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Heavy commercial vehicles and buses — Straight-ahead braking on surfaces with split coefficient of friction — Open-loop test method

Véhicules utilitaires lourds — Freinage en ligne droite sur surfaces à adhérence mixte — Méthode d'essai en boucle ouverte

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 16234 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 9, *Vehicle dynamics and road-holding ability*.

Introduction

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 unique closed-loop system. The task of evaluating the dynamic behaviour is therefore very difficult, since significant interactions of these driver-vehicle-road elements are each complex in themselves. A description of the behaviour of the road vehicle must inevitably involve information obtained from a number of tests of different types.

Since this test method quantifies only a 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, sufficient knowledge is not available to correlate overall vehicle dynamic properties with accident prevention. A large 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. Therefore, it is not possible to use this method and test results for regulation purposes.

Heavy commercial vehicles and buses — Straight-ahead braking on surfaces with split coefficient of friction — Open-loop test method

1 Scope

This international Standard describes an open-loop test method for determining vehicle reactions during a straight-line braking manoeuvre on a surface having a split coefficient of friction.

It applies to heavy vehicles, i.e. 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).

The method is limited to vehicles in which at least the first unit is equipped with an anti-lock braking system. It is valid for braking with service-brake systems only or in combination with retarders and/or engine brakes.

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

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

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 vehicles and buses*

3 Terms, definitions and symbols

3.1 Terms and definitions

For the purposes of this International Standard, the terms and definitions in ISO 611, ISO 15037-2:2002 and ISO 8855 apply.

3.2 Symbols

For the purposes of this International Standard, the symbols in ISO 15037-2:2002 and ISO 8855 apply.

4 Principle

The objective of this test method is to determine the effects on the yaw reaction and the longitudinal acceleration of a vehicle produced by a braking manoeuvre on a straight roadway having a low coefficient of friction on one side and a high coefficient of friction on the other side.

Test results are strongly influenced by friction coefficients as well as the difference in friction between the left and right side of the course. A large difference between the left- and right-side friction conditions is desirable. Surface properties other than friction coefficient (e.g. roughness, ice or synthetic materials, etc.) that are not quantified by the friction coefficient alone exert an important influence on the test results. For this reason, it is difficult to establish the surface conditions in a reproducible way. Therefore, comparison of results should only be made for tests done on a given track within a short time period. It may also be useful to include tests of a reference vehicle.

The initial condition for the test is driving in a straight line at constant velocity. The steering wheel is held fixed after the braking manoeuvre is initiated. During the test, the operating functions and vehicle responses are measured and recorded. Characteristic values are determined from the measured signals.

5 Measuring equipment

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

6 Variables

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 individual vehicle units (See ISO 8855 and ISO 15037-2:2002).

The variables that shall be determined for compliance with this International Standard are:

— longitudinal velocity, v_x,

— yaw velocity of each unit of the test vehicle, $\dot{\psi}_{i,i=1,n}$ n=number of units,

— brake pedal position (for vehicles with air brake systems),

— brake pedal force (for vehicles with hydraulic brake systems),

— steering-wheel angle, δ_H,

— yaw articulation angles, Γ_i^J,

— longitudinal acceleration, a_x,

— initial brake temperatures, $T_{B,0}$.

It is also recommended that the following variables be determined:

— supply pressure and brake pressures of interest, p_B,

— rotational velocity of wheels, $\omega_{i,\ i=1,\ldots\ n}$ or equivalent wheel speeds from electronic systems,

— sideslip angle of the first unit, β_1,

— lateral acceleration, a_y.

Typical operating ranges of the variables to be determined for this International Standard are shown in Table 1 and in ISO 15037-2:2002.

Table 1 — Variables, typical operating ranges and recommended maximum errors of variables not listed in ISO 15037-2:2002

Variable	Typical operating range	Recommended maximum errors of the combined transducer and recorder system
Brake pedal position	0 mm to 100 mm	± 1 %
Brake pedal force	0 N to 1 000 N	± 2 %
Brake pressure in air systems	0 kPa to 1 500 kPa	± 15 kPa
Brake pressure in hydraulic systems	0 mPa to 30 MPa	± 0,3 MPa
Rotational velocity of wheels	0 °/s to 6 000 °/s	± 5 °/s
Yaw velocity	± 20 °/s	± 0,2 °/s
Initial brake temperature	50 °C to 200 °C	± 10 °C

7 Test conditions

7.1 General

The test conditions described in ISO 15037-2:2002, along with the following additions and exceptions, shall apply to this International Standard. Any deviations shall be shown in the test report.

NOTE Large yaw angles and/or large articulation angles may develop during the test. Loss of control is a realistic risk in these tests. For safety, sufficient open space should be provided adjacent to the test surface in case of loss of control.

7.2 Test track

The test surface shall have a high coefficient of friction on one side and a low coefficient of friction on the other side. The difference between the coefficients of friction of the high-friction and low-friction surfaces shall be at least 0,4. This difference and the value of the low-friction coefficient shall be determined at least once before and once after the test and shall be recorded in the report.

Either natural ice or an artificial surface may be used for the low-friction surface. If a lubricated, artificial surface is used, the lubricant shall be evenly distributed prior to each test run. The high-friction surface shall be as described in ISO 15037-2:2002 except that it may be wet.

The following shall be taken into account:

1) that substitute materials may have slip characteristics which differ significantly from that of natural ice; and

2) that the friction of natural ice may change rapidly during a test series.

The split-coefficient track shall be long enough to accommodate the entire period of observation (see 8.4). Both the low- and high-friction portions of the path should also be wide enough to allow testing to determine a reference coefficient of friction for the surface.

NOTE There are two methods to determine friction coefficients: The first method is according to ISO 8349 [1]. In the second method, a reference friction coefficient is determined from ABS-braking tests conducted with all wheels of the test vehicle on the surface being measured [2]. A reference coefficient of friction determined in this manner only approximates the actual coefficient of friction and is dependent on the performance of the ABS.

7.3 Test vehicle

7.3.1 Tyres

The tyre conditions shall be in accordance with ISO 15037-2:2002.

7.3.2 Safety equipment

An anti-jack-knife device should be used when executing tests with heavy vehicle combinations. For vehicles with a risk of rollover, outriggers should be used and reported in Annex A.

7.3.3 Loading conditions

Tests may be performed at the minimum, maximum or other loading conditions as specified in ISO 15037-2:2002.

7.3.4 Condition of the brakes

Prior to testing, the brakes of the test vehicle shall be burnished. The method of burnishing the brakes shall be reported in Annex A.

The brakes of the test vehicle shall not be contaminated with foreign material.

NOTE If brake burnishing or testing are conducted on roads that have been treated with salt or other materials for melting ice, dust from the dried material may be present in the brakes and may change their friction properties.

8 Test method

8.1 Condition and temperature of the brakes

The user shall identify an acceptable range for initial brake temperature. Prior to each individual run, the brakes shall be warmed up or allowed to cool as required such that the initial brake temperatures are within this range. The initial temperature of the brakes shall be reported in the General Data (Annex A).

NOTE Typical initial temperatures of disc brakes are from 50 °C to 200 °C and for drum brakes from 50 °C to 150 °C.

8.2 Initial driving conditions

The initial driving conditions for the test shall be driving straight ahead as specified in ISO 15037-2:2002 with the addition that the steering wheel be held fixed within ± 3° during the time interval from t_1 to t_2.

For safety reasons, the first test runs should be conducted with an initial longitudinal velocity of 30 km/h. The initial longitudinal velocity, v_{x0}, of subsequent tests should be increased in increments of 10 km/h up to the maximum velocity of interest.

8.3 Performance of the braking procedure

The test track should be approached in such a way that the border between high- and low-friction surfaces is located in the X-Z plane of symmetry of the vehicle.

After reaching the initial driving conditions, the steering wheel shall be held fixed by the test driver or by a mechanical device, and the accelerator pedal shall be released and the brakes applied as quickly as possible to 100 % of full braking and maintained during the period of evaluation defined in 8.4.4. For air brake systems, full braking corresponds to 100 % of the full stroke of the brake pedal, and for hydraulic brake systems full braking corresponds to 100 % of the brake-pedal force, i.e. no less than 500 N.

The position of the steering wheel during the period of observation shall not vary more than ± 3° from the mean value of the initial state.

For vehicles with manual transmissions, the test run shall be conducted with the driveline disengaged. Additional tests with the driveline engaged may be performed. For vehicles with automatic transmissions or automatic shifted gearboxes, the selected shift-lever position and driving programme shall remain unchanged during the test run and shall be reported. For vehicles with retarders and/or engine brakes, the settings shall be reported.

The test should be repeated several times so that the results can be examined for repeatability and averaged.

8.4 Time references

8.4.1 Period of observation

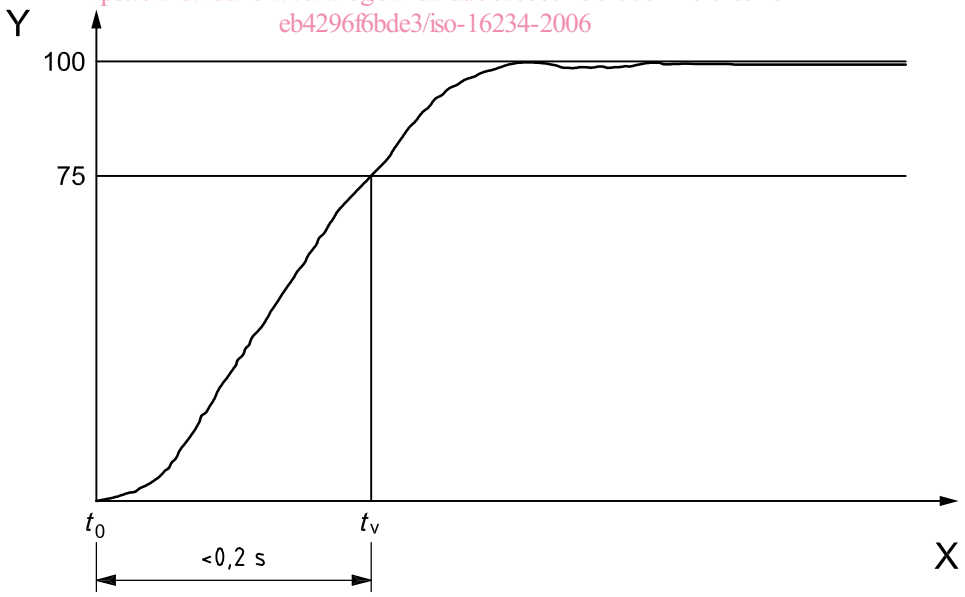
The period of observation is the time interval over which measurements are to be made. The period of observation begins at least 2 s before the beginning of braking (t_0) and ends no earlier than 2 s after the period of evaluation (see 8.4.4).

8.4.2 Time of brake pedal actuation, t_0

The point in time of brake pedal actuation is designated as t_0 (see Figure 1).

8.4.3 Time when brake pedal reaches value of validity, t_v

Figure 1 shows the time history of the brake pedal position and the definition of t_v, the point in time at which the brake pedal position first reaches 75 % of full application (see Figure 1).



Key

X time, t in s

Y brake pedal position/force, % of full application

Figure 1 — Definition of t_0 and t_v