INTERNATIONAL STANDARD

ISO 23671

First edition
2006-02-15

Passenger car tyres — Method for measuring relative wet grip performance — Loaded new tyres

Pneumatiques pour voitures particulières — Méthode de mesure de l'adhérence relative sur revêtement mouillé — Pneumatiques neufs en charge

Reference number
ISO 23671:2006(E)

PDF disclaimer

This PDF file may contain embedded typefaces. In accordance with Adobe's licensing policy, this file may be printed or viewed but shall not be edited unless the typefaces which are embedded are licensed to and installed on the computer performing the editing. In downloading this file, parties accept therein the responsibility of not infringing Adobe's licensing policy. The ISO Central Secretariat accepts no liability in this area.

Adobe is a trademark of Adobe Systems Incorporated.

Details of the software products used to create this PDF file can be found in the General Info relative to the file; the PDF-creation parameters were optimized for printing. Every care has been taken to ensure that the file is suitable for use by ISO member bodies. In the unlikely event that a problem relating to it is found, please inform the Central Secretariat at the address given below.

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

Contents

Page

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 23671 was prepared by Technical Committee ISO/TC 31, *Tyres, rims and valves*, Subcommittee SC 3, *Passenger car tyres and rims*.

Passenger car tyres — Method for measuring relative wet grip performance — Loaded new tyres

1 Scope

This International Standard specifies the method for measuring relative wet grip braking performance index to a reference under loaded conditions for new tyres for use on passenger cars on a wet-paved surface.

The methods developed are meant to reduce variability. The use of a reference tyre is necessary to limit the variability of the testing procedures.

This International Standard applies to all passenger car tyres.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 4000-1, *Passenger car tyres and rims — Part 1: Tyres (metric series)*

ASTM E 303:1993 (re-approved in 1998), *Standard Test Method for Measuring Surface Frictional Properties Using the British Pendulum Tester*

ASTM E 501, *Standard Specification for Standard Rib Tire for Pavement Skid-Resistance Tests*

ASTM E 965, *Standard Test Method for Measuring Pavement Macrotexture Depth Using a Volumetric Technique*

ASTM E 1136, *Standard Specification for a Radial Standard Reference Test Tire*

NF P 98-216-2:1994, *Test relating to pavements. Measurement of the macrotexture — Part 2: Method for measuring, without contact*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
test run
single pass of a loaded tyre over a given test surface

3.2
candidate tyre (set)
test tyre (set) that is part of an evaluation programme

3.3
reference tyre (set)
special test tyre (set) that is used as a benchmark in an evaluation programme

NOTE These tyres usually have carefully controlled design features to minimize variation.

3.4
control tyre (set)
tyre (set) that is part of an evaluation programme; it is an intermediate tyre (set) which is used when the candidate tyre and the reference tyre cannot be directly compared on the same vehicle

3.5
braking force of a tyre
longitudinal force, expressed in newtons, resulting from braking torque application

3.6
braking force coefficient of a tyre
ratio of braking force to vertical load

3.7
peak braking force coefficient of a tyre
maximum value of tyre braking force coefficient that occurs prior to wheel lockup as the braking torque is progressively increased

3.8
lockup of a wheel
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

3.9
vertical load
normal reaction of the tyre on the road

3.10
tyre test vehicle
dedicated vehicle which has instruments to measure the vertical and the longitudinal forces on one tyre during braking

4 Methods for measuring wet grip

Relative wet grip braking performance for loaded passenger car new tyres travelling straight ahead on a wet, paved surface can be measured by one of the following methods:

— vehicle method consisting of testing a set of tyres mounted on a standard vehicle;

— test method using a trailer or a tyre test vehicle equipped with the test tyres.

5 General test conditions

5.1 Track characteristics

The surface shall have a uniform grade of not more than 2 % and shall not deviate more than 6 mm when tested with a 3 m straight edge.

The test surface shall have a pavement of uniform age, composition, and wear. The test surface shall be free of loose material and foreign deposits.

It shall be a dense asphalt surface.

The maximum chipping size shall be from 8 mm to 13 mm.

The sand depth measured as specified in NF P 98-216-2 and ASTM E 965 shall be (0,7 ± 0,3) mm.

In order to verify the frictional properties of the surface, a) or b) shall be used.

a) British Pendulum Number (BPN) method

The averaged British Pendulum Number (BPN) (British Pendulum Tester method as specified in ASTM E 303 using the pad as specified in ASTM E 501) shall be (50 ± 10) BPN after temperature correction.

Pad rubber component formulation and physical properties are to be requested.

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

$$\text{temperature correction} = -0{,}001\,8\,t^2 + 0{,}34\,t - 6{,}1$$

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 ASTM E 303:1993, 5.2.2 and Figure 3.

Checking track surface BPN constancy for the measurement of wet grip on a standard vehicle: To decrease the dispersion of test results, the BPN values of the track should not vary over the entire stopping distance. The operation shall be repeated five times at each point of the BPN measurement. So the BPN shall be measured every 10 m on the braking lane and the coefficient of variation of the BPN averages shall not exceed 10 %.

b) Standard Reference Test Tyre (SRTT) method

The average peak braking coefficient ($\mu_{\text{peak,ave}}$) of the ASTM E 1136 SRTT[1)] (see Clause 7) shall be 0,7 ± 0,1 at 65 km/h.

For the trailer method, testing is run in such a way that braking occurs within 2 m of where the surface was examined.

The average peak braking coefficient ($\mu_{\text{peak,ave}}$) of the ASTM E 1136 SRTT shall be corrected by the wetted road surface temperature:

$$\text{temperature correction} = 0{,}003\,5(t - 20)$$

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

5.2 Wetting conditions

The surface may be wetted from the track-side or by a wetting system incorporated in the test vehicle or the trailer.

If “external watering” is used, water the test surface 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.

1) The size of the ASTM E 1136 SRTT is P195/75R14.

For the whole testing area, the water depth shall be between 0,5 mm and 1,5 mm.

5.3 Atmospheric conditions

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

The wetted surface temperature shall be between 5 °C and 35 °C and shall not vary during the test by more than 10 °C.

5.4 Reference tyre

The specifications of the SRTT are defined in ASTM E 1136.

6 Measurement of tyre wet grip on a standard vehicle

6.1 Principle

The test method covers a procedure for measuring the deceleration performance of passenger car tyres during braking, using an instrumented passenger car having an Antilock Braking System (ABS).

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 defined speeds, with an initial speed of 80 km/h and a final speed of 20 km/h. When the braking system is not operating automatically, a minimum of 600 N pedal effort is required.

6.2 Equipment

6.2.1 Vehicle

Permitted modifications using a standard-model passenger car equipped with an ABS are as follows:

— those allowing the number of tyre sizes that can be mounted on the vehicle to be increased;

— those permitting automatic activation of the braking device to be installed.

Any other modification of the braking system is prohibited.

6.2.2 Measuring equipment

The exposed portions of the system shall tolerate 100 % 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 speed-measuring system should be used.

The following tolerances shall be respected:

— for speed measurement: $\pm$ 1 % or $\pm$ 0,5 km/h, whichever is greater;

— for distance: $\pm 1 \times 10^{-1}$ m.

The measured speed or the difference between the measured speed and the reference speed for the test should be displayed inside the vehicle, so that the driver can adjust the speed of the vehicle.

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

6.3 Conditioning of the test track

Condition the pavement by conducting at least ten test runs with tyres not involved in the test programme at 90 km/h (which is higher than the initial test speed to guarantee that a sufficient length of track is conditioned).

6.4 Test speed measurement requirements

The speed at the start of braking shall be (85 ± 2) km/h.

The average deceleration shall be calculated between 80 km/h and 20 km/h.

6.5 Tyres and rims

6.5.1 Tyre preparation and break-in

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

Fit the test tyres on rims in accordance with ISO 4000-1 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.

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.

For tyre break-in, perform two braking runs.

6.5.2 Tyre load

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

6.5.3 Tyre inflation pressure

On the front and rear axles, the inflation pressures shall be 220 kPa (for standard- and extra-load versions).

Check the tyre pressure just prior to testing at ambient temperature.

6.6 Procedure

First, mount the set of reference tyres on the vehicle.

Accelerate the vehicle in the starting zone up to (85 ± 2) km/h.

The brakes shall always be activated at the same place on the track, with a longitudinal tolerance of 5 m and a transverse tolerance of 0,5 m.

According to the type of transmission, two cases are possible.

a) Manual transmission: As soon as the driver is in the measuring zone and having reached (85 ± 2) km/h, release the clutch and depress the brake pedal sharply, holding it down as long as necessary to perform the measurement.

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

Automatic activation of the brakes can also be performed by means of a detection system made of two parts, one indexed to the track and one on board the vehicle. In this case, braking is more severe on the same portion of the track.

If any of the above-mentioned conditions is not met when a measurement is made (speed tolerance, braking time, etc.), the measurement is discarded and a new measurement is made.

For each test and for new tyres, the first two braking measurements are discarded.

After at least three valid measurements have been made, the reference tyres are replaced by a set of the candidate tyres and at least six valid measurements shall be performed.

A maximum of three sets of candidate tyres can be tested before the reference tyre is re-tested.

EXAMPLES

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

R-T_1-T_2-T_3-R

The run order for a test of five sets of candidate tyres (T_1 to T_5) plus a reference tyre R would be the following:

R-T_1-T_2-T_3-R-T_4-T_5-R

6.7 Processing of measurement results

6.7.1 Calculation of the average deceleration, AD

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

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

where

S_f is the final speed ($m \cdot s^{-1}$);

S_i is the initial speed ($m \cdot s^{-1}$);

d is the distance covered (m) between S_i and the S_f.

6.7.2 Validation of results

For the reference tyre: If the “coefficient of variation” of AD of any two consecutive groups of three runs of the reference tyre is higher than 3 %, discard all data and repeat the test for all tyres (the candidate tyres and the reference tyre).

The coefficient of variation is calculated by the following relation:

$$\frac{\text{standard deviation}}{\text{average}} \times 100$$

For the candidate tyres: The coefficients of variation $\frac{\text{standard deviation}}{\text{average}} \times 100$ are calculated for all the candidate tyres. If one coefficient of variation is greater than 3 %, discard the data for this candidate tyre and repeat the test.

6.7.3 Calculation of average AD

If R_1 is the average of the AD values in the first test of the reference tyre and R_2 is the average of the AD values in the second test of the reference tyre, the following operations are performed, according to Table 1.

Tableau 1

Number of sets of candidate tyres between two successive runs of the reference tyre	Set of candidate tyres to be qualified	R_a
1 R-T_1-R	T_1	$R_a = 1/2\ (R_1 + R_2)$
2 R-T_1-T_2-R	T_1	$R_a = 2/3\ R_1 + 1/3\ R_2$
	T_2	$R_a = 1/3\ R_1 + 2/3\ R_2$
3 R-T_1-T_2-T_3-R	T_1	$R_a = 3/4\ R_1 + 1/4\ R_2$
	T_2	$R_a = 1/2\ (R_1 + R_2)$
	T_3	$R_a = 1/4\ R_1 + 3/4\ R_2$

T_a (a = 1, 2, etc.) is the average of the AD values for a test of a candidate tyre.

6.7.4 Calculation of braking force coefficient, BFC

BFC(R) and BFC(T) are calculated according to Table 2.

Tableau 2

Tyre type	Braking force coefficient, for a braking on the two axles
Reference tyre	$BFC(\mathrm{R}) = \frac{R_a}{g}$
Candidate tyre	$BFC(\mathrm{T}) = \frac{T_a}{g}$
R_a and T_a are expressed in m·s^{-2}. g is the acceleration due to gravity (rounded to 9,81 m·s^{-2}).	

6.7.5 Calculation of the relative wet grip performance index of the tyre

The wet grip index of the tyre is calculated by the formula

$$\text{wet grip index(T)} = \frac{BFC(\mathrm{T})}{BFC(\mathrm{R})} \times 100$$

which represents the relative wet grip performance index of the candidate tyre compared to the reference tyre.

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

6.8.1 General

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

6.8.2 Principle of the approach

The principle is the use of a control tyre and two different vehicles for the assessment of a candidate tyre in comparison with a reference tyre.

One vehicle can be fitted with the reference tyre and the control tyre, the other with the control tyre and the candidate tyre. All conditions are in conformity with 6.2 to 6.5.

The first assessment is a comparison between the control tyre and the reference tyre.

The second assessment is a comparison between the candidate tyre and the control tyre.

The second assessment is done on the same track as the first assessment. The wetted surface temperature shall be within $\pm$ 5 °C of the temperature of the first assessment. The control tyre set (four tyres) is the same set as was used for the first assessment.

The wet grip performance index of the candidate tyre compared to the reference tyre is deduced by multiplying the relative efficiencies calculated above:

$$\text{wet grip index 1} \times \text{wet grip index 2} \times 10^{-2}$$

where

wet grip index 1 is the relative efficiency of the control tyre compared to the reference tyre;

wet grip index 2 is the relative efficiency of the candidate tyre compared to the control tyre.

6.8.3 Selection of a control tyre set

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

6.8.4 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. The storage conditions can be considered the same as for the ASTM E 1136 SRTT.

6.8.5 Replacement of 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.

7 Test method using a trailer or a tyre test vehicle

7.1 Principle

The measurements are conducted on tyres mounted on a trailer towed by a vehicle or 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.

7.2 Test apparatus

7.2.1 The test apparatus consists of tow vehicle and trailer or a tyre test vehicle.

7.2.1.1 The test apparatus shall have the capability of maintaining the specified speed, (65 ± 2) km/h, even under the maximum braking forces.

7.2.1.2 The test apparatus shall be equipped with one test position and the following accessories:

— equipment to actuate brakes in the test position;

— a water tank to store sufficient water to supply the watering system, unless external watering is used;

— 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 trailer, 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”.

7.2.1.3 The limiting change of toe and camber for the test position shall be within $\pm$ 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.

7.2.1.4 The test position shall be equipped with a typical or special automotive hydraulic brake system which can apply sufficient braking torque to produce the maximum value of braking test wheel longitudinal force at the conditions specified.

7.2.1.5 The brake application system shall be able to control the time interval between initial brake application and peak longitudinal force as specified in 7.4.3.2.

7.2.1.6 The test apparatus shall be designed to accommodate the range of passenger car tyre sizes to be tested.

7.2.1.7 The test apparatus shall have provisions for adjustment of vertical load as specified in 7.5.

7.2.2 The apparatus 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 over-spray. 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 0,25 m to 0,45 m ahead of the centre of tyre contact. The nozzle shall be located 25 mm above the pavement or at the minimum height required to clear obstacles which the tester is expected to encounter, but in no case more than 100 mm above the pavement. The water layer shall be at least 25 mm wider than the test tyre tread and applied so the tyre is centrally located between the edges. 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 $l \cdot s^{-1}$ per metre of width of wetted surface. The nominal values of rate of water application shall be maintained within $\pm$ 10 %.

7.2.3 Instrumentation

The test wheel position on the trailer or the tyre test vehicle shall be equipped with a wheel rotational velocity measuring system and with transducers to measure the braking force and vertical load at the test wheel.

7.2.3.1 General requirements for measurement system

The instrumentation system shall conform to the following overall requirements at ambient temperatures between 0 °C and 45 °C:

— overall system accuracy, force: ± 1,5 % of the full scale of the vertical load or braking force;

— overall system accuracy, speed: ± 1,5 % of speed or ± 1,0 km/h, whichever is greater;

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

7.2.3.2 Vehicle speed

To measure vehicle speed, a fifth wheel or non-contact precision speed-measuring system should be used. Output shall be directly visible to the driver and shall be simultaneously recorded.

7.2.3.3 Braking forces

The braking force-measuring transducers shall measure longitudinal force generated at the tyre–road interface as a result of brake application within a range from 0 % to at least 125 % of the applied vertical load. The transducer design and location shall minimize inertial effects and vibration-induced mechanical resonance. The transducer shall have an output directly proportional to the force with less than 1 % hysteresis and less than 1 % non-linearity at full scale. It shall have less than 2 % cross-axis sensitivity at full scale. The transducer shall be installed in such a manner as to experience less than 1° angular rotation with respect to its measuring axes at a maximum expected braking torque.

7.2.3.4 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.

7.2.3.5 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.

— The minimum frequency response shall be flat from 0 Hz to 50 Hz (100 Hz) within ± 1 % full scale.

— The minimum sampling frequency of digital signals shall be 100 Hz. Tyre vertical load, braking force, vehicle and wheel speeds and a time base shall be recorded in phase (0 Hz to 100 Hz with a maximum phase difference of ± 0,1 rad).

— The signal-to-noise ratio shall be at least 20/1.

— The gain shall be sufficient to permit full-scale display for full-scale input signal level.

— The input impedance shall be at least ten times larger than the output impedance of the signal source.

— The equipment shall be insensitive to vibrations, acceleration, and changes in ambient temperature. The error in reading shall not exceed 1 % full scale when subjected to acceleration of 49,0 m/s^2 (5g) in the 0,5 Hz to 40 Hz frequency range and operating temperature range from 0 °C to 45 °C.

7.3 Selection and preparation of test tyres

7.3.1 Trim the test tyres to remove all protuberances on the tread surface caused by mould air vents or flashes at mould junctions.

7.3.2 Fit the test tyres on rims in accordance with ISO 4000-1 (or as specified by the appropriate tyre and rim standards organizations) using conventional fitting 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.

7.3.3 For tyre break-in, perform two braking runs.

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

7.3.5 Check the test tyres for the specified inflation pressure at ambient temperature (cold), just prior to testing. For the purpose of this International Standard, the testing tyre cold inflation pressure used shall be 180 kPa for standard-load versions. For extra-load tyres, the cold inflation pressure shall be 220 kPa.

NOTE Two pressure values are needed for the trailer, since the load on the tyre is 75 % of its load capacity.

7.3.6 One set of tyres shall be of the ASTM E 1136 SRTT type.

7.4 Preparation of apparatus and test track

7.4.1 Towed trailer

7.4.1.1 Install the test tyre on the measuring device.

7.4.1.2 Load each of the wheels to the specified test load.

7.4.1.3 Adjust the hitch height and transverse position as necessary for a given test.

7.4.1.4 Check the wiring connections between tow vehicle and the trailer for opens and shorts.

7.4.2 Tyre test vehicle

Install the test tyre on the measuring device.

Load the test tyre to the specified test load.

7.4.3 Instrumentation and equipment

7.4.3.1 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.

7.4.3.2 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.

7.4.4 Conditioning of the track

Condition the track by conducting at least ten test runs at 65 km/h with a tyre not involved in the test programme.

7.5 General test conditions

The test load shall be (75 ± 5) % of the load index.

7.6 Procedure

7.6.1 Approach the test site in a straight line at the specified test speed, (65 ± 2) km/h.

7.6.2 Start the recording system.

7.6.3 Deliver water to the pavement ahead of the test tyre approximately 0,5 s prior to brake application (for internal watering system).

7.6.4 When the test tyres reach the test site, apply the trailer brakes. The test should be run at the same spot on the test pad.

7.6.5 Stop the recording system.

7.6.6 For new tyres, the first two braking runs are discarded for tyre break-in. Repeat 7.6.1 to 7.6.5 at least six times, making runs in the same direction.

7.6.7 Test consecutive sets of tyres by repeating 7.6.1 to 7.6.6, provided that the tests are completed within one day.

7.6.8 Test the reference tyre adjacent to each set of test tyres, for example in the sequence R-T_1-T_2-R-T_3-T_4-R, etc., where R is the reference tyre and T_n (where $n = 1, 2$, etc.) is the test tyre.

A maximum of three sets of candidate tyres may be tested before the reference tyre is re-tested.

The examples given in 6.6 (i.e. 6.6, EXAMPLES) apply.

7.7 Processing of measurement results

7.7.1 Use the following equation for each test:

$$\mu(t) = \frac{f_{\mathrm{h}}(t)}{f_{\mathrm{v}}(t)}$$

where

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

$f_{\mathrm{h}}(t)$ is the dynamic braking force in real time, in N;

$f_{\mathrm{v}}(t)$ is the dynamic vertical load in real time, in N.

7.7.2 Using the equation given in 7.7.1, calculate the peak tyre braking force coefficient, μ_{peak}, by determining the highest value of $\mu(t)$ before lockup occurs. Analog signals should be filtered to remove noise. Digitally recorded signals may be filtered using a five-point moving average technique.

7.7.3 Calculate the average values of peak braking coefficient, $\mu_{\mathrm{peak,ave}}$, by averaging four or more repeated runs for each set of test and reference tyres for each test condition.

7.7.4 Validation of results

For the reference tyre: If the coefficient of variation of the peak braking coefficient, which is calculated by $\frac{\text{standard deviation}}{\text{average}} \times 100$ of the reference tyre, is higher than 5 %, discard all data and repeat the test for all tyres (the candidate tyres and the reference tyre).

For the candidate tyres: The coefficients of variation $\left(\frac{\text{standard deviation}}{\text{average}} \times 100\right)$ are calculated for all the candidate tyres. If one coefficient of variation is greater than 5 %, discard the data for this candidate tyre and repeat the test.

7.7.5 If R_1 is the average of the peak braking coefficient in the first test of the reference tyre and R_2 is the average of the peak braking coefficient in the second test of the reference tyre, the following operations are performed, according to Table 3:

Tableau 3

Number of sets of candidate tyres between two successive runs of the reference tyre	Set of candidate tyres to be qualified	R_a
1 R-T_1-R	T_1	$R_a = 1/2\ (R_1 + R_2)$
2 R-T_1-T_2-R	T_1	$R_a = 2/3\ R_1 + 1/3\ R_2$
	T_2	$R_a = 1/3\ R_1 + 2/3\ R_2$
3 R-T_1-T_2-T_3-R	T_1	$R_a = 3/4\ R_1 + 1/4\ R_2$
	T_2	$R_a = 1/2\ (R_1 + R_2)$
	T_3	$R_a = 1/4\ R_1 + 3/4\ R_2$

T_a (a = 1, 2, etc.) is the average of the peak braking coefficient for a test of a candidate tyre.

7.7.6 Calculation of the relative wet grip performance index of the tyre

The wet grip index of the tyre is calculated by the formula

$$\text{wet grip index(T)} = \frac{\mu_{\text{peak,ave}}(\text{T})}{\mu_{\text{peak,ave}}(\text{R})} \times 100$$

which represents the relative wet grip performance index of the candidate tyre compared to the reference tyre.

Annex A
(informative)

Example test report 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} (SRTT):	BPN:
Speed (km/h):	Water depth (mm):

No.		1	2	3	4	5	6	7	8	9	10
Size											
Service description											
Tyre identification											
Rim											
Pattern											
Load (kg)											
Pressure (kPa)											
μ_{peak}	1										
	2										
	3										
	4										
	5										
	6										
	7										
	8										
Average											
Standard deviation, σ											
$\frac{\sigma}{\text{average}} < 5\ \%$											
Adjusted μ_{peak} (SRTT)											
Wet grip index											
Surface temp.											
Remarks											

EXAMPLE 2 Test report of wet grip index using vehicle method

Driver:	Test date:

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

Vehicle	
Brand:	
Model:	
Type:	

	Beginning	End
Air temp. (°C):		
Ground temp. (°C):		
Wind speed (m/s):		

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 E 1136 SRTT		PATTERN B		PATTERN C		PATTERN D		ASTM E 1136 SRTT	
Size		P195/75R14		SIZE B		SIZE C		SIZE D		P195/75R14	
Service description		92S		LI/SS		LI/SS		LI/SS		92S	
Tyre identification		XXXXXXXXX		YYYYYYYYY		ZZZZZZZZZ		NNNNNNNNN		XXXXXXXXX	
Rim											
Front axle pressure (bar)											
Rear axle pressure (bar)											
Front axle load (kg)											
		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** (%) **< 3 %**											
Adjusted average AD of ref. tyre: R_a (m/s^2)											
BFC(R) reference tyre											
BFC(T) candidate tyre											
Wet grip index (%)											

Bibliography

[1] ISO 4223-1, *Definitions of some terms used in the tyre industry — Part 1: Pneumatic tyres*

[2] ISO 8855, *Road vehicles — Vehicle dynamics and road-holding ability — Vocabulary*

[3] ISO 10844:1994, *Acoustics — Specification of test tracks for the purpose of measuring noise emitted by road vehicles*

ICS 83.160.10

Price based on 16 pages