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**Road vehicles — Hydraulic braking  
systems, including those with electronic  
control functions, for motor vehicles —  
Test procedures**

*Véhicules routiers — Systèmes de freinage hydraulique, y compris ceux  
à fonction de commande électronique, pour véhicules à moteur —  
Modes opératoires d'essai*

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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 2.

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 document 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 fourth edition cancels and replaces the third edition (ISO 6597:2002), which has been technically revised.

This fourth edition incorporates the relevant portions of the International Standard ISO 11835: "Road Vehicles-Motor vehicles. Measurement of braking performance under ABS operation" for testing vehicles which are fitted with anti lock function.

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# Road vehicles — Hydraulic braking systems, including those with electronic control functions, for motor vehicles — Test procedures

## 1 Scope

This International Standard specifies the method of testing the hydraulic braking systems of vehicles of categories M and N which are built to comply with ECE-R 13/09, including supplements 1 to 7. The values 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.

NOTE Test methods covering the Electrical Regenerative Braking Systems of Electrical and Hybrid Vehicles are not included in this edition. This omission may be corrected by a further annex once these vehicles are in more common use and suitable practical test methods have been developed.

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## 2 Normative references (standards.iteh.ai)

The following referenced documents are indispensable for the application 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.

ECE Regulation No. 13, *Uniform provisions concerning the approval of vehicles with regard to braking, incorporating the 09 series of amendments including supplements 1 to 7*

ECE R.E.3, *Consolidated Resolution on the Construction of Vehicles*

## 3 Terms and definitions

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

### 3.1

**vehicle categories** as defined in ECE R.E.3

#### 3.1.1

##### **category M**

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

#### 3.1.2

##### **category N**

power-driven vehicles having at least four wheels and used for carriage of goods

### 3.2

**categories of anti-lock braking function (ABS)** as defined in ECE Regulation No. 13, Annex 13

**3.2.1**

**category 1**

that which meets all the requirements of ECE R 13, Annex 13

**3.2.2**

**category 2**

that which meets all the requirements of ECE R 13, Annex 13 except paragraph 5.3.5.

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

**3.2.3**

**category 3**

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

NOTE 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, and tools and spare wheel(s)]

NOTE During the tests, the fuel quantity is maintained at least at 50 % of the tank capacity, with an allowed increase of up to 200 kg over the unladen vehicle level. 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 declares 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**

system operational pressure in an energy storage device at which the energy source is reconnected

**3.4.2**

**cut-out pressure**

system operational pressure in an energy storage device at which the energy source is disconnected

**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 are carried out with the brakes in this cold condition.

### 3.6 wheel control in anti-lock braking (ABS) functions

#### 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 another wheel or other wheels

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

#### 3.7 full cycling

that state of the anti-lock system in which the brake force is repeatedly modulated to prevent the directly controlled wheels from locking

NOTE Brake applications where modulation only occurs once during the stop are not considered to meet this definition.

#### 3.8 Electronic braking system (EBS)

braking system in which control is generated and processed as an electrical signal in the control transmission

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## 4 Symbols

Table 1 — Symbols

Symbols	Meaning	Unit
$E$	Wheelbase	m
$F$	Force	N
$F_{\text{dyn}}$	Normal reaction of road surface under dynamic conditions with the anti-lock system operative	N
$F_i$	Normal reaction of road surface on axle $i$ (f or r) under static conditions	N
$F_{i\text{dyn}}$	$F_{\text{dyn}}$ on axle $i$ (f or r) in case of power-driven vehicles	N
$g$	Acceleration due to gravity (9,81 m/s <sup>2</sup> )	m/s <sup>2</sup>
$h$	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
$k_{\text{lock}}$	Value of adhesion for 100 % slip	1
$k_m$	Mean $k$ -factor of the vehicle (dynamically weighted)	1
$k_{\text{peak}}$	Maximum value of the curve "adhesion versus slip"	1
$k_r$	$k$ -factor of the rear axle	1
$M$	Mass of individual vehicle	kg
$M_{\text{max}}$	Permissible maximum mass	kg
$p$	Pressure	bar
$s$	Stopping distance	m
$t$	Time interval	s
$t_m$	Mean value of several measurements of $t$	s
$t_{\text{min}}$	Minimum value of $t$	s
$v$	Vehicle speed	km/h
$v_{\text{max}}$	Maximum speed of vehicle (declared by the manufacturer)	km/h
$z$	Braking rate	1
$z_{\text{AL}}$	Braking rate $z$ of the vehicle with the antilock system operative	1
$z_m$	Mean braking rate	1
$z_{\text{MALS}}$	$z_{\text{AL}}$ of the power-driven vehicle on a "split surface"	1
$\varepsilon$ $\varepsilon_L, \varepsilon_H$	The adhesion utilized by the vehicle: quotient of the maximum braking rate with the anti-lock system operative ( $z_{\text{AL}}$ ) 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.

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 an anti-lock braking function (ABS)

**5.2.1** An area for tests on vehicles with ABS shall be provided 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. Furthermore this area shall be preceded and followed by a surface which provides a peak coefficient of adhesion of about 0,8, which 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 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 is met, the peak coefficient of adhesion shall be ascertained by using the procedure detailed 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 Plotting this graph may require a special ABS capable of operating at any preset level of slip.

The peak value  $k_{\text{peak}}$  and the value at 100 % slip  $k_{\text{lock}}$  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, up to 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 Regulation No. 13 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 being caused by braking. A period of familiarization with the vehicle braking, steering and suspension systems should 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 is performed at the end of the sequence, and
- adhesion utilization 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 tests.

**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, on 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 shall be mentioned in the appropriate test procedure paragraph.

**7.11** All tests 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.

**7.13** Each specific failure mode appropriate to the vehicle braking equipment shall be considered and the service braking system shall be checked for the worst case failure modes (for EBS see Annex 18 reference in A.1 d)).

**7.14** Where fault conditions are imposed on the braking system, they shall be removed after the appropriate test has been conducted and the correct operation of the braking system shall then be verified.

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8 Recommended test order

Table 2 — Recommended test order

Test required	Engine status		ECE Reg. 13 Paragraph/Comments
	Connected or in gear	Disconnected or neutral	
<b>A — Pre-Test Phase</b>			
1	Documents required		A1, A18
2	Preparation (instrumentation, bedding, etc.)		
3	Line pressure vs. control force, at engine idling after boost is established		Common practice (not an R 13 requirement)
4	Characteristic of pressure reduction valve		
5	Line pressure vs. time curve (vehicle stationary)		A3 § 4
6	ABS warning lamp and mode change check		A13, § 4.1, 4.1.1, 4.1.2
7	Additional tests on vehicles equipped with EBS		§ 5.2.1.27.1
<b>B — Basic Performance Tests — unladen</b>			
1	Type 0 performance		X A4 § 1.4.2, 2.1.1 plot deceleration vs. line pressure
2	Type 0 performance	X	A4 § 1.4.3
3	Wheel locking sequence		A10 § 3.1.4.2-4
<b>C — Failure Tests — unladen</b>			
1	Partial system failure Type 0 performance	X	A4 § 2.2
2	Failed load sensing-proportioning valve control	X	A10 § 6
3	Sensor fault memory test		A13 § 4.1.1
4	Failure of the energy source on vehicles equipped with EBS		§ 5.2.1.27.5, 5.2.1.27.6, 5.2.1.27.7, 5.2.1.27.8
<b>D — ABS Tests — unladen</b>			
1	ABS – failed case		X A13 § 4.3, A 4 § 2.4, 2.2
2	ABS – adhesion, utilisation on high adhesion		X A13 § 5.2.2
3	ABS – determination of $k_H$		X A13 - App.2
4	ABS – adhesion, utilisation on low adhesion		X A13 § 5.2.2
5	ABS – determination of $k_L$		X A13 - App.2
6	ABS – wheel behaviour test on homogeneous surfaces		X A13 § 5.3
7	ABS – transition from high to low adhesion		X A13 § 5.3.2
8	ABS – transition from low to high adhesion		X A13 § 5.3.3
9	ABS – split adhesion test		X A13 App.3 for ABS cat. 1 or 2

Table 2 (continued)

Test required		Engine status		ECE Reg. 13 Paragraph/Comments
		Connected or in gear	Disconnected or neutral	
<b>E — ABS Tests — laden</b>				
1	ABS – failed case			as D1
2	ABS – adhesion utilisation on high adhesion		X	as D2
3	ABS – determination of $k_H$		X	as D3
4	ABS – adhesion utilisation on low adhesion		X	as D4
5	ABS – determination of $k_L$		X	as D5
6	ABS – wheel behaviour tests on homogeneous surfaces		X	as D6
7	ABS – transition from high to low adhesion		X	as D7
8	ABS – transition from low to high adhesion		X	as D8
9	ABS – split adhesion test		X	as D9
10	ABS – energy consumption		X	A13 § 5.1
<b>F — Failure Tests — laden</b>				
1	Partial system failure Type 0 performance		X	A4 § 2.2
2	Failed load sensing /proportioning valve		X	A10 § 6
3	Failed booster test		X	§ 5.2.1.2.7 & A4 § 1.4.2, 2.2
<b>G — Basic Performance Tests — laden</b>				
1	Type 0 performance		X	as B1
2	Type 0 performance	X		as B2
3	Wheel locking sequence test			A10 § 3.1.4.2 to 3.1.4.4
4	Response time		X	A4 § 4.1.1
5	Type II (engine braking, only M3 urban buses)	X		A4 § 1.6 & 1.8.2 if applicable
6	Parking braking system dynamic test		X	A4 § 2.3.6
7	Parking braking system static test		X	A4 § 2.3.1 to 2.3.5
8	Additional tests on vehicles equipped with electrical parking brake			§ 5.2.1.26 to § 5.2.1.26.4
9	Type I fade test	X		A4 § 1.5.1
10	Type 0 hot performance		X	A4 § 1.5.3.1/2, 1.5.4
<b>H — Special test</b>				
Whilst not directly required by ECE Regulation No. 13, this test is called for in Directive 71/320 & 98/12 EEC				
1	Temporary use spare wheels, laden		X	EEC Directive, Annex XIII
<b>I — Special tests — Vacuum/hydr. assisted or power hydraulic actuation</b>				
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		X	5.2.1.5 & A7C § 1.2, 2.1.2/3
5	Low pressure warning			
X	Indicates the status of the engine (connected or disconnected)			

## Annex A (normative)

### Pre-test phase and static tests

#### A.1 Documents and basic data

The vehicle shall be verified based upon the documentation as follows:

- a) Main technical data according to Annex 2 of ECE Regulation No. 13.
- b) Layout and list of the elements of the braking system.
- c) Braking system performance calculation (optional if vehicle is equipped with ABS).
- d) Documentation according to Annex 18 of ECE Regulation No. 13, if the vehicle is equipped with EBS. This documentation includes an explanation of design provisions guaranteeing compliance with all relevant parts of ECE Regulation No. 13 paragraphs 5.1.4.7, 5.2.1.8 and 5.2.1.27 which deal with the special requirements for the verification of the correct operational status, brake force compensation and for EBS. This documentation may also indicate the worst-case failures for EBS.
- e) Report/approval of EMC Tests (if vehicle is equipped with ABS or EBS) in accordance with ECE Regulation No. 10.02.

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#### A.2 Vehicle preparation

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##### A.2.1 Vehicle loading

See 3.3.

##### A.2.2 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.2.3 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 variables 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;
- c) for ABS/EBS which depend on stored energy assistance rather than an electrically powered energy source, a device shall be provided to isolate the energy source;
- d) it is standard practice to use adjustable pressure-limiting valves in the line to each wheel brake that will be used during the determination of  $k_r$  or  $k_p$ ;
- e) optional equipment to show the point of transition of the vehicle from the low to the high-adhesion surface on the permanent record;
- f) optional means of measuring steering wheel angles (only for vehicles which are fitted with a category 1 ABS).

### A.2.4 Provisions for failure simulation

The vehicle shall be equipped with the necessary added devices, piping and wiring according to the manufacturer's recommendations and agreed with the Technical Services, to provide the required failure simulations. Such added devices, piping and wiring shall not significantly affect the intact and/or failed braking system performance.

When a leakage is simulated, the brake fluid shall be returned to the reservoir.

In the electric part of the braking system, a failure generally corresponds to a disconnection, but a short circuit or a ground connection may be specified by the manufacturer in certain instances. This may be done by using prepared components or sections of wiring.

### A.2.5 Tyre conditions

The tyres shall be inflated to the vehicle manufacturer's recommended pressure levels.

It is recommended that the tyre tread wear should not exceed 50 % of the new condition.

### A.2.6 Braking system condition

The braking system components shall be new, or capable of functioning as if new, and within the vehicle manufacturer's specifications. The service and parking brake linings shall be bedded according to the vehicle manufacturer's recommendations.