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**Heavy commercial vehicles and  
buses — Stopping distance in straight-  
line braking with ABS — Open loop  
and closed loop test methods**

*Véhicules utilitaires lourds — Distance d'arrêt de freinage en ligne  
droite avec ABS — Méthodes d'essai en boucle ouverte et boucle  
fermée*

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see [www.iso.org/directives](http://www.iso.org/directives)).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see [www.iso.org/patents](http://www.iso.org/patents)).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 22, *Road vehicles*, Subcommittee SC 9, *Vehicle dynamics and road-holding ability*.

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## Introduction

The main purpose of this International Standard is to provide repeatable and discriminatory test results.

The stopping distance and the dynamic behaviour of a road vehicle is a most important aspect of active vehicle safety. Any given vehicle, together with its driver and the prevailing environment, constitutes a closed-loop system which is unique. The task of evaluating the dynamic behaviour is therefore very difficult, since the significant interaction of these driver-vehicle-road elements are each complex in themselves. A complete and accurate description of the behaviour of the road vehicle shall inevitably involve information obtained from a number of different tests.

Since this test method quantifies only one small part of the complete handling characteristics, the results of this test can only be considered significant for a correspondingly small part of the overall dynamic behaviour.

Moreover, insufficient knowledge is available to correlate overall vehicle dynamic properties with accident prevention. A substantial amount of work is necessary to acquire sufficient and reliable data on the correlation between accident prevention and vehicle dynamic properties in general and the results of this test in particular. Consequently, any application of this test method for regulation purposes will require proven correlation between test results and accident statistics.

Test conditions and tyres have a strong influence on test results. Therefore, only results obtained under comparable test and tyre conditions are comparable.

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# Heavy commercial vehicles and buses — Stopping distance in straight-line braking with ABS — Open loop and closed loop test methods

## 1 Scope

This International Standard describes test methods for determining the stopping distance during a straight-line braking manoeuvre with the braking system fully operational. It applies to heavy vehicles equipped with an anti-lock braking system (ABS), including commercial vehicles, commercial vehicle combinations, buses and articulated buses as defined in ISO 3833 (trucks and trailers with maximum weight above 3,5 tonnes and buses and articulated buses with maximum weight above 5 tonnes, according to ECE and EC vehicle classification, categories M3, N2, N3, O3, and O4).

## 2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. 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 8349, *Road vehicles — Measurement of road surface friction*

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

ISO 15037-2:2002, *Road vehicles — Vehicle dynamics test methods — Part 2: General conditions for heavy commercial vehicles and buses*

## 3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 8855, ISO 15037-2:2002 and the following apply.

### 3.1

#### **actuation time**

time interval from the first pedal contact until the speed of the vehicle is reduced 20 % from its initial value

### 3.2

#### **stopping distance**

distance travelled by the vehicle from the first pedal contact until it comes to a standstill

### 3.3

#### **build-up distance**

distance travelled by the vehicle during the actuation time

### 3.4

#### **braking distance**

distance travelled by the vehicle during the time between two specified velocities

## 4 Principle

This International Standard specifies a method to determine the stopping distance and other braking distances during full braking at certain nominal initial velocities. The driving situation represents an emergency or panic brake application during straight-ahead driving on an even road surface with a uniform coefficient of friction.

The evaluation range is ideally from the actuation of the brakes to standstill of the vehicle. As it might be difficult to measure accurately at low velocities, the evaluation range may be ended at a certain low velocity. From the initial velocity and the velocity at the end of the evaluation range, and the distance between these two velocities, the mean longitudinal deceleration is determined.

$$a_x = \frac{v_0^2 - v_2^2}{2s_x} \quad (1)$$

where

$a_x$  is the calculated deceleration;

$v_0$  is the initial velocity;

$v_2$  is the velocity at the end of the evaluation range;

$s_x$  is the measured distance between  $v_0$  and  $v_2$ .

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The stopping distance from the nominal initial velocity is calculated from

$$s_{ref} = \frac{v_{nom}^2}{2a_x} \quad (2)$$

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where

$s_{ref}$  is the stopping distance for a single test run referenced to the nominal velocity;

$v_{nom}$  is the nominal initial velocity for the test series.

Test results can only be compared if measurements took place under identical conditions, on the same test surface and under very similar ambient conditions. Therefore, comparison of results should only be made for tests done on a given surface within a short time period. 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 specific character of brake-pedal actuation. To minimize this influence, this International Standard specifies rules for brake pedal actuation.

For vehicle combinations, test results depend on the performance of each vehicle unit. Therefore, the performance of first vehicle units can only be compared when the following units are identical in the vehicle combination. When measuring the performance of vehicle combinations, weight transfer between the units has significant influence on the results. Furthermore, electronic braking systems can include settings for the compatibility between the vehicle units, which can also influence the results.

## 5 Variables

### 5.1 Reference system

The reference system specified in ISO 15037-2 shall apply.



## 5.2 Variables to be measured

The variables of motion used to describe the behaviour of the vehicle shall be related to the intermediate axis system ( $X, Y, Z$ ) of the first vehicle unit (see ISO 8855). The variables that shall be determined for compliance with this International Standard are the following:

- longitudinal velocity,  $v_x$ ;
- time of brake pedal actuation ( $t_0$ );
- longitudinal distance ( $s$ );
- brake pedal position ( $s_B$ ) or actuation force ( $F_P$ ).

It is recommended that the following variables also be determined:

- longitudinal acceleration,  $a_x$ ;
- lateral deviation,  $Y_1$ , of the reference point of the first vehicle unit from the axis  $X$  of the initial straight-ahead vehicle velocity,  $v_0$ ;
- steering-wheel angle,  $\delta_H$ ;
- yaw angle,  $\psi$ ;
- brake temperature for each axle.

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## 6 Measuring equipment (standards.iteh.ai)

The measuring equipment, transducer installation, and data processing shall be in accordance with ISO 15037-2:2002.

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Typical operating ranges of the variables to be determined for this International Standard are shown in [Table 1](#) and in ISO 15037-2:2002. It shall be ensured that changes in vehicle pitch angle during braking do not affect the measurement of the velocity and distance variables.

To monitor the running in of tyres and burnishing of brakes, and to monitor test conditions, brake temperature sensors and a device for measuring and displaying vehicle deceleration are required.

**Table 1 — Variables, typical operating ranges and recommended maximum errors of variables not listed in ISO 15037-2**

Variable	Typical operating range	Recommended maximum errors of the combined transducer and recorder system
Longitudinal velocity	0 km/h to 100 km/h	$\pm 0,5$ km/h
Longitudinal distance	0 m to 100 m	$\pm 0,05$ m
Lateral deviation	0 m to 5 m	$\pm 0,05$ m
Brake pedal position, if rotational	$0^\circ$ to $45^\circ$	$\pm 0,5^\circ$
Brake pedal position, if translational	0 mm to 100 mm	$\pm 1$ mm
Brake pedal actuation force	0 N to 1000 N	$\pm 10$ N
Yaw angle	$\pm 20^\circ$	$\pm 1^\circ$

NOTE The accuracy of the measured longitudinal distance depends not only on the resolution of the recorded signals, but also on the on the sampling frequency. For instance, at 90 km/h, a sampling rate of 100 Hz gives 0,25 m travelled distance per sample.

## 7 Test conditions

### 7.1 General

The test conditions described in ISO 15037-2:2002, along with the following additions, shall apply to this International Standard. General data of the test vehicle shall be recorded as specified in [Annex A](#).

### 7.2 Test track

All tests shall be carried out on an even road surface with a uniform coefficient of friction. The gradient of the test surface shall not exceed 0,5 % longitudinal inclination when measured over any distance interval greater than or equal to the vehicle track. The friction coefficient shall not vary more than  $\pm 5$  % over the length of the test surface. The friction coefficient should be measured according to ISO 8349.

### 7.3 Ambient conditions

For performing the tests on dry road surfaces, the ambient temperature and the temperature of the test surface should be between  $+5$  °C and  $+40$  °C, and their variation shall not exceed 10 °C.

Tests performed on other than dry road surfaces and special tests for the comparison of specific components, such as tyres, can require much smaller temperature ranges in order to be comparable. When performing tests on winter surfaces, other ambient parameters such as intensity and duration of sunshine can influence the test results.

### 7.4 Test vehicle

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#### 7.4.1 General vehicle conditions

The reference condition of the test vehicle is in accordance with the vehicle manufacturer's specifications, particularly with respect to the brake system, the suspension, power train configuration (e.g. differentials and locks), and tyres used, and shall be in accordance with ISO 15037-2:2002. Deviations from this reference condition shall be reported in the test results.

If the vehicle is equipped with additional drive train braking devices (e.g. retarder) or functions other than ABS that influence braking performance (e.g. cross-axle braking difference compensation), the actual condition shall be reported.

#### 7.4.2 Tyres

For the tyres of the test vehicle, the conditions specified in ISO 15037-2:2002 shall apply, with the following additions:

- During run-in, longitudinal and lateral accelerations should not exceed 2 m/s<sup>2</sup>. After run-in, the tyres shall be used at the same position during the tests.
- If test results are to be compared, other than in the case of comparing tyres, the tyres at each axle shall be identical in terms of make, model, size, and thread pattern. It is also recommended that the tyres at each axle come from the same manufacturing batch.

NOTE Repeated severe braking results in a so-called brake-in effect of tyres which shortens the braking distance in subsequent tests and which does not represent a real-life condition. It is therefore important to use new tyre sets and to conduct only the run-in procedure described in ISO 15037-2:2002 to condition them.

#### 7.4.3 Brake system

The brake system shall be in a well-maintained condition. The following conditions have a negative impact on braking performance and shall be avoided so as to achieve valid and comparable test results:

- overstressed brake pads or linings (e.g. due to fading tests);

- glazed, heavily, unevenly, or tapered worn brake pads or linings;
- heavily worn or cracked brake discs or brake drums;
- corroded brake callipers, brake discs, or brake drums;
- contaminated friction surfaces (e.g. with de-icing salt, oil);
- incorrect brake supply pressure;
- brake system leaks;
- unequally adjusted brakes.

Any newly installed wheel brakes shall be burnished in accordance with vehicle manufacturer specifications. Alternatively, the burnishing procedure specified in [Annex A](#) can be applied. Hydraulic systems shall be fully bled (free of air residuals), in accordance with the manufacturer's instructions. The brakes of the test vehicle shall not be contaminated with foreign material.

It is recommended to determine and report the maximum pneumatic pressure of the air braking system before conducting the tests.

#### 7.4.4 Loading condition

The loading condition of the vehicle shall be in accordance with ISO 15037-2:2002. Results gained with different vehicles or different vehicle configurations can only be compared under the same loading conditions.

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## 8 Test method

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**8.1 General** <https://standards.iteh.ai/catalog/standards/sist/7e2a51b7-0b27-4adc-9dc7-5730e07cdf2e/iso-16552-2014>

### 8.1.1 Test preparation

To ensure constant friction characteristics, all test runs shall be performed on the same test surface. Comparative measurements should always be started at the same spot to avoid different friction coefficients. However, to avoid long-term road contamination or damage, the initial braking point should vary along the test surface when carrying out entirely different measuring sequences. For conducting the test on a test track with ice or snow surface, different braking lanes should be chosen to avoid polishing of the test track surface.

It shall be ensured that neither tread wear nor frequent braking cause a significant change of the friction coefficient of the test surface.

### 8.1.2 Warm-up

A warm-up procedure according to ISO 15037-2:2002 shall be carried out. The temperature of the brake discs/drums at each axle shall not vary more than  $\pm 30$  °C prior to each measurement within a series of tests. The initial brake temperature for each test run shall be reported. Overheating of the brakes shall be avoided. If required, cooling phases shall be provided.

## 8.2 Performance of the braking procedure

### 8.2.1 Initial driving conditions

The initial driving condition for the test shall be driving straight ahead as specified in ISO 15037-2:2002. The standard nominal initial vehicle velocity at the beginning of the braking is 80 km/h. Other initial velocities may be used, especially for tests on low coefficient of friction surfaces.