

6 December 2012

Agreement

Concerning the adoption of uniform technical prescriptions for wheeled vehicles, equipment and parts which can be fitted and/or be used on wheeled vehicles and the conditions for reciprocal recognition of approvals granted on the basis of these prescriptions*

(Revision 2, including the amendments which entered into force on 16 October 1995)

Addendum 116: Regulation No. 117

Revision 2 – Amendment 1

Supplement 1 to the 02 series of amendments - Date of entry into force: 18 November 2012

Uniform provisions concerning the approval of tyres with regard to rolling sound emissions and to adhesion on wet surfaces



UNITED NATIONS

* Former title of the Agreement: Agreement Concerning the Adoption of Uniform Conditions of Approval and Reciprocal Recognition of Approval for Motor Vehicle Equipment and Parts, done at Geneva on 20 March 1958.

Contents, amend to read:

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Paragraph 2.16., amend to read:

"2.16. "Standard reference test tyre" (SRTT) means a tyre that is produced, controlled and stored in accordance with the ASTM (American Society for Testing and Materials) standards

- (a) E1136-93 (2003) for the size P195/75R14
- (b) F2871 (2011) for the size 245/70R19.5
- (c) F2870 (2011) for the size 315/70R22.5."

Paragraph 2.17., amend to read:

"2.17. Wet Grip or Snow Grip measurements – Specific definitions"

Paragraph 2.17.3., amend to read:

"2.17.3. "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. of Annex 5 and paragraph 3.4.3. of Annex 7 to this Regulation."

Insert new paragraph 2.17.5., to read:

"2.17.5. "Snow grip index ("SG")" means the ratio between the performance of the candidate tyre and the performance of the standard reference test tyre."

Paragraphs 2.17.5. (former) to 2.17.7., renumber as paragraphs 2.17.6. to 2.17.8.

Paragraph 6.4., amend to read:

"6.4. In order to be classified in the category of use "snow tyre", a tyre is required to meet performance requirements based on a test method by which:

- (a) the mean fully developed deceleration ("mfdd") in a braking test,
- (b) or alternatively an average traction force in a traction test,
- (c) or alternatively the average acceleration in an acceleration test

of a candidate tyre is compared to that of a standard reference tyre.

The relative performance shall be indicated by a snow index."

Paragraph 6.4.1.1., amend to read:

"6.4.1.1. Class C1, C2 and C3 tyres

The minimum snow index value, as calculated in the procedure described in Annex 7 and compared with the SRTT shall be as follows:

Class of tyre	Snow gripe index (brake on snow method) ^(a)	Snow grip index (spin traction method) ^(b)	Snow grip index (acceleration method) ^(c)
	Ref. = C1 – SRTT 14	Ref. = C1 – SRTT 14	Ref. = C3N – SRTT 19.5 Ref. = C3W – SRTT 22.5
C1	1.07	1.10	No
C2	No	1.10	No
C3	No	No	1.25

^(a) See paragraph 3. of Annex 7 to this Regulation

^(b) See paragraph 2. of Annex 7 to this Regulation

^(c) See paragraph 4. of Annex 7 to this Regulation "

Annex 5 and its Appendix, amend to read:

"Annex 5

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

1. Reference standards
The following documents listed apply.
 - 1.1. ASTM E 303-93 (Reapproved 2008), Standard Test Method for Measuring Surface Frictional Properties Using the British Pendulum Tester.
 - 1.2. ASTM E 501-08, Standard Specification for Standard Rib Tire for Pavement Skid-Resistance Tests.
 - 1.3. ASTM E 965-96 (Reapproved 2006), Standard Test Method for Measuring Pavement Macrotexture Depth Using a Volumetric Technique.
 - 1.4. ASTM E 1136-93 (Reapproved 2003), Standard Specification for a Radial Standard Reference Test Tire P195/75R14.
 - 1.5. ASTM F 2493-08, Standard Specification for a Radial Standard Reference Test Tire P225/60R16.
2. Definitions
For the purposes of testing wet grip of C1 tyres:
 - 2.1. "Test run" means a single pass of a loaded tyre over a given test track surface.
 - 2.2. "Test tyre(s)" means a candidate tyre, a reference tyre or a control tyre or tyre set that is used in a test run.
 - 2.3. "Candidate tyre(s) (T)" means a tyre or a tyre set that is tested for the purpose of calculating its wet grip index.
 - 2.4. "Reference tyre(s) (R)" means a tyre or a tyre set that has the characteristics indicated in the ASTM F 2493-08 and referred to as the Standard Reference Test Tyre.

- 2.5. *"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.
- 2.6. *"Braking force of a tyre"* means the longitudinal force, expressed in newton, resulting from braking torque application.
- 2.7. *"Braking force coefficient of a tyre (BFC)"* means the ratio of the braking force to the vertical load.
- 2.8. *"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.
- 2.9. *"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.
- 2.10. *"Vertical load"* means the load in newton imposed on the tyre perpendicular to the road surface.
- 2.11. *"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.
- 2.12. "SRTT14" means the ASTM E 1136-93 (Reapproved 2003), Standard Specification for a Radial Standard Reference Test Tire P195/75R14.
- 2.13. "SRTT16" means the ASTM F 2493-08, Standard Specification for a Radial Standard Reference Test Tire P225/60R16.
3. General test conditions
 - 3.1. Track characteristics

The test track shall have the following characteristics:

 - 3.1.1. The surface shall have a dense asphalt surface with a uniform gradient of not more than 2 per cent and shall not deviate more than 6 mm when tested with a 3 m straight edge.
 - 3.1.2. The surface shall have a pavement of uniform age, composition, and wear. The test surface shall be free of loose material and foreign deposits.
 - 3.1.3. The maximum chipping size shall be 10 mm (tolerances permitted from 8 mm to 13 mm).
 - 3.1.4. The texture depth as measured by a sand patch shall be 0.7 ± 0.3 mm. It shall be measured in accordance with ASTM E 965-96 (Reapproved 2006).
 - 3.1.5. 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
 - 3.2.1. British Pendulum Number (BPN) method (a)

The British Pendulum Number method shall be as defined in ASTM E 303-93 (Reapproved in 2008).

Pad rubber component formulation and physical properties shall be as specified in ASTM E 501-08.

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:

BPN = BPN(measured value) + temperature correction

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 2008).

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 per cent.

3.2.2. ASTM E 1136 Standard Reference Test Tyre method (b)

By derogation with paragraph 2.4., this method uses the reference tyre that has the characteristics indicated in the ASTM E 1136-93 (Reapproved 2003) and referred to as SRTT14.

The average peak braking force coefficient ($\mu_{\text{peak,ave}}$) of the SRTT14 shall be 0.7 ± 0.1 at 65 km/h.

The average peak braking force coefficient ($\mu_{\text{peak,ave}}$) of the SRTT14 shall be corrected for the wetted road surface temperature as follows:

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

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.

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

- 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 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.
- 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.
- 4.1.5.1.1. The passenger car is driven in a straight line up to 85 ± 2 km/h.
- 4.1.5.1.2. Once the passenger car has reached 85 ± 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.
- 4.1.5.1.3. The brakes are activated either automatically or manually.
- 4.1.5.1.3.1. 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.
- 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 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.

- 4.1.5.1.4. 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 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 sets of candidate tyres may be measured within the same test cycle:
- 4.1.5.2.1. First, the set of reference tyres are mounted on the instrumented passenger car.
- 4.1.5.2.2. 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.
- 4.1.5.2.3. After six valid measurements of the candidate tyres are performed, two more sets of candidate tyres may be measured.
- 4.1.5.2.4. 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:

- (a) 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

- (b) 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 m/s² as follows:

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

where:

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

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

d is the distance covered between S_i and S_f in metre.

- 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 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).

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 per cent, 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

<i>Number of sets of candidate tyres within one test cycle</i>	<i>Set of candidate tyres</i>	<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, $g = 9.81 m/s^2$	

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

t₀ is the wet surface reference temperature condition, t₀ = 20 °C for normal tyres and t₀ = 10 °C for snow tyres

BFC(R₀) is the braking force coefficient for the reference tyre in the reference conditions, BFC(R₀) = 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)]

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 paragraph 2.5.

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 ±5 °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 index of the candidate tyre (G(T)) is calculated as follows:

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

where:

G₁ 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:

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

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 2003) 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 (b) 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 ± 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:

- (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.

The maximum variation of toe-settings and camber angle 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:

- (a) Overall system accuracy, force: ± 1.5 per cent of the full scale of the vertical load or braking force;
- (b) Overall system accuracy, speed: ± 1.5 per cent of speed or ± 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 per cent to at least 125 per cent 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:

- (a) The minimum frequency response shall be flat from 0 Hz to 50 Hz (100 Hz) within ± 1 per cent full scale;
- (b) The signal-to-noise ratio shall be at least 20/1;
- (c) The gain shall be sufficient to permit full-scale display for full-scale input signal level;
- (d) The input impedance shall be at least ten times larger than the output impedance of the signal source;
- (e) 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 ± 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° 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 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.

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 paragraphs 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 ± 5 per cent of the 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:
- 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.
- 4.2.7.1.2. The recording system is launched.
- 4.2.7.1.3. Water is delivered to the pavement ahead of the test tyre approximately 0.5 s prior to brake application (for internal watering system).
- 4.2.7.1.4. 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 paragraphs 3.1.4. and 3.1.5. . 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.
- 4.2.7.1.5. 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 from 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.
- 4.2.7.2.1. First, the reference tyre is tested.
- 4.2.7.2.2. 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.
- 4.2.7.2.3. After six valid measurements of the candidate tyre are performed, two more candidate tyres may be measured.
- 4.2.7.2.4. The test cycle is closed by six more valid measurements of the same reference tyre as at the beginning of the test cycle.
- Examples:
- (a) 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

- (b) 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 (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.

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

where:

$\mu(t)$ 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 μ_{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 (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).

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

4.2.8.3. Calculation of the adjusted average peak braking force coefficient

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 (R_a) is calculated in accordance with table 3 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 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

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

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

Table 4

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

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:

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

where:

t is the measured wet surface temperature in degree Celsius when the candidate tyre (T) is tested

t₀ is the wet surface reference temperature condition

t₀ = 20 °C for normal tyres t₀=10°C for snow tyres

$\mu_{\text{peak,ave}}(R_0) = 0.85$ 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)]

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											
Tyre identification											
Rim											
Pattern											
Load (N)											
Pressure (kPa)											
μ peak	1										
	2										
	3										
	4										
	5										
	6										
	7										
	8										
Average											
Standard deviation σ											
$(\sigma/\text{average}) \leq 5$ per cent											
Ra, Adjusted											
Wet grip index											
Surface temp. (°C)											
Ambient temp. (°C)											
Remarks											

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

Driver:

Test date:

Track:
Texture depth (mm):
BPN:
Water depth (mm):

Passenger car:
Brand:
Model:
Type:

Initial speed (km/h):
Final speed (km/h):

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	ZZZZZZZZL	NNNNNNNNNN	XXXXXXXXXX					
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 _a (m/s ²)										
BFC(R) reference tyre (SRTT16)										
BFC(T) candidate tyre										
Wet grip index (%)										

..

Annex 6,

Paragraph 3.5., amend to read:

"3.5. Duration and speed.

When the deceleration method is selected, the following requirements apply:

- (a) The deceleration j shall be determined in exact $d\omega/dt$ or approximate $\Delta\omega/\Delta t$ form, where ω is angular velocity, t – time;
- (b) For duration Δt , the time increments shall not exceed 0.5 s;
- (c) Any variation of the test drum speed shall not exceed 1 km/h within one time increment."

Paragraph 4.6.2., amend to read:

"4.6.2. Deceleration method

The deceleration method follows the procedure below:

- (a) Remove the tyre from the test surface;
- (b) Record the deceleration of the test drum $\Delta\omega_{D0}/\Delta t$ and that of the unloaded tyre $\Delta\omega_{T0}/\Delta t^3$ or record the deceleration of the test drum j_{D0} and that of the unloaded tyre j_{T0} in exact or approximate form in accordance with paragraph 3.5."

Paragraph 5.1.5., amend to read:

"5.1.5. Deceleration method

Calculate the parasitic losses F_{pl} , in newton.

$$F_{pl} = \frac{I_D}{R} \left(\frac{\Delta\omega_{D0}}{\Delta t_0} \right) + \frac{I_T}{R_r} \left(\frac{\Delta\omega_{T0}}{\Delta t_0} \right)$$

Where:

- I_D is the test drum inertia in rotation, in kilogram meter squared,
 R is the test drum surface radius, in meter,
 ω_{D0} is the test drum angular speed, without tyre, in radians per second,
 Δt_0 is the time increment chosen for the measurement of the parasitic losses without tyre, in second,
 I_T is the spindle, tyre and wheel inertia in rotation, in kilogram meter squared,
 R is the tyre rolling radius, in metre,
 ω_{T0} is the tyre angular speed, unloaded tyre, in radian per second.
or

$$F_{pl} = \frac{I_D}{R} j_{D0} + \frac{I_T}{R_r} j_{T0}$$

Where:

- I_D is the test drum inertia in rotation, in kilogram meter squared,
 R is the test drum surface radius, in meter,
 j_{D0} is the deceleration of the test drum, without tyre, in radians per second squared,
 I_T is the spindle, tyre and wheel inertia in rotation, in kilogram meter squared,
 R_r is the tyre rolling radius, in metre,
 j_{T0} is the deceleration of unloaded tyre, in radians per second squared."

Paragraph 5.2.5., amend to read:

"5.2.5. Deceleration method

The rolling resistance F_r , in newton, is calculated using the

$$\text{equation: } F_r = \frac{I_D}{R} \left(\frac{\Delta\omega_v}{\Delta t_v} \right) + \frac{R I_T}{R_r^2} \left(\frac{\Delta\omega_v}{\Delta t_v} \right) - F_{pl}$$

Where:

- I_D is the test drum inertia in rotation, in kilogram metre squared,
 R is the test drum surface radius, in meter,
 F_{pl} represents the parasitic losses as calculated in paragraph 5.1.5.,
 Δt_v is the time increment chosen for measurement, in second,
 $\Delta\omega_v$ is the test drum angular speed increment, without tyre, in radian per second,
 I_T is the spindle, tyre and wheel inertia in rotation, in kilogram metre squared,
 R_r is the tyre rolling radius, in metre,
 F_r is the rolling resistance, in newton.

or

$$Fr = \frac{I_D}{R} j_V + \frac{RI_T}{R_r^2} j_V - F_{pl}$$

Where:

- I_D is the test drum inertia in rotation, in kilogram metre squared,
 R is the test drum surface radius, in meter,
 F_{pl} represents the parasitic losses as calculated in paragraph 5.1.5.,
 j_V is the deceleration of the test drum, in radians per second squared,
 I_T is the spindle, tyre and wheel inertia in rotation, in kilogram metre squared,
 R_r is the tyre rolling radius, in metre,
 F_r is the rolling resistance, in newton."

Annex 6, Appendix 1

Paragraph 4., amend to read:

- "4. Control accuracy
...
(d) time: +/- 0.5 ms
..."

Annex 7,

Insert a new paragraph 1.4., to read:

- "1.4. "Acceleration test" means a series of specified number of traction controlled acceleration test runs of the same tyre repeated within a short timeframe."

Paragraph 3.1.2., amend to read:

- "3.1.2. Vehicle
The test shall be conducted with a standard production vehicle in good running order and equipped with an ABS system.
The vehicle used shall be such that the loads on each wheel are appropriate to the tyres being tested. Several different tyre sizes can be tested on the same vehicle."

Paragraph 3.1.3., amend to read:

- "3.1.3. Tyres
The tyres should be "broken-in" prior to testing to remove spew, compound nodules or flashes resulting from moulding process. The tyre surface in contact with snow shall be cleaned before performing a test.
Tyres shall be conditioned at the outdoor ambient temperature at least two hours before their mounting for tests. Tyre pressures shall then be adjusted to the values specified for the test."

In case a vehicle cannot accommodate both the reference and candidate tyres, a third tyre ("control" tyre) may be used as an intermediate. First test control vs. reference on another vehicle, then test candidate vs. control on the vehicle."

Insert new paragraphs 3.4.3. to 4.10., to read:

- "3.4.3. In the case where the candidate tyres cannot be fitted to the same vehicle as the SRTT, for example, due to tyre size, inability to achieve required loading and so on, comparison shall be made using intermediate tyres, hereinafter referred to as "control tyres", and two different vehicles. One vehicle shall be capable of being fitted with the SRTT and the control tyre and the other vehicle shall be capable of being fitted with the control tyre and the candidate tyre.
- 3.4.3.1. The snow grip index of the control tyre relative to the SRTT (SG1) and of the candidate tyre relative to the control tyre (SG2) shall be established using the procedure in paragraphs 3.1. to 3.4.2.
- The snow grip index of the candidate tyre relative to the SRTT shall be the product of the two resulting snow grip indices that is $SG1 \times SG2$.
- 3.4.3.2. The ambient conditions shall be comparable. All tests shall be completed within the same day.
- 3.4.3.3. The same set of control tyres shall be used for comparison with the SRTT and with the candidate tyre and shall be fitted in the same wheel positions.
- 3.4.3.4. Control tyres that have been used for testing shall subsequently be stored under the same conditions as required for the SRTT.
- 3.4.3.5. The SRTT and control tyres shall be discarded if there is irregular wear or damage or when the performance appears to have been deteriorated.
4. Acceleration method for Class C3 tyres
- 4.1. According to the definition of C3 tyres reported into paragraph 2.4.3., the additional classification for the purpose of this test method only applies:
- (a) C3 Narrow (C3N), when the C3 tyre Nominal Section Width is lower than 285 mm
 - (b) C3Wide (C3W), when the C3 tyre Nominal Section Width is greater or equal to 285 mm
- 4.2. Methods for measuring Snow Grip Index
- Snow performance is based on a test method by which the average acceleration in an acceleration test, of a candidate tyre is compared to that of a standard reference tyre.
- The relative performance shall be indicated by a Snow Grip Index (SG).
- When tested in accordance with the acceleration test in paragraph 4.7., the average acceleration of a candidate snow tyre shall be at least 1.25 compared to one of the two equivalent SRTTs – ASTM F 2870 and ASTM F 2871.
- 4.3. Measuring equipment
- 4.3.1. A sensor suitable for measuring speed and distance covered on snow/ice surface between two speeds must be used.

To measure vehicle speed, a fifth wheel or non-contact speed-measuring system (including radar, GPS ...) shall be used.

- 4.3.2. The following tolerances shall be respected:
- (a) For speed measurements : ± 1 per cent (km/h) or 0.5 km/h whichever is greater.
 - (b) For distance measurements: $\pm 1 \times 10^{-1}$ m

4.3.3. A display of the measured speed or the difference between the measured speed and the reference speed for the test is recommended inside the vehicle so that the driver can adjust the speed of the vehicle.

4.3.4. For Acceleration test covered in paragraph 4.7., a display of the slip ratio of the driven tyres is recommended inside the vehicle and shall be used in the particular case of paragraph 4.7.2.1.1.

The slip ratio is calculated by

$$\text{Slip Ratio \%} = \left[\frac{\text{Wheel Speed} - \text{Vehicle Speed}}{\text{Vehicle Speed}} \right] \times 100$$

- (a) Vehicle speed is measured as defined in 4.3.1. (m/s)
- (b) Wheel speed is calculated on a tyre of the driven axle by measuring its angular velocity and its loaded diameter

$$\text{Wheel Speed} = \pi \times \text{loaded diameter} \times \text{angular speed}$$

Where, $\pi = 3.1416$ (m/360deg), the loaded diameter (m) and the angular speed (revolution per second = 360 deg/sec).

4.3.5. A data acquisition system can be used for storing the measurements.

4.4. General conditions

4.4.1. Test course

The test shall be done on a flat test surface of sufficient length and width, with a maximum 2 per cent gradient, covered with packed snow.

4.4.1.1 The snow surface shall be composed of a hard packed snow base at least 3 cm thick and a surface layer of medium packed and prepared snow about 2 cm thick.

4.4.1.2. The snow compaction index measured with a CTI penetrometer shall be between 80 and 90. Refer to the appendix of ASTM F1805 for additional details on measuring method.

4.4.1.3. The air temperature, measured about one meter above the ground, shall be between -2 °C and -15 °C; the snow temperature, measured at a depth of about one centimetre, shall be between -4 °C and -15 °C.

Air temperature shall not vary more than 10 deg C during the test.

4.5. Tyres preparation and break-in

4.5.1. Fit the test tyres on rims as per ISO 4209-1 using conventional mounting methods. 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.

- 4.5.2. The tyres should be "broken-in" prior to testing to remove spew, compound nodules or flashes resulting from moulding process.
- 4.5.3. Tyres shall be conditioned at the outdoor ambient temperature at least two hours before their mounting for tests.
- They should be placed such that they all have the same ambient temperature prior to testing and be shielded from the sun to avoid excessive heating by solar radiation.
- The tyre surface in contact with snow shall be cleaned before performing a test.
- Tyre pressures shall then be adjusted to the values specified for the test.
- 4.6. Testing sequence
- If only one candidate tyre is to be evaluated, the order of testing shall be:
- R1, T, R2
- where:
- R1 is the initial test of the SRTT, R2 is the repeat test of the SRTT and T is the test of the candidate tyre to be evaluated.
- A maximum of 3 candidate tyres may be tested before repeating the SRTT test, for example: R1, T1, T2, T3, R2.
- Recommendations are that the zones where acceleration is fully applied shall not overlap without reworking and when a new set of tyres is tested;
- The runs are performed after shifting the vehicle trajectory in order not to accelerate on the tracks of the previous tyre; when it is no longer possible not to overlap full acceleration zones, the test course should be re-groomed.
- 4.7. Acceleration on Snow Test Procedure for Snow Grip Index of Class C3N and C3W
- 4.7.1. Principle
- The test method covers a procedure for measuring the Snow Grip performance of commercial vehicle tyres during acceleration, using a commercial vehicle having a Traction Control System (TCS, ASR, etc.).
- Starting with a defined initial speed, the full throttle is applied to activate the Traction Control system, the Average acceleration is calculated between two defined speeds.
- 4.7.2. Vehicle
- 4.7.2.1 The test shall be conducted with a 2 axles standard model commercial vehicle in good running conditions equipped with:
- (a) Low rear axle weight and enough powerful engine to ensure the average percentage of slip during the test as required in points 4.7.5.1. and 4.7.5.2.1. below;
 - (b) A manual gearbox (automatic gearbox with manual shift allowed) having a gear ratio covering a 19 km/h range between 4 and 30 km/h;
 - (c) Blocking differential on driven axle is recommended as increasing repeatability;

- (d) A standard commercial system controlling/limiting the slip of the driving axle when accelerating (called Traction Control, ASR, TCS, etc.).
- 4.7.2.1.1. In the particular case where it is not possible to find a standard commercial vehicle equipped with a traction control system, a vehicle without Traction Control/ASR/TCS is allowed with a mandatory display of the percentage slip as stated in 4.3.4. and a mandatory blocking differential on the driven axle to put in practice the operating procedure 4.7.5.2.1.
- 4.7.2.2. The permitted modifications are:
 - (a) Those allowing to increase the number of tyre sizes capable to be mounted on the vehicle;
 - (b) Those permitting to install an automatic activation of the acceleration and the measurements.Any other modification of the acceleration system is prohibited.
- 4.7.3. Vehicle fitting

The rear driven axle may be indifferently fitted with 2 or 4 test tyres if respecting the loading by tyre.

The front steer non driven axle is equipped with 2 tyres having a size suitable for the axle load. These 2 front tyres could be maintained along the test.
- 4.7.4. Load and inflation pressure
- 4.7.4.1. The static load on each rear driven test tyres must be between 20 per cent and 55 per cent of the tested tyre load capacity written on the sidewall.

The vehicle front steer total static axle load should be between 60 per cent and 160 per cent of the driven rear total axle load.

The static tyre load on the same driven axle should not differ by more than 10 per cent.
- 4.7.4.2. The driven tyres inflation pressure shall be 70 per cent of the one written on the sidewall.

The steer tyres are inflated at nominal sidewall pressure
- 4.7.5. Testing Runs
- 4.7.5.1. Mount first the set of reference tyres on the vehicle and when on the testing area.

Drive the vehicle at an initial constant speed between 4 km/h and 11 km/h and the gear ratio capable of covering the speed range of 19 km/h.

Recommended Gear ratio selected is 3rd or 4th shall give minimum 13 per cent average slip ratio in the measured range of speed.
- 4.7.5.2. In case of Traction Control system equipped vehicles (already switched "on" before the run) apply full throttle until the vehicle has reached the final speed.

Final speed = Initial speed + 15 km/h

No rearward restraining force shall be applied to the test vehicle.
- 4.7.5.2.1. In the particular case of paragraph 4.7.2.1.1. where it is not possible to find a standard commercial vehicle having the Traction Control system, the driver

maintains manually the averaged slip ratio range of 20 per cent \pm 10 per cent (Controlled Slip procedure in place of the Full Slip) in the same range of speeds. All the tyres and runs in the test session are performed with Controlled Slip procedure.

- 4.7.5.3. Measure the distance and the time between the initial speed and the final speed.
- 4.7.5.4. For every candidate tyre and the standard reference tyre, the acceleration test runs shall be repeated a minimum of 6 times and the coefficients of variation (standard deviation/average*100) calculated for minimum 6 valid runs on the distance and the time should be lower than or equal to 6 per cent.
- 4.7.5.5. In case of Traction Control System equipped vehicle, the Average Slip ratio shall be in the range from 13 per cent to 40 per cent (calculated as per in paragraph 4.3.4.)
- 4.7.5.6. Apply testing sequence as defined in paragraph 4.6.
- 4.8. Processing of measurement results
- 4.8.1. Calculation of the Average Acceleration AA

Each time the measurement is repeated, the average acceleration AA ($m \cdot s^{-2}$) is calculated by

$$AA = \frac{S_f^2 - S_i^2}{2D}$$

Where D (m) is the distance covered between the initial speed S_i ($m \cdot s^{-1}$) and the final speed S_f ($m \cdot s^{-1}$).

- 4.8.2. Validation of results

For the candidate tyres:

The coefficients of variation of the Average Acceleration is calculated for all the candidate tyres. If one coefficient of variation is greater than 6 per cent, discard the data for this candidate tyre and repeat the test.

$$\text{coefficient of variation} = \frac{\text{stdev}}{\text{average}} \times 100$$

For the reference tyre:

If the coefficient of variation of the average Acceleration "AA" for each group of min 6 runs of the reference tyre is higher than 6 per cent, discard all data and repeat the test for all tyres (the candidate tyres and the reference tyre).

In addition and in order to take in account possible test evolution, the coefficient of validation is calculated on the basis of the average values of any two consecutive groups of min 6 runs of the reference tyre. If the coefficient of validation is greater than 6 per cent, discard the data for all the candidate tyres and repeat the test.

$$\text{coefficient of validation} = \left| \frac{\text{Average2} - \text{Average1}}{\text{Average1}} \right| \times 100$$

4.8.3. Calculation of the "average AA"

If R1 is the average of the "AA" values in the first test of the reference tyre, R2 is the average of the "AA" values in the second test of the reference tyre, the following operations are performed, according to Table 1:

Table 1

If the number of sets of candidate tyres between two successive runs of the reference tyre is:	and the set of candidate tyres to be qualified is:	then "Ra" is calculated by applying the following:
1 R - T1 - R	T1	Ra = 1/2 (R1 + R2)
2 R - T1 - T2 - R	T1	Ra = 2/3 R1 + 1/3 R2
	T2	Ra = 1/3 R1 + 2/3 R2
3 R - T1 - T2 - T3 - R	T1	Ra = 3/4 R1 + 1/4 R2
	T2	Ra = 1/2 (R1 + R2)
	T3	Ra = 1/4 R1 + 3/4 R2

"Ta" (a = 1, 2, ...) is the average of the AA values for a test of a candidate tyre.

4.8.4 "AFC" Calculation (Acceleration Force Coefficient)

Also called AFC Acceleration Force Coefficient

Calculation on of AFC(Ta) and AFC(Ra) as defined in table 2 :

Table 2

	The Acceleration Force Coefficient "AFC" is:
Reference tyre	$AFC(R) = \frac{Ra}{g}$
Candidate tyre	$AFC(T) = \frac{Ta}{g}$
<i>Ra and Ta are in m/s²</i>	
<i>"g"= gravity acceleration (rounded to 9.81 m/s²)</i>	

4.8.5. Calculation of the relative Snow Grip Index of the tyre

The Snow grip index represents the relative performance of the candidate tyre compared to the reference tyre.

$$\text{Snow Grip Index} = \frac{AFC(T)}{AFC(R)}$$

4.8.6. Calculation of the Slip Ratio

The slip ratio can be calculated as the average of Slip ratio as mentioned in paragraph 4.3.4. or by comparing the average distance referred to in paragraph 4.7.5.3. of the min 6 runs to the distance of a run done without slip (very low acceleration)

$$\text{Slip Ratio \%} = \left[\frac{\text{Average distance} - \text{No slip distance}}{\text{No slip distance}} \right] \times 100$$

4.9. Snow grip performance comparison between a candidate tyre and a reference tyre using a control tyre

4.9.1. Scope

When the candidate tyre size is significantly different from the reference tyre a direct comparison on the same vehicle may be not possible. This is an approach using an intermediate tyre, hereinafter called the control tyre.

4.9.2. Principle of the approach

The principle lies upon the use of a control tyre and 2 different vehicles for the assessment of a candidate tyre in comparison with a reference tyre.

One vehicle can fit the reference tyre and the control tyre, the other the control tyre and the candidate tyre. All conditions are in conformity with paragraph 4.7.

The first assessment is a comparison between the control tyre and the reference tyre. The result (Snow Grip Index 1) is the relative efficiency of the control tyre compared to the reference tyre.

The second assessment is a comparison between the candidate tyre and the control tyre. The result (Snow grip index 2) is the relative efficiency of the candidate tyre compared to the control tyre.

The second assessment is done on the same track as the first one. The air temperature must be in the range of +/- 5 deg C of the temperature of the first assessment. The control tyre set is the same set as the set used for the first assessment.

The Snow Grip performance Index of the candidate tyre compared to the reference tyre is deduced by multiplying the relative efficiencies calculated above:

$$\text{Snow Grip Index} = \text{SG1} \times \text{SG2}$$

4.9.3. Selection of a set of tyres as a control tyre set

A control tyre set is a group of identical tyres made in the same factory during one week period.

4.10. Storage and preservation

Before the first assessment (control tyre / reference tyre), normal storage conditions can be used. 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 assessed in comparison with the reference tyre, specific storage conditions shall be applied for Control tyres replacement.

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

Annex 7,

Appendix 2,

Paragraph 4.3., amend the table to read :

"

	<i>SRTT</i> (1st test)	<i>Candidate</i>	<i>Candidate</i>	<i>SRTT</i> (2nd test)
Tyre dimensions				
Test rim width code				
Tyre loads F/R (kg)				
Load index F/R (per cent)				
Tyre pressure F/R (kPa)				

"

Annex 7, insert a new Appendix 3, to read:

"Annex 7 - Appendix 3

Test reports and test data for C3 tyres

Part 1 - Report

1. Type Approval Authority or Technical Service:
2. Name and address of applicant:
3. Test report No.:
4. Manufacturer and brand name or trade description:
5. Tyre class:
6. Category of use:
7. Snow index relative to SRTT according to paragraph 8.5.
- 7.1. Test procedure and SRTT used
8. Comments (if any):
9. Date:
10. Signature:

Part 2 - Test data

1. Date of test:
2. Location of test track:
- 2.1. Test track characteristics:

	<i>At start of tests</i>	<i>At end of tests</i>	<i>specification</i>
Weather			
Ambient temperature			-2 °C to -15 °C
Snow temperature			-4 °C to -15 °C
CTI index			80 to 90
Other			

3. Test vehicle (make, model and type, year):
4. Test tyre details
- 4.1. Tyre size designation and service description:
- 4.2. Tyre brand and trade description:
- 4.3. Test tyre data:

	<i>SRTT (1st test)</i>	<i>Candidate 1</i>	<i>Candidate 2</i>	<i>Candidate 3</i>	<i>SRTT (2nd test)</i>
Tyre dimensions					
Test rim width code					
Tyre loads F/R (kg)					
Load index F/R (per cent)					
Tyre pressure F/R (kPa)					

5. Test results: average accelerations (m/s²)

<i>Run number</i>	<i>Specification</i>	<i>SRTT (1st test)</i>	<i>Candidate 1</i>	<i>Candidate 2</i>	<i>Candidate 3</i>	<i>SRTT (2nd test)</i>
1						
2						
3						
4						
5						
6						
Mean						
Std-deviation						
Slip ratio (per cent)						
CV (per cent)	< 6 per cent					
Validation SRTT	(SRTT) < 5 per cent					
SRTT average						
Snow index		1,00				