
Road vehicles — Motor vehicles with hydraulic braking systems with and without antilock device — Measurement of braking performance

Véhicules routiers — Véhicules à moteur avec dispositif de freinage hydraulique avec et sans dispositif antiblocage — Mesurage des performances de freinage

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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.ch
Web www.iso.ch

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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.

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.

Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 6597 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 2, *Braking systems and equipment*.

This third edition cancels and replaces the second edition (ISO 6597:1991), which has been technically revised.

Annexes A to I form a normative part of this International Standard.

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Road vehicles — Motor vehicles with hydraulic braking systems with and without antilock device — Measurement of braking performance

1 Scope

This International Standard specifies the method of testing the hydraulic braking systems of vehicles of categories M and N (with and without antilock device) which are built to comply with ECE-R 13/09 without supplements. The values given in square brackets are taken from ECE Regulation No. 13 for information.

Hydraulic braking systems include vacuum-assisted and power hydraulic-assisted braking systems as well as full power hydraulic braking systems.

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.

ECE Regulation No. 13, *Uniform provisions concerning the approval of vehicles with regard to braking, incorporating the 09 series of amendments without supplements*

3 Terms and definitions

For the purposes of this International Standard, the following terms and definitions apply.

3.1

vehicle categories as defined in R.E.3, the Consolidated Resolution on the Construction of Vehicles

category **M**: power-driven vehicles having at least four wheels and used for the carriage of passengers

category **N**: power-driven vehicles having at least four wheels and used for carriage of goods

3.2

categories of antilock device (ABS) as defined in ECE R 13, Annex 13

category **1**: that which meets all the requirements of ECE R 13, Annex 13

category **2**: that which meets all the requirements of ECE R 13, Annex 13 except paragraph 5.3.5

NOTE 1 No braking rate on split-adhesion surfaces is prescribed.

category **3**: that which meets all the requirements of ECE R 13, Annex 13 except paragraphs 5.3.4 and 5.3.5

NOTE 2 All split-adhesion tests are omitted.

**3.3
vehicle loading**

**3.3.1
laden vehicle**

vehicle laden to its maximum technically permissible mass M_{\max} as specified by the vehicle manufacturer and acknowledged by the technical services

NOTE This mass may exceed the "maximum authorized total mass" permitted by national regulations. Mass distribution on the axles is to be stated by the vehicle manufacturer.

In the event of several load distribution patterns being planned, the distribution of the maximum mass among the axles is such that the load on each axle is proportional to that maximum technically permissible load for that axle.

**3.3.2
unladen vehicle**

vehicle at its kerb mass [without load or occupant but with the fuel tank filled at the start of the test to at least 90 % of the capacity stated by the vehicle manufacturer and complete with cooling fluid and lubricants, tools and spare wheel(s)]

NOTE During the tests, the fuel quantity should be maintained at least to 50 % of its capacity. An increase of up to 200 kg over the unladen vehicle level is allowed; this comprises, for instance, the driver, one observer and instrumentation. If necessary, some vehicle mass may have to be removed.

For a vehicle without a body, the manufacturer is to declare the minimum mass which has to be reached on each axle, to represent the vehicle with a body and spare wheel(s) if these provisions are foreseen.

**3.4
hydraulic pressures (booster and full power systems)**

**3.4.1
cut-in pressure**

minimum system operational pressure specified by the manufacturer

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**3.4.2
cut-out pressure**

maximum system operational pressure specified by the manufacturer

**3.5
cold brakes**

brakes, the hottest of which has an initial temperature, when measured on the disc or on the outside of the drum or on the brake linings, lower than [100] °C before each stop

NOTE With the exception of the hot braking performance test, all other tests should be carried out with the brakes in this cold condition.

**3.6
wheel control in antilock device**

**3.6.1
directly controlled wheel**

wheel whose braking force is modulated according to data provided at least by its own sensor

**3.6.2
indirectly controlled wheel**

wheel whose braking force is modulated according to data provided by the sensor(s) of other wheels

NOTE Antilock braking systems with select-high control are deemed to include both directly and indirectly controlled wheels. In devices with select-low control, all sensed wheels are deemed to be directly controlled wheels.

4 Symbols

See Table 1.

Table 1 — Symbols and their meanings

Symbol	Meaning	Unit
d	Stopping distance.	m
E	Wheelbase.	m
F	Force.	N
F_{dyn}	Normal reaction of road surface under dynamic conditions with the antilock system operative.	N
F_i	Normal reaction of road surface on axle i (front or rear) under static conditions.	N
F_{idyn}	F_{dyn} on axle i (front or rear) in case of power-driven vehicles.	N
g	Acceleration due to gravity (9,81 m/s ²).	m/s ²
h	Height of centre of gravity specified by the manufacturer and agreed by the technical service conducting the approval test.	m
k	Coefficient of adhesion between tyre and road.	1
k_f	k -factor of the front axle.	1
k_H	k -value determined on high-adhesion surface.	1
k_L	k -value determined on the low-adhesion surface.	1
k_m	Mean k -factor of the vehicle (dynamically weighted).	1
k_{lock}	Value of adhesion for 100 % slip.	1
k_{peak}	Maximum value of the curve "adhesion versus slip".	1
k_r	k -factor of the rear axle.	1
M	Mass of individual vehicle.	kg
M_{max}	Permissible maximum mass.	kg
p	Pressure.	bar
t	Time interval.	s
t_m	Mean value of several measurements of t .	s
t_{min}	Minimum value of t .	s
v	Vehicle speed.	km/h
v_{max}	Maximum speed of vehicle (declared by the manufacturer).	km/h
z	Braking rate.	1
z_{AL}	Braking rate z of the vehicle with the antilock system operative.	1
z_m	Mean braking rate.	1
z_{MALS}	Z_{AL} of the power-driven vehicle on a "split surface".	1
ε $\varepsilon_H, \varepsilon_L$	The adhesion used by the vehicle: quotient of the maximum braking rate with the antilock system operative (z_{AL}) and the coefficient of adhesion (k) values for high and low adhesion surfaces respectively.	1

5 Test site conditions

5.1 Road conditions

5.1.1 Surface

Except for ABS tests (see 5.2) the road surface shall be a smooth, hard surfaced roadway of asphalt, concrete or other surface with an equivalent coefficient of adhesion.

The road surface shall be free from loose material and dry for those tests requiring high adhesion.

5.1.2 Gradient

The road surface shall be substantially level; a tolerance of $\pm 1\%$ average gradient, measured over a minimum distance of 50 m, is allowed.

NOTE The type II test or the braking system hill-holding test may be conducted on a specified gradient or on a level road using a towing vehicle.

5.1.3 Camber

The camber or transverse gradient across the road surface shall not exceed 2 %.

5.2 Test area for vehicles with anti lock device (ABS)

5.2.1 An area for tests on vehicles with ABS, consisting of a surface providing a peak coefficient of adhesion ($k_{\text{peak}} \leq 0,4$) and of a size sufficient to enable the tests to be performed in safety. This area shall be preceded and followed by a surface which provides a peak coefficient of adhesion of about 0,8, and is of sufficient length on the approach side to enable the test speeds to be attained.

For testing vehicles fitted with ABS of categories 1 or 2, a low-adhesion surface shall have a high-adhesion surface on at least one side so as to enable the split-adhesion tests to be performed. Each surface shall be sufficiently wide in order to allow the separate determination of its peak coefficient of adhesion.

5.2.2 The surfaces used for the split adhesion tests shall be such that:

$$k_H \geq [0,5] \text{ and } k_H/k_L \geq [2]$$

If any doubt arises that this requirement be met, the peak coefficient of adhesion shall be ascertained by using the procedure described in D.3. It is always necessary to measure the peak coefficient of adhesion when testing a vehicle fitted with ABS of categories 1 or 2.

5.2.3 For tests of the ABS, the track used shall be regularly characterized by preparation (for the low-adhesion surface) of a curve showing the actual coefficient of adhesion versus slip from 0 % to 100 % slip at a speed of approximately 40 km/h.

NOTE To plot such a graph may require a special ABS capable of operating at any preset level of slip.

The peak value k_{peak} and the value at 100 % slip k_{lock} shall be measured and the ratio $k_{\text{peak}}/k_{\text{lock}}$ calculated and rounded to 1 decimal place.

For the surface to qualify, this ratio shall be:

$$1 \leq k_{\text{peak}}/k_{\text{lock}} \leq 2$$

Information on the method of measurement of adhesion levels shall be made available.

5.3 Ambient conditions

The wind speed shall not exceed an average of 5 m/s.

The air temperature shall not exceed 35 °C. In exceptional circumstances, 45 °C may be accepted.

This shall be recorded in the test report.

6 General information

6.1 Deceleration measurements used in this procedure, refer to the “mean fully developed deceleration” (MFDD). When reference is made to “prescribed effectiveness”, this is the MFDD and stopping distance performance required in ECE R13 for the relevant test.

6.2 The use of either pedal-application machines or of robots does not reflect real-life vehicle braking and should be discouraged.

6.3 The determination of the optimum vehicle braking performance shall be entrusted to skilled test drivers. This shall be achieved without wheel-locking, except immediately before stopping, and without significant deviation caused by braking. A period of familiarization with the vehicle braking, steering and suspension systems shall be allowed.

7 Preliminary comments on test procedures and requirements

7.1 The tests should be carried out in the recommended sequence described in Table 2, but it is recognized that practical circumstances may require variations from this sequence. However, because of thermal influence on friction material behaviour, it is most strongly recommended that:

- the fade test be performed at the end of the sequence;
- adhesion utilisation tests be performed before the corresponding k factor determination.

Any variation in the recommended sequence shall be noted.

7.2 To reduce load changes, all unladen tests are grouped together and followed by the laden test.

7.3 The parking braking system tests and the response time measurements may be carried out at any time selected by the vehicle manufacturer and agreed with the technical services during the testing sequence.

7.4 A preliminary series of five braking system applications may be carried out for vehicle familiarization. Because the total number of stops can significantly change the thermal and mechanical properties of the friction materials (and thus possibly the vehicle braking performance), it is recommended that each test condition be run no more than four times.

7.5 Re-testing in the course of the full procedure shall be avoided, although one or two extra stops are unlikely to prejudice subsequent road test results.

7.6 Full or partial re-tests, after a failed test or to approve alternative braking system components, shall again follow this procedure and with particular emphasis on the vehicle preparation and bedding procedures.

7.7 In order to avoid delays, tests may be carried out under adverse conditions, but with due consideration for safety; such adverse conditions shall be reported. Any failed test under such conditions may be repeated under the correct conditions, but it is not necessary that all tests be repeated.

7.8 During the tests with the engine connected to vehicles with a manual gearbox, the clutch may be disengaged just before the vehicle stops, to avoid stalling the engine.

7.9 Tests with the engine connected should be carried out in the appropriate gear, defined as the lowest gear which would normally be used to reach the speed without exceeding the manufacturer's recommended maximum engine speed.

7.10 Control forces should be applied rapidly, but without significant overshoot, and then be maintained constant during the stop to allow meaningful measurements to be made. Any departure from this International Standard will be mentioned in the appropriate test procedure paragraph.

7.11 All tests shall start with cold brakes, except the hot performance tests.

7.12 During all phases of this procedure, any unusual braking performance characteristics, such as deviation or vibration, shall be reported.

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8 Recommended test order

See Table 2.

Table 2 — Recommended test order

Test required	Engine status		Reg. 13 Paragraph/Comments
	Connected or in gear	Disconnected or neutral	

A – Pre-test phase

1	Preparation (documents, instrumentation, bedding etc.)			
2	Line pressure vs control force, with engine idling after boost is established.			Common practice (not an R 13 requirement)
3	Characteristic of pressure reduction valve			
4	Line pressure vs time curve (vehicle stationary)			A4 § 4
5	ABS – warning lamp and mode change check			A 13 § 4.1, 4.1.1, 4.1.2

B – Basic performance tests — unladen

1	Type 0 performance		#	A4 § 1.4.2, 2.1.1 plot deceleration vs line pressure
2	Type 0 performance		#	A4 § 1.4.3

C – Failure Tests — unladen

1	Partial system failure Type 0 performance		#	A4 § 2.2
2	Failed load sensing-proportioning valve control		#	A4 § 2.2

D – ABS tests — unladen

1	ABS – failed case		#	A13 § 4.3, A4 § 2.4, 2.2
2	ABS – adhesion, utilisation on high adhesion		#	A13 § 5.2.2
3	ABS – determination of k_H		#	A13 - App.2
4	ABS – adhesion, utilisation on low adhesion		#	A13 § 5.2.2
5	ABS – determination of k_L		#	A13 - App.2
6	ABS – wheel behaviour test on homogeneous surfaces		#	A13 § 5.3
7	ABS – transition from high to low adhesion		#	A13 § 5.3.2
8	ABS – transition from low to high adhesion		#	A13 § 5.3.3
9	ABS – split adhesion test		#	A13 App.3 for ABS cat. 1 or 2

E – ABS tests — laden

1	ABS – failed case			as D1
2	ABS – adhesion, utilisation on high adhesion		#	as D2
3	ABS – determination of k_H		#	as D3
4	ABS – adhesion, utilisation on low adhesion		#	as D4
5	ABS – determination of k_L		#	as D5
6	ABS – wheel behaviour tests on homogeneous surfaces		#	as D6

Table 2 (continued)

Test required		Engine status		Reg. 13 Paragraph/Comments
		Connected or in gear	Disconnected or neutral	
7	ABS – transition from high to low adhesion		#	as D7
8	ABS – transition from low to high adhesion		#	as D8
9	ABS – split adhesion test		#	as D9
10	ABS – energy consumption		#	A13 § 5.1

F – Failure Tests — laden

1	Partial system failure Type 0 performance		#	A4 § 2.2
2	Failed load sensing valve/proportioning valve		#	A 10 § 6
3	Failed booster test		#	§ 5.2.1.2.6 and A4 § 1.4.2, 2.2

G – Basic performance tests — laden

1	Type 0 performance		#	as B1
2	Type 0 performance	#		as B2
3	Response time		#	A4 § 4.1.1
4	Type II (engine braking, only M3) urban buses	#		A4 § 1.6 & 1.8.2. if applicable
5	Parking braking system dynamic test		#	A4 § 2.3.6
6	Parking braking system static test		#	A4 § 2.3.1 to 2.3.5
7	Type I fade test	ISO 6597:2002		A4 § 1.5.1
8	Type 0 hot performance		#	A4 § 1.5.3.1/2

H- Special test

Whilst not required by reg. 13/09, this test is called for in directive 71/320 & 98/12 EEC.

1	Temporary use spare wheels, laden		#	EEC directive, annex XIII
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I – Special tests vacuum /hydraulic assisted or power hydraulic actuation

1	General information			
2	Vacuum booster system tests			A7B § 1.2, 2.2
3	Hydraulic booster system tests			A7C § 1.2 , 2.1.2/3
4	Hydraulic full power system tests		#	5.2.1.5 & A7C § 1.2, 2.1.2/3
5	Low pressure warning			§ 5.2.1.12/13

Annex A (normative)

Pre-test phase

A.1 Vehicle preparation

A.1.1 Vehicle loading

See 3.3.

A.1.2 Basic instrumentation needed for vehicle tests

The vehicle shall be prepared for testing by the addition of the following instruments and/or calibration of existing standard instruments, as required. Other instruments may be useful in providing accurate data, but care needs to be exercised to ensure that instruments added to the standard vehicle braking equipment do not significantly affect the braking system performance.

All the following appropriate data acquisition system instruments shall be checked to ensure that they are functioning correctly and, with the vehicle stationary on a level test surface and without any brake application, all the instruments shall be set to zero:

- a) control force gauge for the service braking systems;
- b) control force gauge for the parking braking system;
- c) control force gauge for the secondary braking system, if this system is not part of either the service or the parking braking system;
- d) decelerometer;
- e) speed-measuring device or calibrated speedometer;
- f) stopping-distance measuring means;
- g) time measuring means;
- h) brake temperature indicating system;
- i) line pressure gauges/transducers. Regulations call for pressure measurements to be made at the least favourable brake actuator and in other parts of the system;
- j) optional instruments may include wheel lock indicators, control device travel gauges.

A.1.3 Additional instrumentation needed for test on vehicles with ABS

- a) vehicle speed and, optionally, stopping distance and/or deceleration-measuring equipment shall be capable of producing a permanent record of these criteria during braking. The acquisition system shall also produce a time base;
- b) optional equipment to ascertain when and for what period the wheels directly controlled by an ABS actually lock during the test;