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Passenger cars — Stopping distance at straight-line braking with ABS — Open-loop test method

Voitures particulières — Distance d'arrêt de freinage en ligne droite avec ABS — Méthode d'essai en boucle ouverte

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Foreword

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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 21994 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 9, *Vehicle dynamics and road-holding ability*.

Introduction

The stopping distance of a road vehicle is an important part of vehicle performance and active vehicle safety. Any given vehicle, together with its driver and the prevailing environment, constitutes a unique closed-loop system. The task of determining the stopping distance is therefore very difficult, since there is a significant interaction between these driver-vehicle-environment elements, each of which is complex in itself.

Test conditions and tyres have a strong influence on test results. Therefore, only vehicle stopping distances obtained under comparable test and tyre conditions are comparable to one another.

Passenger cars — Stopping distance at straight-line braking with ABS — Open-loop test method

1 Scope

This International Standard specifies an open-loop test method to determine the stopping distance of a vehicle during a straight-line braking manoeuvre, with the Anti-lock Braking System (ABS) fully engaged. This International Standard applies to passenger cars as defined in ISO 3833 and light trucks.

This International Standard specifies a reference method and is especially designed to ensure high repeatability.

2 Normative references

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.

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

ISO/TR 8349, *Road vehicles — Measurement of road surface friction*

ISO 8855, *Road vehicles — Vehicle dynamics and road-holding ability — Vocabulary*

ISO 15037-1:2006, *Road vehicles — Vehicle dynamics test methods — Part 1: General conditions for passenger cars*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 8855 and the general conditions given in ISO 15037-1 shall apply. For specific terms see Annex C.

4 Principle

This International Standard specifies a method to determine the braking distances characterizing the deceleration build-up phase at the beginning of a braking manoeuvre and at full braking until the vehicle comes to a standstill.

The driving situation represents an emergency or panic braking phase (pushing the brake pedal with a very high activation speed) during straight-ahead driving on an even and dry road surface with a high coefficient of friction.

Using this International Standard, three results become available:

— stopping distance from initial brake pedal contact until vehicle comes to a standstill (s_{A100});

— ABS-braking distance describing the distance travelled under full ABS-controlled braking from 90 km/h until vehicle comes to a standstill (s_{L90}); and

— estimation of the build-up distance from initial brake pedal contact until a velocity reduction of 10 km/h is achieved (s_{F10}).

Apart from the technical equipment and especially the braking characteristics of the vehicle, the distance travelled after the first pedal contact very strongly depends on the individual pedal actuation of the driver. To minimize this influence, this International Standard specifies rules for brake pedal actuation.

To achieve reproducible, reliable and comparable measurement results, a multitude of further test conditions shall be observed.

Measurement results can only be compared if measurements took place under identical conditions. In particular, this means:

— same track (see also Annex C); and

— very similar weather and ambient conditions (wind, temperature, etc.).

5 Variables

5.1 Reference system

The reference system specified in ISO 15037-1 shall apply.

5.2 Variables to be measured

The following variables shall be measured:

— longitudinal velocity: (v_X);

— time of brake pedal actuation: (t_0);

— longitudinal distance: (s);

— brake pedal actuation force: (F_P).

The variable longitudinal velocity is defined in ISO 8855.

6 Measuring equipment

6.1 Description

All variables shall be measured by means of appropriate transducers, and their time histories shall be recorded by a multi-channel recording system. Alternatively, data measured may be recorded and processed directly in a calculation unit of the measuring system without the possibility to access time histories. Typical operating ranges, and recommended maximum errors of the transducer and recording system, are given in Table 1. If initial longitudinal velocities different from 100 km/h are chosen, the following operating ranges shall be changed accordingly, but maximum errors shall be unchanged.

Table 1 — Variables, their typical operating ranges and recommended maximum errors — Additions and exceptions to ISO 15037-1

Variable	Typical operating range	Recommended maximum error of the combined transducer and recorder system
Initial longitudinal velocity[a]	102 km/h – 98 km/h	± 0,5 km/h
Longitudinal velocity[b]	93 km/h – 5 km/h	± 0,5 km/h
Longitudinal distance	100 m	± 1 % (⩽ 50 m) ± 0,50 m (> 50 m)
Brake force trigger	⩽ 10 N (triggering point)	± 5 N
Brake pedal actuation force[c]	0 N – 1 000 N (max. 1 500 N)	± 2 %

[a] Determined in averaging interval 0,2 s-0 s before brake pedal contact.

[b] Deviations of the measured velocity are normally found in the transition area from steady state driving to full braking.

[c] It is recommended to use a lateral force compensated brake force transducer.

The trigger signal for brake pedal contact shall be activated at a pedal force of 10 N or less. The time delay of the trigger signal shall be 5 ms or less. If the pedal force transducer does not fulfil this specification, it is recommended to use a contact switch on the brake pedal's step pad.

To monitor test preparation (run-in) and test conditions, the following measuring devices are required:

— brake (disc/drum or pad/lining) temperature sensor; and

— device for measuring and displaying vehicle deceleration (run-in).

6.2 Transducer installation

The requirements of 4.2 of ISO 15037-1:2006 shall apply. In addition, it shall be ensured that transient vehicle pitch angle changes during braking do not affect the measurement of the velocity and distance variables for the chosen transducer system.

6.3 Calibration

All transducers shall be calibrated according to the manufacturer's instructions. The transducer manufacturer's recommended application software and firmware version shall be used. If parts of the measuring system used can be adjusted, such calibration shall be performed immediately before the beginning of the tests.

For a detailed procedure of calibration, see Annex E.

6.4 Data processing

The recording system and data processing requirements contained in 4.3 of ISO 15037-1:2006 shall apply.

7 Test conditions

7.1 General test conditions

The test conditions shall be in accordance with Clause 5 of ISO 15037-1:2006, unless otherwise specified in this International Standard.

7.2 General data

General data on the test vehicle and test conditions shall be recorded as specified in ISO 15037-1:2006, 5.4.1 and Annexes A and B, with the additions of the braking system and tyre data as listed in Annex A of this International Standard.

7.3 Test track

All tests shall be carried out on a smooth, clean, dry and uniform paved road surface.

The gradient of the test surface to be used shall not exceed 1 % longitudinal inclination and 2 % transversal inclination when measured over any distance interval between that corresponding to the vehicle track and 25 m.

It is recommended to use a lane width of 3,5 m or more.

The friction coefficient of the test surface shall be a minimum of 0,9, and its variation shall not exceed ± 5 % over the length of the test surface. These requirements are generally fulfilled on concrete and rough asphalt surfaces. (See also C.2.2 and C.2.3.)

7.4 Environmental conditions

The weather conditions shall remain unchanged during a sequence of measurements. The ambient wind velocity (regardless of the wind direction) shall either not exceed 3 m/s or, if the wind velocity ranges between 3 m/s and 5 m/s maximum, an equal number of measurements specified shall be carried out in both driving directions. The total number of measurements shall remain the same (see 8.2.5).

The ambient temperature shall be between + 5 °C and + 35 °C and its variation during a sequence of measurements shall not exceed 10 °C.

The surface temperature of the test track shall be between + 10 °C and + 40 °C and its variation during a sequence of measurements shall not exceed 10 °C.

Additionally, the variation in surface temperature along the length of the test track (e.g. due to changes from sunlit to shaded areas) shall not exceed 10 °C.

Measurements performed within acceptable temperature ranges as specified above can only be compared if, additionally, the temperature difference between one another is below 10 °C. Special tests with specific structural components such as tyres may require much smaller tolerance ranges in order to become comparable.

7.5 Test vehicle

7.5.1 General vehicle condition

The condition of the test vehicle shall be in accordance with the vehicle manufacturer's specifications, particularly with respect to the complete brake system, the suspension geometries, power train (e.g. differentials and locks) configuration and tyres used.

7.5.2 Tyres

Generally, all measurements shall be conducted with summer tyres.

For a general tyre condition, new tyres shall be fitted on the test vehicle according to the manufacturer's specifications. If not specified otherwise by the tyre manufacturer, they shall be run in on the test vehicle for at least 150 km on a road surface with high friction or on an equivalent vehicle without excessively harsh use, for example braking, acceleration, cornering, hitting the kerb, etc. Therefore, longitudinal and lateral accelerations shall not exceed 3 m/s^2 during run-in. After run-in the tyres shall be used at the same vehicle locations for the tests.

The existing tread depth and the type of wear have an impact on the length of the braking distance (see C.2.5). Therefore, when comparing vehicles or tyres, new tyres shall be used for the measurements as a general rule. If no new tyres are used, the tyre parameters and tread widths should show a steady wear condition with a tread depth of at least 90 % of the original value across the whole breadth of the tread and around the whole circumference of that of the new tyre.

Tyres shall be manufactured not more than one year before the test. The date of manufacturing (DOT-stamp) shall be noted in the presentation of test conditions (see Annex A).

Tyres shall be inflated to the pressure as specified by the vehicle manufacturer for the test vehicle configuration. The tolerance for setting the cold inflation pressure is ± 5 kPa for pressures up to 250 kPa and ± 2 % for pressure above 250 kPa.

Tyre data, the inflation pressure and tread depth of the tyres determined before tyre warm-up and after the test runs shall be recorded in the test report (see Annex B).

7.5.3 Braking system

The braking system shall be in a technically perfect condition (see also C.2.9). Any newly installed wheel brakes (brake discs, brake drums, brake pads) must be burnished in accordance with vehicle manufacturer specifications. Alternatively, the burnishing procedure for brakes as specified in C.2.5.2 may be applied. Hydraulic systems shall be fully bled (free of air residuals) in accordance with the manufacturer's instructions.

7.5.4 Loading conditions of the vehicle

The fuel tank shall be full and, in the course of the measurement sequence, the indicated fuel level should not drop below "half-full".

The total load of the driver plus instrumentation should not exceed 150 kg.

If the vehicle is to be tested in any other load condition (e.g. GVM), then the additional payload shall be evenly distributed such that cross-axle variations do not exceed 50 kg (see C.2.6).

8 Test procedure

8.1 Test preparation

8.1.1 Defining the measurement distance

To ensure constant friction characteristics, all test runs shall be performed on the same track section.

It shall be ensured that neither tread wear nor frequent braking can cause a relevant change of the track surface and hence a different road friction coefficient.

Comparative measurements should always be started at the same spot to avoid different friction coefficients.

However, to avoid punctual road contamination or damage in the long run, the initial braking point should vary along the track when carrying out entirely different measuring sequences.

Since friction coefficients often vary considerably across the driving track, it shall be ensured that the tests are all performed on the same driving track in order to achieve reproducible test results.

8.1.2 Conditioning tyres and brake system

The tyres and at the same time the brakes are submitted to a two-step conditioning procedure on the test track directly before the braking distance measurements:

1) 5 (five) ABS controlled brakings from about 100 km/h to a stop without excessively heating the brake, i.e. the brake disc temperatures must not exceed 120 °C at the beginning of each braking; and

2) cooling down the tyres (normal ride for about 10 km recommended).

8.2 Measurements

8.2.1 Brake disc temperature

Before each measurement, the temperature of the front brake discs shall be between 80 °C and 120 °C and that of the rear brake discs (brake drums) below 120 °C (100 °C). If required, cooling phases shall be provided.

8.2.2 Initial driving condition

The initial driving condition is a steady-state straight ahead run (see 6.2.2 of ISO 15037-1). The longitudinal acceleration shall not exceed ± 0,3 m/s^2.

The specified vehicle velocity at the beginning of the braking is 100 km/h with a maximum tolerance of ± 2 km/h. To minimize dynamic effects, the vehicle should be driven at a steady velocity for at least 1,5 s (about 50 m) before braking is initiated (see also C.2.7).

Depending on the vehicle transmission type, one of the following driving conditions shall be selected:

— automatic transmission: standard drive mode D;

— manual transmission: starting; usually with the fourth or a higher gear engaged, disengaging in the course of the braking, i.e. it should be disengaged at the latest at a velocity of about 80 km/h.

The gear chosen (for automatic transmissions, selected driving range) shall be documented in the test record.

Alternatively, neutral gear may be selected before commencing the brake application. Comparisons of braking distances are only possible if the condition of engagement is the same (gearbox: disengaged/declutched, respectively in neutral mode “N”; or gearbox: engaged, respectively drive mode “D”).

On vehicles equipped with a vacuum brake booster, the brake force depends on the vacuum level of the vacuum brake booster. Therefore, a sufficient vacuum shall be ensured at the beginning of braking. To achieve a sufficient vacuum level, it is recommended to move the vehicle in a drag operation for a short time during the cooling phases between the individual brakings. When doing so, the driving pedal can be released for at least 10 s at high engine speed (e.g. by engaging a suitable gear). Afterwards, the brake shall not be operated before the next measurement because this will reduce the vacuum level that was established before.

8.2.3 Brake pedal actuation

8.2.3.1 Determination of the minimum brake pedal force

The brake pedal shall be applied very fast and with sufficient pedal force. The brake pedal force must be high enough to guarantee ABS-control throughout the whole braking phase of the test run. Therefore, a minimum force of 500 N shall be applied. This force shall be at least 1,5 times F_ABS or higher. F_ABS shall be determined for the test vehicle as described in Annex D.

8.2.3.2 Brake pedal application

The measurement shall start at the instant of first foot contact with the brake pedal. This instant is defined by either a signal of a contact switch or determined from the pedal force signal. The signal representing the initial pedal contact shall be triggered at a pedal force of 10 N or lower.