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Test methods of rolling resistance for motor vehicle tyres and motorcycles tyres - Multi-point test

汽车轮胎和摩托车轮胎 滚动阻力试验方法 多点试验

(ISO 18164:2005, Passenger car, truck, bus and motorcycle tyres - Methods of measuring rolling resistance, MOD)

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Test methods of rolling resistance for motor vehicle tyres and motorcycles tyres - Multi-point test

1 Scope

This standard specifies a method, for measuring the rolling resistance of new car, truck and motorcycle tyres, under controlled laboratory conditions.

This standard applies to new car pneumatic tyres, truck pneumatic tyres, motorcycle pneumatic tyres, except for tyres only for temporary replacement use.

2 Normative references

The following documents are essential to the application of this document. For the dated documents, only the versions with the dates indicated are applicable to this document; for the undated documents, only the latest version (including all the amendments) is applicable to this standard.

GB/T 2977 Size designation, dimensions, inflation pressure and load capacity for truck tyres

GB/T 2978 Size designation, dimensions, inflation pressure and load capacity for passenger car tyres

GB/T 2983 Series of motorcycle tyres (GB/T 2983-2008, ISO 4249-1:1985, Motorcycle tyres and rims (code-designated series) – Part 1: Tyre; ISO 4249-2:1990, Motorcycle tyres and rims (code-designated series) -Part 2: Tyre load ratings; ISO 4249-3:2004, Motorcycle tyres and rims (code-designated series) - Part 3: Rims; ISO 5751-1:2004, Motorcycle tyres and rims (metric series) - Part 1: Design guides; ISO 5751-2:2004, Motorcycle tyres and rims (metric series) - Part 2: Tyre dimensions and load-carrying capacities; ISO 5751-3:2004, Motorcycle tyres and rims (metric series) - Part 3: Range of approved rim contours; ISO 5995-1:1982, Moped tyres and rims - Part 1: Tyres; ISO 6054-1:1994, Motorcycle tyres and rims (code-designated series) - Diameter codes 4 to 12 - Part 1: Tyres, NEQ)

GB/T 6326 Tyre terms and definitions (GB/T 6326-2005, ISO 4223-1:2002, Definitions of some terms used in tyre industry - Part 1: pneumatic tyres, NEQ)

5.1.1 Drum diameter

The diameter of the drum of the testing machine is as follows: The diameter of the drum for car and motorcycle tyres is at least 1.5 m (the standard drum diameter is 1.7 m); the diameter of the drum for truck tyres is at least 1.7 m. The values of rolling resistance and rolling resistance coefficient shall be expressed as values for a 1.7 m drum. It shall be noted that the rolling resistance results are different for different drum diameters. According to 9.3, if necessary, different drum diameters can be converted.

5.1.2 Drum surface quality

The outer surface of the drum shall be smooth steel or textured; it shall be kept clean. The roughness of the steel surface shall comply with the requirements given in C.6. See Appendix D.4 for textured drumheads.

5.1.3 Drumhead width

The drum surface width shall be greater than the running surface width of the test tyre.

5.2 Test rims

The tyre shall be mounted on the test rim, which is specified in Appendix C.

5.3 Load, positioning, control, instrument accuracy

The tyres, their loads and positioning shall comply with the requirements given in C.3. The control accuracy shall comply with the provisions of C.4. The instrument accuracy shall comply with the provisions of C.5.

5.4 Ambient temperature

5.4.1 Standard ambient temperature

The standard ambient temperature is 25 °C. The ambient temperature shall be measured on the extension line of the wheel axle centerline, at 0.15 m ~ 1 m away from the nearest sidewall surface of the tyre.

5.4.2 Allowable ambient temperature

If the standard ambient temperature cannot be reached, the test is allowed within the ambient temperature range of 20 °C ~ 30 °C. However, the test data shall be corrected to the rolling resistance value under standard ambient temperature conditions, according to 9.2.

5.4.3 Drum surface temperature

At the beginning of the test, the temperature of the outer peripheral surface of the drum is approximately the same as the ambient temperature.

pressure of passenger car tyres, truck tyres, motorcycle tyres shall comply with the provisions of Table 2. The control accuracy of the test starting air pressure shall comply with the provisions of C.4.1.

6.5 Time and velocity variables of deceleration method

When the deceleration method is selected, the increment of running time (Δt) shall not be greater than 0.5 s; the variation of test speed shall not be greater than 1 km/h.

6.6 Selected test conditions

If it is necessary to conduct a sensitivity test of tyre pressure, load, speed to tyre rolling resistance, please refer to the test conditions given in Appendix D.

7 Test procedures

7.1 General

The stages of the test procedure shall be carried out in the order given below.

7.2 Test run

Install the test tyre on the measuring rim. Inflate it according to the test air pressure, which is specified in 6.4. Install it on the testing machine. Run it for at least 1 hour, according to the test load specified in 6.3 and at a test speed not lower than that specified in 6.2.

7.3 Thermal balance

Place the tyre and rim assembly at the test site. Place the test tyre at the test ambient temperature, to reach thermal equilibrium, to allow the test tyre to reach the ambient temperature. The thermal equilibrium time of car and motorcycle tyres is more than 3 hours; the thermal equilibrium time of truck tyres is more than 6 hours.

7.4 Air pressure adjustment

After thermal equilibrium, check the air pressure of the test tyre; adjust it to meet the requirements of 6.4; recheck after 10 minutes, to ensure the specified test air pressure of the tyre.

7.5 Warm up

Warm up the test tyre and drive it, according to the test load specified in 6.3 and the test speed specified in 6.2, until its rolling resistance value becomes stable. The minimum warm-up driving time shall comply with the requirements in Table 3.

- Car tyres and motorcycle tyres: Recommended value is 100 N, but no more than 200 N;

- Truck tyres (load index ≤ 121): Recommended value is 150 N. However, for equipment specially designed for car tyres or light truck tyres, it shall not exceed 200 N; OR for equipment specially designed for truck tyres, it shall not exceed 500 N;

- Truck tyres (load index > 121): Recommended value 400 N, but not exceeding 500 N;

- For standard tests and calibration tests, the skim test load values shall be the same;

b) Record the applicable data, in axle force (F_t), input torque (T_t) or input power;

c) Record the tyre load (L_m) perpendicular to the drum surface.

Note 1: In addition to the force measurement method, the measured values include bearing losses and aerodynamic losses of the tyre rim assembly and drum.

Note 2: The bearing friction -- between the tyre shaft and the drum -- depends on the applied load. Therefore, the value of the bearing friction when measuring the axle force under load is different from when measuring the parasitic loss using the skim test reading. In practice, however, the difference is negligible.

7.7.3 Machine method

The machine method is carried out, according to the following procedure:

a) Move the tyre away from the drum;

b) Record the input torque and input power at the test speed.

Note: Measurements include bearing and aerodynamic losses of the tyre rim assembly and drum.

7.7.4 Deceleration method

The deceleration method is carried out, according to the following procedure:

a) Move the tyre away from the drum surface;

b) Record the deceleration of the drum $\frac{\Delta\omega_{D0}}{\Delta t}$ and the deceleration of the unloaded tyre $\frac{\Delta\omega_{T0}}{\Delta t}$.

Note 1: Measurements include bearing and aerodynamic losses of the tyre rim assembly and

drum, which also need to be considered.

Note 2: It is well known that the bearing friction of the tyre shaft and the drum depends on the applied load; therefore, the value of the bearing friction, when measuring the deceleration under load, is different from that when measured by the skim test method. In practice, however, the difference is negligible.

8 Data processing

8.1 Calculation of parasitic losses

8.1.1 General

The parasitic loss F_{pl} at the tyre/drum interface shall be calculated, based on the force F_t, torque, power or deceleration, according to the formulas 8.1.2 ~ 8.1.5 below, expressed in N.

8.1.2 Force measurement method

The parasitic loss F_{pl}, represented by N, is calculated according to formula (1):

$$F_{pl} = F_t(1 + r_L/R) \qquad \cdots\cdots(1)$$

Where:

F_t - Axle force (see 7.7.2), in Newton (N);

r_L - The distance from the center line of the tyre shaft to the outer surface of the drum, under steady state, in meters (m);

R - Radius of drum, in meters (m).

8.1.3 Torque method

The parasitic loss F_{pl}, represented by N, is calculated according to formula (2):

$$F_{pl} = T_t/R \qquad \cdots\cdots(2)$$

Where:

T_t - Input torque (see 7.7.2), in Newton meter (N·m);

R - Radius of drum, in meters (m).

8.1.4 Power method

The parasitic loss F_{pl}, represented by N, is calculated according to formula (3):

$$F_r = F_t[1 + (r_L/R)] - F_{pl} \quad \cdots\cdots(5)$$

Where:

F_t - Axle force, in Newton (N);

F_{pl} - Parasitic loss calculated according to Article 8.1.2, in Newton (N);

r_L - Under steady-state conditions, the distance from the center line of the tyre shaft to the outer surface of the drum, in meters (m);

R - Radius of drum, in meter (m).

8.2.3 Drum shaft torque method

The rolling resistance F_r is calculated by formula (6), unit in N:

$$F_r = \frac{T_t}{R} - F_{pl} \quad \cdots\cdots(6)$$

Where:

T_t - Input torque, in Newton meter (N·m);

F_{pl} - Parasitic loss calculated according to 8.1.3, in Newton (N);

R - Radius of drum, in meter (m).

8.2.4 Power method

The rolling resistance F_r is calculated by formula (7), unit in N:

$$F_r = \frac{3.6V \times A}{U_n} - F_{pl} \quad \cdots\cdots(7)$$

Where:

V - The voltage of the driving motor of the testing machine, in volts (V);

A - The current of the driving motor of the testing machine, in amperes (A);

U_n - The drum speed, in kilometers per hour (km/h);

F_{pl} - The parasitic loss calculated according to 8.1.4, in Newton (N).

8.2.5 Deceleration method

The rolling resistance F_r is calculated by formula (8), unit in N:

$$F_r = \frac{I_D}{R}\left[\frac{\Delta\omega_v}{\Delta t_v}\right] + \frac{RI_T}{R_r^2}\left[\frac{\Delta\omega_v}{\Delta t_v}\right] - F_{pl} \quad \cdots\cdots (8)$$

Where:

I_D - Moment of inertia of the drum (see Appendix E), in kilogram square meter ($kg \cdot m^2$);

R - Radius of drum, in meters (m);

F_{pl} - Parasitic loss calculated according to 8.1.5, in Newton (N);

Δt_v - Time increment selected during measurement, in seconds (s);

Δw_v - Angular velocity increment of the test drum when the tyre is loaded, in radians per second (rad/s);

I_T - Moment of inertia of the wheel shaft and tyre rim assembly, in kilogram square meter ($kg \cdot m^2$);

R_r - Tyre rolling radius, in meters (m);

F_r - Rolling resistance, in Newton (N).

Note: See Appendix E for guidance and examples of measuring moment of inertia for deceleration method.

9 Data analysis

9.1 Rolling resistance coefficient

The rolling resistance coefficient C_r is calculated by dividing the rolling resistance by the tyre test load, using the formula (9):

$$C_r = \frac{F_r}{L_m} \quad \cdots\cdots (9)$$

Where:

F_r - Rolling resistance, in Newton (N);

L_m - Test load, in kilonewton (kN).

9.2 Temperature correction

The test temperature range is 20 °C ~ 30 °C. If the measurement is performed at a temperature other than 25 °C, use the formula (10) for temperature correction, where F_{r25} is the rolling resistance at 25 °C, represented by N:

Appendix C

(Normative)

Accuracy of test equipment

C.1 Overview

In order to ensure the repeatability of the test results and to have good correlation between the tyre test results, which are obtained on each test equipment, it is necessary to stipulate the accuracy of the test equipment. The provisions in this Appendix are necessary conditions for obtaining reliable test results; however, they are not all design requirements for test equipment.

C.2 Test rim

C.2.1 Width

The width of the test rim shall conform to the measured rim width for the test tyre specification, which is specified in the corresponding standard. The width of the car tyre test rim shall comply with the requirements of GB/T 2978; the width of the truck tyre test rim shall comply with the requirements of GB/T 2977; the width of the motorcycle tyre test rim shall comply with the requirements of GB/T 2983.

C.2.2 Deviation

The deviation of the test rim shall meet the following requirements:

a) The maximum radial runout at the tyre seat is not greater than 0.5 mm;

b) The maximum axial runout at the rim is not greater than 0.5 mm.

C.3 Positioning

C.3.1 Loading direction

The loading direction of the test tyre shall be perpendicular to the contact center plane, between the tyre and the drum. Meanwhile, it shall pass through the center of the wheel. The allowable deviation is as follows:

a) In the force measurement method and deceleration method, it is not more than 0.06° (1 mrad);

b) In the torque method and power method, it is not more than 0.29° (5 mrad).

C.3.2 Tyre alignment

C.3.2.1 Wheel camber angle

The center plane of the wheel shall be perpendicular to the center plane of contact, between the tyre and the drum. In any measurement method, the wheel camber angle shall not be greater than 0.11° (2 mrad).

C.3.2.2 Tyre slip angle

The forward direction of the center of contact -- between the test tyre and the drum -- shall be parallel to the center plane of the wheel. In any measurement method, the slip angle of the test tyre shall not be greater than 0.06° (1 mrad).

C.4 Control accuracy

C.4.1 Overall accuracy

In addition to disturbances due to non-uniformity of the test tyre and rim, the test equipment shall be able to measure the changing values of each variable, within the following range:

a) Tyre test pressure: ±3 kPa;

b) Test load: ±20 N for load index 121 and below; ±45 N for load index 122 and above;

c) Test speed (drum outer peripheral surface speed): ±0.5 km/h in the force measurement method; ±0.2 km/h in the torque method, power method, deceleration method;

d) Time: ±0.02 s;

e) Angular velocity: ±0.2% of measured value.

C.4.2 Compensation for interference between load and axle force and load direction deviation

When using the force measurement method, one of the following methods shall be used, to eliminate the interference between the load and the axle force, as well as the influence of the load direction deviation on the axle force.

a) By measuring the axle force of the test tyre in forward and reverse rotation, subtract the "reverse rotation" value from the "forward rotation" value, then divide the calculation result by 2, as the compensated axle force value;

b) Through the calibration of the test equipment, find the compensation coefficient correction measurement value of the load and axle force.

C.5 Instrument accuracy

Instruments used to measure and record test data shall have the accuracy, which is

formula (E.1) (the friction moment of the pulley bearing is ignored):

$$I_D = \frac{mgR - C}{(\Delta\omega_D / \Delta t)} - mR^2 - I_p \frac{R^2}{r^2} \qquad \text{(E.1)}$$

Where:

I_D - Moment of inertia of the drum, in kilogram square meter ($kg \cdot m^2$);

m - The mass of the weight, in kilograms (kg);

g - Acceleration due to gravity, which takes 9.81 m/s^2;

R - Radius of drum, in meter (m);

C - Friction torque of drum bearing, in Newton meter (N·m);

$\Delta_{wD}/\Delta t$ - Angular acceleration or angular deceleration of the drum, in radians per square second (rad/s^2);

I_p - Moment of inertia of the pulley, in kilogram square meter ($kg \cdot m^2$);

r - Pulley radius, in meters (m).

E.2.1.3 Method

When a weight, which has a known mass, is hung on one end of the wire rope, the drum rotates under the gravity of the weight. The angular acceleration of the drum can be measured through an angle encoder and a timer, which are installed on the drum shaft. After the weight has gained sufficient momentum, separate the wire rope from the drum; then measure the angular deceleration of the drum. Its relationship with the friction moment of the drum bearing can be expressed by formula (E.2), as follows:

$$C = I_D \left[\frac{\Delta\omega_D}{\Delta t} \right] \qquad \text{(E.2)}$$

Where:

C - Friction torque of drum bearing, in Newton meter (N·m);

I_D - Moment of inertia of the drum, in kilogram square meter ($kg \cdot m^2$);

$\Delta_{wD}/\Delta t$ - Angular deceleration of the drum, in radians per square second (rad/s^2).

E.2.2 Estimation method

First calculate the moment of inertia of each component of the drum. Then find their sum, using the formula (E.3):

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