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Road vehicles — Brake lining assemblies — Inertia dynamometer test method

Véhicules routiers — Ensembles de garniture de frein — Méthode d'essai sur banc dynamométrique à inertie

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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 3.

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.

International Standard ISO 11157 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 2, *Braking systems and equipment*.

Road vehicles — Brake lining assemblies — Inertia dynamometer test method

1 Scope

This International Standard specifies a dynamometer test method to homologate alternative types of brake linings (including pads) mounted on original equipment, in accordance with UN-ECE Regulation No. 13-08, annex 15.

This International Standard is applicable to road vehicles of categories M, N and O (see 3.1) as defined in UN-ECE *Consolidated resolution of the construction of vehicles*, RE.3, annex 7.

Application for approval corresponding to this test method is to be made by the vehicle manufacturer (in the case of vehicles of category O the application is to be made by the axle or brake manufacturer) or by his duly accredited representative.

The values in square brackets [ ] are taken from UN-ECE Regulation No. 13-08 for information.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 611:1994, *Road vehicles — Braking of automotive vehicles and their trailers — Vocabulary*.

ISO 1176:1990, *Road vehicles — Masses — Vocabulary and codes*.

ISO 3833:1977, *Road vehicles — Types — Terms and definitions*.

UN-ECE Regulation No. 13, *Uniform provisions concerning the approval of vehicles of categories M, N and O with regard to braking* (incorporating the 08 series of amendments).

3 Definitions and symbols

3.1 Definitions

For the purposes of this International Standard, the definitions given in ISO 611, ISO 1176, ISO 3833 and the following definitions apply.

3.1.1
category M
power-driven vehicles having at least four wheels or having three wheels when the maximum mass exceeds 1 t, and used for the carriage of passengers [UN-ECE Regulation No. 13-08]

3.1.2
category N
power-driven vehicles having at least four wheels or having three wheels when the maximum mass exceeds 1 t, and used for the carriage of goods [UN-ECE Regulation No. 13-08]

3.1.3
category O
trailers (including semi-trailers) [UN-ECE Regulation No. 13-08]

3.2 Symbols

For the purposes of this International Standard, the symbols given in Table 1 apply.

Table 1 — Symbols

Symbol	Unit	Description
I	kg·m^2	Rotational inertia
r	m	Dynamic tyre rolling radius
m	kg	Mass
v	km/h	Speed
v_1	km/h	Initial speed at the initiation of braking
n	—	Number of revolutions
n_0	—	Number of revolutions until stop
T_n	N·m	Braking torque averaged over number of revolutions
T_{nc}	N·m	Calculated braking torque averaged over number of revolutions
T_t	N·m	Braking torque averaged over time
T_{tc}	N·m	Calculated braking torque averaged over time
$T(n)$	N·m	Measured braking torque as a function of revolutions
$T(t)$	N·m	Measured braking torque as a function of time
t, τ	s	Time
t_0	s	Stopping time
ω_0	l/s	Initial angular speed
$\omega(t)$	l/s	Measured angular speed as a function of time

4 General

4.1 The test method described can be applied in the event of a modification of vehicle type resulting from the fitting of alternative types of brake linings on the original equipment of vehicles which have been approved in accordance with UN-ECE Regulation No. 13-08.

4.2 The alternative types of brake linings shall be checked by comparing their performance with that obtained from the brake linings with which the vehicle was equipped at the time of approval and conforming to the components identified in the relevant information document, a model of which is given in UN-ECE Regulation No. 13-08, annex 2.

4.3 The technical service which is responsible for conducting approval tests may, at its discretion, require that comparison of the performance of the brake linings be carried out in accordance with UN-ECE Regulation No. 13-08, annex 4.

4.4 Application for approval by comparison shall be made by the vehicle manufacturer (in the case of category O vehicles the application shall be made by the axle or brake manufacturer) or by his duly accredited representative.

4.5 For the purposes of this procedure, the term “vehicle” means the vehicle type which has been approved according to UN-ECE Regulation No. 13-08 and for which the comparison is required to lead to satisfactory results.

4.6 The vehicle (or axle/brake) manufacturer shall ensure that all requirements of UN-ECE Regulation No. 13-08 for the vehicle (or axle/brake) fitted with the alternative types of linings are fulfilled.

5 Test equipment

5.1 An inertia dynamometer having the characteristics specified in 5.2 to 5.5 shall be used for the test.

5.2 The dynamometer shall be capable of generating the inertia specified in 6.1, and have the capacity to meet the requirements specified in 1.5 and 1.6 of UN-ECE Regulation No. 13-08, annex 4, with respect to type I and type II fade tests.

5.3 The brake fitted shall be identical with that of the original vehicle type. Inconsequential changes to the lining configuration are permitted (i.e. chamfers, slots, wear indicators, anti noise devices etc.).

5.4 Air cooling, if provided, shall be in accordance with 6.4.

5.5 The instrumentation for the test shall be capable of providing at least the following data:

a) continuous recording of disc or drum rotational speed;

b) number of revolutions completed during a stop, with a tolerance equal to or better than one eighth of a revolution;

c) stopping time;

d) continuous recording of the temperature measured at the centre of the path followed by the lining, or at mid-thickness of the disc or drum or lining;

e) continous recording of control line pressure or force during brake application;

f) continuous recording of brake output torque.

6 Test conditions

6.1 The inertia dynamometer shall be set as close as possible, with a tolerance of ± [5] %, to the rotary inertia which corresponds to that part of the total inertia of the vehicle braked by the wheel(s) under consideration, according to the following formula:

$$I = mr^2$$

where m is that part of the maximum mass of the vehicle braked by the wheel(s) under consideration. This mass shall be calculated from the design braking force distribution for vehicles of categories M and N when deceleration corresponds to the appropriate value given in 2.1 of UN-ECE Regulation No. 13-08, annex 4. For category O

vehicles the value of m is that of the mass acting on the ground for the wheel(s) under consideration, when the vehicle is stationary and loaded to its maximum mass.

6.2 The initial rotational speed of the inertia dynamometer shall correspond to the vehicle speed as specified in UN-ECE Regulation No. 13-08 and shall be based on the dynamic rolling radius of the tyre.

6.3 Brake linings shall be at least 80 % bedded and shall not have exceeded a temperature of 180 °C during bedding, or alternatively, at the vehicle manufacturer's request, be bedded in accordance with his recommendations.

6.4 Cooling air may be used, directed perpendicularly to the axis of rotation of the wheel. The speed of the cooling air flowing over the brake shall be in accordance with the vehicle manufacturer's recommendations and approved by the technical service[1)].

The cooling air shall be at ambient temperature.

6.5 The same dynamometer and equipment shall be used to conduct the test described in clause 7.

7 Test method

7.1 General

7.1.1 Five (or less as agreed with the technical service, but at least three) sample sets of the alternative types of brake linings shall be subjected to the comparison test; they shall be compared with the same number of sample sets of the original equipment brake linings conforming to the original components identified in the information document for the first approval of the vehicle.

For category O vehicles the information document concerning the appropriate axle or brake type approval test shall be used as the basis.

7.1.2 Brake lining equivalence shall be based on comparison of the results achieved using the test methods in this International Standard and in accordance with the requirements of 7.2 to 7.4.

7.2 Type 0 test (cold performance test)

7.2.1 The brake applications shall be made when the initial temperature is between 50 °C and [100] °C measured in accordance with 5.5 d).

7.2.2 Brake applications shall be made from an initial rotational speed equivalent to the specified test speed of the vehicle (see Table 2). This test shall consist of a least five stops from the specified speed and use reasonably spaced increments of input to generate a graph of “braking performance” (force, torque, or derived values thereof) versus “input” (force, line pressure etc.) for each sample. One measurement shall be at least equal to the specified braking performance (see Table 2) which will be used as the “type 0 test reference value”.

In addition, tests shall also be carried out at rotational speeds equivalent to [30] % and [80] % of the maximum speed of the vehicle of categories M and N.

1) A change of cooling air velocity which reflects the industry’s viewpoint has been presented for approval to the GRRF. This modification would increase the velocity from the prescribed constant 10 km/h to a value of 0,3 V, where V is the starting speed of the test. However, approval for this proposal was still pending at the time of publication of this International Standard

Table 2 a) — Legal requirements for vehicle categories M and N

Vehicle category	Specified test speed km/h	Specified braking performance m/s^2
M_1	80	5,8
M_2	60	5
M_3	60	5
N_1	80	5
N_2	60	5
N_3	60	5

Table 2 b) — Legal requirements for vehicle category O

Vehicle type	Specified test speed km/h	Specified braking rate
O (semi-trailer)	60/40[a]	0,45
O (full trailer)	60/40[a]	0,5
O (centre axle trailer)	60/40[a]	0,5
[a] 40 km/h for cold performance test as comparison for type I test and for hot performance test after heating in type I and type II tests.		

7.2.3 The braking torque assessed during the cold performance test on the alternative types of brake linings being tested for the purposes of comparison shall be, for the same input, within the test limits ± [15] % of the braking torque assessed with the original equipment brake linings (see 8.2).

7.3 Type I test (fade test)

7.3.1 With repeated braking

The correct input shall generate a deceleration within [3] m/s^2 to 3,3 m/s^2 on the first snub of the heating procedure and shall be taken from the graph of “braking performance” versus “input” generated in 7.2.2.

7.3.2 Heating procedure with repeated braking (categories M and N)

The brake shall be heated by carrying out the following procedure.

7.3.2.1 The brake shall be cold, i.e. the initial temperature shall be between 50 °C and [100] °C (at the beginning of the first snub only) measured in accordance with 5.5 d).

7.3.2.2 The initial rotational speed at the initiation of braking should be v_1, where v_1 = [80] % v_{max}, but without exceeding:

— [120] km/h, for categories M_1 and N_1;

— [100] km/h, for category M_2;

— [60] km/h, for other categories M and N.

7.3.2.3 The input shall be constant and shall generate a deceleration within [3] m/s^2 to 3,3 m/s^2. It should remain constant for subsequent snubs (although possibly generating different deceleration levels).

7.3.2.4 Release the brake when the speed reaches [1/2] v_1.

7.3.2.5 Immediately after releasing the brake the speed v_1 shall be regained in the shortest possible time, allowing at least [10] s to stabilise this speed before commencing the next braking cycle.

7.3.2.6 The next braking cycle shall be initiated [45] s (category M_1), [55] s (category N_1, M_2) or [60] s (other categories) after commencing the previous braking cycle.

7.3.2.7 Execute a total of [15] braking cycles (categories M_1, N_1, M_2) or [20] braking cycles (categories M_3, N_2, N_3).

7.3.3 Heating procedure with continuous braking (category O)

The brake shall be heated by carrying out the following procedure.

7.3.3.1 The brake shall be cold, i.e. the initial temperature shall be between 50 °C and [100] °C (at the beginning of the heating procedure) measured in accordance with 5.5 d).

7.3.3.2 The rotational speed shall be equivalent to [40] km/h and kept constant for a period of [153] s (i.e. time elapsed travelling a distance of [1 700] m) with a constant braking torque equivalent to the torque required to keep the vehicle speed constant on a 6 % gradient (i.e. [7] % gradient minus [1] % rolling resistance).

7.3.4 Braking efficiency test with hot brakes (hot braking performance for categories M, N and O)

7.3.4.1 This hot performance test shall be carried out under the same conditions as for the type 0 test.

7.3.4.2 Immediately after completing the heating procedure, regain the prescribed test speed in the type 0 test (see Table 2) in the shortest time possible.

7.3.4.3 Within [60] s after completing the heating procedure, execute one stop with an input corresponding to the specified braking performance (see Table 2).

7.3.4.4 The average of the braking torques evaluated during the hot performance test of the alternative types of brake linings tested for the purpose of comparison shall be, for the same input, within ± [15] % of the average of the braking torques evaluated with the original equipment brake linings (see 8.3).

7.4 Type II test (downhill behaviour test)

7.4.1 General

7.4.1.1 This test is required only if, on the vehicle type in question, the friction brakes are used for the type II test.

7.4.1.2 Brake linings for vehicles of category M_3 equal to or less than 10 t, for vehicles of category N_3 and for vehicles of category O_4 shall be tested according to the method given in 7.4.2 to 7.4.4.

7.4.2 Heating procedure for vehicles of categories M_3 and N_3

The input into the brake shall be equal to that which was used for the basic vehicle test. The corresponding braking torque shall be applied at a constant rotational speed equivalent to a vehicle speed of [30] km/h for a period of [12] min (i.e. time elapsed travelling a distance of [6] km).

7.4.3 Heating procedure for vehicles of category O_4

The rotational speed shall be equivalent to [30] km/h and kept constant for a period of [12] min (i.e. time elapsed travelling a distance of [6] km) with a constant braking torque equivalent to the torque required to keep the vehicle speed constant on a 5 % gradient (i.e. [6] % gradient minus [1] % rolling resistance).

7.4.4 Braking efficiency test with hot brakes (hot braking performance for categories M_3, N_3 and O_4)

7.4.4.1 This hot performance test shall be carried out under the same conditions as for the type 0 test.

7.4.4.2 Immediately after completing the heating procedure, regain the prescribed test speed in the type 0 test (see Table 2) in the shortest time possible time.

7.4.4.3 Within [60] s after completing the heating procedure, execute one stop with an input corresponding to the specified braking performance (see Table 2).

7.4.4.4 The average of the braking torque assessed during the hot performance test on the alternative types of brake linings tested for the purpose of comparison shall be, for the same input, within ± [15] % of the average of the braking torques assessed with the original equipment brake linings (see 8.3).

8 Assessment of test data and presentation of results

8.1 Formulae for the calculation of braking torque

The braking torque showing the equivalence of the original equipment brake linings and the alternative types of brake linings can be calculated by one of the following formulae:

a)

$$T_n = \frac{1}{n_0}\int_0^{n_0} T(n)\,\mathrm{d}n$$

$$= \frac{1}{2\pi n_0}\int_0^{t_0} T(t)\times\omega(t)\,\mathrm{d}t$$

b)

$$|T_n| = \frac{\omega_0}{2\pi n_0}\int_0^{t_0} |T(t)|\,\mathrm{d}t = \frac{1}{2\pi I n_0}\int_0^{t_0} |T(t)|\int_0^{t} |T(\tau)|\,\mathrm{d}\tau\times\mathrm{d}t$$

c)

$$T_t = \frac{1}{t_0}\int_0^{t_0} T(t)\,\mathrm{d}t$$

d)

$$T_{nc} = \frac{I\times\omega_0^2}{4\pi n_0}$$

e)

$$T_{tc} = \frac{I\times\omega_0}{t_0}$$

The chosen formula shall be used for the assessment of the results of the complete comparison test.