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Passenger car, truck and bus tyres — Methods of measuring rolling resistance — Single point test and correlation of measurement results

Pneumatiques pour voitures particulières, camions et autobus — Méthodes de mesure de la résistance au roulement — Essai à condition de mesure unique et corrélation des résultats de mesure

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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

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Foreword

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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.

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ISO 28580 was prepared by Technical Committee ISO/TC 31, *Tyres, rims and valves*.

Passenger car, truck and bus tyres — Methods of measuring rolling resistance — Single point test and correlation of measurement results

1 Scope

This International Standard specifies methods for measuring rolling resistance, under controlled laboratory conditions, for new pneumatic tyres designed primarily for use on passenger cars, trucks and buses. Tyres intended for temporary use only are not included in this International Standard.

This International Standard includes a method for correlating measurement results to allow inter-laboratory comparisons. Measurement of tyres using this method enables comparisons to be made between the rolling resistance of new test tyres when they are free-rolling straight ahead, in a position perpendicular to the drum outer surface, and in steady-state conditions.

In measuring tyre rolling resistance, it is necessary to measure small forces in the presence of much larger forces. It is, therefore, essential that equipment and instrumentation of appropriate accuracy be used.

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 4000-1:2007, *Passenger car tyres and rims — Part 1: Tyres (metric series)*

ISO 4209-1:2001, *Truck and bus tyres and rims (metric series) — Part 1: Tyres*

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

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in 4223-1 and the following apply.

3.1
rolling resistance
F_r
loss of energy (or energy consumed) per unit of distance travelled

NOTE The International System of Units (SI) unit conventionally used for the rolling resistance is the newton-metre per metre, which is equivalent to a drag force in newtons.

3.2
rolling resistance coefficient
C_r
ratio of the rolling resistance to the load on the tyre

NOTE The rolling resistance is expressed in newtons and the load is expressed in kilonewtons. The rolling resistance coefficient is dimensionless.

3.3
capped inflation
process of inflating the tyre and allowing the inflation pressure to build up, as the tyre is warmed up while running

3.4
parasitic loss
loss of energy (or energy consumed) per unit distance excluding internal tyre losses, attributable to aerodynamic loss of the different rotating elements of the test equipment, bearing friction and other sources of systematic loss which may be inherent in the measurement

NOTE This International Standard describes which sources of loss are to be excluded from the result of the measurement.

3.5
skim test reading
type of parasitic loss measurement in which the tyre is kept rolling, without slippage, while reducing the tyre load to a level at which energy loss within the tyre itself is virtually zero

3.6
inertia
moment of inertia
ratio of the torque applied to a rotating body to the rotational acceleration of this body

NOTE 1 The rotating body can be, for example, a tyre assembly or machine drum.

NOTE 2 See Annex B.

3.7
new test tyre
tyre which has not previously been used in a rolling deflected test that raises its temperature above that generated in rolling resistance tests, and which has not previously been exposed to a temperature above 40 °C

NOTE 1 In addition to the tests described in this International Standard, rolling resistance tests are also described in ISO 18164, SAE J1269 and SAE J2452.

NOTE 2 It is permissible to repeat an accepted test procedure.

3.8
measurement result correlation
set of rolling resistance measurements to be carried out on a regular time basis by separate laboratories, in order to allow direct comparisons between their rolling resistance results

NOTE The results of these measurements are used to compute “alignment” corrective coefficients and permit calculation of aligned rolling resistance measurement, $C_{r,aligned}$ (see Clause 10).

3.9
reference machine
machine considered as a reference for an alignment

3.10
alignment tyres
set of two predetermined tyres measured by both the candidate and reference machines to perform machine alignment

NOTE See Clause 10.

3.11
laboratory control tyre
tyre used by an individual laboratory to control machine behaviour as a function of time

NOTE An example of machine behaviour is drift.

3.12
measurement reproducibility
σ_m
capability of a machine to measure rolling resistance

NOTE σ_m can be estimated by measuring n times (where $n \geqslant 3$) the whole procedure described in Clause 7 for the two alignment tyres, assuming that the variances of the two alignment tyres are homogeneous, as follows:

$$\sigma_m = \sqrt{\frac{1}{2}\sum_{i}^{2} \sigma_{m,i}^{\ 2}}$$

$$\sigma_{m,i} = \sqrt{\frac{1}{n-1}\sum_{j=1}^{n}\left[C_{r,i,j} - \left(\frac{1}{n}\sum_{j=1}^{n} C_{r,i,j}\right)\right]^2}$$

where

i is either 1 or 2, corresponding to each of the alignment tyres;

j is the counter from 1 to n for the number of repetitions of each measurement for a given tyre;

n is the number of repetitions of tyre measurements.

3.13
deviation of alignment tyre
difference in terms of time compared with the mean rolling resistance coefficient measurement results for a given alignment tyre with the appropriate number of repetitions

NOTE See 10.4.

4 Test methods

The alternative measurement methods listed below are given in this International Standard. The choice of an individual method is left to the tester. For each method, the test measurements shall be converted to a force acting at the tyre/drum interface. The measured parameters are:

a) in the force method: the reaction force measured or converted at the tyre spindle;

NOTE 1 The measured value in the force method also includes the bearing and aerodynamic losses of the wheel and the tyre, which are also to be considered for further data interpretation.

b) in the torque method: the torque input measured at the test drum;

c) in the deceleration method: the measurement of deceleration of the test drum and tyre assembly;

d) in the power method: the measurement of the power input to the test drum.

NOTE 2 The measured value in the torque, deceleration and power methods also includes the bearing and aerodynamic losses of the wheel, the tyre and the drum, which are also to be considered for further data interpretation.

5 Test equipment

5.1 Drum specifications

5.1.1 Diameter

The test dynamometer shall have a cylindrical flywheel (drum) with a diameter of at least 1,7 m.

The F_r and C_r values shall be expressed relative to a drum diameter of 2,0 m. If a drum diameter other than 2,0 m is used, a correlation adjustment shall be made in accordance with 9.3.

5.1.2 Surface

The surface of the drum shall be smooth steel. Alternatively, in order to improve skim test reading accuracy, a textured surface may also be used, which shall be kept clean.

The F_r and C_r values shall be expressed relative to the "smooth" drum surface. If a textured drum surface is used, see Clause A.7.

5.1.3 Width

The width of the drum test surface shall exceed the width of the test tyre contact patch.

5.2 Measuring rim

The tyre shall be mounted on a steel or light alloy measuring rim, as follows:

— for passenger car tyres, the width of the rim shall be as defined in ISO 4000-1:2007, 6.2.2;

— for truck and bus tyres, the width of the rim shall be as defined in ISO 4209-1:2001, 5.1.3.

No other rim width shall be allowed.

See Annex C.

5.3 Load, alignment, control and instrumentation accuracies

Measurement of these parameters shall be sufficiently accurate and precise to provide the required test data. The specific and respective values are shown in Annex A.

5.4 Thermal environment

5.4.1 Reference conditions

The reference ambient temperature, measured at a distance not less than 0,15 m and not more than 1 m from the tyre sidewall, shall be 25 °C.

5.4.2 Alternative conditions

If the test ambient temperature is different from the reference ambient temperature, the rolling resistance measurement shall be corrected to the reference ambient temperature in accordance with 9.2.

5.4.3 Drum surface temperature

Care should be taken to ensure that the temperature of the test drum surface is the same as the ambient temperature at the beginning of the test.

6 Test conditions

6.1 General

The test consists of a measurement of rolling resistance in which the tyre is inflated and the inflation pressure is allowed to build up, i.e. “capped air”.

6.2 Test speeds

The value shall be obtained at the appropriate drum speed specified in Table 1.

Table 1 — Test speeds

	Tyre type			
	Passenger car		Truck and bus	
Load index LI	All	LI ⩽ 121	LI > 121	LI > 121
Speed symbol	All	All	J [a] and lower or tyres not marked with speed symbol	K [b] and higher
Test speed km/h	80	80	60	80

[a] 100 km/h.

[b] 110 km/h.

6.3 Test load

The standard test load shall be computed from the values shown in Table 2 and shall be kept within the tolerance specified in Annex A.

6.4 Test inflation pressure

The inflation pressure shall be in accordance with that shown in Table 2 and shall be capped with the accuracy specified in Clause A.4.

Table 2 — Test loads and inflation pressures

	Tyre type		
	Passenger car		Truck and bus
	Standard load	Reinforced or extra load	
Load % of maximum load capacity	80 [a]	80 [a]	85 [b]
Inflation pressure kPa	210	250	Corresponding to maximum load capacity for single application [c]
NOTE The inflation pressure is capped with the accuracy specified in Clause A.4.			

[a] For those passenger car tyres belonging to categories not shown in ISO 4000-1:2007, Annex B, the inflation pressure shall be the inflation pressure recommended by the tyre manufacturer, corresponding to the maximum tyre load capacity, reduced by 30 kPa.

[b] As a percentage of single load, or 85 % of maximum load capacity for single application specified in applicable tyre standards manuals if not marked on tyre.

[c] Inflation pressure marked on sidewall, or if not marked on sidewall, as specified in applicable tyre standards manuals corresponding to maximum load capacity for single application.

6.5 Duration and speed

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

a) for duration Δt , the time increments shall not exceed 0,5 s;

b) any variation of the test drum speed shall not exceed 1 km/h within one time increment.

7 Test procedure

7.1 General

The test procedure steps described below shall be followed in the sequence given.

7.2 Thermal conditioning

The inflated tyre shall be placed in the thermal environment of the test location for a minimum of:

— 3 h for passenger car tyres;

— 6 h for truck and bus tyres.

7.3 Pressure adjustment

After thermal conditioning, the inflation pressure shall be adjusted to the test pressure and verified 10 min after the adjustment is made.

7.4 Warm-up

The warm-up durations shall be as specified in Table 3.

Table 3 — Warm-up durations

	Tyre type			
	Passenger car	Truck and bus		
Load index LI	All	LI ⩽ 121	LI > 121	LI > 121
Nominal rim diameter code	All	All	< 22.5	⩾ 22.5
Warm-up duration min	30	50	150	180

7.5 Measurement and recording

The following shall be measured and recorded (see Figure 1):

a) the test speed, U_n;

b) the load on the tyre normal to the drum surface, L_m;

c) the initial test inflation pressure, as defined in 6.4;

d) the rolling resistance coefficient, C_r, and its corrected value, $C_{r,corrected}$, at 25 °C and for a drum diameter of 2 m;

e) the distance from the tyre axis to the drum outer surface under steady-state conditions, r_L, expressed in metres;

f) the ambient temperature, t_{amb};

g) the test drum radius, R;

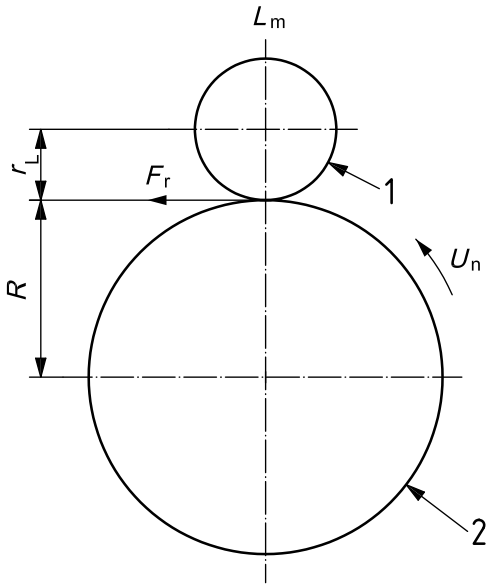
h) the test method chosen;

i) the test rim (size and material);

j) the tyre size, manufacturer, type, identity number (if one exists), speed symbol, load index, DOT number[1)].

All the mechanical quantities (forces, torques) shall be oriented in accordance with the axis systems specified in ISO 8855. The directional tyres shall be run in their specified rotation direction.

1) DOT: Department of Transportation.



Key

1 tyre
2 drum
F_r rolling resistance
L_m load on tyre normal to drum surface
R test drum radius
r_L distance from tyre axis to drum outer surface under steady-state conditions
U_n test speed

Figure 1 — Measurement orientation

7.6 Measurement of parasitic losses

7.6.1 General

The parasitic losses shall be determined by one of the procedures given in 7.6.2 or 7.6.3.

7.6.2 Skim test reading

Skim test reading follows the procedure below.

a) Reduce the load to maintain the tyre at the test speed without slippage. The load values should be as follows:

- passenger car tyres: recommended value of 100 N, but not exceeding 200 N;
- truck and bus tyres (LI $\leqslant$ 121): recommended value of 150 N, but not exceeding 200 N for machines designed for passenger car tyre measurement or 500 N for machines designed for truck and bus tyres;
- truck and bus tyres (LI > 121): recommended value of 400 N, but not exceeding 500 N;
- skim values shall be the same for both standard testing and alignment (see Clause 10).

b) Record the spindle force, F_t, the input torque, T_t, or the power, whichever applies.

c) Record the load on the tyre normal to the drum surface, L_m.