

## **European Union Activity on tyre wet grip labelling**

### **INTRODUCTION**

The European Union in Regulation (EC) No 1222/2009 has adopted information requirements for new tyres.

The new Regulation, (EC) No 1222/2009, creates a labelling scheme for C1, C2 and C3 tyres (tyres mainly fitted on passenger cars, light- and heavy-duty vehicles). It requires from 1 November 2012 that standardised information is supplied not only on fuel efficiency but also on wet grip and external rolling noise, so that consumers and end-users can make an informed choice. It will guarantee that the information is made available to end-users via different media (e.g. electronic, catalogues, stickers). Further details, including the full text of the Regulation can be found on the following link:

[http://ec.europa.eu/energy/efficiency/labelling/labelling\\_of\\_tyres\\_en.htm](http://ec.europa.eu/energy/efficiency/labelling/labelling_of_tyres_en.htm)

The objective of this Regulation is to promote the market transformation towards fuel-efficient tyres, together with safer and quieter tyres.

Directed at the demand side, the Regulation on tyre labelling complements the type-approval legislation on tyres which addresses the supply side by means of minimum requirements. The minimum requirements governing rolling resistance, wet grip and external rolling noise will start to take effect by 1 November 2012 through Regulation (EC) No 2009/661 which will effectively require all new tyres to meet the relevant requirements of the latest level of UNECE Regulation 117. This will guarantee a standard level of tyre quality, while further improvements above these levels will be driven by the labelling scheme.

This approach will ensure that all three parameters, which are essential for the end-users, are optimised without improving one parameter at the cost of the other. This is crucial in particular in the replacement market which accounts for 78% of market share where no initiatives currently support investments in improved performances beyond the minimum requirements.

### **Specific Requirements for Wet Grip Labelling**

Although the basic Regulation, (EC) No 1222/2009, has now been agreed, implementing measures concerning the detailed functioning of the scheme are still under discussion. A key requirement is that manufacturers have to be able to demonstrate that their products meet the performance bands that have been claimed on the label. Clearly, it is desirable that the test

methods used for testing parameters such as rolling resistance and wet grip for labelling purposes are compatible with the methods used for the type-approval of tyres. However, type-approval regulations such as UNECE Regulation 117 are generally designed with a single pass/fail threshold. A multi-band labelling scheme requires much finer discrimination between the performance levels of competing tyres, and a test procedure designed for type-approval cannot always offer this degree of discrimination in a reliable manner. This is particularly the case with the Regulation 117 wet grip test which is not sufficiently precise and reproducible to be used to check conformity to the labelling requirements, due to a number of factors including:

- Variations in the test track surface
- Variations in temperature conditions
- The use of an outdated size of reference tyre, which is not representative of current production tyres and might not fit modern test vehicles.

A revised test method for wet grip, aimed at limiting the above sources of variation, is being developed through a Commission working group, with participation by experts from EU Member States. The current draft is included in the attached **Annex**. The main changes proposed, compared to the test method set out in Regulation 117, are as follows:

- Reference tyre: P225/60R16 ASTM F2493-08 instead of SRTT 14" E1136.
- Reference tyre index = 125% (on the SRTT 14" scale)
- Different test conditions for Normal and Snow tyres
- Introduction of Temperature and Friction coefficient correction in the calculation of the wet grip index values.

Currently, only C1 tyres are included for the wet grip testing/labelling (as is the case with Regulation 117) but, in the future, it is planned to include C2 and C3 tyres as well, once work on an ISO test method has been finalised (i.e. revision of ISO 15222 - expected by the first quarter of 2011).

It should be emphasised that the attached is not a type-approval test; it is a test method used as the basis of self-declaration by manufacturers to support a claimed grading band. It should also be emphasised that the Annex does not represent the final text. A further working group meeting is scheduled for 30 September. It was agreed with Member States that Commission will proceed to the adoption of the revised test method after that meeting. However, since the proposed enhanced test method appears to improve on the accuracy of the current Regulation 117 test method, with little additional cost, **GRRF may wish to consider updating the Regulation 117 wet grip procedure by incorporating the improvements proposed by the enhanced test method**, once finalised. This will also ensure that harmonisation between the test methods is maintained.

The Commission will provide a further update on the progress of the Commission Working Group at the next GRRF in February 2011.

## ANNEX

### "ANNEX V

#### Testing method for measuring the wet grip index (G) of C1 tyres

##### 1. MANDATORY STANDARDS

The following documents listed apply.

- (1) ASTM E 303-93 (Reapproved 2003), Standard Test Method for Measuring Surface Frictional Properties Using the British Pendulum Tester;
- (2) ASTM E 501-06, Standard Specification for Standard Rib Tire for Pavement Skid-Resistance Tests;
- (3) ASTM E 965-96 (Reapproved 2001), Standard Test Method for Measuring Pavement Macrotexture Depth Using a Volumetric Technique;
- (4) ASTM E 1136-93 (Reapproved 2008), Standard Specification for a Radial Standard Reference Test Tire (SRTT14”);
- (5) ASTM F 2493-08, Standard Specification for a Radial Standard Reference Test Tire (SRTT16”).

##### 2. DEFINITIONS

For the purposes of testing wet grip of C1 tyres, the following definitions apply:

- (1) 'test run' means a single pass of a loaded tyre over a given test track surface;
- (2) 'test tyre(s)' means a candidate tyre, a reference tyre or a control tyre or tyre set that is used in a test run;
- (3) 'candidate tyre(s) (*T*)' means a tyre or a tyre set that is tested for the purpose of calculating its wet grip index;
- (4) 'reference tyre(s) (*R*)' means a tyre or a tyre set that has the characteristics indicated in ASTM F 2493-08 and referred to as Standard Reference Test Tyre 16 inches (SRTT16”);
- (5) 'control tyre(s) (*C*)' means an intermediate tyre or a set of intermediate tyres which is used when the candidate tyre and the reference tyre cannot be directly compared on the same vehicle;
- (6) 'braking force of a tyre' means the longitudinal force, expressed in newton, resulting from braking torque application;
- (7) 'braking force coefficient of a tyre (*BFC*)' means the ratio of the braking force to the vertical load;

- (8) 'peak braking force coefficient of a tyre' means the maximum value of a tyre braking force coefficient that occurs prior to wheel lockup as the braking torque is progressively increased;
- (9) 'lockup of a wheel' means the condition of a wheel in which its rotational velocity about the wheel spin axis is zero and it is prevented from rotating in the presence of applied wheel torque;
- (10) 'vertical load' means the load in newton or kilogram force imposed on the tyre perpendicular to the road surface;
- (11) 'tyre test vehicle' means a dedicated special purpose vehicle which has instruments to measure the vertical and the longitudinal forces on one test tyre during braking.

### **3. GENERAL TEST CONDITIONS**

#### **3.1 Track characteristics**

The test track shall have the following characteristics:

- (1) The surface shall have a dense asphalt surface with a uniform gradient of not more than 2 % and shall not deviate more than 6 mm when tested with a 3 m straight edge.
- (2) The surface shall have a pavement of uniform age, composition, and wear. The test surface shall be free of loose material and foreign deposits.
- (3) The maximum chipping size shall be from 8 mm to 13 mm.
- (4) The texture depth as measured by a sand patch shall be  $0,7 \pm 0,3$  mm. It shall be measured every 10 metres in accordance with ASTM E 965-96 (Reapproved 2001).
- (5) The wetted frictional properties of the surface shall be measured with either method (a) or (b) in section 3.2.

#### **3.2 Methods to measure the wetted frictional properties of the surface**

##### **(a) British Pendulum Number (BPN) method**

The British Pendulum Number method shall be as defined in ASTM E 303-93 (Reapproved in 2003).

Pad rubber component formulation and physical properties shall be as specified in ASTM E 501-06.

The averaged British Pendulum Number (BPN) shall be between 42 and 60 BPN after temperature correction as follows.

BPN shall be corrected by the wetted road surface temperature. Unless temperature correction recommendations are indicated by the British pendulum manufacturer, the following formula is used:

$$\text{BPN} = \text{BPN}(\text{measured value}) + \text{temperature correction}$$

$$\text{temperature correction} = -0,0018 t^2 + 0,34 t - 6,1$$

where  $t$  is the wetted road surface temperature in degrees Celsius.

Effects of slider pad wear: The pad shall be removed for maximum wear when the wear on the striking edge of the slider reaches 3,2 mm in the plane of the slider or 1,6 mm vertical to it in accordance with section 5.2.2 and Figure 3 of ASTM E 303-93 (Reapproved 2003).

For the purpose of checking track surface BPN consistency for the measurement of wet grip on an instrumented passenger car : the BPN values of the test track should not vary over the entire stopping distance so as to decrease the dispersion of test results. The wetted frictional properties of the surface shall be measured five times at each point of the BPN measurement every 10 meters and the coefficient of variation of the averaged BPN shall not exceed 10 %.

### **(b) ASTM E 1136 Standard Reference Test Tyre (SRTT14<sup>1</sup>) method**

By derogation with point (4) of section 2, this method uses the reference tyre that has the characteristics indicated in ASTM E 1136-93 (Reapproved 2008) and referred to as SRTT14<sup>1</sup>.

The average peak braking coefficient ( $\mu_{\text{peak,ave}}$ ) of the SRTT14<sup>1</sup> shall be  $0,7 \pm 0,1$  at 65 km/h.

The average peak braking coefficient ( $\mu_{\text{peak,ave}}$ ) of the SRTT14<sup>1</sup> shall be corrected by the wetted road surface temperature as follows:

$$\text{peak braking coefficient } (\mu_{\text{peak,ave}}) = \text{peak braking coefficient (measured)} + \text{temperature correction}$$

$$\text{temperature correction} = 0,0035 \times (t - 20)$$

where  $t$  is the wetted road surface temperature in degrees Celsius.

## **3.3 Atmospheric conditions**

The wind conditions shall not interfere with wetting of the surface (wind-shields are allowed).

Both the wetted surface temperature and the ambient temperature shall be between 2°C and 20°C for snow tyres and 5°C and 35°C for normal tyres.

The wetted surface temperature shall not vary during the test by more than 10°C.

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• <sup>1</sup> The size of the ASTM E 1136 SRTT is P195/75R14

The ambient temperature must remain close to the wetted surface temperature; the difference between the ambient and the wetted surface temperatures must be less than 10°C.

#### **4. TESTING METHODS FOR MEASURING WET GRIP**

For the calculation 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 vehicle travelling straight ahead on a wet, paved surface. It is measured with one of the following methods:

- vehicle method consisting of testing a set of tyres mounted on an instrumented passenger car;
- testing method using a trailer towed by a vehicle or a tyre test vehicle, equipped with the test tyre(s).

##### **4.1 Testing method using an instrumented passenger car**

###### *4.1.1 Principle*

The testing method covers a procedure for measuring the deceleration performance of C1 tyres during braking, using an instrumented passenger car equipped with an Antilock Braking System (ABS), where 'instrumented passenger car' means a passenger car that is fitted with the measuring equipment listed in section 4.1.2.2 for the purpose of this testing method. Starting with a defined initial speed, the brakes are applied hard enough on four wheels at the same time to activate the ABS. The average deceleration is calculated between two pre-defined speeds.

###### *4.1.2 Equipment*

###### *4.1.2.1 Vehicle*

Permitted modifications on the passenger car are as follows:

- those allowing the number of tyre sizes that can be mounted on the vehicle to be increased;
- those permitting automatic activation of the braking device to be installed.

Any other modification of the braking system is prohibited.

###### *4.1.2.2 Measuring equipment*

The vehicle shall be fitted with a sensor suitable for measuring speed on a wet surface and distance covered between two speeds.

To measure vehicle speed, a fifth wheel or non-contact speed-measuring system shall be used.

###### *4.1.3 Conditioning of the test track and wetting condition*

The test track surface shall be watered at least half an hour prior to testing in order to equalize the surface temperature and water temperature. External watering should be supplied continuously throughout testing. For the whole testing area, the water depth shall be  $1.0 \pm 0.5$  mm.

The test track should then be conditioned by conducting at least ten test runs with tyres not involved in the test programme at 90 km/h.

#### 4.1.4 Tyres and rims

##### 4.1.4.1 Tyre preparation and break-in

The test tyres shall be trimmed to remove all protuberances on the tread surface caused by mould air vents or flashes at mould junctions.

The test tyres shall be mounted on the test rim declared by the tyre manufacturer.

A proper bead seat should be achieved by the use of a suitable lubricant. Excessive use of lubricant should be avoided to prevent slipping of the tyre on the wheel rim.

The test tyres/rim assemblies shall be stored in a location for a minimum of two hours such that they all have the same ambient temperature prior to testing. They should be shielded from the sun to avoid excessive heating by solar radiation.

For tyre break-in, two braking runs shall be performed.

##### 4.1.4.2 Tyre load

The static load on each front axle tyre shall lie between 60 % and 90 % of the tested tyre load capacity. Tyre loads on the same axle should not differ by more than 10 %.

##### 4.1.4.3 Tyre inflation pressure

On the front and rear axles, the inflation pressures shall be 220 kPa (for standard- and extra-load tyres). The tyre pressure should be checked just prior to testing at ambient temperature and adjusted if required.

#### 4.1.5 Procedure

##### 4.1.5.1 Test run

The following test procedure applies for each test run:

- (1) The passenger car is driven in a straight line up to  $85 \pm 2$  km/h.
- (2) Once the passenger car has reached  $85 \pm 2$  km/h, the brakes are always activated at the same place on the test track referred to as 'braking starting point', with a longitudinal tolerance of 5 m and a transverse tolerance of 0,5 m.
- (3) The brakes are activated either automatically or manually.
  - (i) The automatic activation of the brakes is performed by means of a detection system made of two parts, one indexed to the test track and one on board the passenger car.
  - (ii) The manual activation of the brakes depends on the type of transmission as follows. In both cases, a minimum of 600 N pedal efforts is required.

For manual transmission, the driver should release the clutch and depress the brake pedal sharply, holding it down as long as necessary to perform the measurement.

For automatic transmission, the driver should select neutral gear and then depress the brake pedal sharply, holding it down as long as necessary to perform the measurement.

(4) The average deceleration is calculated between 80 km/h and 20 km/h.

If any of the specifications listed above (including speed tolerance, longitudinal and transverse tolerance for the braking starting point, and braking time) are not met when a test run is made, the measurement is discarded and a new test run is made.

#### 4.1.5.2 Test cycle

A number of test runs are made in order to measure the wet grip index of a set of candidate tyres (T) according to the following procedure, whereby each test run shall be made in the same direction and up to three different set of candidate tyres may be measured within the same test cycle:

- (1) First, the set of reference tyres are mounted on the instrumented passenger car.
- (2) After at least three valid measurements have been made in accordance with section 4.1.5.1, the set of reference tyres is replaced by a set of candidate tyres.
- (3) After six valid measurements of the candidate tyres are performed, two more set of candidate tyres may be measured.
- (4) The test cycle is closed by three more valid measurements of the same set of reference tyres as at the beginning of the test cycle.

#### EXAMPLES:

- The run order for a test cycle of three sets of candidate tyres (T1 to T3) plus a set of reference tyres (R) would be the following:

R-T1-T2-T3-R

- The run order for a test cycle of five sets of candidate tyres (T1 to T5) plus a set of reference tyres (R) would be the following:

R-T1-T2-T3-R-T4-T5-R

#### 4.1.6 Processing of measurement results

##### 4.1.6.1 Calculation of the average deceleration (AD)

The average deceleration (AD) is calculated for each valid test run in  $\text{m}\cdot\text{s}^{-2}$  as follows:

$$AD = \left| \frac{S_f^2 - S_i^2}{2d} \right|$$

where:

$S_f$  is the final speed in  $\text{m}\cdot\text{s}^{-1}$ ;  $S_f = 20 \text{ km/h} = 5.556 \text{ m}\cdot\text{s}^{-1}$

$S_i$  is the initial speed in  $\text{m}\cdot\text{s}^{-1}$ ;  $S_i = 80 \text{ km/h} = 22.222 \text{ m}\cdot\text{s}^{-1}$

$d$  is the distance covered in m between  $S_i$  and  $S_f$ .

##### 4.1.6.2 Validation of results

The AD coefficient of variation is calculated as follows:

(Standard Deviation / Average) x 100.



For the reference tyres (*R*): If the *AD* coefficient of variation of any two consecutive groups of three test runs of the reference tyre set is higher than 3 %, all data should be discarded and the test repeated for all test tyres (the candidate tyres and the reference tyres).

For the candidate tyres (*T*): The *AD* coefficients of variation are calculated for each candidate tyre set. If one coefficient of variation is higher than 3 %, the data should be discarded and the test repeated for that candidate tyre set.

#### 4.1.6.3 Calculation of adjusted average deceleration (*Ra*)

The average deceleration (*AD*) of the reference tyre set used for the calculation of its braking force coefficient is adjusted according to the positioning of each candidate tyre set in a given test cycle.

This adjusted *AD* of the reference tyre (*Ra*) is calculated in  $m.s^{-2}$  in accordance with table 1 where  $R_1$  is the average of the *AD* values in the first test of the reference tyre set (*R*) and  $R_2$  is the average of the *AD* values in the second test of the same reference tyre set (*R*).

**Table 1**

Number of sets of candidate tyres within one test cycle	Set of candidate tyres	<i>Ra</i>
1 ( $R_1-T1-R_2$ )	T1	$Ra = 1/2 (R_1 + R_2)$
2 ( $R_1-T1-T2-R_2$ )	T1	$Ra = 2/3 R_1 + 1/3 R_2$
	T2	$Ra = 1/3 R_1 + 2/3 R_2$
3 ( $R_1-T1-T2-T3-R_2$ )	T1	$Ra = 3/4 R_1 + 1/4 R_2$
	T2	$Ra = 1/2 (R_1 + R_2)$
	T3	$Ra = 1/4 R_1 + 3/4 R_2$

#### 4.1.6.4 Calculation of the braking force coefficient (*BFC*)

The braking force coefficient (*BFC*) is calculated for a braking on the two axles according to Table 2 where  $Ta$  ( $a = 1, 2$  or  $3$ ) is the average of the *AD* values for each candidate tyre (*T*) set that is part of a test cycle.

**Table 2**

Test Tyre	Braking force coefficient		
Reference tyre	$BFC(R)=$	$Ra/g$	
Candidate tyre	$BFC(T)=$	$Ta/g$	
$g$ is the acceleration due to gravity, $g= 9,81 m \cdot s^{-2}$			

#### 4.1.6.5 Calculation of the wet grip index of the candidate tyre

The wet grip index of the candidate tyre ( $G(T)$ ) is calculated as follows:

$$G(T) = \left[ \frac{BFC(T)}{BFC(R)} \times 125 + a \times (t - t_0) + b \times \left( \frac{BFC(R)}{BFC(R_0)} - 1,0 \right) \right] \times 10^{-2}$$

where:

- $t$  is the measured wet surface temperature in degree Celsius when the candidate tyre ( $T$ ) is tested
- $t_0$  is the wet surface reference temperature condition,  $t_0=20^\circ\text{C}$  for normal tyres and  $t_0=10^\circ\text{C}$  for snow tyres
- $BFC(R_0)$  is the braking force coefficient for the reference tyre in the reference conditions,  $BFC(R_0) = 0,68$
- $a = -0,4232$  and  $b = -8,297$  for normal tyres,  $a = 0,7721$  and  $b = 31,18$  for snow tyres

#### 4.1.7 Wet grip performance comparison between a candidate tyre and a reference tyre using a control tyre

##### 4.1.7.1 General

Where the candidate tyre size is significantly different from that of the reference tyre, a direct comparison on the same instrumented passenger car may not be possible. This testing method uses an intermediate tyre, hereinafter called the control tyre as defined in point 5 of section 2.

##### 4.1.7.2 Principle of the approach

The principle is the use of a control tyre set and two different instrumented passenger cars for the test cycle of a candidate tyre set in comparison with a reference tyre set.

One instrumented passenger car is fitted with the reference tyre set followed by the control tyre set, the other with the control tyre set followed by the candidate tyre set.

The specifications listed in sections 4.1.2. to 4.1.4 apply.

The first test cycle is a comparison between the control tyre set and the reference tyre set.

The second test cycle is a comparison between the candidate tyre set and the control tyre set. It is done on the same test track and during the same day as the first test cycle. The wetted surface temperature shall be within  $\pm 5^\circ\text{C}$  of the temperature of the first test cycle. The same control tyre set shall be used for the first and the second test cycles.

The wet grip performance index of the candidate tyre ( $G(T)$ ) is calculated as follows:

$$G(T) = G_1 \times G_2$$

where:

- $G_1$  is the relative wet grip index of the control tyre ( $C$ ) compared to the reference tyre ( $R$ ) calculated as follows:

$$G_1 = \left[ \frac{BFC(C)}{BFC(R)} \times 125 + a \times (t - t_0) + b \times \left( \frac{BFC(R)}{BFC(R_0)} - 1,0 \right) \right] \times 10^{-2}$$

- $G_2$  is the relative wet grip index of the candidate tyre ( $T$ ) compared to the control tyre ( $C$ ) calculated as follows:

$$G_2 = \frac{BFC(T)}{BFC(C)}$$

#### 4.1.7.3 Storage and preservation

It is necessary that all the tyres of a control tyre set have been stored in the same conditions. As soon as the control tyre set has been tested in comparison with the reference tyre, the specific storage conditions defined in ASTM E 1136-93 (Reapproved 2008) shall be applied.

#### 4.1.7.4 Replacement of reference tyres and control tyres

When irregular wear or damage results from tests, or when wear influences the test results, the use of the tyre shall be discontinued.

### 4.2 Testing method using a trailer towed by a vehicle or a tyre test vehicle

#### 4.2.1 Principle

The measurements are conducted on test tyres mounted on a trailer towed by a vehicle (hereafter referred to as tow vehicle) or on a tyre test vehicle. The brake in the test position is applied firmly until sufficient braking torque is generated to produce the maximum braking force that will occur prior to wheel lockup at a test speed of 65 km/h.

#### 4.2.2 Equipment

##### 4.2.2.1 Tow vehicle and trailer or tyre test vehicle

- The tow vehicle or the tyre test vehicle shall have the capability of maintaining the specified speed of  $65 \pm 2$  km/h even under the maximum braking forces.
- The trailer or the tyre test vehicle shall be equipped with one place where the tyre can be fitted for measurement purposes hereafter called 'test position' and the following accessories:
  - (i) equipment to activate brakes in the test position;
  - (ii) a water tank to store sufficient water to supply the road surface wetting system, unless external watering is used;
  - (iii) recording equipment to record signals from transducers installed at the test position and to monitor water application rate if the self-watering option is used.
- The limiting change of toe and camber for the test position shall be within  $\pm 0,5^\circ$  with maximum vertical load. Suspension arms and bushings shall have sufficient rigidity necessary to minimize free play and ensure compliance under application of maximum braking forces. The suspension system shall provide adequate load-carrying capacity and be of such a design as to isolate suspension resonance.
- The test position shall be equipped with a typical or special automotive brake system which can apply sufficient braking torque to produce the maximum value of braking test wheel longitudinal force at the conditions specified.
- The brake application system shall be able to control the time interval between initial brake application and peak longitudinal force as specified in section 4.2.7.1.
- The trailer or the tyre test vehicle shall be designed to accommodate the range of candidate tyre sizes to be tested.

- The trailer or the tyre test vehicle shall have provisions for adjustment of vertical load as specified in section 4.2.5.2.

#### 4.2.2.2 Measuring equipment

- The test wheel position on the trailer or the tyre test vehicle shall be equipped with a rotational wheel velocity measuring system and with transducers to measure the braking force and vertical load at the test wheel.
- General requirements for measurement system: The instrumentation system shall conform to the following overall requirements at ambient temperatures between 0 °C and 45 °C:
  - (i) overall system accuracy, force:  $\pm 1,5$  % of the full scale of the vertical load or braking force;
  - (ii) overall system accuracy, speed:  $\pm 1,5$  % of speed or  $\pm 1,0$  km/h, whichever is greater;
- Vehicle speed: To measure vehicle speed, a fifth wheel or non-contact precision speed-measuring system should be used.
- Braking forces: The braking force-measuring transducers shall measure longitudinal force generated at the tyre–road interface as a result of brake application within a range from 0 % to at least 125 % of the applied vertical load. The transducer design and location shall minimize inertial effects and vibration-induced mechanical resonance.
- Vertical load: The vertical load-measuring transducer shall measure the vertical load at the test position during brake application. The transducer shall have the same specifications as described previously.
- Signal conditioning and recording system: All signal conditioning and recording equipment shall provide linear output with necessary gain and data reading resolution to meet the specified previous requirements. In addition, the following requirements apply:
  - (i) The minimum frequency response shall be flat from 0 Hz to 50 Hz (100 Hz) within  $\pm 1$  % full scale.
  - (ii) The signal-to-noise ratio shall be at least 20/1.
  - (iii) The gain shall be sufficient to permit full-scale display for full-scale input signal level.
  - (iv) The input impedance shall be at least ten times larger than the output impedance of the signal source.
  - (v) The equipment shall be insensitive to vibrations, acceleration, and changes in ambient temperature.

#### 4.2.3 *Conditioning of the test track*

The test track should be conditioned by conducting at least ten test runs with tyres not involved in the test program at  $65 \pm 2$  km/h.

#### 4.2.4 *Wetting conditions*

The tow vehicle and trailer or the tyre test vehicle may be optionally equipped with a pavement-wetting system, less the storage tank, which, in the case of the trailer, is mounted on the tow vehicle. The water being applied to the pavement ahead of the test tyres shall be supplied by a nozzle suitably designed to ensure that the water layer encountered by the test tyre has a uniform cross section at the test speed with a minimum splash and overspray.

The nozzle configuration and position shall ensure that the water jets are directed towards the test tyre and pointed towards the pavement at an angle of  $20^\circ$  to  $30^\circ$ .

The water shall strike the pavement 0,25 m to 0,45 m ahead of the centre of tyre contact. The nozzle shall be located 25 mm above the pavement or at the minimum height required to clear obstacles which the tester is expected to encounter, but in no case more than 100 mm above the pavement.

The water layer shall be at least 25 mm wider than the test tyre tread and applied so the tyre is centrally located between the edges. Water delivery rate shall ensure a water depth of  $1.0 \pm 0.5$  mm and shall be consistent throughout the test to within  $\pm 10$  per cent. The volume of water per unit of wetted width shall be directly proportional to the test speed. The quantity of water applied at 65 km/h shall be  $18 \text{ l}\cdot\text{s}^{-1}$  per meter of width of wetted surface in case of a water depth of 1.0 mm.

#### 4.2.5 *Tyres and rims*

##### 4.2.5.1 *Tyre preparation and break-in*

The test tyres shall be trimmed to remove all protuberances on the tread surface caused by mould air vents or flashes at mould junctions.

The test tyre shall be mounted on the test rim declared by the tyre manufacturer.

A proper bead seat should be achieved by the use of a suitable lubricant. Excessive use of lubricant should be avoided to prevent slipping of the tyre on the wheel rim.

The test tyres/rim assemblies shall be stored in a location for a minimum of two hours such that they all have the same ambient temperature prior to testing. They should be shielded from the sun to avoid excessive heating by solar radiation.

For tyre break-in, two braking runs shall be performed under the load, pressure and speed as specified in 4.2.5.2, 4.2.5.3 and 4.2.7.1 respectively.

##### 4.2.5.2 *Tyre load*

The test load on the test tyre is  $75 \pm 5$  % of the test tyre load capacity.

##### 4.2.5.3 *Tyre inflation pressure*

The test tyre cold inflation pressure shall be 180 kPa for standard-load tyres. For extra-load tyres, the cold inflation pressure shall be 220 kPa.

The tyre pressure should be checked just prior to testing at ambient temperature and adjusted if required.

#### 4.2.6 *Preparation of the tow vehicle and trailer or the tyre test vehicle*

##### 4.2.6.1 Trailer

For one axle trailers, the hitch height and transverse position shall be adjusted once the test tyre has been loaded to the specified test load in order to avoid any disturbance of the measuring results. The longitudinal distance from the centre line of the articulation point of the coupling to the transverse centre line of the axle of the trailer shall be at least ten times the “hitch height” or the “coupling (hitch) height”.

##### 4.2.6.2 Instrumentation and equipment

Install the fifth wheel, when used, in accordance with the manufacturer’s specifications and locate it as near as possible to the mid-track position of the tow trailer or the tyre test vehicle.

#### 4.2.7 *Procedure*

##### 4.2.7.1 Test run

The following procedure applies for each test run:

- (1) The tow vehicle or the tyre test vehicle is driven onto the test track in a straight line at the specified test speed  $65 \pm 2$  km/h.
- (2) The recording system is launched.
- (3) Water is delivered to the pavement ahead of the test tyre approximately 0,5 s prior to brake application (for internal watering system).
- (4) The trailer brakes are activated within 2 metres of a measurement point of the wetted frictional properties of the surface and sand depth in accordance with points 4 and 5 of section 3.1. The rate of braking application shall be such that the time interval between initial application of force and peak longitudinal force is in the range 0,2 s to 0,5 s.
- (5) The recording system is stopped.

##### 4.2.7.2 Test cycle

A number of test runs are made in order to measure the wet grip index of the candidate tyre (T) according to the following procedure, whereby each test run shall be made at the same spot on the test track and in the same direction. Up to three candidate tyres may be measured within the same test cycle, provided that the tests are completed within one day.

- (1) First, the reference tyre is tested.
- (2) After at least six valid measurements are performed in accordance with section 4.2.7.1, the reference tyre is replaced by the candidate tyre.
- (3) After six valid measurements of the candidate tyre are performed, two more candidate tyres may be measured.
- (4) The test cycle is closed by six more valid measurements of the same reference tyre as at the beginning of the test cycle.

EXAMPLES:

- The run order for a test cycle of three candidate tyres (T1 to T3) plus the reference tyre (R) would be the following:

R-T1-T2-T3-R

- The run order for a test cycle of five candidate tyres (T1 to T5) plus the reference tyre R would be the following:

R-T1-T2-T3-R-T4-T5-R

#### 4.2.8 Processing of measurement results

##### 4.2.8.1 Calculation of the peak braking force coefficient

The tyre peak braking force coefficient ( $\mu_{peak}$ ) is the highest value of  $\mu(t)$  before lockup occurs calculated as follows for each test run. Analogue signals should be filtered to remove noise. Digitally recorded signals must be filtered using a moving average technique.

$$\mu(t) = \left| \frac{fh(t)}{fv(t)} \right|$$

w

here:

$\mu(t)$  is the dynamic tyre braking force coefficient in real time;

$fh(t)$  is the dynamic braking force in real time, in N;

$fv(t)$  is the dynamic vertical load in real time, in N.

##### 4.2.8.2 Validation of results

The  $\mu_{peak}$  coefficient of variation is calculated as follows:

(Standard Deviation / Average) x 100

For the reference tyre (R): If the coefficient of variation of the peak braking force coefficient ( $\mu_{peak}$ ) of the reference tyre is higher than 5 %, all data should be discarded and the test repeated for all test tyres (the candidate tyre(s) and the reference tyre).

For the candidate tyre(s) (T): The coefficient of variation of the peak braking force coefficient ( $\mu_{peak}$ ) is calculated for each candidate tyre. If one coefficient of variation is higher than 5 %, the data should be discarded and the test repeated for this candidate tyre.

##### 4.2.8.3 Calculation of the adjusted average peak braking coefficient

The average peak braking coefficient of the reference tyre used for the calculation of its braking force coefficient is adjusted according to the positioning of each candidate tyre in a given test cycle.

This adjusted average peak braking coefficient of the reference tyre ( $Ra$ ) is calculated in accordance with table 1 where  $R_1$  is the average peak tyre braking coefficient in the first test of the reference tyre (R) and  $R_2$  is the average peak tyre braking coefficient in the second test of the same reference tyre (R).

**Table 3**

Number of candidate tyre(s) within one test cycle	candidate tyre	$Ra$
1 ( $R_1$ -T1- $R_2$ )	T1	$Ra = 1/2 (R_1 + R_2)$

2 (R <sub>1</sub> -T <sub>1</sub> -T <sub>2</sub> -R <sub>2</sub> )	T1	$Ra = 2/3 R_1 + 1/3 R_2$
	T2	$Ra = 1/3 R_1 + 2/3 R_2$
3 (R <sub>1</sub> -T <sub>1</sub> -T <sub>2</sub> -T <sub>3</sub> -R <sub>2</sub> )	T1	$Ra = 3/4 R_1 + 1/4 R_2$
	T2	$Ra = 1/2 (R_1 + R_2)$
	T3	$Ra = 1/4 R_1 + 3/4 R_2$

#### 4.2.8.4 Calculation of the average peak tyre braking coefficient ( $\mu_{peak,ave}$ )

The average value of the peak tyre braking coefficients ( $\mu_{peak,ave}$ ) is calculated according to table 4 whereby  $Ta$  ( $a= 1, 2$  or  $3$ ) is the average of the peak braking coefficients measured for one candidate tyre within one test cycle.

**Table 4**

Test tyre	$\mu_{peak,ave}$
Reference tyre	$\mu_{peak,ave}(R) = Ra$ as per Table 3
Candidate tyre	$\mu_{peak,ave}(T) = Ta$

#### 4.2.8.5 Calculation of the wet grip index of the candidate tyre

The wet grip index of the candidate tyre ( $G(T)$ ) is calculated as follows:

$$G(T) = \left[ \frac{\mu_{peak,ave}(T)}{\mu_{peak,ave}(R)} \times 125 + a \times (t - t_0) + b \times \left( \frac{\mu_{peak,ave}(R)}{\mu_{peak,ave}(R_0)} - 1,0 \right) \right] \times 10^{-2}$$

where:

- $t$  is the measured wet surface temperature in degree Celsius when the candidate tyre ( $T$ ) is tested
- $t_0$  is the wet surface reference temperature condition
- $t_0=20^\circ\text{C}$  for normal tyres  $t_0=10^\circ\text{C}$  for snow tyres
- $\mu_{peak,ave}(R_0) = 0,85$  is the peak braking force coefficient for the reference tyre in the reference conditions
- $a= -0,4232$  and  $b = -8,297$  for normal tyres,  $a = 0,7721$  and  $b = 31,18$  for snow tyres



**Annex A: Test reports examples of wet grip index**

EXAMPLE 1: Test report of wet grip index using trailer method

Test report number: \_\_\_\_\_

Test date: \_\_\_\_\_

Type of road surface: \_\_\_\_\_

Texture depth (mm): \_\_\_\_\_

$\mu$  peak (SRTT14" E 1136): \_\_\_\_\_

BPN: \_\_\_\_\_

Speed (km/h): \_\_\_\_\_

Water depth (mm): \_\_\_\_\_

No.		1	2	3	4	5	6	7	8	9	10
Size											
Service description											
Tyre identification											
Rim											
Pattern											
Load (kg)											
Pressure											
$\mu$ peak	1										
	2										
	3										
	4										
	5										
	6										
	7										
	8										
Average											
Standard deviation $\sigma$											
$(\sigma/average) \leq 5\%$											
Ra, Adjusted											
Wet grip index											
Surface temp.											
Ambient temp.											
Remarks											

EXAMPLE 2: Test report of wet grip index using passenger car method

Driver:

Test date:

Track:

Passenger car:

Initial speed (km/h):

Final speed (km/h):

Texture depth (mm):

Brand:

BPN:

Model:

Water depth (mm):

Type:

No.	1	2	3	4	5					
Brand	Uniroyal	TYRE B	TYRE C	TYRE D	Uniroyal					
Pattern	ASTM F 2493 SRTT16"	PATTERN B	PATTERN C	PATTERN D	ASTM F 2493 SRTT16"					
Size	P225/60R16	SIZE B	SIZE C	SIZE D	P225/60R16					
Service description	97S	LI/SS	LI/SS	LI/SS	97S					
Tyre identification	XXXXXXXXXX	YYYYYYYYYY	ZZZZZZZZZ	NNNNNNNNNN	XXXXXXXXXX					
Rim										
Front axle pressure (bar)										
Rear axle pressure (bar)										
Front axle load (kg)										
Wet surface temp (°C)										
Ambient temp (°C)										
	Braking distance (m)	Average deceleration (m/s <sup>2</sup> )	Braking distance (m)	Average deceleration (m/s <sup>2</sup> )	Braking distance (m)	Average deceleration (m/s <sup>2</sup> )	Braking distance (m)	Average deceleration (m/s <sup>2</sup> )	Braking distance (m)	Average deceleration (m/s <sup>2</sup> )
Measurement	1									
	2									
	3									
	4									
	5									
	6									
	7									
	8									
	9									
	10									
Average AD (m/s <sup>2</sup> )										
Standard deviation (m/s <sup>2</sup> )										
Validation of results										
Coeff. of variation (%) < 3 %										
Adjusted average AD of ref. tyre: R <sub>a</sub> (m/s <sup>2</sup> )										
BFC(R) reference tyre (SRTT16")										
BFC(T) candidate tyre										
Wet grip index (%)										

"