INTERNATIONAL STANDARD

ISO 28580

Second edition
2018-07

Passenger car, truck and bus tyre rolling resistance measurement method — Single point test and correlation of measurement results

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

Reference number
ISO 28580:2018(E)

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

Page

Foreword ..... **v**

1 Scope **1**

2 Normative references **1**

3 Terms and definitions **1**

4 Test methods **4**

5 Test equipment **4**
5.1 General 4
5.2 Drum specifications 5
5.2.1 Diameter 5
5.2.2 Surface 5
5.2.3 Width 5
5.3 Measuring rim 5
5.4 Load, alignment, control and instrumentation accuracies 5
5.5 Thermal environment 5
5.5.1 Reference conditions 5
5.5.2 Alternative conditions 5

6 Test conditions **5**
6.1 General 5
6.2 Test speeds 6
6.3 Test load 6
6.4 Test inflation pressure 6
6.5 Duration and speed 6

7 Test procedure **7**
7.1 General 7
7.2 Thermal conditioning 7
7.3 Pressure adjustment 7
7.4 Warm-up 7
7.5 Measurement and recording 7
7.6 Measurement of parasitic losses 8
7.6.1 General 8
7.6.2 Skim test reading 8
7.6.3 Deceleration method 9
7.7 Allowance for machines exceeding σ_m criterion 9

8 Data interpretation **9**
8.1 Determination of parasitic losses 9
8.1.1 General 9
8.1.2 Force method at tyre spindle 9
8.1.3 Torque method at drum axis 10
8.1.4 Power method at drum axis 10
8.1.5 Deceleration method 10
8.2 Rolling resistance calculation 11
8.2.1 General 11
8.2.2 Force method at tyre spindle 11
8.2.3 Torque method at drum axis 11
8.2.4 Power method at drum axis 11
8.2.5 Deceleration method 12

9 Data analysis **12**
9.1 Rolling resistance coefficient 12
9.2 Temperature correction 12
9.3 Drum diameter correction 13
9.4 Measurement result 13

10 Measurement machines alignment and monitoring requirements 14
10.1 General 14
10.2 Conditions for reference machine 14
10.3 Conditions for candidate machine 14
10.4 Alignment tyre requirements 15
10.5 Alignment procedure 15
Annex A (normative) **Test equipment tolerances 17**
Annex B (informative) **Measurement methods of moment of inertia for drum and tyre assembly — Deceleration method 20**
Annex C (informative) **Test rim runout 25**
Annex D (informative) **Publications of tyre standards organizations 26**
Annex E (informative) **Example for larger truck bus warm-up duration 27**
Annex F (informative) **Example for machine drift evaluation 29**
Bibliography 32

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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by ISO/TC 31, *Tyres, rims and valves*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

This second edition cancels and replaces the first edition (ISO 28580:2009), which has been technically revised. The main changes compared to the previous edition are as follows:

— Incorporation of clarifications and additional detail, for example those identified in ISO/TR 16377;

— Expansion of the concept of reference machine to include two possible types, a physical reference or a virtual reference;

— Allowance for alignment to be carried out based on a set of two or more alignment tyres as defined by the authorizing body;

— Ability to reduce the warm-up duration of larger truck and bus tyres under certain conditions;

— Alignment improvement through the use of four measures of each alignment tyre, using only the last three measures for computations;

— Additional information concerning machine drift evaluation.

Passenger car, truck and bus tyre rolling resistance measurement method — Single point test and correlation of measurement results

1 Scope

This document specifies methods for measuring rolling resistance, under controlled laboratory conditions, for new pneumatic tyres designed primarily for use on passenger cars, trucks and buses. This document is not applicable to tyres intended for temporary use only. It includes a method for correlating measurement results to allow inter-laboratory comparisons. It is designed to facilitate international cooperation and, possibly, regulation building.

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.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 4000-1:2015, *Passenger car tyres and rims — Part 1: Tyres*

ISO 4209-1, *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*

ISO 17025, *General requirements for the competence of testing and calibration laboratories*

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

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

Note 1 to entry: The SI unit conventionally used for the rolling resistance is the newton metre per metre (N m/m). This is equivalent to a drag force in newtons (N).

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

Note 1 to entry: Rolling resistance is measured in newtons (N).

Note 2 to entry: Load on the tyre is measured in kilonewtons (kN).

Note 3 to entry: Although this quantity is dimensionless, it is conventionally expressed in N/kN.

3.3
capped inflation
process of inflating the tyre to the required cold pressure 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, and attributable to aerodynamic loss of the different rotating elements of the test equipment, bearing friction and other sources of systematic loss which can be inherent in the measurement

Note 1 to entry: This document describes which of them 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
moment of inertia
inertia
ratio of the torque applied to a rotating body, such as a tyre assembly or machine drum, to the rotational acceleration of this body

Note 1 to entry: See Annex B.

3.7
new test tyre
tyre which has not been previously used in a rolling deflected test which elevates the tyre's temperature to higher than that generated in rolling resistance tests or has not been exposed to a temperature higher than 40 °C

Note 1 to entry: Repetition of allowed test procedures is permitted.

Note 2 to entry: See examples in this document, ISO 18164, SAE J1269, SAE J2452.

3.8
correlation of measurement results
computations on a 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 1 to entry: 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
any machine considered as a reference for an alignment

Note 1 to entry: Every tyre testing spindle in one specific measurement method is considered a machine for the purposes of this standard. For example, two spindles acting on the same drum shall not be considered as one machine. One spindle able to measure tyre rolling resistance through different methods shall not be considered as one machine.

3.9.1
physical reference machine
machine (and its corresponding laboratory quality systems) used to set alignment values

3.9.2
virtual reference machine
several machines (and their corresponding laboratory quality systems) used to set alignment values

3.10
candidate machine
machine intended to measure new test tyres, with alignment to a reference machine, according to this document

3.11
alignment tyres
set of tyres measured by both the candidate and reference machines to perform machine alignment

3.12
laboratory control tyre
tyre used by an individual laboratory to control machine behaviour, e.g. machine drift, as a function of time

3.13
measurement repeatability
σ_m
dispersion of the results obtained on one machine for different measurements performed on the same tyre(s) over a short period of time under the same testing conditions

Note 1 to entry: Measurement repeatability is estimated by measuring $n + 1$ times the whole process described in Clause 7 ($n \geq 3$) for p alignment tyres, assuming that the variances of the alignment tyres are homogeneous:

$$\sigma_m = \sqrt{\frac{1}{p} \cdot \Sigma_{i=1}^{p} \sigma_{m,i}^2} \quad \text{with} \quad \sigma_{m,i} = \sqrt{\frac{1}{(n-1)} \cdot \sum_{j=2}^{n+1} \left(C_{ri,j} - \frac{1}{n} \sum_{j=2}^{n+1} C_{ri,j} \right)^2}$$

where

p is the number of alignment tyres;

i is the counter from 1 to p for the alignment tyres;

j is the counter from 2 to $n + 1$ for the n last repetitions of each measurement of a given alignment tyre;

$n + 1$ is the number of repetitions of tyre measurements ($n + 1=4$ for reference laboratories and $n + 1 \geq 4$ for candidate laboratories). The last n measurement results are used for the computation.

3.14
machine drift
change in the measured value over time which can be attributed to systematic (or progressive) sources of variation

3.15
passenger car tyre
tyre of a group intended for application on 4-wheeled vehicles designed primarily for carrying fewer than 10 persons

Note 1 to entry: See Annex D for a list of standards which identify this tyre type.

3.16
truck and bus tyre
tyre of a group intended for application on vehicles designed primarily for the transportation of property or for carrying more than 10 persons

Note 1 to entry: Such tyres are normally primarily designed for use on light trucks, trucks, buses and their trailers and include those tyres marked with "LT", "C", "ST", "CP".

Note 2 to entry: See Annex D for a list of standards which identify this tyre type.

3.16.1
smaller truck and bus tyre
truck and bus tyre with a load index of 121 and smaller or, where the load index is not marked, a maximum load of 1 450 kg and lower

3.16.2
larger truck and bus tyre
truck and bus tyre with a load index greater than 121 or, where the load index is not marked, a maximum load of more than 1 450 kg

4 Test methods

The following are alternative measurement methods. 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) Force method: the reaction force measured or converted at the tyre spindle (see NOTE 1);

b) Torque method: the torque input measured at the test drum (see NOTE 2);

c) Deceleration method: the measurement of deceleration of the test drum and tyre assembly (see NOTE 2);

d) Power method: the measurement of the power input to the test drum (see NOTE 2).

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

NOTE 2 This measured value also includes the bearing and aerodynamic losses of the wheel, the tyre, and the drum losses which are also to be considered for further data interpretation.

5 Test equipment

5.1 General

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.

5.2 Drum specifications

5.2.1 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 following the method in 9.3.

5.2.2 Surface

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

The F_r and C_r values shall be expressed relative to the "smooth" drum surface. If textured drum surface is used, reference A.6.

5.2.3 Width

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

5.3 Measuring rim

The tyre shall be mounted on a steel or light alloy measuring rim, with the width as defined in ISO 4000-1 for passenger car tyre rims and as defined in ISO 4209-1 for truck and bus tyre rims. If a size is not included in ISO 4000-1 or ISO 4209-1, refer to the relevant calculation section. Mounting tyres on other rim widths shall be done with the agreement of the requestor and the tester and such deviation shall be noted on the test report. Rim runout guidelines are listed in Annex C.

5.4 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.

5.5 Thermal environment

5.5.1 Reference conditions

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

5.5.2 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.

6 Test conditions

6.1 General

The test consists of a measurement of rolling resistance in which the tyre is inflated to the required cold pressure and the inflation pressure allowed to build up (i.e. "capped inflation").

Any measurement other than what is prescribed within this document shall be done under the requestor's responsibility and should be noted on the test report (e.g. retread tyres, buffed tyres, different rim width, pressures, loads, etc.). Studded tyres are not allowed due to potential drum damage.

6.2 Test speeds

The rolling resistance coefficient value shall be obtained at a drum speed as shown in Table 1.

Table 1 — Test speeds

Speeds in km/h

Tyre type	Passenger car	Smaller truck and bus	Larger truck and bus	
Speed symbol[a]	All	All	J (100 km/h) and lower	K (110 km/h) and higher
Speed	80	80	60	80

[a] If the tyre is not marked with a speed symbol, consult the manufacturer databook for the maximum rated speed and select a test speed of 60 km/h for maximum rated speed of 100 km/h or lower; otherwise, test speed is 80 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 A.4.

Table 2 — Test loads and inflation pressures

Tyre type	Passenger car[a]		Truck and bus[b]
	Standard load or light load	Reinforced or extra load	
Load — % of maximum load capacity	80	80	85[c] (% of single load)
Inflation pressure[d] kPa	210	250	Corresponding to maximum single tyre load carrying capacity[e]

[a] For those passenger car tyres belonging to categories which are not shown in ISO 4000-1:2015, 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] If there are multiple values given, the highest load and corresponding pressure should be selected, disregarding any additional service description, which, if present, is located in a circle close to the primary service description.

[c] 85 % of maximum load capacity for single application specified in applicable tyre standards manuals.

[d] The inflation pressure shall be capped with the accuracy specified in A.4.

[e] Inflation pressure as specified in applicable tyre standards manuals corresponding to maximum single tyre load carrying capacity.

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 are to be followed in the sequence given.

7.2 Thermal conditioning

Place the inflated tyre in the thermal environment of the test location for a minimum of 3 h for passenger car tyres and a minimum of 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

Warm-up duration is given in Table 3.

Table 3 — Warm-up duration

Tyre type	Passenger car	Smaller truck and bus	Larger truck and bus[a]	
Nominal rim diameter code	All	All	<22,5	≥22,5
Warm-up duration	30 min	50 min	150 min	180 min

[a] For the torque and force methods, larger truck and bus warm-up duration can be decreased from the specified values if the following requirements can be met:

1) Real time machine monitoring is available for input torque or spindle force with data averages every minute, and

2) It can be demonstrated that a tyre has reached a stabilized steady-state value of rolling resistance when the absolute difference between data samples over a 10 min period is ≤0,1 N.

An example is provided in Annex E. The warm-up duration shall be indicated on the test report if different from that shown in the table.

7.5 Measurement and recording

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

a) Test speed, U_n;

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

c) Test inflation pressure: initial, as defined in 6.4;

d) Rolling resistance coefficient measured, C_r, and its corrected value, C_{rc}, at 25 °C and for a drum diameter of 2 m;

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

f) Ambient temperature, t_{amb};

g) Test drum radius, R;

h) Test method chosen;

i) Test rim (size and material). If not the prescribed measuring rim, the deviation shall be highlighted;