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Road vehicles — Test method to evaluate the performance of autonomous emergency braking systems —

Part 1:
Car-to-car

Véhicules routiers — Méthode d'essai pour évaluer la performance des systèmes automatiques de freinage d'urgence —

Partie 1: Voiture à voiture

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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

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Foreword

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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).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 22, *Road Vehicles*, Subcommittee SC 33, *Vehicle dynamics and chassis components*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The capacity to avoid or mitigate a collision during described accident like situation is an important part of the performance of an autonomous emergency braking system fitted in a road vehicle. This document is intented to assess performance of an autonomous emergency braking system fitted in a road vehicle under defined test scenario only.

Scenarios or conditions decribed below are not in scope of this document:

— The capacity to avoid or mitigate collision during other situations not described in this test method (more complex scenarios, other weather conditions);

— The capacity to avoid undesired braking.

NOTE Moreover, insufficient knowledge is available concerning the relationship between overall vehicle dynamic properties and accident avoidance. A substantial amount of work is necessary to acquire enough and reliable data on the correlation between accident avoidance and vehicle dynamic properties in general and the results of these tests in particular.

Road vehicles — Test method to evaluate the performance of autonomous emergency braking systems —

Part 1:
Car-to-car

1 Scope

This document specifies a method to evaluate the behaviour of a vehicle equipped with an autonomous emergency braking system (AEBS), or dynamic brake support (DBS) during several accidents scenarios, which occur during a straight line driving when the vehicle under test approaches another vehicle in the same lane, where the longitudinal axis of the two vehicles are almost the same.

The most important part of the vehicle behaviour during these accidents scenarios is the capacity to avoid or mitigate the collision.

A system requiring a driver intervention is not in scope of this document.

NOTE Depending on accidentology, only a part of the scenarios can be used for an evaluation of performance.

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 3833:1977, *Road vehicles — Types — Terms and definitions*

ISO 8855:1994, *Road vehicles — Vehicle dynamics and road holding ability — Vocabulary*

ISO 15037-1:1998, *Road vehicles — Vehicle dynamics test methods — Part 1: General conditions for passenger cars*

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

ISO 22839:2013, *Intelligent transport systems — Forward vehicle collision mitigation systems — Operation, performance, and verification requirements*

ISO 21994:2007, *Passenger cars — Stopping distance at straight-line braking with ABS — Open-loop test method*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 8855, ISO 15037-1 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
Autonomous emergency braking (AEB)
braking applied automatically by the vehicle in response to the detection of a likely collision to reduce the vehicle speed and potentially avoid the collision

3.2
Car-to-Car Rear Stationary (CCRs)
collision in which a vehicle travels forward towards another stationary vehicle and the frontal structure of the vehicle strikes the rear structure of stationary vehicle

3.3
Car-to-Car Rear Moving (CCRm)
collision in which a vehicle travels forward towards another vehicle that is travelling at constant speed and the frontal structure of the vehicle strikes the rear structure of stationary of the leading vehicle

3.4
Car-to-Car Rear Braking (CCRb)
collision in which a vehicle travels forward towards another vehicle that is travelling at constant speed, and then decelerates and the frontal structure of the vehicle strikes the rear structure of the leading vehicle

3.5
Dynamic Brake Support (DBS)
system that further amplifies the driver braking demand in response to the detection of a likely collision to achieve a greater deceleration than would otherwise be achieved for the braking demand in normal driving conditions

3.6
Equivalent Vehicle Target (EVT)
vehicle target as defined by ISO 19206-1

3.7
Forward Collision Warning (FCW)
audiovisual warning that is provided automatically by the vehicle in response to the detection of a likely collision to alert the driver

3.8
Peak Braking Coefficient (PBC)
measure of tyre to road surface friction based on the maximum deceleration of a rolling tyre

Note 1 to entry: Measured using the American Society for Testing and Materials (ASTM) E1136-10 (2010) standard reference test tyre, in accordance with ASTM Method E 1337-90 (reapproved 1996), at a speed of 64,4 km/h, without water delivery

3.9
Time To Collision (TTC)
means the remaining time before the VUT strikes the EVT, assuming that the VUT and EVT travel at constant speed

3.10
T_{AEB}
means the time when the AEB system activates. Activation time is determined by identifying the last data point where the filtered acceleration signal is below -1 m/s^2, and then going back to the point in time where the acceleration first crossed -0,3 m/s^2

3.11
T_{FCW}
means the time when the audible warning of the FCW starts. The starting point is determined by audible analysis or video analysis

3.12
V_{impact}
vehicle velocity at which the VUT hits the EVT

3.13
V_{rel_impact}
relative speed at which the VUT hits the EVT by subtracting the velocity of the EVT from V_{impact} at the time of collision

3.14
Vehicle under test (VUT)
vehicle tested with with a pre-crash collision mitigation or avoidance system on board

4 Variables

4.1 Coordinate system

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

4.2 Lateral offset

The lateral offset is determined as the lateral distance between the center of the front of the VUT and the centre of the rear of the EVT when measured in parallel to the intended straight-lined path as shown in the Figure 1 below.

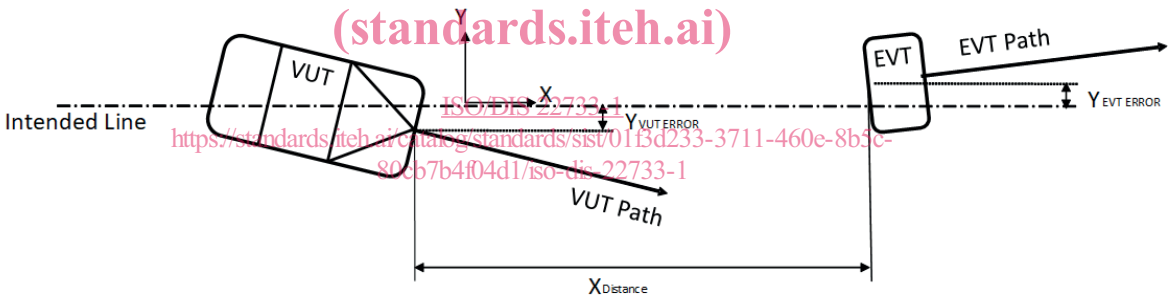

Figure 1 — Coordinate system and notation

Lateral offset = $Y_{VUTerror}+Y_{EVT\ error}$

Reference earth frame is defined as follows

X axis = intended straight line path projected on the ground to front

Y axis = perpendicular to X axis on the ground to left

Z axis = perpendicular to the ground to the top

Origin is an arbitrary point on X axis

Y_{vut} and Y_{target} error are measured in the reference frame.

Y_{target} error is identical to Y_{EVT} error.

4.3 Variables to be measured

Sample and record all dynamic data at a frequency of at least 100 Hz. Data of the EVT and data of the VUT shall be synchronize using the Differential GPS (DGPS) time stamp the EVT.

Variable		Symbol
Time	CCRs and CCRm: T0 equals TTC = 4 s	$^{T}0$
	CCRb: T0 when EVT starts decelerating	
	TAEB, time when AEB activates	TAEB
	TFCW, time when FCW activates	TFCW
	Timpact, time when VUT impacts EVT	Timpact
Position	Position of the VUT during the entire test	X_{VUT}, Y_{VUT}
	Position of the EVT during the entire test	XEVT, YEVT
Speed	Speed of the VUT during the entire test	VVUT
	— Vimpact, speed when VUT impacts EVT	Vimpact
	— Vrel,impact, relative speed when VUT impacts EVT	Vrel,impact
	Speed of the EVT during the entire test	VEVT
Yaw velocity	Yaw velocity of the VUT during the entire test	$\dot{\psi}_{VUT}$
	Yaw velocity of the EVT during the entire test	$\dot{\psi}_{EVT}$
Acceleration	Acceleration of the VUT during the entire test	AVUT
	Acceleration of the EVT during the entire test	AEVT

Example of test report is given in Annex B

5 Equivalent Vehicle Target

The Equivalent Vehicle Target (EVT) shall meet the requirements of ISO 19206-1.

6 Measuring equipment

6.1 Description

VUT and EVT shall be equipped with data measurement and acquisition equipment to sample and record data with an accuracy of at least:

— VUT and EVT speed to 0,1 km/h;

— VUT and EVT lateral and longitudinal position to 0,03 m;

— VUT and EVT yaw rate to 0,1 °/s;

— VUT and EVT longitudinal acceleration to 0,1 m/s^2;

— Steering wheel velocity to 1,0 °/s.

6.2 Transducer installation

The requirements of ISO 15037-1:1998, paragraph 4.2 shall apply. In addition, ensured that transient vehicle pitch changes do not adversely 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 can be adjusted, such calibration shall be performed immediately before the beginning of the tests.

6.4 Data processing

Filter the measured data as follows:

— Position and speed are not filtered and are used in their raw state;

— Acceleration with a 12-pole phaseless Butterworth filter with a cut off frequency of 10 Hz;

— Yaw rate with a 12-pole phaseless Butterworth filter with a cut off frequency of 10 Hz;

— Force with a 12-pole phaseless Butterworth filter with a cut off frequency of 10 Hz.

7 Test conditions

The test conditions shall be in accordance with ISO 15037-1:1998, clause 5, unless otherwise specified below.

7.1 General data

General data on the test vehicle and test conditions shall be recorded as specified in clause 5.4.1 of ISO 15037-1:1998.

7.2 Test track

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

Conduct tests on a dry (no visible moisture on the surface), uniform, solid-paved surface with a consistent slope between level and 1 %. The test surface shall have a minimal peak braking coefficient (PBC) of 0,9.

The surface shall be paved and shall not contain any irregularities (e.g. large dips or cracks, manhole covers or reflective studs) that may give rise to abnormal sensor measurements within a lateral distance of 3.0 m to either side of the theoretical path line and with a longitudinal distance of 30 m beyond the position of VUT/EVT at the end of the test.

Lane markings are allowed. However, testing may only be conducted in an area where typical road markings depicting a driving lane may not be parallel to the test path within 3.0 m either side. Lines or markings may cross the test path but may not be present in the area where AEB activation and/or braking after FCW is expected.

7.3 Weather conditions

Conduct tests in dry conditions with ambient temperature above 5°C and below 30°C.

The surface temperature of the test track shall be between +10°C and +40°C.

No precipitation falling and horizontal visibility at ground level greater than 1 km.

Wind speeds shall be below 5 m/s to minimise EVT and VUT disturbance.

Natural ambient illumination shall be homogenous in the test area and in excess of 2 000 lux for daylight testing with no strong shadows cast across the test area other than those caused by the VUT or EVT. Ensure testing is not performed driving towards, or away from the sun when there is direct sunlight.