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Tyres: UN Regulation No. 117 (Tyre rolling resistance, rolling noise and wet grip)

Proposal for amendments to UN Regulation No. 117

Submitted by the experts from the European Tyre and Rim Technical Organisation*

The text reproduced below was prepared by the experts from the European Tyre and Rim Technical Organisation (ETRTO). The modifications to the existing text of the UN Regulation are marked in bold for new or strikethrough for deleted characters.

* In accordance with the programme of work of the Inland Transport Committee for 2020 as outlined in proposed programme budget for 2020 (A/74/6 (part V sect. 20) para 20.37), the World Forum will develop, harmonize and update UN Regulations in order to enhance the performance of vehicles. The present document is submitted in conformity with that mandate.

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I. Proposal

Paragraph 2.18., amend to read:

"2.18. "*Standard Reference Test Tyre ~~(SRTT)~~*" or "*SRTT*" means a tyre that is produced, controlled and stored in accordance with the ~~American Society for Testing and Materials (ASTM)~~ standards **of ASTM International:**

(a) E1136 – 17 for the size P195/75R14 and referred to as "SRTT14",

(b) F2872 – 16 for the size 225/75R16C and referred to as "SRTT16C",

(c) F2871 – 16 for the size 245/70R19.5 and referred to as "SRTT19.5",

(d) F2870 – 16 for the size 315/70R22.5 and referred to as "SRTT22.5",

(e) ~~F2493 – 18~~ **F2493 – 19** for the size P225/60R16 and referred to as "SRTT16"."

Paragraph 2.19.3., amend to read:

"2.19.3. "*Control tyre*" means a normal production tyre that is used to establish the wet grip or snow grip performance of tyre sizes unable to be fitted to the same vehicle as the standard reference test tyre – see paragraph ~~4.1.7.~~**2.2.8.** of Annex 5**, part (B)** and paragraph 3.4.3. of Annex 7 to this Regulation."

Paragraph 2.19.4., amend to read:

"2.19.4. "*Wet grip index ~~("G")~~*" **(*G*)** means ~~the ratio between~~ the **wet grip** performance of ~~the~~ **a** candidate tyre ~~and the performance~~ **relative to that** of the **applicable** standard reference test tyre."

Insert new paragraphs 12.yy.and 12.zz. to read:

"**12.yy. Until 3 months after the date of entry into force of Supplement XX to the 02 series of amendments to this Regulation, Contracting Parties applying this Regulation can continue to grant type approvals according to the 02 series of amendments to this Regulation, without taking into account the provisions of Supplement XX.**

12.zz. Until 1 September 2024, Contracting Parties applying this Regulation may continue to grant type approvals according to the 02 series of amendments to this Regulation, based on the test procedure for measuring wet grip described in Annex 5 part A of this Regulation, without taking into account the provisions of Supplement XX."

Annex 5, title, amend to read:

"Test procedures for measuring **the** wet grip **index of new tyres**"

Annex 5, Part (A),

Paragraphs 1.1. and 1.2., delete.

Paragraph 1.3., renumber as 1.1.

Insert new paragraphs 2.2. and 2.3. to read:

"**2.2. "*Braking test*" means a series of a specified number of test runs of the same test tyre (set) repeated within a short time frame.**

2.3. "*Test cycle*" means a sequence of braking tests of the test tyres."

Paragraph 2.2., renumber as 2.4. and amend to read:

"2.4. "*Test tyre~~(s)~~*" **or "*test tyre set*"** means a ~~candidate tyre, a reference tyre or a control~~ tyre or **a** tyre set ~~that is used in a test run~~ **whose wet grip braking performance is measured in a braking test**."

Paragraph 2.3., renumber as 2.5. and amend to read:

"2.5. "*Candidate tyre~~(s) (T)~~*" **or "*Candidate tyre set*"** means a tyre or a tyre set ~~that is tested for the purpose of calculating its wet grip index~~ **whose wet grip braking performance is evaluated relative to that of a reference tyre or reference tyre set**."

Paragraph 2.4., renumber as 2.6. and amend to read:

"2.6. "*Reference tyre~~(s) (R)~~*" **or "*Reference tyre set*"** means a tyre or a tyre set of Standard Reference Test Tyres SRTT16."

Paragraph 2.5. (former), delete.

Paragraph 2.6., renumber as 2.7. and amend to read:

"2.7. "*Braking force ~~of a tyre~~*" means the longitudinal force, expressed in ~~newton~~ **newtons**, resulting from braking torque application."

Paragraph 2.7., renumber as 2.8. and amend to read:

"2.8. "***Average** Braking Force Coefficient ~~of a tyre (BFC)~~*" **(BFC)** means**, for the vehicle method,** the ratio of the ~~braking force~~ **average deceleration in a braking test** to the ~~vertical load~~ **acceleration due to gravity (rounded to 9.81 m·s^{-2})**."

Insert a new paragraph 2.9. to read:

"**2.9. "*Dynamic braking force coefficient*" ($\mu(t)$) means, for the trailer (or tyre test vehicle) method, the ratio of the braking force to the vertical load acquired in real time.**"

Paragraph 2.8., renumber as 2.10. and amend to read:

"2.10. "*Peak braking force coefficient ~~of a tyre~~*" **(μ_{peak})** means**, for the trailer (or tyre test vehicle) method,** the maximum value of ~~a tyre~~ **the dynamic** braking force coefficient that occurs prior to **lockup of the** wheel ~~lockup~~ as the braking torque is progressively increased."

Paragraph 2.9., renumber as 2.11.

Paragraph 2.10., renumber as 2.12. and amend to read:

"2.12. "*Vertical load*" means the ~~load~~ **normal force, expressed** in ~~newton~~ **newtons, ~~imposed on the tyre perpendicular to the road surface~~ exerted on the road resulting from the mass supported by the tyre**."

Paragraph 2.11., renumber as 2.13.

Insert a new paragraph 2.14. to read:

"**2.14. "*Tyre set*" means, for the trailer (or tyre test vehicle) method, one (1) tyre and, for the vehicle method, four (4) tyres.**"

Insert a new paragraph 2.15. to read:

"**2.15. "*Instrumented passenger car*" means a commercialized passenger car equipped with an Antilock Braking System (ABS) and the measuring equipment listed in paragraph 4.1.2.2. of this Annex.**"

Paragraph 3.1.1., amend to read:

"3.1.1. The surface shall have a dense asphalt surface with a uniform gradient of not more than 2 per cent **in both longitudinal and lateral directions** and shall not deviate more than 6 mm when tested with a 3 m straight edge."

Paragraph 3.1.4., amend to read:

"3.1.4. The **average macro** texture depth as measured **in accordance with ASTM E965-96 (Reapproved 2006)** by a sand patch shall be ~~0.7 ± 0.3 mm~~**(0.7 ± 0.3) mm**. ~~It shall be measured in accordance with ASTM E 965-96 (Reapproved 2006).~~ **In case the vehicle method is used, the average macro**

texture depth shall be determined in both lanes where the tyres are going to brake."

Paragraph 3.1.5., amend to read:

"3.1.5. The wetted frictional properties of the surface shall be measured **using the Standard Reference Test Tyre SRTT16 either** with ~~either method (a) or (b) in paragraph 3.2.~~ **the method described in paragraph 3.2.1. of this Annex in case the vehicle method (according to paragraph 4.1. below) is used, or with the method described in paragraph 3.2.2. in this Annex in case the trailer (or tyre test vehicle) method is used.**"

Paragraph 3.2.1., replace and amend to read:

"**3.2.1. Using the procedure described in paragraph 4.1. of this Annex, perform two braking tests of the reference tyre, each consisting of at least six (6) valid test runs in the same direction on aligned segments of the track. The braking tests shall cover the entire potential braking area, including where the texture depth was measured.**

Evaluate the braking tests as described in paragraphs 4.1.6.1. and 4.1.6.2. of this Annex. If the coefficient of variation of one braking test CV_{BFC} exceeds 4 per cent, dismiss the results and repeat the braking tests.

For each braking test, the arithmetic mean $\overline{BFC_{\mathrm{ave}}}$ of the average Braking Force Coefficients shall be corrected for effects of temperature as follows:

$$BFC_{\mathrm{ave,corr}} = \overline{BFC_{\mathrm{ave}}} + a \cdot (\vartheta - \vartheta_0)$$

where

ϑ is the wetted surface temperature in degrees Celsius,

$a = 0.002\ ^{\circ}\mathrm{C}^{-1}$ and $\vartheta_0 = 20\ ^{\circ}\mathrm{C}$.

For each braking test, the temperature-corrected average Braking Force Coefficient ($BFC_{\mathrm{ave,corr}}$) shall be not less than 0.57 and not greater than 0.79.

The arithmetic means of the temperature-corrected average Braking Force Coefficients of the two braking tests shall not differ by more than 10 per cent of the average of the two values:

$$CVal(BFC_{\mathrm{ave,corr}}) = 2 \cdot \left| \frac{BFC_{\mathrm{ave,corr,1}} - BFC_{\mathrm{ave,corr,2}}}{BFC_{\mathrm{ave,corr,1}} + BFC_{\mathrm{ave,corr,2}}} \right| \leq 10\ \%$$

"

Paragraph 3.2.2., amend to read:

"3.2.2. ~~Standard Reference Test Tyre method~~

~~This method uses the Standard Reference Test Tyre SRTT14.~~

Using the procedure described in paragraph 4.2. of this Annex, perform in the same area where the average macro texture depth was measured one braking test of the reference tyre, consisting of ~~Perform~~ at least six (6) valid **test runs in the same direction** ~~measurements of the peak braking force coefficient with the SRTT14 using the trailer towed by a vehicle or a tyre test vehicle test procedure as specified in clause 4.2. (at 65 km/h and 180 kPa)~~.

Evaluate the braking test as described in paragraphs 4.2.8.1. and 4.2.8.2. of this Annex. If the coefficient of variation CV_{μ} exceeds 4 per cent, dismiss the results and repeat the braking test.

The ~~average ($\mu_{\mathrm{peak,ave}}$)~~ **arithmetic mean ($\overline{\mu_{\mathrm{peak}}}$)** of the measured peak braking force ~~coefficient~~ **coefficients** shall be corrected for effects of temperature as follows:

~~$\mu_{peak,corr} = \mu_{peak,ave} + 0.0035 \cdot (t - 20)$~~

$$\mu_{peak,corr} = \overline{\mu_{peak}} + a \cdot (\vartheta - \vartheta_0)$$

where ~~t~~

ϑ is the wetted road surface temperature in degrees Celsius**,**

$a = 0.002\ °C^{-1}$ **and** $\vartheta_0 = 20\ °C$.

The temperature-corrected average peak braking force coefficient ($\mu_{peak,corr}$) shall be ~~0.7 ± 0.1~~ **not less than 0.65 and not greater than 0.90**."

Paragraph 3.3., amend to read:

"3.3. Atmospheric conditions

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

The ~~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.~~

Category of use		*Wetted surface temperature*	*Ambient temperature*
Normal tyres		**12 °C – 35 °C**	**12 °C – 40 °C**
Snow tyres		**5 °C – 35 °C**	**5 °C – 40 °C**
	Snow tyres for use in severe snow conditions	**5 °C – 20 °C**	**5 °C – 20 °C**
Special use tyres		**not applicable**	**not applicable**

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

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

Paragraph 4.1.1., amend to read:

"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 paragraph 4.1.2.2. below 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."

Paragraph 4.1.2.1., amend to read:

"4.1.2.1. Vehicle

Age of the car shall be less than 5 years and its mechanical conditions shall be according to car manufacturer recommendations with no alert from ABS (e.g. warning lights).

Permitted modifications on the passenger car are as follows:

(a) Those allowing the number of tyre sizes that can be mounted on the vehicle to be increased;

(b) Those permitting automatic activation of the braking device to be installed;

(c) **Those permitting the vehicle to be guided or accelerated externally.**

Any other modification **of the vehicle and specifically** of the braking system is prohibited."

Paragraph 4.1.2.2., amend to read:

"4.1.2.2. Measuring equipment

The exposed portions of the system shall tolerate 100 per cent relative humidity (rain or spray) and all other conditions, such as dust, shock and vibrations, which may be encountered in regular operation.

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 **precision (including e. g. radar, GPS, etc.)** speed-measuring system shall be used.

The following tolerances shall be respected:

— **for speed measurement: ± 1 % or ± 0.5 km/h, whichever is greater;**

— **for distance: ± 1 · 10^{-1} m.**"

Paragraph 4.1.3., amend to read:

"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 ± 0.5 mm~~ **(1.0 ± 0.5) mm**, measured from the peak of the pavement.

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."

Paragraph 4.1.4.1., amend to read:

"4.1.4.1. Tyre preparation and ~~break in~~ **stabilization, rims and fitment on the vehicle**

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

Fit the test tyres on rims specified by a recognized tyre and rim standards organization as listed in Appendix 4 to Annex 6 to this Regulation. **Rim width code shall not differ by more than 0.5 from the measuring rim width code. Ensure proper bead seating 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 tyres should be stabilized in performance prior to testing, which means that no evolution of the BFC value in test runs should be detectable; in any case there will be an ex-post verification according to paragraph 4.1.6.2. of this Annex. 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.

Place the fitted test tyres in a location such that they all have the same ambient temperature prior to testing and shield them from the sun to avoid excessive heating by solar radiation.

Maximum spacer (adapter) width allowed to mount tyres on the vehicle is 60 mm."

Paragraph 4.1.4.2., amend to read:

"4.1.4.2. Tyre load

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

It is prohibited to exceed the maximum axle load of the vehicle."

Paragraph 4.1.4.3., amend to read:

"4.1.4.3. Tyre inflation pressure

On the front axle, the inflation pressures *p* shall be calculated as follows:

$$p = p_{\text{ref}} \cdot \left(1.3 \cdot \frac{Q}{Q_{\text{ref}}}\right)^{1.25}$$

where

***p*ref** **is the reference inflation pressure (250 kPa for standard-load and 290 kPa for extra-load versions, regardless of the reference pressure in the applicable standard);**

Q **is the average tyre vertical load on the front axle;**

***Q*ref** **is the reference vertical load associated with the load-capacity index.**

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

Paragraph 4.1.5.1.1., amend to read:

"4.1.5.1.1. The passenger car is driven in a straight line up to ~~85 ± 2 km/h~~ **(85 ± 2) km/h**."

Paragraph 4.1.5.1.2., amend to read:

"4.1.5.1.2. Once the passenger car has reached ~~85 ± 2 km/h~~ **(85 ± 2) km/h**, the brakes ~~are~~ **shall** always **be** 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. **Braking tests shall occur on the same lanes and in the same direction that was used to examine the surface, including where the macro texture depth was measured, in accordance with paragraphs 3.1.4. and 3.1.5. above (with a transverse tolerance of 0.5 m).**"

Paragraph 4.1.5.1.3.2., amend to read:

"4.1.5.1.3.2. The manual activation of the brakes depends on the type of transmission as follows. In both cases, ~~a minimum of 600 N~~ **the** pedal ~~efforts is required~~ **effort shall be high enough to activate the ABS**.

For manual transmission, **as soon as the driver is in the measuring zone and having reached (85 ± 2) km/h,** 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, **as soon as the driver is in the measuring zone and having reached (85 ± 2) km/h,** the driver should select neutral gear and then depress the brake pedal sharply, holding it down as long as necessary to perform the measurement.

For each braking test and for tyres not tested before, the first two runs shall be discarded."

Paragraph 4.1.5.1.4., amend to read:

"4.1.5.1.4. ~~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~~ **test run** is ~~discarded~~ **invalidated** and a new test run is made."

Paragraph 4.1.5.2., amend to read:

"4.1.5.2. ~~Test~~ **Braking test and 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 sets of candidate tyres may be measured within the same test cycle:~~

Within the same test cycle, each test run of each braking test shall be made in the same direction and in accordance with paragraph 4.1.5.1. of this Annex. Several test cycles may be performed consecutively, where the final braking test of the reference tyre set of a test cycle may serve as the initial braking test of the reference test tyre set for the next test cycle.

Up to three different candidate tyre sets may be measured within the same test cycle according to the following procedure:"

Paragraph 4.1.5.2.1., amend to read:

"4.1.5.2.1. **Initial braking test of the reference tyre (R_i):** First, the ~~set of reference tyres are~~ **reference tyre set is** mounted on the instrumented passenger car **and at least four (4) valid test runs shall be made**."

Paragraph 4.1.5.2.2., amend to read:

"4.1.5.2.2. **Braking test of a candidate tyre set (T_n):** ~~After at least three valid measurements have been made in accordance with paragraph 4.1.5.1. above, the set of reference tyres~~ **The reference tyre set** is replaced by a ~~set of~~ candidate ~~tyres~~ **tyre set (T_n) and at least six (6) valid test runs of the candidate tyres shall be performed**."

Paragraph 4.1.5.2.3., amend to read:

"4.1.5.2.3. After ~~six valid measurements~~ **the braking test** of the **first** candidate ~~tyres~~ **tyre set** ~~are performed~~, **up to** two more ~~sets of~~ candidate ~~tyres~~ **tyre sets** may be measured."

Paragraph 4.1.5.2.4., amend to read:

"4.1.5.2.4. **Final braking test of the reference tyres (R_f):** The test cycle is closed by ~~three more~~ **at least four (4)** valid ~~measurements~~ **test runs** of the same ~~set of~~ reference ~~tyres~~ **tyre set** as at the beginning of the test cycle.

Examples:

(a) The run order for a test cycle of three ~~sets of candidate tyres (T1 to T3) plus a set of reference tyres (R)~~ **candidate tyre sets (T_1 to T_3)** would be the following:

~~R T1 T2 T3 R~~ **$R_i – T_1 – T_2 – T_3 – R_f$**

(b) The run order for a **braking test (consisting of two** test ~~cycle~~ **cycles)** of five ~~sets of candidate tyres (T1 to T5) plus a set of reference tyres (R)~~ **candidate tyre sets (T_1 to T_5)** would be the following:

~~R T1 T2 T3 R T4 T5 R~~ **$R_i – T_1 – T_2 – T_3 – R_f/R_i – T_4 – T_5 – R_f$**"

Paragraph 4.1.6.1., amend to read:

"4.1.6.1. Calculation of the ~~Average Deceleration (AD)~~ **average Braking Force Coefficient**

~~The Average Deceleration (AD)~~ **For each valid test run *j*, the average Braking Force Coefficient $BFC_{ave,j}$** is calculated ~~for each valid test run in m/s^2~~ **from the distance d_j covered between 80 km/h and 20 km/h** as follows:

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

$$BFC_{ave,j} = \frac{v_i^2 - v_f^2}{2 \cdot d_j \cdot g}$$

where

~~S_f~~ ~~v_f~~ is the final speed in m/s; ~~S_f~~ ~~v_f~~ = 20 km/h = 5.556 m/s

~~S_i~~ ~~v_i~~ is the initial speed in m/s; ~~S_i~~ v_i = 80 km/h = 22.222 m/s

~~d~~ d_j is the distance covered **in test run** j between ~~S_i~~ ~~v_i~~ and ~~S_f~~ ~~v_f~~ in meters;

g **is the acceleration due to gravity = 9.81 m·s^{-2}**."

Paragraph 4.1.6.2., amend to read:

"4.1.6.2. Validation of results

The ~~AD~~ coefficient of variation ~~CV_{AD}~~ CV_{BFC} is calculated as follows:

~~$$CV_{AD} = 100\% \cdot \frac{\sigma_{AD}}{\overline{AD}}$$~~

$$CV_{BFC} = 100\% \cdot \frac{\sigma_{BFC}}{\overline{BFC_{ave}}}$$

where

~~$\sigma_{AD} = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(AD_i - \overline{AD})^2}$~~ $\sigma_{BFC} = \sqrt{\frac{1}{N-1}\sum_{j=1}^{N}\left(BFC_{ave,j} - \overline{BFC_{ave}}\right)^2}$

denotes the corrected sample standard deviation and

~~$\overline{AD}$~~ $\overline{BFC_{ave}}$ the arithmetic mean of the ~~Average Decelerations (AD_i)~~ **average Braking Force Coefficients** $BFC_{ave,j}$ of N test runs.

For the reference ~~tyres (R)~~ **tyre**:

~~If the AD coefficient of variation of any two consecutive groups of three tests runs of the reference tyre set is higher than 3 per cent, all data should be discarded and the test repeated for all test tyres (the candidate tyres and the reference tyres).~~

(a) The coefficient of variation CV_{BFC} of the initial and the final braking test of the reference tyre within one test cycle shall be less than or equal to 4 per cent.

(b) The arithmetic means of the average Braking Force Coefficients of the initial and the final braking test shall not differ by more than 5 per cent of the average of the two values:

$$CVal(BFC_{ave}) = 100\% \cdot 2 \cdot \left|\frac{\overline{BFC_{ave}}(\mathrm{R_i}) - \overline{BFC_{ave}}(\mathrm{R_f})}{\overline{BFC_{ave}}(\mathrm{R_i}) + \overline{BFC_{ave}}(\mathrm{R_f})}\right| \leq 5\%$$

where

$\overline{BFC_{ave}}(\mathrm{R_i})$ / $\overline{BFC_{ave}}(\mathrm{R_f})$ is the arithmetic mean of the average Braking Force Coefficients in the initial/final braking test of the reference tyre within a test cycle.

(c) The temperature-corrected average Braking Force Coefficients ($BFC_{ave,corr}$, see paragraph 3.2.1. of this Annex) as calculated from the initial and from the final braking tests of the reference tyre within a test cycle shall be not less than 0.57 and not greater than 0.79.

If one or more of the above conditions is not met, the complete test cycle shall be performed again.

For the candidate tyres (T):

The ~~AD coefficients~~ **coefficient** of variation CV_{BFC} ~~are~~ **is** calculated for each candidate tyre set. If one coefficient of variation is higher than ~~3 per cent~~ **4 per**

cent, the data ~~should~~ **shall** be discarded and the **braking** test repeated for that candidate tyre set."

Paragraph 4.1.6.3., amend to read:

"4.1.6.3. Calculation of adjusted average ~~deceleration (Ra)~~ **Braking Force Coefficient**

The ~~Average Deceleration (AD)~~ **average Braking Force Coefficient** 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~~ **average Braking Force Coefficient** of the reference tyre ~~(Ra)~~ $\boldsymbol{BFC_{adj}(R)}$ is calculated ~~in m/s²~~ in accordance with Table 1 where ~~R_1~~ $\boldsymbol{\overline{BFC_{ave}}(R_i)}$ is the ~~average~~ **arithmetic mean** of the ~~AD values~~**average Braking Force Coefficients** in the ~~first~~ **initial braking** test of the reference tyre set ~~(R)~~ **(R_i)** and ~~R_2~~ $\boldsymbol{\overline{BFC_{ave}}(R_f)}$ is the ~~average~~ **arithmetic mean** of the ~~AD values~~ **average Braking Force Coefficients** in the ~~second~~ **final braking** test of the same reference tyre set ~~(R)~~ **(R_f) within the test cycle**.

Table 1

~~*Number of sets of candidate tyres within one test cycle*~~	~~*Set of candidate tyres*~~	~~*Ra*~~
~~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~~

If the number and the sequence of candidate tyre sets within one test cycle is:	***and the candidate tyre set to be qualified within this test cycle is:***	***the corresponding adjusted average Braking Force Coefficient of the reference tyre is calculated as follows:***
1 R_i – T_1 – R_f	**T_1**	$\boldsymbol{BFC_{adj}(R) = {}^1\!/_2 \cdot [\overline{BFC_{ave}}(R_i) + \overline{BFC_{ave}}(R_f)]}$
2 R_i – T_1 – T_2 – R_f	**T_1**	$\boldsymbol{BFC_{adj}(R) = {}^2\!/_3 \cdot \overline{BFC_{ave}}(R_i) + {}^1\!/_3 \cdot \overline{BFC_{ave}}(R_f)}$
	T_2	$\boldsymbol{BFC_{adj}(R) = {}^1\!/_3 \cdot \overline{BFC_{ave}}(R_i) + {}^2\!/_3 \cdot \overline{BFC_{ave}}(R_f)}$
3 R_i – T_1 – T_2 – T_3 – R_f	**T_1**	$\boldsymbol{BFC_{adj}(R) = {}^3\!/_4 \cdot \overline{BFC_{ave}}(R_i) + {}^1\!/_4 \cdot \overline{BFC_{ave}}(R_f)}$
	T_2	$\boldsymbol{BFC_{adj}(R) = {}^1\!/_2 \cdot [\overline{BFC_{ave}}(R_i) + \overline{BFC_{ave}}(R_f)]}$
	T_3	$\boldsymbol{BFC_{adj}(R) = {}^1\!/_4 \cdot \overline{BFC_{ave}}(R_i) + {}^3\!/_4 \cdot \overline{BFC_{ave}}(R_f)}$

"

Paragraph 4.1.6.4., delete.

Paragraph 4.1.6.5., renumber as 4.1.6.4. and amend to read:

"~~4.1.6.5.~~**4.1.6.4.** Calculation of the wet grip index of the candidate tyre

The wet grip index ***G(T_n)*** of the candidate tyre ~~G(T)~~ **T_n (n = 1, 2 or 3)** is calculated as follows:

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

$$\boldsymbol{G(T_n) = K_{vehicle} \cdot \{\overline{BFC_{ave}}(T_n) - [a \cdot \Delta BFC(R) + b \cdot \Delta\vartheta + c \cdot (\Delta\vartheta)^2 + d \cdot \Delta MTD]\}}$$

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 °C for normal tyres and t_0 = 10 °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 [a is expressed as (1/°C)]~~

$\overline{BFC_{ave}}(T_n)$ is the arithmetic mean of the average Braking Force Coefficients of the candidate tyre T_n within a braking test;

$$\Delta BFC(R) = BFC_{adj}(R) - BFC(R_0)$$

$BFC_{adj}(R)$ is the adjusted average Braking Force Coefficient in accordance with Table 1;

$BFC(R_0) = 0.68$ is fixed as the Braking Force Coefficient for the reference tyre in the reference conditions;

$$\Delta\vartheta = \vartheta - \vartheta_0$$

ϑ is the measured wet surface temperature in degrees Celsius when the candidate tyre T_n is tested;

ϑ_0 is the wetted surface reference temperature for the candidate tyre according to its category of use as listed in Table 2;

$$\Delta MTD = MTD - MTD_0$$

MTD **is the measured macro texture depth in mm of the track (see paragraph 3.1.4. of this Annex);**

$MTD_0 = 0.8$ mm is the macro texture depth of the reference track;

$K_{vehicle} = 1.87$ is a factor to grant consistency between previous calculation of the wet grip index and this one, and to ensure convergence between vehicle and trailer method and

coefficients *a*, *b*, *c* and *d* are given in Table 2.

Table 2

Category of use		ϑ_0 (°C)	*a*	*b* ($°C^{-1}$)	*c* ($°C^{-2}$)	*d* (mm^{-1})
Normal tyre		**20**	**+0.99382**	**+0.00269**	**−0.00028**	**−0.02472**
Snow tyre		**15**	**+0.92654**	**−0.00121**	**−0.00007**	**−0.04279**
	Snow tyre for use in severe snow conditions	**10**	**+0.72029**	**−0.00539**	**+0.00022**	**−0.03037**
Special-use tyre		**not defined**				

"

Paragraph 4.1.7., amend to read:

"4.1.7. **When a direct** ~~Wet grip performance~~ comparison between a candidate tyre and a reference tyre ~~using a control tyre~~ **on the same vehicle is not possible the test method using a trailer or a tyre test vehicle (paragraph 4.2. of this Annex) shall be used.**"

Paragraphs 4.1.7.1. to 4.1.7.3., delete.

Paragraph 4.1.7.4,. renumber as 3.4. and amend to read:

"~~4.1.7.4.~~**3.4.** Replacement of reference tyres ~~and control tyres~~

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

Paragraph 4.2.2.1., amend to read:

"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 ± 2 km/h~~ **(65 ± 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~~ **hereinafter** called "test position"**,** and the following accessories:

(a) Equipment to activate brakes in the test position;

(b) A water tank to store sufficient water to supply the road surface wetting system, unless external watering is used;

(c) 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.

In the case of the one axle trailer, in order to reduce "pitch disturbance", 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".

In order to reduce "lateral disturbance", the trailer or the tyre test vehicle should be technically designed to minimize lateral displacement during the application of maximum braking force. Visual lateral displacement should be avoided during braking manoeuvre.

The maximum variation of toe-settings and camber angle for the test position shall be within ±0.5° 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 paragraph 4.2.7.1. below.

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 paragraph 4.2.5.2. below."

Paragraph 4.2.2.2., amend to read:

"4.2.2.2. Measuring equipment

…

(a) The minimum frequency response shall be flat from 0 Hz to ~~50 Hz (100 Hz)~~ **100 Hz** within ±1 per cent full scale;

…"

Paragraph 4.2.3., amend to read:

"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 ± 2 km/h~~ **(65 ± 2) km/h**."

Paragraph 4.2.4., amend to read:

"4.2.4. Wetting conditions

The surface may be wetted from the track-side ("external watering") or by a wetting system incorporated in the test vehicle or the trailer ("self watering").

4.2.4.1. If "external watering" is used, 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 braking lanes used, the water depth shall be between 0.5 mm and 1.5 mm, measured from the peak of the pavement.

4.2.4.2. For "self watering" systems, the~~The~~ tow vehicle and trailer or the tyre test vehicle ~~may be optionally~~ **is** 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° to 30°.

The water shall strike the pavement 250 mm to 450 mm 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 ± 0.5 mm~~ **(1.0 ± 0.5) mm** and shall be consistent throughout the test to within ±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 l/s per meter of width of wetted surface in case of a water depth of 1.0 mm."

Paragraph 4.2.5.1., amend to read:

"4.2.5.1. Tyre preparation and ~~break in~~ **stabilization and rims**

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~~ **a** rim ~~declared by the tyre manufacturer~~ **specified by a recognized tyre and rim standards organization as listed in Appendix 4 to Annex 6 to this Regulation. The rim width code shall not differ by more than 0.5 from the measuring rim width code**.

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 tyres should be stabilized in performance prior to testing, which means that no evolution of the μ_{peak} value in test runs should be detectable; in any case there will be an ex-post verification according to paragraph 4.2.8.2. of this Annex. 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.

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 paragraphs 4.2.5.2, 4.2.5.3 and 4.2.7.1 respectively.~~"

Paragraph 4.2.5.2., amend to read:

"4.2.5.2. Tyre load

The test load on the test tyre is ~~75 ± 5 per cent~~ **(75 ± 5) per cent** of the tyre load capacity."

Paragraph 4.2.6.1., amend to read:

"4.2.6.1. ~~Trailer~~ **The test tyre set shall be installed on the measuring device and loaded to the specified test load according to paragraph 4.2.5.2. of this Annex.**

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".~~"

Paragraph 4.2.7.1.1., amend to read:

"4.2.7.1.1. The tow vehicle or the tyre test vehicle is driven onto the test track in a straight line at the specified test speed ~~65 ± 2 km/h~~ **(65 ± 2) km/h**."

Paragraph 4.2.7.1.3., amend to read:

"4.2.7.1.3. **For self-watering system,** ~~Water is~~ **water shall be** delivered to the pavement ahead of the test tyre approximately 0.5 s prior to brake application ~~(for internal watering system)~~."

Paragraph 4.2.7.1.4., amend to read:

"4.2.7.1.4. The ~~trailer~~ brakes ~~are~~ **shall be** activated within ~~2 meters~~ **an area of six (6) meters in the longitudinal direction and 0.5 meters in the transversal direction** of a measurement point of the wetted frictional properties of the surface and sand depth in accordance with paragraphs 3.1.4. and 3.1.5. above. **The test shall be run in the same direction as in paragraph 3.2.2. of this Annex.** 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."

Paragraph 4.2.7.2., amend to read:

"4.2.7.2. Test cycle

Within the same 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 **of each braking test** shall be made ~~from the same spot on the test track and~~ in the same direction **and in accordance with paragraph 4.2.7.1. of this Annex. Several test cycles may be performed consecutively, where the final braking test of the reference tyre set of a test cycle may serve as the initial braking test of the reference tyre set for the next test cycle**.

Up to three candidate ~~tyres~~ **tyre sets** may be measured within the same test cycle, provided that the tests are completed within one day."

Paragraph 4.2.7.2.1., amend to read:

"4.2.7.2.1. **Initial braking test of the reference tyre set (R_i): first** ~~First~~, the reference tyre **set** is ~~tested~~ **mounted and at least six (6) valid test runs shall be made in accordance with paragraph 4.2.7.1. above**."

Paragraph 4.2.7.2.2., amend to read:

"4.2.7.2.2. **Braking test of a candidate tyre set (T_n):** ~~After at least six valid measurements are performed in accordance with paragraph 4.2.7.1. above,~~ the reference tyre **set** is replaced by ~~the~~ **a** candidate tyre **set and at least six (6) valid test runs with the candidate tyre set shall be performed**."

Paragraph 4.2.7.2.3., amend to read:

"4.2.7.2.3. After ~~six valid measurements~~ **the braking test** of the **first** candidate tyre **set** ~~are performed~~, **up to** two more candidate ~~tyres~~ **tyre sets** may be measured."

Paragraph 4.2.7.2.4., amend to read:

"4.2.7.2.4. **Final braking test of the reference tyre set (R_f): the** ~~The~~ test cycle ~~is~~ **shall be** closed by **at least** six **(6)** more valid ~~measurements~~ **test runs** of the same reference tyre **set** as at the beginning of the test cycle.

Examples:

(a) The run order for a test cycle ~~of~~ **with** three candidate ~~tyres~~ **tyre sets (T_1 to T_3)** ~~(T1 to T3) plus the reference tyre (R)~~ would be the following:

~~R T1 T2 T3 R~~ **$R_i – T_1 – T_2 – T_3 – R_f$**

(b) The run order for a **braking** test **(consisting of two test** ~~cycle~~ **cycles)** of five candidate ~~tyres~~ **tyre sets (T_1 to T_5)** ~~(T1 to T5) plus the reference tyre R~~ would be the following:

~~R T1 T2 T3 R T4 T5 R~~ **$R_i – T_1 – T_2 – T_3 – R_f/R_i – T_4 – T_5 – R_f$** "

Paragraph 4.2.8.1., amend to read:

"4.2.8.1. Calculation of the peak braking force coefficient

~~The tyre~~ **For each test run, the** peak braking force coefficient (μ_{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.

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

$$\boldsymbol{\mu(t) = \left| \frac{f_h(t)}{f_v(t)} \right|}$$

where:

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

~~fh(t)~~ $\boldsymbol{f_h(t)}$ is the dynamic braking force in real time, in N;

~~$f_v(t)$~~ $f_v(t)$ is the dynamic vertical load in real time, in N."

Annex 5, Part (A), paragraph 4.2.8.2., amend to read:

"4.2.8.2. Validation of results

The μ_{peak} coefficient of variation CV_μ is calculated as follows:

$$CV_\mu = 100\% \cdot \frac{\sigma_\mu}{\overline{\mu_{peak}}}$$

where

$\sigma_\mu = \sqrt{\frac{1}{N-1}\sum_{j=1}^{N}\left(\mu_{peak,j} - \overline{\mu_{peak}}\right)^2}$ denotes the corrected sample standard deviation and

$\overline{\mu_{peak}}$ the arithmetic mean of the peak braking force coefficients ($\mu_{peak,j}$) of N test runs.

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

(a) The coefficients of variation CV_μ of the initial and the final braking tests of the reference tyre within one test cycle shall be less than or equal to 4 per cent;

(b) The arithmetic mean of the peak braking force coefficients of initial and the final braking test of the reference tyre within one test cycle shall not differ by more than 5 per cent of the average of the two values:

$$\boldsymbol{CVal(\mu_{peak}) = 100\% \cdot 2 \cdot \left|\frac{\overline{\mu_{peak}}(R_i) - \overline{\mu_{peak}}(R_f)}{\overline{\mu_{peak}}(R_i) + \overline{\mu_{peak}}(R_f)}\right| \leq 5\ \%}$$

where

$\overline{\mu_{peak}}(R_i)$ / $\overline{\mu_{peak}}(R_i)$ is the arithmetic mean of the peak braking force coefficients in the initial/final braking test of the reference tyre within a test cycle;

(c) The temperature-corrected average peak braking force coefficients ($\mu_{peak,corr}$, see paragraph 3.2.2. of this Annex) as calculated from the initial and from the final braking test of the reference tyre within a test cycle shall be not less than 0.65 and not greater than 0.90.

If one or more of the above conditions is not met, the complete test cycle shall be performed again.

For the candidate tyre(s) (T_n):

The coefficient of variation of the peak braking force coefficient ~~(μ_{peak})~~ CV_μ is calculated for each candidate tyre. If one coefficient of variation is ~~higher~~ **greater** than 5 per cent, the data ~~should~~ **shall** be discarded and the **braking** test repeated for this candidate tyre."

Paragraph 4.2.8.3., amend to read:

"4.2.8.3. Calculation of the adjusted average peak braking force coefficient **of the reference tyre**

The average peak braking force 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 force coefficient of the reference tyre ~~(Ra)~~ $\mu_{peak,adj}(\mathbf{R})$ is calculated in accordance with Table 3 where ~~R_1~~ ~~$\overline{\mu_{peak}}(R_i)$~~ is the ~~average~~ **arithmetic mean of the** peak ~~tyre~~ braking **force coefficients** ~~coefficient~~ in the ~~first~~ **initial** test of the reference tyre ~~(R)~~ **(R_i)** and ~~R_2~~ ~~$\overline{\mu_{peak}}(R_f)$~~ is the ~~average~~ **arithmetic mean of the** peak ~~tyre~~ braking **force coefficients** ~~coefficient~~ in the ~~second~~ **final** test of the same reference tyre ~~(R)~~ **(R_f) within one test cycle**.

Table 3

~~*Number of candidate tyre(s) within one test cycle*~~	~~*Candidate tyre*~~	~~*Ra*~~
~~1 (R1-T1-R2)~~	~~T1~~	~~Ra = 1/2 (R_1 + R_2)~~
~~2 (R1-T1-T2-R2)~~	~~T1~~	~~Ra = 2/3 R_1 + 1/3 R_2~~
	~~T2~~	~~Ra = 1/3 R_1 + 2/3 R_2~~
~~3 (R1-T1-T2-T3-R2)~~	~~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~~

If the number and the sequence of candidate tyre sets within one test cycle is:	***and the candidate tyre set to be qualified within this test cycle is:***	***the corresponding adjusted peak braking force coefficients of the reference tyre is calculated as follows:***
1 $R_i – T_1 – R_f$	**T_1**	$\mu_{peak,adj}(\mathbf{R}) = {}^{1}/_{2} \cdot [\overline{\mu_{peak}}(\mathbf{R_i}) + \overline{\mu_{peak}}(\mathbf{R_f})]$
2 $R_i – T_1 – T_2 – R_f$	**T_1**	$\mu_{peak,adj}(\mathbf{R}) = {}^{2}/_{3} \cdot \overline{\mu_{peak}}(\mathbf{R_i}) + {}^{1}/_{3} \cdot \overline{\mu_{peak}}(\mathbf{R_f})$
	T_2	$\mu_{peak,adj}(\mathbf{R}) = {}^{1}/_{3} \cdot \overline{\mu_{peak}}(\mathbf{R_i}) + {}^{2}/_{3} \cdot \overline{\mu_{peak}}(\mathbf{R_f})$
3 $R_i – T_1 – T_2 – T_3 – R_f$	**T_1**	$\mu_{peak,adj}(\mathbf{R}) = {}^{3}/_{4} \cdot \overline{\mu_{peak}}(\mathbf{R_i}) + {}^{1}/_{4} \cdot \overline{\mu_{peak}}(\mathbf{R_f})$
	T_2	$\mu_{peak,adj}(\boldsymbol{R}) = {}^{1}/_{2} \cdot [\overline{\mu_{peak}}(\mathbf{R_i}) + \overline{\mu_{peak}}(\mathbf{R_f})]$
	T_3	$\mu_{peak,adj}(\mathbf{R}) = {}^{1}/_{4} \cdot \overline{\mu_{peak}}(\mathbf{R_i}) + {}^{3}/_{4} \cdot \overline{\mu_{peak}}(\mathbf{R_f})$

"

Paragraph 4.2.8.4., delete.

Paragraph 4.2.8.5., renumber as 4.2.8.4. and amend to read:

"~~4.2.8.5.~~ **4.2.8.4.** Calculation of the wet grip index of the candidate tyre

The wet grip index ***G(*$\mathbf{T}_n$*)*** of the candidate tyre ~~(G(T))~~ $\mathbf{T}_n$ **(n = 1, 2, 3)** is calculated as follows:

~~$$G(T) = \left[\frac{\mu_{peak,ave}(T)}{\mu_{peak,ave}(R)} \times 125 + a \times (t - t_0) + b \times \left(\frac{\mu_{peak,ave}(R)}{\mu_{peak,ave}(R_0)} - 1.0 \right) \right] \times 10^{-2}$$~~

$$\boldsymbol{G}(\mathbf{T_n}) = \boldsymbol{K}_{\mathbf{trailer}} \cdot \{\overline{\boldsymbol{\mu_{peak}}}(\mathbf{T_n}) - [\boldsymbol{a} \cdot \Delta\boldsymbol{\mu_{peak}}(\mathbf{R}) + \boldsymbol{b} \cdot \Delta\boldsymbol{\vartheta} + \boldsymbol{c} \cdot (\Delta\boldsymbol{\vartheta})^2 + \boldsymbol{d} \cdot \Delta\boldsymbol{MTD}]\}$$

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 °C for normal tyres t_0=10°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 [a is expressed as (1/°C)].~~"

$\overline{\mu_{peak}}(T_n)$ **is the arithmetic mean of the peak braking force coefficients of the candidate tyre T_n within a braking test;**

$$\Delta\mu_{peak}(R) = \mu_{peak,adj}(R) - \mu_{peak}(R_0)$$

$\mu_{peak,adj}(R)$ **is the adjusted peak braking force coefficient in accordance with Table 3;**

$\mu_{peak}(R_0) = 0.85$ **is fixed as the peak braking force coefficient for the reference tyre in the reference conditions;**

$$\Delta\vartheta = \vartheta - \vartheta_0$$

ϑ **is the measured wet surface temperature in degrees Celsius when the candidate tyre T_n is tested;**

ϑ_0 **is the wetted surface reference temperature for the candidate tyre according to its sidewall marking as listed in Table 4;**

$$\Delta MTD = MTD - MTD_0$$

MTD **is the measured macro texture depth of the track**

$MTD_0 = 0.8$ **mm is fixed as the macro texture depth of the reference track;**

$K_{trailer} = 1.50$ **is a factor to grant consistency between previous calculation of the wet grip index and this one, and to ensure convergence between vehicle and trailer method and**

coefficient *a*, *b*, *c* and *d* are given in Table 4.

Table 4

Category of use		ϑ_0 (°C)	*a*	*b* ($°C^{-1}$)	*c* ($°C^{-2}$)	*d* (mm^{-1})
Normal tyre		**20**	**+0.99757**	**+0.00251**	**−0.00028**	**+0.07759**
Snow tyre		**15**	**+0.87084**	**−0.00025**	**+0.00004**	**−0.01635**
	Snow tyre for use in severe snow conditions	**10**	**+0.67929**	**+0.00115**	**−0.00005**	**+0.03963**
Special-use tyre		**not defined**				

"

Annex 5 – Appendix, amend to read*:*

"Annex 5 – Appendix

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):~~
~~µ peak (SRTT14-E1136) :~~	~~or BPN:~~
~~Speed (km/h):~~	~~Water depth (mm):~~

~~*No.*~~		~~*1*~~	~~*2*~~	~~*3*~~	~~*4*~~	~~*5*~~	~~*6*~~	~~*7*~~	~~*8*~~	~~*9*~~	~~*10*~~
~~Size~~											
~~Service description~~											
~~Reference (test) inflation pressure[(1)] (kPa)~~											
~~Tyre identification~~											
~~Rim~~											
~~Pattern~~											
~~Load (N)~~											
~~Pressure (kPa)~~											
~~µpeak~~	~~1~~										
	~~2~~										
	~~3~~										
	~~4~~										
	~~5~~										
	~~6~~										
	~~7~~										
	~~8~~										
~~Average~~											
~~Standard deviation σ~~											
~~(σ/average)≤5 per cent~~											
~~Ra, Adjusted~~											
~~Wet Grip Index~~											
~~Surface temp. (°C)~~											
~~Ambient temp. (°C)~~											
~~Remarks~~											

~~[(1)] for C2 and C3 tyres, corresponding to the indication of the inflation pressure marked on the sidewall as required by paragraph 4.1. of this Regulation~~

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

Driver:	Test date:

Track:		Passenger car:	Initial speed (km/h):
	Texture depth (mm):	Brand:	Final speed (km/h):
	BPN:	Model:	
	Water depth (mm):	Type	

No.		*1*		*2*		*3*		*4*		*5*	
Brand name		Uniroyal		TYRE B		TYRE C		TYRE D		Uniroyal	
Pattern/Trade description		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	
Reference (test) inflation pressure[(1)] (kPa)											
Tyre identification		XXXXXXXXX		YYYYYYYY		ZZZZZZZZ		NNNNNNNNN		XXXXXXXXX	
Rim											
Front axle pressure (kPa)											
Rear axle pressure (kPa)											
Front axle load (kg)											
Rear axle load (kg)											
Wet surface temp (°C)											
Ambient temp (°C)											
		Braking distance (m)	*Average deceleration (m/s^2)*	*Braking distance (m)*	*Average deceleration (m/s^2)*	*Braking distance (m)*	*Average deceleration (m/s^2)*	*Braking distance (m)*	*Average deceleration (m/s^2)*	*Braking distance (m)*	*Average deceleration (m/s^2)*
Measurement	1										
	2										
	3										
	4										
	5										
	6										
	7										
	8										
	9										
	10										
Average AD (m/s^2)											
Standard deviation (m/s^2)											
Validation of results Coeff. of variation (per cent) < 3 per cent											
Adjusted average AD of ref. tyre: R_e (m/s^2)											
BFC(R) reference tyre (SRTT16)											
BFC(T) candidate tyre											
Wet grip index (%)											

[(1)] for C2 and C3 tyres, corresponding to the indication of the inflation pressure marked on the sidewall as required by paragraph 4.1. of this Regulation

Example 1: **Test report of wet grip index using trailer or tyre test vehicle method**

Test report number:		**Test date:**	

Track:	
Texture depth (mm):	
$\mu_{peak,corr}$:	
Water depth (mm):	

	Minimum:	**Maximum:**
Wetted surface temp. (°C):		
Ambient temp (°C):		

Speed (km/h):	

No.		***1***	***2***	***3***	***4***	***5***
Brand						
Pattern/Trade description		**SRTT…**				**SRTT…**
Size						
Service description						
Reference (test) inflation pressure[(1)] (kPa)						
Tyre identification						
M+S marking (Y/N)						
3PMSF marking (Y/N)						
Rim						
Load (kg)						
Pressure (kPa)						
μ_{peak}	**1**					
	2					
	3					
	4					
	5					
	6					
	7					
	8					
$\overline{\mu_{peak}}$						
Standard deviation, σ_μ						
$CV_\mu \leq 4$ %						
$CVal(\mu_{peak}) \leq 5$ %						
$\mu_{peak,corr}$(R)						
$\mu_{peak,adj}$(R)						
Wet grip index						
Wetted surface temp. (°C)						
Ambient temp. (°C)						
Remarks						

[(1)] for C2 and C3 tyres, corresponding to the indication of the inflation pressure marked on the sidewall as required by paragraph 4.1. of this Regulation

Example 2: **Test report of wet grip index using vehicle method**

Test report number:		**Test date:**			**Driver:**		
Track:			**Minimum:**	**Maximum:**	**Vehicle**		
Texture depth (mm):		**Wetted surface temp. (°C):**			**Brand:**		
$BFC_{ave,corr,1}$**:**		**Ambient temp (°C):**			**Model:**		
$BFC_{ave,corr,2}$**:**					**Type:**		
$CVal(BFC_{ave,corr})$**:**					**Year of registration:**		
Water depth (mm):					**Maximum axle load:**	**Front**	**Rear**
Initial speed (km/h):		**Final speed (km/h):**					

No.		***1***		***2***		***3***		***4***		***5***	
Brand											
Pattern/Trade description		**SRTT…**								**SRTT…**	
Size											
Service description											
Reference (test) inflation pressure(1) (kPa)											
Tyre identification											
M+S marking (Y/N)											
3PMSF marking (Y/N)											
Rim											
Front axle pressure (kPa)		**left:**	**right:**	**left:**	**right:**	**left:**	**right:**	**left:**	**right:**	**left:**	**right:**
Rear axle pressure (kPa)		**left:**	**right:**	**left:**	**right:**	**left:**	**right:**	**left:**	**right:**	**left:**	**right:**
Front axle load (kg)		**left:**	**right:**	**left:**	**right:**	**left:**	**right:**	**left:**	**right:**	**left:**	**right:**
Rear axle load (kg)		**left:**	**right:**	**left:**	**right:**	**left:**	**right:**	**left:**	**right:**	**left:**	**right:**
		Braking distance (m)	BFC_i	***Braking distance (m)***	BFC_i	***Braking distance (m)***	BFC_i	***Braking distance (m)***	BFC_i	***Braking distance (m)***	BFC_i
Measurement	**1**										
	2										
	3										
	4										
	5										
	6										
	7										
	8										
	9										
	10										
$\overline{BFC_{ave}}$											
Standard deviation, σ_{BFC}											
$CV_{BFC} \leq 4$ **%**											
$CVal(BFC_{ave}) \leq 5$ **%**											
$BFC_{ave,corr}$**(R)**											
BFC_{adj}**(R)**											
Wet grip index											

Wetted surface temp. (°C)					
Ambient temp. (°C)					
Remarks					

(1) for C2 and C3 tyres, corresponding to the indication of the inflation pressure marked on the sidewall as required by paragraph 4.1. of this Regulation."

II. Justification

1. As presented in Informal documents GRB-68-15 and GRBP-70-20, the goal of this amendment is to improve the reproducibility of the test method. Standard ISO 23671 is in the process of being revised in the same way as proposed in this document in order to ensure global standardization and to promote harmonization worldwide.

2. The transitional provisions 12.zz. are introduced to ensure that technical services may adapt the test tracks to the new requirements.

3. The revision of standard ASTM F2493-19 is purely editorial and it now includes the maximum load and pressure information.

4. Test report templates are aligned to the new test procedure.