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Passenger cars — Vehicle dynamic simulation and validation — Steady-state circular driving behaviour

Voitures particulières — Simulation et validation dynamique des véhicules — Tenue de route en régime permanent sur trajectoire circulaire

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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. www.iso.org/directives

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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/TC22/SC9 which will be in 2015 TC22/SC33.

Introduction

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

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

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

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 sufficient and reliable data on the correlation between accident avoidance and vehicle dynamic properties in general and the results of these tests in particular. Consequently, any application of this test method for regulation purposes will require proven correlation between test results and accident statistics.

Passenger cars — Vehicle dynamic simulation and validation — Steady-state circular driving behaviour

1 Scope

This International Standard specifies a method for comparing computer simulation results from a vehicle mathematical model to measured test data for an existing vehicle according to steady-state circular driving tests as specified in ISO 4138 or the Slowly Iincreasing Steer test that is an alternative to ISO 4138. The comparison is made for the purpose of validating the simulation tool for this type of test when applied to variants of the tested vehicle.

It is applicable to passenger cars as defined in ISO 3833.

NOTE The Slowly Increasing Steer method is described in regulations such as USA FMVSS 126 “Federal Register Vol 72, No. 66, April 6, 2007” and UN/ECE Regulation No. 13-H, “Uniform provisions concerning the approval of passenger cars with regard to braking.”

2 Normative references

The following referenced documents are indispensable for the application of this document. For these undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 1176, *Road vehicles — Masses — Vocabulary and codes*

ISO 2416, *Passenger cars — Mass distribution*

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

ISO 4138, *Passenger cars — Steady-state circular driving behaviour — Open-loop test methods*

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

ISO 15037-1, *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 1176, ISO 2416, ISO 3833, ISO 8855 and the following apply.

3.1
simulation
calculation of motion variables of a vehicle from equations in a mathematical model of the vehicle system

3.2
simulation tool
simulation environment including software, models, input data, and hardware in case of hardware in the loop simulation

3.3
cross plot
plot where the horizontal axis shows values for a variable other than time (e.g., lateral acceleration)

4 Principle

Open-loop test methods defined in ISO 4138 are used to determine the steady-state circular driving behaviour of passenger cars as defined in ISO 3833.

The test characterizes vehicle-handling behaviour in steady-state conditions covering a range of cornering conditions from straight-line up to limit conditions for steering control. Results are typically reported by cross plotting steady-state measures of variables of interest against steady-state levels of lateral acceleration, and possibly calculating characteristic values based on gradients of the plotted data.

Within this International Standard, the purpose of the test is to demonstrate that a vehicle simulation tool can predict the vehicle behaviour within specified tolerances. The vehicle simulation tool is used to simulate a specific existing vehicle running through a steady-state test as specified in ISO 4138, or, alternatively, a Slowly Increasing Steer test used in stability control evaluation. Simulation results are used to define graphical boundaries for overlaid cross-plots, and the data from physical testing are overlaid to see if the measurements fall within the acceptable ranges.

NOTE This International Standard may be used for several purposes. Depending on the purpose of the validation, only parts of the validation requirements may be met.

The existing vehicle is physically tested at least three times to allow the test data to be compared with the simulation results.

5 Variables

The following variables shall be compared:

- Lateral acceleration
- Steering wheel angle
- Side slip angle
- Roll angle

The steering wheel torque shall also be compared if this International Standard is used to validate a simulation tool for the purpose of predicting steering torque during steady-state circular driving as defined in ISO 4138.

Measurement requirements shall be taken from ISO 4138 and ISO 15037-1 unless noted otherwise.

NOTE For the purpose of this International Standard, lateral acceleration should be measured directly by an inertial measurement unit, rather than using the alternative calculation methods provided in ISO 4138.

6 Simulation Tool Requirements

6.1 General

The simulation tool used to predict behaviour of a vehicle of interest shall include a mathematical model capable of calculating variables of interest for the test procedures being simulated. In this

International Standard, the mathematical model is used to simulate a steady-state cornering manoeuvre (see 7.2) and provide calculated values of the variables of interest from Clause 5.

NOTE 1 Procedure for obtaining input data from experiments may differ for simulation tools, however, the input data should not be manipulated for better correlation.

NOTE 2 Active controllers and active intervention systems that prevent a steady state condition from being established are not relevant for the tests covered in this International Standard.

6.2 Mass and inertia

The mathematical model should include all masses, such as the chassis, engine, payloads, unsprung masses, etc. The value of the mass and the location of the centre of mass are essential properties of the vehicle for the tests covered in this International Standard. On the other hand, moments and products of inertia have no effect under steady-state conditions, when angular accelerations are negligible.

Vehicles with significant torsional frame compliance require a more detailed representation that includes frame-twist effects that occur in extreme manoeuvres.

6.3 Tires

The vertical, lateral, and longitudinal forces and moments where each tire contacts the ground provide the main actions on the vehicle. The fidelity of the prediction of vehicle movement depends on the fidelity of the calculated tire forces and moments.

Large lateral slip angles can occur under the conditions covered in this International Standard. Longitudinal slip ratios are usually limited to the amounts needed to generate longitudinal forces to maintain a target speed in the test. The tire model should cover the entire ranges of slip (lateral and longitudinal), inclination angle relative to the ground, and load that occur in the tests being simulated.

The surface friction coefficient between the tire and ground is an important property for the limit friction conditions that can be encountered in steady-state circular driving tests.

The simulated tests take place on a flat homogenous surface; detailed tire models that handle uneven surfaces are not needed.

The simulated tests involve conditions that are intended to be steady state; therefore, transient effects in tire response (e.g., relaxation length) are not needed.

6.4 Suspensions

The properties of the suspensions that determine how the tire is geometrically located, oriented, and loaded against the ground shall be represented properly in the model in order for the tire model to generate the correct tire forces and moments. The suspension properties also determine how active and reactive forces and moments from the tires are transferred to the sprung mass.

The suspension properties should include change of location and orientation of the wheel due to suspension deflection and applied load as would be measured in a physical system in kinematics and compliance (K&C) tests.

