INTERNATIONAL STANDARD

ISO 11835

Second edition
2002-11-15

Road vehicles — Motor vehicles with antilock braking systems (ABS) — Measurement of braking performance

Véhicules routiers — Véhicules à moteur équipés de dispositifs de freinage à antiblocage (ABS) — Mesurage des performances de freinage

Reference number
ISO 11835:2002(E)

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

Printed in Switzerland

Contents

Page

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 11835 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 2, *Braking systems and equipment*.

This second edition cancels and replaces the first edition (ISO 11835:1995), which has been technically revised.

Annex A of this International Standard is for information only.

Road vehicles — Motor vehicles with antilock braking systems (ABS) — Measurement of braking performance

1 Scope

This International Standard specifies a method for testing the braking performance of motor vehicles of categories M and N, as defined in UNECE (United Nations Economic Commission for Europe) Regulation No. 13, equipped with antilock braking systems (ABS).

NOTE Pending the harmonization of national and international braking standards, regulations and directives, the test method itself is based on UNECE Regulation No. 13.

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, *Road vehicles — Braking of automotive vehicles and their trailers — Vocabulary*

ISO 1176, *Road vehicles — Masses — Vocabulary and codes*

ISO 3833, *Road vehicles — Types — Terms and definitions*

ISO 7638 (all parts) 1997, *Road vehicles — Electrical connectors for braking systems*

UNECE Regulation No. 13:1996[1)], *Uniform provisions concerning the approval of vehicles with regard to braking*

3 Terms, definitions and symbols

For the purposes of this International Standard, the terms and definitions given in ISO 611, ISO 1176 and ISO 3833, and the following terms, definitions and symbols (see Table 1) apply.

3.1
category M vehicle
power-driven vehicle having at least four wheels or having three wheels when the maximum mass exceeds 1 t, and used for the carriage of passengers

[UNECE Regulation No. 13]

1) Incorporating the 09 series of amendments, but without the supplements to those amendments.

3.2
category N vehicle
power-driven vehicle having at least four wheels or having three wheels when the maximum mass exceeds 1 t, and used for the carriage of goods

[UNECE Regulation No. 13]

3.3
directly controlled wheel
wheel whose braking force is modulated according to data provided at least by its own sensor

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.

3.4
indirectly controlled wheel
wheel whose braking force is modulated according to data provided by sensor(s) of other wheel(s)

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.

Table 1 — Symbols

Symbol	Description	Unit
E	Wheelbase	m
ε	Vehicle adhesion utilized: quotient of the maximum braking rate with the antilock system operative (z_{AL}) and the coefficient of adhesion (k)	1
ε_i	ε value measured on axle i, in the case of a power-driven vehicle with a category 3 antilock braking system (see clause 4)	1
ε_H	ε value on the high-adhesion surface	1
ε_L	ε value on the low-adhesion surface	1
F	Force	N
F_{dyn}	Normal reaction of road surface under dynamic conditions and with antilock system operative	N
F_{idyn}	F_{dyn} on axle i in case of power-driven vehicles or full trailers	N
F_i	Normal reaction of road surface on axle i under static conditions	N
F_1	Normal reaction of road surface on axle 1 under static conditions	N
F_2	Normal reaction of road surface on axle 2 under static conditions	N
F_M	Total normal static reaction of road surface on all wheels of power-driven (towing) vehicle	N
F_{Mnd}[a]	Total normal static reaction of road surface on the unbraked upon and non-driven axles of the power-driven vehicle	N
F_{Md}[a]	Total normal static reaction of road surface on the unbraked upon and driven axles of the power-driven vehicle	N
F_{wM}[a]	$0{,}01\ F_{Mnd} + 0{,}015\ F_{Md}$	N
g	Acceleration due to gravity (9,81 m/s^2)	m/s^2
h	Height of center of gravity specified by the manufacturer and agreed by the technical service conducting the approval test	m
h_k	Height of fifth wheel coupling (king pin)	m
k	Coefficient of adhesion between tyre and road	1
k_f	k factor of one front axle	1

Table 1 — Symbols *(continued)*

Symbol	Description	Unit
k_H	k value determined on the high-adhesion surface	1
k_i	k value determined on axle i for a vehicle with a category 3 antilock braking system (see clause 4)	1
k_L	k value determined on the low-adhesion surface	1
k_{lock}	Value of adhesion for 100 % slip	1
k_M	k factor of the power-driven vehicle	1
k_{peak}	Maximum value of the curve "adhesion versus slip"	1
k_r	k factor of one rear axle	1
P	Mass of individual vehicle	kg
R	Ratio of k_{peak} to k_{lock}	—
t	Time interval	s
t_m	Mean value of t	s
t_{min}	Minimum value of t	s
v_{max}	Maximum speed	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_{mf}	Mean braking rate of front axle	1
z_{mr}	Mean braking rate of rear axle	1
z_{max}	Maximum value of z.	1
z_{MALS}	z_{AL} of the power-driven vehicle on a "split-surface"	1
[a] In the case of two-axled power-driven vehicles, F_{Mnd} and F_{Md} may be simplified to the corresponding F_i symbols.		

4 General

Antilock braking systems (ABS) are divided into the following three categories:

a) category 1 ABS, which meet all the requirements of UNECE Regulation No. 13:1996, annex 13;

b) category 2 ABS, which meet all the requirements of UNECE Regulation No. 13:1996, annex 13, excepting those of 5.3.5 (no braking rate on split-adhesion surfaces is prescribed);

c) category 3 ABS, which meet all the requirements of UNECE Regulation No. 13:1996, annex 13, excepting those of 5.3.4 and 5.3.5 (all split-adhesion surface tests are omitted).

The test method used will depend on the ABS category. The manufacturer should therefore declare this category before testing commences.

Where type I and II tests are combined with the method given in this International Standard, the antilock tests shall be carried out after completing all type 0 laden and unladen tests and before starting the type I and type II tests.

As an alternative, all the measurements, including the warm-up runs, retarder tests and antilock tests of the laden vehicle may be performed first, followed by all the measurements with the unladen vehicle. The sequence of tests shall be noted.

In this International Standard, where a value is indicated between square brackets [...] it is taken from UNECE Regulation No. 13.

5 Test apparatus

5.1 Vehicle speed-measuring equipment and, optionally, stopping distance- or deceleration-measuring equipment, or both, capable of producing a permanent record of these criteria during braking. The recording system shall also produce a timebase.

5.2 Pedal-effort or line-pressure gauge, or both, and pressure transducers.

5.3 Equipment for ascertaining when and for how long the wheels directly controlled by an ABS actually lock during the test (optional).

5.4 0,5 l reservoir, for motor vehicles authorized to draw a trailer fitted with airbrakes [see clause 13 e)].

5.5 Device for isolating the energy source, for ABS dependent on non-muscular energy or on energy assistance [see clause 13 f)].

5.6 Adjustable pressure-limiting valves, which could be required in the line to each wheel that will be used during the determination of k_{peak} (see clause 9).

5.7 Equipment for indicating the point of transition of the vehicle from low-to high-adhesion surface on the permanent record (optional) [see 12.2 b)].

5.8 Means of measuring steering wheel angles (optional) — only for vehicles fitted with category 1 or 2 ABS (see 12.1.2).

6 Test area

6.1 The test area shall consist of a surface providing a peak coefficient of adhesion, k_{peak}, of [0,3], of sufficient size to enable the tests to be performed in safety. However, until such test surfaces become generally available, tyres at the limit of wear and higher values of up to 0,4 may be used at the discretion of the technical service carrying out the tests. The actual value obtained and the type of tyres and surface shall be recorded.

6.2 The test area shall be both preceded and followed by a surface providing a k_{peak} of about 0,8, and of sufficient length on the approach side to enable the test speeds to be attained. For test vehicles fitted with ABS of category 1 or 2, a low-adhesion surface shall also have a high-adhesion surface on at least one side for the split-adhesion tests. Both surfaces shall be sufficiently wide to allow the peak coefficients of adhesion to be determined separately.

6.3 The surfaces used for the tests in 12.2 shall be such that k_H is or greater than or equal to [0,5] and k_H/k_L is greater than or equal to [2]. If there is any doubt that this requirement cannot be met, the peak coefficients of adhesion shall be ascertained using the procedure given in clause 9. When testing a vehicle fitted with an ABS of category 1, the peak coefficients of adhesion shall always be measured.

7 General checks

Perform the following checks and verifications.

a) For all motor vehicles authorized to draw a trailer fitted with air brakes, irrespective of the category of ABS fitted:

   1) check the manufacturer's calculations of compatibility in the laden state and ensure that the results conform with the requirements of annex 10 of UNECE Regulation No. 13:1996;

   2) verify that a specific optical warning device is fitted that will signal to the driver any electrical brak in the supply of electricity to the ABS;

   3) check that this warning device lights up when the ABS is energized and is extinguished after a verification phase only when such defects are absent, when the warning signal may light up again provided that it is extinguished before the vehicle reaches 10 km/h;

   4) check that the warning signal is visible in daylight and that it is easy for the driver to verify whether it is in working order;

   5) in addition, for an electrically controlled pneumatic modulator valve or valves, verify that the valve or valves cycle at least once during the verification phase (before the warning signal is extinguished).

b) For vehicles authorized to tow a trailer equipped with an ABS with the exception of vehicles of category M1 or N1:

   1) verify that a separate optical warning device for the ABS of the trailer is fitted, activated via pin 5 of a special connector in accordance with ISO 7638;

   2) check that this warning device automatically does not light up when a trailer without an ABS, or when no trailer, is coupled;

   3) check that the warning signal is visible even in daylight and that it is easy for the driver to verify whether it is in working order;

   4) check that electrical connections for the ABS of a trailer are effected by the connector specified in 1).

c) Check that the operation of the ABS is not adversely affected by electromagnetic fields, in accordance with the relevant test procedures.

d) For vehicles fitted with a manual device for disconnecting or changing the control mode of the ABS.

   1) Check that the manufacturer's calculations show that, with the ABS disconnected or the control mode changed, the vehicle conforms with annex 10 of UNECE Regulation No. 13:1996.

      NOTE This check is not necessary if, in the changed control mode condition, all requirements for the vehicle's antilock braking system are fulfilled.

   2) Check that an optical warning signal informs the driver that the ABS has been disconnected or the control mode changed. The antilock optical warning device may be used for this purpose.

   3) Check that the ABS is automatically reconnected/returned to normal mode when the ignition (start) device is again set to the “on” position.

   4) Check that the vehicle user's handbook provided by the manufacturer warns the driver of the consequences of manual disconnection or mode change of the ABS.

5) Verify that there is no separate device to disconnect/change the control mode of a trailer ABS, and that this can only be done in conjunction with the towing vehicle.

e) Adjustment of the brakes, including automatically adjusting brakes, shall be performed prior to the static and dynamic tests in accordance with the vehicle manufacturer's recommendations for type approval testing.

8 Dynamic test of laden vehicle

For this test, perform the following procedure.

a) Ensure that the vehicle is fully laden to its maximum mass as for type 0 tests.

b) Disconnect the supply of electricity to the ABS, then disconnect the other electrical connections to the controller or controllers and modulator or modulators, one after the other. In each case, check that it is still possible to achieve the prescribed residual braking performance via the service braking system control device, with any one of these electrical failures.

NOTE This requirement does not replace the normal secondary braking system requirements in the event of any service braking system failure.

9 Determination of peak coefficient of adhesion — Low-adhesion surface — Laden vehicle

This test procedure should be carried out at soon as possible following completion of the adhesion-utilization tests in accordance with clauses 10 and 11, in order to minimize surface adhesion changes.

The following test sequence allows the determination of the peak coefficient of adhesion of the surface — first as k_f, for the front axle, then as k_r, for the rear axle or axles — by a repeat process, with the front axle brakes disabled and the rear circuit brakes enabled. The results are then used for the calculations of clause 10.

a) Disable the ABS function and the rear service brake operation.

b) After ensuring that all the necessary test equipment is operational, carry out a number of brake applications on the test surface with a low peak coefficient of adhesion.

The line pressure shall be set in increasing steps for each run until optimum performance is established (this will normally be when slight locking occurs — wheel lock could occur below 20 km/h). To ensure that the highest possible result has been included, the series of increments is extended to the point where the wheels lock above 20 km/h. The tests shall be performed from an initial vehicle speed of [50] km/h, with the braking rate calculated by reference to the time, t, in seconds, taken for the speed to be reduced from [40] km/h to [20] km/h, using the following equation:

$$z = \frac{[0{,}566]}{t} \tag{1}$$

c) Starting from t_{min} (the minimum measured value of t), select three values of t between t_{min} and $1{,}05t_{min}$, and calculate their arithmetical mean value, t_m. Then calculate

$$z_m = \frac{[0{,}566]}{t_m} \tag{2}$$

If for practical reasons it can be demonstrated that the three values defined above cannot be obtained, then t_{min} may be used instead.

NOTE 1 This procedure might be able to be carried out with the most accuracy when some form of adjustable line pressure regulator is fitted.

NOTE 2 In order to obtain a valid result, both wheels of the axle need to reach lock point simultaneously. For the purposes of establishing the k value, it could be necessary to make special adjustments to individual line pressures to achieve this.

d) Calculate the values of k_f and k_r using the following equations. These take into account the rolling resistance of the axle that is not braked on and the dynamic load transfer.

— In the case of a two-axle, rear-wheel drive vehicle, with braking on the front axle, k_f, is given by

$$k_f = \frac{z_{mf} \times P \times g - 0{,}015 \times F_2}{F_1 + \left(\frac{h}{E}\right) \times z_{mf} \times P \times g} \quad (3)$$

(see Table 1 for symbols).

— In the case of a two-axle, rear-wheel-drive vehicle, with braking on the rear axle, k_r, is given by

$$k_r = \frac{z_{mr} \times P \times g - 0{,}01 \times F_1}{F_2 - \left(\frac{h}{E}\right) \times z_{mr} \times P \times g} \quad (4)$$

(see Table 1 for symbols).

Round the values to the third decimal place.

NOTE 3 Vehicles of categories N2 and N3 having a wheelbase less than 3,8 m and an h/E ratio of $\geqslant$ 0,25 do not require a separate value for the rear axle coefficient of adhesion.

For vehicles equipped with three axles, only the axle not associated with a close-coupled bogie shall be used to establish a k value for the vehicle.

10 Determination of adhesion utilization — Low-adhesion surface — Laden vehicle

10.1 Vehicles with category 1 or 2 ABS

The test procedure for the determination of adhesion utilization is as follows.

a) Reconnect the ABS and ensure that, when the service braking system control device is applied, all brakes function normally.

b) From an initial vehicle speed of [55] km/h, and using the same test surface on which the peak coefficient of adhesion was determined (see clause 9), ascertain the braking rate the ABS can achieve. Perform the test with sufficient line pressure or pedal effort to ensure that the ABS functions. The result shall be calculated to the time, t, in seconds, taken to reduce the speed from [45] km/h to [15] km/h, using the following equation:

$$z = \frac{[0{,}849]}{t} \quad (5)$$

c) Repeat b) twice more and calculate the average of the three t values, (t_m) which will then give the z_{AL} value to be used in calculating the adhesion utilization with the following equation:

$$z_{AL} = \frac{[0{,}849]}{t_m} \quad (6)$$

d) Determine the coefficient of adhesion, k_m, by weighting with the dynamic axle loads, using the following equation:

$$k_m = \frac{k_f \times F_{fdyn} + k_r \times F_{rdyn}}{P \times g} \quad (7)$$

where

$$F_{fdyn} = F_1 + \frac{h}{E}\left(z_{AL} \times P \times g\right)$$

and

$$F_{rdyn} = F_2 - \frac{h}{E}\left(z_{AL} \times P \times g\right)$$

Round the value to two decimal places.

e) Calculate the adhesion utilization, ε, using the following equation:

$$\varepsilon = \frac{z_{AL}}{k_m} \quad (8)$$

10.2 Vehicles with category 3 ABS

Some multi-axle vehicles in this category have only a partially installed antilock control on the braking system. The adhesion utilization shall therefore be obtained separately for each controlled axle.

The test procedure for the determination of adhesion utilization is as follows.

a) Reconnect the ABS device and ensure that, when the service braking system control device is applied, only the brakes on one axle having at least one directly controlled wheel will function normally, and that the service braking system on the other axles is non-operational.

b) From an initial vehicle speed of [55] km/h, and using the same test surface on which the peak coefficient of adhesion was determined (see clause 9), ascertain the braking rate the ABS can achieve. Perform the test with sufficient line pressure or pedal effort to ensure that the ABS functions. The result shall be calculated to the time, t, in seconds, taken to reduce speed from [45] km/h to [15] km/h, using equation (5).

c) repeat b) twice more and calculate the average of the three t values (t_m) which will then give the z_{AL} value to be used in calculating the adhesion utilization with equation (6).

d) Calculate the adhesion utilization, ε, taking into account the rolling resistance of the unbraked upon axle or axles and load transfer using the following equation. In the case of a two-axle, rear-wheel drive vehicle, ε is given as follows:

— if a front axle, z_{AL} measured = z_{AL1}

$$\varepsilon_1 = \frac{z_{AL1} \times P \times g - 0{,}015 \times F_2}{k_f\left[F_1 + \frac{h}{E}\left(z_{AL1} \times P \times g\right)\right]} \quad (9)$$

— If a rear axle, z_{AL} measured = z_{AL2}

$$\varepsilon_2 = \frac{z_{AL2} \times P \times g - 0{,}01 \times F_1}{k_r \left[F_2 - \frac{h}{E}\left(z_{AL2} \times P \times g\right) \right]} \quad (10)$$

If $\varepsilon > 1$, repeat the measurements of the coefficients of adhesion. A tolerance of 10 % is acceptable.

e) If the vehicle has more than one axle with at least one directly controlled wheel, repeat steps a) to d) for the other axle or axles, by braking on one axle at a time.

f) If the vehicle has an axle (or bogie) which does not have at least one directly controlled wheel, check by calculation that the adhesion utilization and wheel-lock sequence requirements of annex 10 of UNECE Regulation No. 13:1996 are satisfied by that axle (or bogie).

g) If, with f), it is found that the relative position on the adhesion utilization curves does not meet those requirements, carry out additional dynamic tests in order to verify that the wheels on at least one rear axle do not lock before those of the front axle or axles. This is done by performing a number of stops (with the ABS in operation) from an initial vehicle speed or [50] km/h on both the high- and low-adhesion surfaces, using increments of line pressure until wheel lock occurs. The vehicle mass distribution shall be that used for the adhesion utilization calculations.

11 Determination of adhesion utilization — High-adhesion surface — Laden vehicle

Using a test surface with a high peak coefficient of adhesion of about [0,8] and a laden vehicle, repeat the tests given in clauses 9 and 10, as applicable.

This test procedure may be omitted if the prescribed force on the control device does not achieve full cycling.

12 Additional checks — Laden vehicle

12.1 General

12.1.1 In the test procedure specified in 12.2, momentary locking of directly controlled wheels (e.g. when passing from a high- to low-adhesion surface or when using a retarder) is permitted when the test vehicle's speed is more than [15] km/h; locking of directly controlled wheels is permitted when vehicle speed is less than [15] km/h. Indirectly controlled wheels may lock at any speed, but stability and steerability shall not be affected.

12.1.2 Steering control correction is permitted during the tests, provided the angular rotation of the steering wheels is within [120]° during the initial [2] s of the braking system application, and within [240]° during the remainder of the test.

12.1.3 The meaning of "fully applied" or "a full application of the service braking system control device" is maximum line pressure in the case of an air braking system and maximum permitted pedal effort for the vehicle category in the case of other braking systems. A higher service ABS control force shall be used if necessary to cause the ABS to come into operation.

12.2 Procedure for transition tests

With all brakes operational and the ABS connected, carry out the following test procedure, verifying that the directly controlled wheels do not lock when the brakes are suddenly fully applied. Perform these tests on both low- and high-adhesion surfaces as specified in clauses 9, 10 and 11, from initial vehicle speeds of, respectively, [40] km/h and [80] % of the vehicle maximum speed, v_{max}, but not exceeding 70 km/h and 80 km/h for semi-trailer tractors artificially loaded to simulate the effects of a laden semi-trailer (see Table A.2).

a) Check that when an axle passes from a high- to low-adhesion surface with the brakes fully applied the directly controlled wheels do not lock. The vehicle speed and the timing of the full brake application shall be such that the ABS cycles fully on the high-adhesion surface and the transition from high- to low-adhesion surface occurs at the two vehicle speeds specified above.

b) Check that when the vehicle passes from a low- to high-adhesion surface, with the brakes fully applied, the vehicle braking rate rises to an appropriate value for the high-adhesion surface within a reasonable time — typically 1 s to 2 s — without the vehicle deviating from its initial course. For this test, the vehicle speed shall be such that the ABS cycles fully on the low-adhesion surface and the transition from low- to high-adhesion surface occurs at approximately [50] km/h.

NOTE It could be necessary to install additional equipment (see 6.8) to show the point of transition of the surfaces on the record.

12.3 Procedure for split-adhesion tests

a) For vehicles fitted with category 1 or 2 ABS, check that directly controlled wheels do not lock when the right- and left-hand wheels are on surfaces with different peak coefficients of adhesion (k_H and k_L) and that the brakes are suddenly fully applied at a vehicle speed of [50] km/h. The vehicle shall be positioned centrally over the division between the two surfaces at the start of the test. During the test, no part of the tyres shall cross the division (outer tyres in the case of twin tyres).

b) For vehicles fitted with category 1 ABS, check that when the preceding test is performed, the vehicle meets the prescribed braking rate, z_{MALS}, as follows:

$$z_{MALS} \geqslant \frac{0{,}75\left(4k_L + k_H\right)}{5} \tag{11}$$

$$z_{MALS} \geqslant k_L \tag{12}$$

13 Energy consumption — Low-adhesion surface — Laden vehicle

This series of tests is to be performed only on those vehicles fitted with ABS using stored energy or whose energy source has a limited capacity. Indirectly controlled wheels and non-controlled wheels may lock during these tests.

a) Check that when the service braking system control device is applied, all brakes function normally. Ensure that any auxiliary storage device fitted is isolated from the service braking system.

b) Calculate the braking time, t, in seconds, to be used in the energy consumption test using the following equation:

$$t = \frac{v_{max}}{7} \tag{13}$$

where v_{max} is the maximum design speed of the vehicle, in kilometres per hour, with an upper limit of [160] km/h.

The braking time calculated shall be greater than or equal to [15] s.

c) Taking into consideration t obtained in b) and the length of the low-adhesion surface available, the minimum initial speed for performing the energy consumption test can be calculated. When making this calculation, the braking rate likely to be achieved shall be based on the coefficient of adhesion in accordance with clause 9. If an ABS becomes ineffective below about [15] km/h or [4,2] m/s, then the time of application shall only be that taken to reduce the vehicle speed to this lower speed. It is permissible to complete t in phases, up to a maximum of four, so as to reduce initial speed and the distance required. The initial speed shall be at least [50] km/h.

EXAMPLE Taking the following values:

v_{max} = 129 km/h

v_u = 15 km/h = 4,2 m/s

g = 10 m/s^2

k = 0,3

$$t = \frac{129}{7}$$

= 18,4 s

The speed is given by

$$v = v_u + k \times g \times t \tag{14}$$

Assuming four phases:

$$v = v_u + k \times g \times \frac{t}{4} = 4,2 + \frac{0,3 \times 10 \times 18,4}{4} \tag{15}$$

= 18 m/s = 64,8 km/h

Assuming three phases:

$$v = v_u + k \times g \times \frac{t}{3} = 4,2 + \frac{0,3 \times 10 \times 18,4}{3} \tag{16}$$

= 22,6 m/s = 81,4 km/h

The braking distance is given by

$$s = \frac{v^2 - v_u^2}{2k \times g} \tag{17}$$

Assuming four phases:

$$s = \frac{(18)^2 - (4,2)^2}{2 \times 0,3 \times 10} \tag{18}$$

= 51,1 m

Assuming three phases:

$$s = \frac{(22,6)^2 - (4,2)^2}{2 \times 0,3 \times 10} \tag{19}$$

= 82,2 m

If this calculation method is used, ensure that the pressure in the reservoirs or accumulators is that specified by the manufacturer, then carry out a number of test runs with the engine disconnected and idling to ensure that the calculations are realistic and, when the consumption test is carried out, with the vehicle speed at the end of the total application time as low as possible — but not lower than [15] km/h.

Also ensure that it will be possible to bring the vehicle to rest at the end of t without the use of any stored energy of the service braking system. If track space permits, the vehicle may be allowed to roll to rest.

Alternatively, at the end of t, bring the vehicle to rest by applying the service brake system control device without the ABS functioning and without releasing the brakes at rest. With the vehicle stationary, increase the brake application up to a full application and release subsequently. This is considered to be the first static application.

d) Check that the pressure in the service braking system reservoirs or accumulators is as specified by the manufacturer, is at least sufficient to achieve the prescribed service braking system performance, and that provision has been made to stop the supply of energy to these at the end of the application time on each run — preferably by a solenoid valve switched by the service braking system control device movement.

e) If the vehicle is authorized to draw a trailer equipped with air brakes, ensure that the supply line for the trailer is shut off and that a 0,5 l reservoir (see 5.4) is attached to the control line coupling.

f) From the initial speed, which shall not be less then [50] km/h, and using the low-adhesion test surface in accordance with clause 9, apply the service braking system control device fully, with the engine disconnected and idling, until t is completed, noting the time taken. Ensure that during t the ABS cycles continuously. Release the service braking system control device and simultaneously cut off the supply of energy to the service braking system reservoirs or accumulators.

g) Repeat f), if necessary, up to a maximum of four times in all, until the total time t has been achieved, ensuring that the energy supply is reconnected the instant the control device is applied and cut off the instant it is released.

The ABS shall continue to function during the whole of t [see i)].

From the second phase, the energy consumption corresponding to the initial brake application may be taken into account by subtracting one full brake application from the full four applications.

h) Bring the vehicle to rest without reducing the level of the stored energy of the service braking system. After ensuring that all brakes are released, fully apply and release the service braking system control device four times.

During the test, additional energy shall not be supplied to the service braking system reservoirs or accumulators.

i) Check that when the brakes are applied for the fifth time it is possible to achieve the prescribed secondary performance in the laden condition. This may be carried out either by performing a test on a surface with sufficient adhesion or by making a fifth static application and checking that the line pressure is sufficient to achieve secondary performance.

During the test, additional energy shall not be supplied to the service braking system reservoirs or accumulators.

It may be necessary to partially off-load some vehicles in order to ensure that the ABS still operates as the pressure reduces. This is acceptable, but the requirement for secondary performance is still relative to the maximum mass of the laden vehicle.

j) In addition, if the vehicle is authorized to draw a trailer equipped with air brakes, check that when the brakes are supplied for a fifth time the pressure supplied to the control line is at least [50] % of that supplied on the first full application of the service braking system, with the initial pressure level specified by the manufacturer.

During the test, additional energy shall not be supplied to the service braking system reservoirs or accumulators.

14 Tests on unladen vehicle

Repeat the tests in accordance with clauses 9, 10, 11 and 12 on the unladen vehicle, but omitting the split-adhesion performance test given in 12.3 b).

Annex A
(informative)

Equivalence with UNECE Regulation No. 13

Table A.1 indicates those paragraphs of UNECE Regulation No. 13:1996, annex 13, corresponding to the elements of this International Standard.

Table A.2 indicates speeds for transition tests.

Table A.1

ISO 11835 Clause/subclause	**UNECE Regulation No. 13, Annex 13** Paragraph	**ISO 11835** Clause/subclause	**UNECE Regulation No. 13, Annex 13** Paragraph
3.3	2.5	12.1.1	5.3.6
3.4	2.6	12.1.2	5.3.7
Table 1	Appendix 1	12.1.3	5.3.1 footnote 8
5	3.1	12.2	5.3.1
5 a)	3.1.1	12.2 a)	5.3.2
5 b)	3.1.2	12.2 b)	5.3.3
5 c)	3.1.3	13 a)	5.1.1.1
7 a), 1)	1.1	13 b)	5.1.2.3
7 a), 2) to 5)	4.1, 4.3	13 c)	5.1.1.2, 5.1.2.2, 5.1.2.4
7 b), 1) to 3)	4.2	13 d)	5.1.1.1, 5.1.1.3
7 b), 4)	4.4	13 e)	5.1.1.6
7 c)	4.6 and footnote 5	13 f)	5.1.1.2, 5.1.1.3, 5.1.2.2
7 d)	4.7	13 g)	5.1.1.2, 5.1.2.4, 5.1.2.5
8 b), Note	4.5	7	5.1.1.3, 5.1.1.4, 5.1.2.5
9	Appendix 2	13 i)	5.1.1.1, 5.1.1.3, 5.1.1.5, 5.1.2.5, 5.1.2.6
10	Appendix 2	13 j)	5.1.1.3, 5.1.1.6, 5.1.2.5
11	5.2	14	5.2.5, 5.3, 5.3.5

Table A.2

Test surface	**Vehicle category**	**Maximum test speed** km/h
High-adhesion surface	All categories, except N2 and N3, laden	$0{,}8\ v_{max} \approx 120$
	N2, N3 laden	$0{,}8\ v_{max} \approx 80$
Low-adhesion surface	M1, N1	$0{,}8\ v_{max} \approx 120$
	M2, M3, N2 except semi-trailer tractors	$0{,}8\ v_{max} \approx 80$
	N3 and semi-trailer tractors N2	$0{,}8\ v_{max} \approx 70$

Bibliography

[1] ISO 7634, *Road vehicles — Towed vehicles with compressed-air braking system with and without antilock — Measurement of braking performance*

[2] ISO 7637-1, *Road vehicles —Electrical disturbances from conduction and coupling — Part 1: Definitions and general considerations*

[3] ISO 7637-2, *Road vehicles — Electrical disturbances from conduction and coupling — Part 2: Electrical transient conduction along supply lines only*

[4] ISO 7637-3, *Road vehicles — Electrical disturbance by conduction and coupling — Part 3: Vehicles with nominal 12 V or 24 V supply voltage — Electrical transient transmission by capacitive and inductive coupling via lines other than supply lines*

[5] ISO/TR 10305, *Road vehicles — Generation of standard EM field for calibration of power density meters from 20 kHz to 1000 MHz*

[6] ISO 10605, *Road vehicles — Test methods for electrical disturbances from electrostatic discharge*

[7] ISO 11451-1, *Road vehicles — Vehicule test methods for electrical disturbances from narrowband radiated electromagnetic energy — Part 1: General and definitions*

[8] ISO 11451-2, *Road vehicles — Vehicule test methods for electrical disturbances from narrowband radiated electromagnetic energy — Part 2: Off-vehicle radiation source*

[9] ISO 11451-3, *Road vehicles — Electrical disturbances by narrowband radiated electromagnetic energy — Vehicle test methods — Part 3: On-board transmitter simulation*

[10] ISO 11451-4, *Road vehicles — Electrical disturbances by narrowband radiated electromagnetic energy — Vehicle test methods — Part 4: Bulk current injection (BCI)*

[11] ISO 11452-1, *Road vehicles — Component test methods for electrical disturbances from narrowband radiated electromagnetic energy — Part 1: General and definitions*

[12] ISO 11452-2, *Road vehicles — Electrical disturbances by narrowband radiated electromagnetic energy — Component test methods — Part 2: Absorber-lined chamber*

[13] ISO 11452-3, *Road vehicles — Component test methods for electrical disturbances from narrowband radiated electromagnetic energy — Part 3: Transverse electromagnetic mode (TEM) cell*

[14] ISO 11452-4, *Road vehicles — Component test methods for electrical disturbances from narrowband radiated electromagnetic energy — Part 4: Bulk current injection (BCI)*

[15] ISO 11452-5, *Road vehicles — Component test methods for electrical disturbances from narrowband radiated electromagnetic energy — Part 5: Stripline*

[16] ISO 11452-6, *Road vehicles — Electrical disturbances by narrowband radiated electromagnetic energy — Component test methods — Part 6: Parallel plate antenna*

[17] ISO 11452-7, *Road vehicles — Component test methods for electrical disturbances from narrowband radiated electromagnetic energy — Part 7: Direct radio frequency (RF) power injection*

ICS 43.040.40

Price based on 14 pages