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Road vehicles — Air or air over hydraulic braking systems — Measurement of braking performance

Véhicules routiers — Dispositifs de freinage à transmission pneumatique ou hydropneumatique — Mesurage des performances de freinage

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Contents

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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.

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 7635 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Sub-Committee SC 2, *Brake systems and equipment*.

Annex A forms an integral part of this International Standard.

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Road vehicles — Air or air over hydraulic braking systems — Measurement of braking performance

1 Scope

This International Standard specifies the test method for testing the air or air over hydraulic braking systems of road vehicles of categories M and N[1] as defined in UN-ECE Regulation No. 13.

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

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 611:1980, *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 with regard to braking,* incorporating the 05 series of amendments.

3 Definitions and symbols

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

3.1 Braking systems

3.1.1 air over hydraulic system: System in which the energy-supplying device exclusively supplies compressed air, and the transmission device includes both air and hydraulic fluid. For a typical system diagram, see annex A, figure A.1.

3.1.2 full air system: System in which the energy-supplying device and the transmission device work exclusively with air. For a typical system diagram, see annex A, figure A.2.

3.2 Vehicle loading

3.2.1 laden vehicle: Vehicle laden so as to reach its maximum mass.

3.2.1.1 laden motor vehicle other than semi-trailer tractor: Vehicle laden to technically feasible maximum mass specified by the vehicle manufacturer and acknowledged by the Technical Services. 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

1) Definitions from UN-ECE Regulation No. 13, amendment 05:

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.

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.

the load on each axle is proportional to the maximum technically permissible load for each axle.

3.2.1.2 laden semi-trailer tractor: Vehicle laden as in 3.2.1.1 , except that the load may be repositioned halfway between the kingpin position and the centre-line of the rear axle(s).

3.2.2 Unladen vehicle

3.2.2.1 unladen motor vehicle other than semi-trailer tractor: Vehicle laden to kerb mass without load or occupant but with the fuel tank filled to at least 90 % of the capacity stated by the vehicle manufacturer at the start of test and complete with cooling fluid and lubricants, and tools and spare wheel, if provided.

During the tests, the fuel quantity is to be maintained at least to 50 % of its capacity.

An increase up to 200 kg mass over this mass is allowed; this corresponds, for instance, to the driver, one observer and instrumentation. If necessary, some vehicle mass may have to be removed.

For a vehicle without body, the manufacturer is to declare the minimum mass reached on each axle for the vehicle with a body.

3.2.2.2 unladen semi-trailer tractor: Vehicle laden as in 3.2.2.1 including the fifth wheel or an equivalent load (in value and in position).

3.3 Pneumatic pressures

3.3.1 pressure indicated by manufacturer: Pressure specified by the manufacturer from which it is possible to achieve the required efficiency for service braking, energy depletion and energy pump-up times.

3.3.2 maximum pressure: Pressure available for normal operation, viz.:

— cut-out pressure, in the case of an installation with unloader;

— [90] % of the asymptotic pressure, in the case of an installation with a pressure-limited compressor.

3.3.3 minimum pressure: Pressure available for normal operation, viz.:

— cut-in pressure, in the case of an installation with unloader;

— [90] % of the pressure indicated by the manufacturer, in the case of an installation with pressure-limited compressor.

3.4 Road test parameters

v is the vehicle test speed at the initiation of braking, in kilometres per hour;

v_{max} is the maximum vehicle speed declared by the manufacturer, in kilometres per hour.

4 Test site conditions

4.1 Road surface condition

4.1.1 Surface

The road surface shall be a dry, smooth, hard-surfaced roadway of Portland cement concrete, or other surfaces with an equivalent coefficient of surface friction.

The road surface shall be free from loose material.

4.1.2 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 1 The parking brake system hill-holding test may be conducted on a specified gradient or on a level road (see 12.2.1).

4.1.3 Camber

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

4.2 Ambient conditions

4.2.1 Wind speed

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

4.2.2 Air temperature

The air temperature shall not exceed 35 °C.

In exceptional circumstances, 45 °C may be accepted. This shall be recorded in the test report.

5 Vehicle preparation

NOTE 2 Definitions in clause 3 also include some requirements which are an integral part of the tests.

5.1 Instrumentation

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 shall be exercised to ensure that instruments added to the standard vehicle braking equipment do not significantly affect the braking system performance.

All the installed instruments indicated in 5.1.1 to 5.1.11 shall be checked to ensure that they are functioning correctly and, with the vehicle stationary on the test surface, all the test instruments shall be set.

5.1.1 Control force gauge for the service braking system.

5.1.2 Control force gauge for the parking brake system.

5.1.3 Control force gauge for the secondary braking system (if this system is not combined with either the service or the parking brake system).

5.1.4 Decelerometer.

5.1.5 Speed-measuring device or calibrated speedometer.

5.1.6 Stopping-distance-measuring device.

5.1.7 Time-measuring device.

5.1.8 Brake temperature indicating system.

5.1.9 Initial response time and build-up time measuring equipment.

5.1.10 Line pressure gauges/transducers.

5.1.11 Optional instruments, which may include

a) control travel gauges,

b) wheel lock indicators.

5.2 Provision for failure simulation

The vehicle shall be equipped with the necessary added devices and piping according to the manufacturer's recommendations and agreed with the Technical Services to provide the required failure simulations. Such added devices and piping shall not interact with the standard vehicle braking equipment in such a manner as to affect significantly the intact and/or failed system performance.

5.2.1 On the pneumatic part of the braking system, a free leakage corresponds to an uncoupled pipe.

5.2.2 On the hydraulic part of the braking system, a leakage will be simulated and the brake fluid may return towards its tank.

5.3 Tyre conditions

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

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

5.4 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 in according to the vehicle manufacturer's recommendations.

5.5 Adjustment of braking equipment

Adjustable brake components shall be set according to the vehicle manufacturer's recommendations. Re-adjustment of the brakes, including automatically adjusted brakes, in accordance with the vehicle manufacturer's recommendations (manual or otherwise), may be made prior to each specific test.

Where a secondary braking system effectiveness test is carried out on the rear axle only, automatic adjustment devices may be disconnected, if requested by the manufacturer.

5.6 Vehicle to tow test vehicle

A towing vehicle may be used for the simulated downhill behaviour test (categories M_3 and N_3). It shall be equipped with the instruments in 5.6.1 to 5.6.4.

5.6.1 Speed-measuring device or calibrated speedometer.

5.6.2 Time-measuring device.

5.6.3 Stopping-distance-measuring device.

5.6.4 Towing-force-measuring device.

6 Test requirements

6.1 During all phases of this procedure, any unusual braking performance characteristics, such as undue deviation or abnormal vibration, shall be observed and reported.

6.2 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 engine stalling.

6.3 Deceleration measurements used in this procedure, unless otherwise stated, refer to the "mean fully developed deceleration"—not to the mean deceleration based on the stopping distance/time relationship. When reference is made to "prescribed effectiveness", this is the effectiveness presented in UN-ECE Regulation No. 13 for the individual test.

6.4 Tests may be carried out under adverse conditions to avoid delays, but with due consideration for safety; such adverse conditions shall be reported. Any test failures under such conditions shall be repeated under the correct conditions, but not all tests need necessarily be repeated.

6.5 The tests should preferably be carried out in the recommended sequence described in this procedure; however, the parking brake 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 procedure.

Furthermore, all unladen tests may be grouped together and be followed by the laden tests.

Any variation in the recommended sequence shall be noted.

6.6 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.

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

6.8 Control forces shall be applied rapidly, but without significant overshoot, and then be maintained constant during the stop or varied progressively, as required.

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

6.10 Skilled test drivers shall be used to determine the optimum vehicle braking performance without wheel-locking except immediately before stopping and without significant deviation, after appropriately familiarizing themselves with the vehicle braking, steering and suspension systems.

6.11 Tests with the engine connected shall be carried out in the appropriate gear, defined as that gear used normally to reach the speed without exceeding the manufacturer's recommended maximum engine speed.

6.12 The brakes are deemed to be cold when the initial temperature of the hottest brake measured on the disc or on the outside of the drum or on the brake linings is higher than 50 °C and lower than [100] °C before each test stop.

7 Service braking system — Cold effectiveness test (UN-ECE type 0 test)

7.1 Test procedure

This test procedure shall be carried out for each specified loading condition and from all the nominated vehicle speeds, with the engine disconnected and connected as prescribed. The appropriate gear for engine-connected tests is defined in 6.11.

Each test stop shall be made with cold brakes as defined in 6.12.

Determine the optimum mean fully developed deceleration and/or stopping distance for each vehicle speed/vehicle loading condition as specified in 7.1.1 and 7.1.2, without exceeding the maximum permitted control force (see annex A) and without wheel-locking.

A preliminary series of five braking system applications may be carried out for vehicle familiarization, but because the total number of stops can significantly change the thermal and mechanical properties of the friction materials (and thus possibly the vehicle performance), it is recommended that each test condition should be run no more than four times (unless otherwise specified); in any event, the total number of stops made in this clause should not exceed 35.

The test sequence in 7.1.1 to 7.1.2.2 is recommended.

7.1.1 Unladen stops

7.1.1.1 From the prescribed test speed (see annex A) with the engine disconnected. The result of this test shall be at least equal to the prescribed braking efficiency.

7.1.1.2 From [30] %, 55 %, [80] % of v_{max} with the engine connected in an appropriate gear.

7.1.2 Laden stops

7.1.2.1 From the prescribed test speed (see annex A) with the engine disconnected. The result of this test shall be at least equal to the prescribed braking efficiency.

This test shall consist of several stops from the specified speed, using reasonably spaced increments of control force or line pressure to generate

the graph of braking rate against control force or line pressure. This graph can be used for the tests in 14.1 and 14.2.

One measurement shall be at least equal to the prescribed braking efficiency.

7.1.2.2 From [30] %, 55 %, [80] % of v_{max} with the engine connected in an appropriate gear, but not exceeding [80] km/h in the case of semi-trailer tractors.

7.2 Presentation of results

7.2.1 During each test stop, the following information shall be recorded:

a) the actual speed of the vehicle at the initiation of braking;

b) the control force or line pressure;

c) the mean fully developed deceleration and/or stopping distance;

d) any locking of the wheels, deviation of the vehicle from its course or abnormal vibration.

7.2.2 The following additional information shall also be recorded:

a) the ambient conditions;

b) the vehicle identification;

c) the vehicle loading conditions (including individual axle masses for each loading condition);

d) the relevant tyre information.

7.2.3 All test results in 7.2 may be given in the form of a table.

The test results corresponding to 7.1.2 may be presented in a graph.

7.3 Complementary tests

If the same test vehicle is used, complementary tests, to generate base data for subsequent performance tests, may conveniently be carried out at the time of the cold effectiveness tests, as required; for example, preliminary test for the response time measurement (see clause 13). In this case it is recommended that line pressure gauges/transducers (see 5.1.10) should be installed in each service braking system circuit, in order to determine the line pressure at the least favourably placed axle corresponding to the prescribed braking performance, when carrying out the test described in 7.1.2.

8 Secondary braking system — Service braking system partial failure test (UN-ECE type 0 test)

8.1 General

8.1.1 Secondary braking system

Two types of secondary braking systems are considered (at the option of the vehicle manufacturer):

a) combined with the service braking system;

b) independent of the service braking system and/or combined with the parking brake system.

8.1.2 Secondary braking performance

This is considered to be the minimum performance required of the secondary braking system.

8.1.3 Residual braking performance of service braking system

This is considered to be the minimum performance required of the service braking system in case of a transmission circuit failure, when the secondary braking system is not combined with the service braking system.

8.2 Test procedure — General requirements

8.2.1 The secondary and/or residual braking performance (see 8.1.2 or 8.1.3) shall be checked for each specific failure mode appropriate to the vehicle braking equipment.

8.2.2 For each test condition (see 8.3 and 8.4), determine the optimum mean fully developed deceleration and/or stopping distance:

a) vehicle speed (see annex A);

b) without exceeding the maximum permissible control force (see annex A);

c) engine disconnected or connected (as prescribed);

d) without wheel-locking, except immediately before stopping;

e) with steering-wheel corrections, if necessary, to keep the vehicle on course;

f) loading condition: unless otherwise specified, all tests should be carried out with the vehicle laden and unladen.

A single stop suffices for each test condition. Additional stops may be run, if necessary.

Each test shall be made with cold brakes as defined in 6.12. For engine-connected tests, the appropriate gear is defined in 6.11.

8.3 Secondary braking system test

8.3.1 Secondary braking system combined with service braking system (circuit failure)

The failure of one circuit of the service braking system shall be simulated by an open-circuit leakage type failure which ensures that the circuit line pressure remains at zero during the entire test phase.

The test conditions shall be as follows:

a) engine disconnected, from the prescribed test speed for secondary braking: prescribed effectiveness shall be equal to secondary braking effectiveness;

b) engine connected in an appropriate gear, from [30] %, 55 % and [80] % of v_{max}, but not exceeding [80] km/h in the case of laden semi-trailer tractors.

No value for the effectiveness is specified: however, the measured efficiency and the behaviour of the vehicle shall be recorded in the test report.

The entire test series shall be repeated for every other circuit of the service braking system, by inducing one failure at a time.

8.3.2 Secondary braking system independent of service braking system and/or combined with parking brake system

In this case, both the secondary braking system and the service braking system with a partial failure shall be tested. The sequence in 8.3.2.1 and 8.3.2.2 is recommended.

8.3.2.1 Separate secondary braking system test

The test conditions shall be as follows:

a) engine disconnected, from the prescribed test speed for secondary braking: prescribed effectiveness shall be equal to secondary braking effectiveness;

b) engine connected in an appropriate gear, from [30] % 55 % and [80] % of v_{max}, but not exceeding [80] km/h in the case of semi-trailer tractors.

No value for the effectiveness is specified: however, the measured efficiency and the behaviour of the vehicle shall be recorded in the test report.

8.3.2.2 Service braking system partial failure test

The circuit failure shall be simulated as in 8.3.1; the test is not required for semi-trailer tractors.

The test conditions shall be as follows:

a) engine disconnected, from the prescribed test speed for secondary braking;

b) prescribed effectiveness shall be equal to residual braking effectiveness.

8.4 Service braking system partial failure tests

This test simulates the failure of the load-sensing valve control, if fitted, by disconnecting the valve control.

When a valve control failure affects the trailer control line pressure, the resulting pressure shall be between [6,5] bar to [8,0] bar.

The test conditions shall be as follows:

a) engine disconnected, from the prescribed test speed for secondary braking;

b) prescribed effectiveness shall be equal to secondary braking effectiveness.

9 Service braking system — Fade test (UN-ECE type I test)

9.1 Test conditions

The test track may include bends and corners, although it is preferable for the braking and stops to be carried out on straight track sections.

9.2 Test procedure

This test procedure comprises three separate stages, to be carried out with the vehicle laden in accordance with 3.2.1.

9.2.1 Determination of control force

The correct control force (or line pressure) shall generate a deceleration of [3] m/s² on the first braking of the heating procedure, engine connected, in the highest gear (excluding overdrive), where the initial speed is [80] % v_{max} and brakes are released at [40] % v_{max}.

If [80] % v_{max} exceeds [120] km/h, brake from [120] km/h to [60] km/h for categories M_1 and N_1.

If [80] % v_{max} exceeds [100] km/h, brake from [100] km/h to [50] km/h for category M_2.

If [80] % v_{max} exceeds [60] km/h, brake from [60] km/h to [30] km/h for other categories.

Alternatively, if the driver is sufficiently skilled and familiar with the vehicle braking equipment, he may proceed directly with the heating procedure and note the correct control force (or line pressure).

Corresponding control force (or line pressure) shall be directly defined from tests or by interpolation with a graphical method.

9.2.2 Heating procedure with repeated braking

The brakes shall be heated by carrying out the procedure in 9.2.2.1 to 9.2.2.8.

9.2.2.1 The brakes shall be cold as defined in 6.12 at the beginning of the first braking only.

9.2.2.2 The vehicle test speed at the initiation of braking should be v_1, where v_1 = [80] % v_{max}, but not exceeding

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

— [100] km/h, for category M_2;

— [60] km/h, for other categories.

9.2.2.3 The control force on the service braking system control device shall generate a deceleration of [3] m/s^2; this control force shall remain constant for subsequent brakings (although possibly generating different deceleration levels).

9.2.2.4 The brakes shall be released when the vehicle speed drops to [½]v_1.

9.2.2.5 During the brakings, the engine shall remain connected in the highest gear (excluding overdrive).

9.2.2.6 Immediately after releasing the brakes, the speed v_1 shall be regained in the shortest possible time, using the maximum acceleration allowed by the engine and gearbox.

Before commencing the next braking cycle, stabilize the vehicle speed at v_1 for at least [10] s.

9.2.2.7 The next braking cycle shall be initiated:

— [45] s for category M_1,

— [55] s for categories N_1 and M_2,

— [60] s for other categories,

after initiation of the previous braking cycle (see 9.2.2.2).

If the vehicle acceleration performance does not permit compliance with this cycle time, this interval may be increased, but in any case the [10] s stabilization period of 9.2.2.6 shall be respected.

9.2.2.8 A total of [15] braking cycles for categories M_1, N_1, M_2, or [20] braking cycles for categories M_3, N_2 and N_3 shall be completed.

9.2.3 Braking efficiency test with hot brakes

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

The procedure in 9.2.3.1 to 9.2.3.3 is recommended.

9.2.3.1 Immediately after completing the last braking cycle of the heating procedure, the vehicle shall be accelerated as quickly as possible to the prescribed service braking system test speed in the type 0 test, engine disconnected (see annex A).

9.2.3.2 Within 60 s of completing the last braking cycle, one stop shall be made under the conditions of 7.1.2.1 (but with different brake temperatures) and with the control force recorded during the corresponding type 0 test (vehicle laden, engine disconnected, from the specified service braking system test speed).

The hot braking effectiveness achieved shall satisfy two conditions:

a) not less than [60] % of the recorded braking effectiveness during the corresponding type 0 test (see 7.1.2.1);

b) not less than [80] % of the prescribed service braking system effectiveness.

9.2.3.3 If 9.2.3.2 a) or b) cannot be achieved during the braking, the hot test may be repeated immediately or following a new heating procedure under the conditions of 9.2.2.

During this second hot test under the conditions of 9.2.3.1 and 9.2.3.2, the control force may be increased up to the maximum permitted value (see annex A) in order to satisfy the conditions in 9.2.3.2 a) or b).

9.3 Alternative test procedures

If the test site does not permit the correct heating procedure to be maintained, then either the cycle times or the vehicle speeds may be varied, provided