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Tyre stiffness index testing procedure for passenger car extended mobility and run flat tyres

Procédure d'essai de l'indice de rigidité de pneumatiques à mobilité étendue et pour roulage à plat pour voiture particulière

Reference number
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Foreword

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

Tyre stiffness index testing procedure for passenger car extended mobility and run flat tyres

1 Scope

This document specifies the testing method for determining the tyre stiffness index of passenger car tyres for the products capable of supplying the vehicle with the basic tyre functions, at least, at a speed of 80 km/h (50 mph) and a distance of 80 km when operating in flat tyre running mode, as per ISO 16992.

This method is meant to determine the above mentioned index, for the characterization of the expected tyre's stiffness through its air and structural components.

To reach the target, the vertical force and the vertical deflection, in the sense of absolute position in Z direction under different operating conditions, are measured (approximated in case of zero inflation pressure) and combined through the metrics defined in this document.

This method is not intended to be used for conventional tyres.

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

ISO 4000-2, *Passenger car tyres and rims — Part 2: Rims*

ISO 16992, *Passenger car tyres — Spare unit substitutive equipment (SUSE)*

3 Terms and definitions

For the purposes of this document, the following terms and definitions 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
conventional tyre
pneumatic tyre designed for use in an inflated state

3.2
run flat tyre
self supporting tyre
SST
pneumatic tyre structure provided with any technical solutions (for example, reinforced sidewalls, etc.) designed to operate in an inflated mode and allowing the tyre, mounted on the appropriate wheel and in the absence of any supplementary component, to supply the vehicle with the basic tyre functions at a specified speed and distance when operating in flat tyre running mode

3.3
extended mobility tyre
EMT
pneumatic tyre featuring technology designed on purpose to operate in an inflated mode and allowing the tyre, mounted on the appropriate wheel and in the absence of any supplementary component, to supply the vehicle with the basic tyre functions at a specified speed and distance when operating in flat tyre running mode

3.4
test rim
rim on which a tyre is required to be fitted for testing

3.5
inflation pressure
pressure taken with the tyre at ambient temperature, as indicated by the tyre manufacturer and which does not include any pressure build-up due to tyre usage

3.6
zero inflation pressure running mode
state of the tyre while operating in deflated condition, obtained by removing the valve-core

3.7
speed symbol
code signifying the maximum speed at which the tyre can carry a load corresponding to its *load index* (3.8) under service conditions specified by the tyre manufacturer

Note 1 to entry: Refer to ISO 4000-1:2015, Table 3.

3.8
load index
LI
numerical code associated to the maximum load that a tyre can carry at the speed indicated by its *speed symbol* (3.7) under service conditions specified by the tyre manufacturer

Note 1 to entry: Refer to ISO 4000-1:2015, Table 2.

3.9
loading force
F_Z
force measured during the loading condition (either in wheel spindle axle or in the loading plate), in the loading direction

3.10
loading speed
v_L
speed used to apply the load on the tyre

3.11
absolute position
z
position of either the tyre or the loading plate

Note 1 to entry: Absolute position is expressed in mm.

3.12
reference inflation pressure
P_{ref}
inflation pressure (3.5) to be used as a first step in testing conditions

Note 1 to entry: See Table 1.

3.13
test inflation pressure
P_i
inflation pressure (3.5) at each step "*i*"

Note 1 to entry: Inflation pressure is expressed in kPa.

3.14
vertical stiffness
K_Z
tyre stiffness measured under vertical force input in inflated conditions

Note 1 to entry: Vertical stiffness is expressed in N/mm.

3.15
total stiffness
K_{tot}
tyre characteristic linked to tyre *structural stiffness* (3.16) and *air stiffness* (3.17), for each test inflation pressure value

Note 1 to entry: In case the test inflation pressure is P_{ref} (3.12), then K_{tot} is equal to tyre's *vertical stiffness*, K_Z (3.14).

3.16
structural stiffness
K_{str}
tyre *vertical stiffness* (3.14) measured in "zero i.p. running mode"

Note 1 to entry: Structural stiffness is expressed in N/mm.

Note 2 to entry: It is a function of the tyre's construction and technological content.

3.17
air stiffness
K_{air}
tyre characteristic, calculated as the difference between tyre *vertical stiffness* (3.14) and tyre *structural stiffness* (3.16)

Note 1 to entry: Air stiffness is expressed in N/mm.

Note 2 to entry: It is a function of the air volume and the *inflation pressure* (3.5) of the tyre itself.

3.18
deflection
S_Z
vertical displacement of the plate in the z direction

3.19
tyre diameter offset
IG
change of the outer diameter due to the inflation of the tyre

4 Test method

4.1 General

Tyres, to be considered run flat tyre or self-supporting tyre (SST) or extended mobility tyre (EMT) shall successfully complete the related endurance tests as described in ISO 16992.

4.2 Inflated tyre — Vertical stiffness measurement

4.2.1 Tyre inflation pressure

Set the tyre inflation pressure according to the ISO 4000-1 reference pressure:

— 250 kPa for the standard load tyres;

— 290 kPa for the reinforced or extra load tyres.

After fitting the tyre on the proper rim, the assembly shall be stored for at least 3 h at (25 ± 3) °C.

The accuracy for the inflation pressure shall be ±3 kPa.

4.2.2 Tyre positioning

The tyre shall be measured at three locations equally distributed around the tyre‘s circumference:

— at the reference position, free to be chosen, but it needs to be in contact with the platform and free from splices, if visible;

— two additional positions equally distributed around the tyre’s circumference: distance between measurement positions approximately 120°.

4.2.3 Rims

The rims for the measurement shall have humps (flat or round) on both rim sides, in accordance with ISO 4000-2; the measuring rim width shall be in accordance with ISO 4000-1. As a general rule, stiff alloy or heavy duty rims should be used.

4.2.4 Equipment minimum requirements

A system able to apply a relative load between the tyre and a plate, with plate dimensions higher than the tyre footprint and relative movement of the two (tyre towards plate or plate towards tyre) is needed.

The theoretic tyre rotational axis shall be parallel to the plate and the relative movement of the two parts shall be as such to be able to keep the parallelism (e.g. as for plunger or footprint machine).

The machine maximum speed shall be 1 mm/s and the acquisition rate shall be at least 5 data points for each millimetre of displacement.

4.2.5 Machine set-up

a) Reset the tyre load cell before testing:

   — as the load cells usually start the data acquisition at approximately 100 N, the measurement data acquisition shall start at 100 N or below.

b) At least the following channels shall be recorded:

   — loading force (F_Z) (N), accuracy ±0,5 % of maximum load cell capacity, but in any case, maximum 100 N.

   — absolute position (z) (mm) accuracy ±0,5 mm.

One vertical load value (F_Z) shall correspond to only one absolute position value (z) and vice versa.

The ambient temperature at the measuring machine shall be (25 ± 5) °C.

The total number of acquired data points shall be in the range between 100 and 1 000 per inflation pressure step (refer to Table 1).

The surface of the platform in contact with the tyre during the measurement shall be smooth steel. The surface shall be cleaned with appropriate liquids according to the maintenance instructions of the machine.

4.2.6 Maximum testing load

The maximum load at P_{ref} to be reached during the test is 150 % of the maximum load associated to the load index value of the tyre (refer to ISO 4000-1:2015, Table 2).

4.2.7 Procedure

4.2.7.1 Mount the tyre on the machine.

4.2.7.2 The initial distance between the tyre and the plate shall be at least 10 mm, measured as vertical distance between the lowest tyre point and the plate.

To set the starting point for data acquisition, the inflated tyre is loaded with a light load ($F_Z \leq 100$ N) to determine the contact point between the tyre and the loading plate. From this point, the tyre is moved back by at least 10 mm. This last position is the starting point (0,0) to be used for all of the next inflation pressure steps.

4.2.7.3 Start the channel recording.

4.2.7.4 Start loading the tyre using a constant loading speed of maximum 1 mm/s.

4.2.7.5 Inflation pressure step 1 is stopped at the maximum load (150 % LI), where the maximum deflection, S_{Zmax}, is recorded and set as stopping criterion for the following inflation pressure steps.

4.2.7.6 Unload the tyre and move back to the (0,0) position as defined in 4.2.7.2.

4.2.7.7 Repeat 4.2.7.3, 4.2.7.4 and 4.2.7.6 for the inflation pressure steps 2, 3 and 4. For each of them, the proper test inflation pressure is reported in Table 1, while the loading stop criterion is S_{zmax} for all of them.

Table 1 — Testing conditions for each inflation pressure step

Inflation pressure steps, i	Stop criterion	Test inflation pressure, P_i (kPa)
1	150 % LI	P_{ref}
2	S_{Zmax}	100
3	S_{Zmax}	70
4	S_{Zmax}	30

An example of the measurement results at 30 kPa, 70 kPa, 100 kPa and P_{ref} is shown in Figure 1.