYPOLOGIES**

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</th>
<th>Snow for use in severe snow conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Normal</td>
<td>Snow</td>
<td>Snow for use in severe snow conditions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>M+S - not 3PMSF</td>
<td>M+S and 3PMSF</td>
</tr>
<tr>
<td>Examples of commercialized products and intended performance</td>
<td>e.g. tyres named SUMMER</td>
<td>e.g. tyres named ALL SEASON in USA</td>
<td>e.g. tyres named ALL SEASON in EU</td>
</tr>
<tr>
<td></td>
<td>Designed to perform best in warm weather and are not typically used at low temperature</td>
<td>intended to perform across most temperature ranges. They are designed also for use in lower temperatures but not at the level of a Severe Snow (Winter) tire. They can operate at higher temperatures, without the typical limitations of Severe Snow (Winter) tires</td>
<td>guarantee the min 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 12-35 °C</td>
<td>T ref = 15 5-35°C</td>
<td>T ref = 10 5-20 °C</td>
</tr>
</tbody>
</table>

**WET GRIP test CONDITIONS**

Each tyre typology has its own behavior vs friction & temperature → specific /different correction formulas and coefficients shall be applied.

- Normal
  - T ref = 20
  - 12-35 °C

- Snow
  - M+S - not 3PMSF
  - T ref = 15
  - 5-35°C

- Snow for use in severe snow conditions
  - M+S and 3PMSF
  - T ref = 10
  - 5-20 °C

Examples of commercialized products and intended performance:
- e.g. tyres named SUMMER: Designed to perform best in warm weather and are not typically used at low temperature.
- e.g. tyres named ALL SEASON in USA: intended to perform across most temperature ranges. They are designed also for use in lower temperatures but not at the level of a Severe Snow (Winter) tire. They can operate at higher temperatures, without the typical limitations of Severe Snow (Winter) tires.
- e.g. tyres named ALL SEASON in EU: guarantee the min 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.
- e.g. tyres named WINTER: Severe Snow tires are designed to perform best in severe cold weather conditions and are not typically used during extended warm weather conditions.
CORRECTION FORMULAS – BASIC IDEA

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

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

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

\[\begin{align*}
\text{Evident linear relation between} \\
\mu\text{-cand and} \mu\text{-SRTT16 (track friction)}
\end{align*}\]

Correction should be applied directly to \( \mu\text{-cand tyre} \)
The grip of the track has a strong influence on the results.

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

\[ \mu(\text{test}) \approx \mu(\text{SRTT16}) \]

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

\[ \mu(\text{test}) \approx f(T) \]

CORRECTION FORMULAS – BASIC IDEA

\[ \mathrm{correction} = f(\Delta T, \Delta \mu, \Delta MTD) = a \Delta \mu + b \Delta T + c \Delta T^2 + (d \Delta \mu^2 \Delta T) + e \Delta MTD \]

different depending on tyres typologies

Example for Normal
G(T) must NOT be based on: raw µ candidate / raw µ SRTT16” (as done today), but be based on: µ candidate at reference conditions / µ SRTT16” at reference conditions

FROM

\[ G(T) = \frac{\mu_{test}}{\mu_{SRTT16}} \cdot 1.25 + a \cdot \Delta T + b \cdot \Delta \mu \]

TO

NEW \[ G(T) = K \cdot [\mu_{test} - (a \Delta \mu + b \Delta T + c \Delta T^2 + e\Delta MTD)] \]

where:

\[ \Delta T = T_{test} - T_{ref} \]
\[ \Delta \mu = \mu_{SRTT16} - 0.85 \]
\[ \Delta MTD = MTD - 0.8 \]

\( K \) is a factor to grant consistency between future revised standard and current standard

\( K \) value under confirmation
Correction coefficients $[a, b, c, e]$ are optimized for each tyre typology: They minimize the dispersion using all Round Robin Test measurements 1163 data points of 37 different tires (18 “Normal”, 9 “M+S”, 10 “3PMSF”).

The $d$ coefficient of the term $\Delta \mu^2 \Delta T$ was recently removed after confirmation that it is not statistically significant.

<table>
<thead>
<tr>
<th>REFERENCE CONDITIONS</th>
<th>Mu SRTT 16” ref</th>
<th>0.85</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temp ref N</td>
<td>20 °C</td>
<td></td>
</tr>
<tr>
<td>Temp ref M+S</td>
<td>15 °C</td>
<td></td>
</tr>
<tr>
<td>Temp ref 3PMSF 10</td>
<td>°C</td>
<td></td>
</tr>
<tr>
<td>MTD ref</td>
<td>0.80</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CALCULATED COEFFICIENTS RMA*+RRT1+RRT2 (excl. outliers)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tyre type</td>
</tr>
<tr>
<td>-----------------</td>
</tr>
<tr>
<td>DeltaMu16</td>
</tr>
<tr>
<td>DeltaT</td>
</tr>
<tr>
<td>DeltaT^2</td>
</tr>
<tr>
<td>DeltaMu16^2*DeltaT</td>
</tr>
<tr>
<td>NORMAL</td>
</tr>
<tr>
<td>M+S (only)</td>
</tr>
<tr>
<td>3PMSF (Severe Snow)</td>
</tr>
</tbody>
</table>
With the new proposed approach, the dispersion of the test is significantly reduced for each tyre typology.

<table>
<thead>
<tr>
<th>Weighted Std NORMAL</th>
<th>Data Points</th>
<th>Current WGI</th>
<th>Proposed WGI</th>
<th>W-STDEV Evolution</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>596</td>
<td>0.083</td>
<td>0.064</td>
<td>-24%</td>
</tr>
<tr>
<td>Weighted Std M+S</td>
<td>285</td>
<td>0.077</td>
<td>0.059</td>
<td>-23%</td>
</tr>
<tr>
<td>Weighted Std 3PMSF</td>
<td>282</td>
<td>0.088</td>
<td>0.059</td>
<td>-34%</td>
</tr>
</tbody>
</table>

Provisional v/s Current Wet Grip Index (WGI) values

On average, similar WGI values as current procedure.

The proposed procedure grants more stability (vs tests conditions) than current procedure: possible differences in WGI (proposed and current) on single tests results depend on the conditions.

K factor can be further optimized also to align proposed and current procedure.
Some of - but not all - the technical findings on trailer can be automatically transposed to vehicle methodology.

ETRTO (EU only) is carrying-out dedicated test campaign on vehicle; main purposes are:

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)

Based on today information, the directions for the VEHICLE method could be similar to the trailer:

- Better definition of the track surface
- Restricting the testing conditions ranges
- Revised mathematical corrections formulas (different from the trailer ones)
- Stabilizing of the tyre prior the Wet Grip test
- Tyres Inflation Pressure adjusted depending on actual load of the vehicle
- Technical specification for vehicle to be used and further limitations
• CURRENT REGULATORY FRAMEWORK

• CURRENT WET GRIP PROCEDURE - TECHNICAL PRINCIPLES

• ISO ACTIVITIES - TECHNICAL DIRECTIONS

• TIMELINE
**TIMELINE**

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

### TIMELINE

<table>
<thead>
<tr>
<th>Year</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
<th>2019</th>
<th>2020</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3Q</td>
<td>4Q</td>
<td>1Q</td>
<td>2Q</td>
<td>3Q</td>
<td>4Q</td>
</tr>
<tr>
<td></td>
<td>1Q</td>
<td>2Q</td>
<td>3Q</td>
<td>4Q</td>
<td>1Q</td>
<td>2Q</td>
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<td>3Q</td>
<td>4Q</td>
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<td>3Q</td>
<td>4Q</td>
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<tr>
<td></td>
<td>1Q</td>
<td>2Q</td>
<td>3Q</td>
<td>4Q</td>
<td>1Q</td>
<td>2Q</td>
</tr>
</tbody>
</table>

**TRAILER activities**
- ETRTO (EU) & JATMA (Jap)

**ETRTO (EU)**
- Completion of data analysis

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

**RMA (USA) test + ETRTO (EU) analysis**

**VEHICLE testing activities**
- ETRTO (EU)

**Completion of data analysis**

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*Image credits to ETRTO*
APPENDIX
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** is calculated between two pre-defined speeds (80 → 20 km/h).

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.