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

A list of all parts in the ISO 22733 series can be found on the ISO website.

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 potential accident is an important part of the performance of an autonomous emergency braking system. This document is intended to assess performance of an autonomous emergency braking system under defined test scenario only.

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 accident scenarios. Those accidents occur during a straight-line driving when the vehicle under test (VUT) approaches another vehicle in the same lane. Both vehicles are aligned in longitudinal axis to each other.

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

Systems requiring driver intervention are not in the scope of this document.

NOTE Depending on accidentology, only a part of the scenarios can be used for an evaluation of performance. AEB system evaluation based upon this document is limited to longitudinal accident scenarios.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 8855:2011, *Road vehicles — Vehicle dynamics and road-holding ability — Vocabulary*

ISO 15037-1:2019, *Road vehicles — Vehicle dynamics test methods — Part 1: General conditions for passenger cars*

ISO 19206-1, *Road vehicles — Test devices for target vehicles, vulnerable road users and other objects, for assessment of active safety functions — Part 1: Requirements for passenger vehicle rear-end targets*

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 https://www.electropedia.org/

3.1
AEB
autonomous emergency braking
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
CCRs
car-to-car rear stationary
collision in which a vehicle travels forward towards another stationary vehicle and the frontal structure of the vehicle strikes the rear structure of the stationary vehicle

3.3
CCRm
car-to-car rear moving
collision in which a vehicle travels forward towards another vehicle travelling at constant speed and the frontal structure of the vehicle strikes the rear structure of the leading vehicle

3.4
CCRb
car-to-car rear braking
collision in which a vehicle travels forward towards another vehicle travelling at constant speed and then decelerates, and the frontal structure of the vehicle strikes the rear structure of the leading vehicle

3.5
DBS
dynamic brake support
system that further amplifies the driver braking demand in response to the detection of a likely collision to achieve a greater deceleration

3.6
EVT
equivalent vehicle target
vehicle target as defined in ISO 19206-1

3.7
FCW
forward collision warning
audiovisual warning 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 ASTM E1136-10, at a speed of 64,4 km/h, without water delivery.

3.9
TTC
time-to-collision
remaining time before the VUT strikes the *EVT* (3.6), assuming that the VUT and EVT travel at constant speed

3.10
VUT
vehicle under test
vehicle tested with a pre-crash collision mitigation or avoidance system on board

3.11
T_{AEB}
time when the *AEB* (3.1) system activates

Note 1 to entry: 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.

3.12
T_{FCW}
time when the audible warning of the *FCW* (3.7) starts

Note 1 to entry: The starting point is determined by audible analysis or video analysis.

3.13
V_{impact}
vehicle velocity at which the VUT hits the *EVT* (3.6)

3.14
V_{rel_impact}
relative speed at which the VUT hits the *EVT* (3.6) by subtracting the velocity of the EVT from *Vimpact* (3.13) at the time of collision

4 Variables

4.1 Reference system

The reference earth frame according to ISO 8855:2011, 2.8 is defined as:

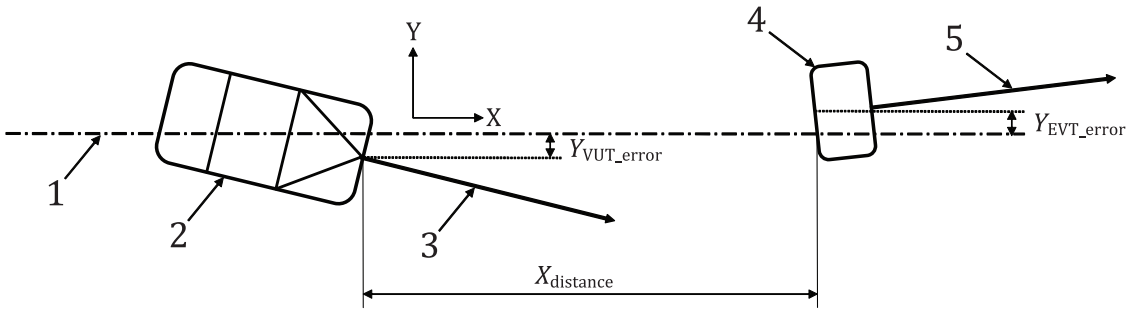
— X axis: intended straight line path projected on the ground to front;

— Y axis: perpendicular to X axis on the ground to left;

— Z axis: perpendicular to the ground to the top.

4.2 Lateral offset

The lateral offset is determined as the lateral distance between the centre 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 Figure 1.



Key

1 intended straight-lined path
2 VUT
3 VUT path
4 EVT
5 EVT path

Figure 1 — Coordinate system and notation

The lateral offset is defined as $Y_{VUT\_error} + Y_{EVT\_error}$.

The origin is an arbitrary point on X axis. The Y_{VUT} and Y_{target_error} are measured in the reference frame and the Y_{target_error} is identical to Y_{EVT_error}.

4.3 Variables to be measured

Table 1 lists all relevant variables to be measured. All dynamic data shall be sampled and recorded at a frequency of at least 100 Hz. EVT and VUT data shall be synchronized by using the differential GPS (DGPS) time stamp of the EVT.

Table 1 — Variables to be measured

Variable		Symbol
Time	CCRs and CCRm: T_0 equals TTC = 4 s	T_0
	CCRb: T_0 when EVT starts decelerating	
	T_{AEB}, time when AEB activates	T_{AEB}
	T_{FCW}, time when FCW activates	T_{FCW}
	T_{impact}, time when VUT impacts EVT	T_{impact}
Position	Position of the VUT during the entire test	X_{VUT}, Y_{VUT}
	Position of the EVT during the entire test	X_{EVT}, Y_{EVT}
Speed	Speed of the VUT during the entire test:	V_{VUT}
	— V_{impact}, speed when VUT impacts EVT	V_{impact}
	— V_{rel_impact}, relative speed when VUT impacts EVT	V_{rel_impact}
	Speed of the EVT during the entire test	V_{EVT}
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	A_{EVT}
	Acceleration of the EVT during the entire test	A_{EVT}

An example of a test report is given in Annex B.

5 Equivalent vehicle target

The equivalent vehicle target (EVT) shall meet the requirements as defined in ISO 19206-1.

6 Measuring equipment and data processing

6.1 General

The test conditions on measurement equipment and data processing shall be in accordance with ISO 15037-1:2019, Clause 6, unless otherwise specified below.

6.2 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.

6.3 Transducer installation

The transient vehicle pitch changes shall not adversely affect the measurement of the velocity and distance variables for the chosen transducer system.

6.4 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.

6.5 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

7.1 General

The test conditions shall be in accordance with ISO 15037-1:2019, Clause 6, unless otherwise specified below.

7.2 General data

General data on the test vehicle and test conditions shall be recorded as specified in ISO 15037-1:2019, 6.4.1.

7.3 Test track

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.

7.4 Weather conditions

Conduct tests in dry conditions with ambient temperature above 0 °C and below 45 °C.

The surface temperature of the test track shall be between +10 °C and +50 °C.