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Passenger cars — Steady-state circular driving behaviour — Open-loop test methods

Voitures particulières — Tenue de route en régime permanent sur trajectoire circulaire — Méthodes d'essai en boucle ouverte

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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*.

This fifth edition cancels and replaces the fourth edition (ISO 4138:2012), which has been technically revised.

The main changes compared to the previous edition are as follows:

— editorial changes,

— a third variation of the constant speed test method was added. This variation involves slowly increasing the steering-wheel angle.

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 main purpose of this document 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 interactions of these driver–vehicle–environment elements are each complex in themselves. A complete and accurate description of the behaviour of the road vehicle involves 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 need proven correlation between test results and accident statistics.

Passenger cars — Steady-state circular driving behaviour — Open-loop test methods

1 Scope

This document specifies open-loop test methods for determining the steady-state circular driving behaviour of passenger cars as defined in ISO 3833 and of light trucks, such behaviour being one of the factors comprising vehicle dynamics and road-holding properties. The open-loop manoeuvres included in these methods are not representative of real driving conditions, but are nevertheless useful for obtaining measures of vehicle steady-state behaviour resulting from several specific types of control inputs under closely controlled test conditions.

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, *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*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 8855 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
low-speed path radius
radius of the circular path transcribed by the origin of the vehicle axis system when the vehicle is operated at constant speed with a given fixed steering-wheel angle and with approximately zero lateral acceleration

4 Principle

4.1 Test methods

Three test methods are specified:

— method 1, the constant-radius test method;

— method 2, the constant steering-wheel angle test method;

— method 3, the constant-speed test method.

Methods 1 and 2 are presented with two variations and method 3 with three variations. The methods differ in requirements for testing space, driver skill and instrumentation. Methods 1 and 3 depend upon the path-keeping ability of the driver to minimize instrumentation requirements. Method 2 uses fixed steering-wheel angle and calculates path radius from measures of inertial instruments.

4.2 Equivalence of test methods

The nature of any stable steady-state is independent of the method by which it is achieved. Therefore, to obtain a desired set of steady-state equilibrium conditions of speed, steering-wheel angle and turning radius, it is possible to hold any one of them constant, vary the second and measure the third. Thus, either a **constant-radius** test method (in which speed is varied and steering-wheel angle is measured), a **constant steering-wheel angle** test method (in which speed is varied and radius is calculated from variables of vehicle motion) or a **constant-speed** test method (in which radius is varied and steering-wheel angle is either measured or varied and the radius calculated from variables of vehicle motion) may be used. The conditions that are to be held constant, varied and measured or calculated are summarized in Table 1.

Table 1 — Test conditions

Test method	Constant	Variable	Measured or calculated	Variation
1	Radius	Speed	Steering wheel angle	With discrete test speeds
				With continuous speed increase
2	Steering-wheel angle	Speed	Radius	With discrete test speeds
				With continuous speed increase
3	Speed	Radius	Steering-wheel angle	With discrete turn radii
		Steering wheel angle	Radius	With discrete steering-wheel angles
				With slowly increasing steering-wheel angle

All three test methods will produce equivalent steady-state results, provided they span the same combination of speed–steer–radius steady-state conditions. Moreover, in principle, an equivalent to any of the methods can be obtained by cross plotting a series of results from one to produce the results from another.

EXAMPLE Taking points at constant speed from a series of constant-radius tests run on different turn radii.

In practice, however, results obtained from tests conducted with different combinations of speed, steer and radius may differ due to differences in road-load throttle, aerodynamics, tyre slip and inclination angles at different steering angles, etc. Also, the steering system is nonlinear in many vehicles and does not have a fixed overall steering ratio. Gradients obtained using one method at a given steady-state equilibrium condition can differ from those obtained using another and, whereas in one method lateral acceleration is controlled by changing speed, in another it is controlled by changing the steering-wheel angle. Practical considerations such as available size of the test area, tyre heating during long test runs and failure to maintain true steady-state also tend to affect test results.

5 Variables

5.1 Reference system

The provisions given in ISO 15037-1 apply.

5.2 Measurement

Measure the following variables:

a) longitudinal velocity, v_X.

b) lateral acceleration, a_Y;

c) steering-wheel angle, δ_H.

Alternatively, lateral acceleration may be determined from other motion variables (see 9.2).

NOTE The method chosen to determine lateral acceleration can require the measurement of additional variables (yaw velocity, vehicle roll angle or sideslip angle) for use in the computation.

The following variables should also be measured:

— yaw velocity, $d\psi/dt$;

— sideslip angle, β and/or lateral velocity, v_Y;

— longitudinal acceleration, a_X;

— vehicle roll angle, φ_V;

— steering-wheel torque, M_H.

The front steer angle, δ_F, and rear steer angle, δ_R, may also be measured.

6 Measuring equipment

6.1 Description

The variables selected for test purposes shall be measured using appropriate transducers and the data recorded on a multi-channel recording system having a time base. Typical operating ranges and recommended maximum errors of the transducer and recording system are given in ISO 15037-1 and Table 2.

6.2 Transducer installation

The transducer installation shall be in accordance with ISO 15037-1:2019, 5.2.

6.3 Data processing

The provisions given in ISO 15037-1:2019, 5.3, apply.

Table 2 — Variables, their typical operating ranges and recommended maximum errors

Variable	Typical operating range	Recommended maximum error of the combined transducer/recorder system
Front-steer angle	±20°	±0,2°
Rear-steer angle	±10°	±0,1°
NOTE Increased measurement accuracy can be desirable for computation of some of the characteristic values given in 10.3.		

7 Test conditions

Test conditions shall be in accordance with ISO 15037-1:2019, Clause 6. General data on the test vehicle shall be recorded as specified in ISO 15037-1:2019, 6.4.1. In addition, the tyre type, tyre brand, any special equipment on the test vehicle, any deviation in type or operating condition of components from the manufacturer's specification, the odometer reading at the beginning and end of the test, and any other condition that could affect test results shall be recorded on the test report for general data (see ISO 15037-1:2019, Annex A).

8 Test procedure

8.1 Warm-up

The warm-up shall be carried out in accordance with ISO 15037-1:2019, 7.1.

8.2 Initial driving condition

The conditions shall be in accordance with ISO 15037-1:2019, 7.2.1 and 7.2.3, and with 8.3 to 8.6 as follows, according to which method and variation is used.

8.3 General test description

All necessary variables shall be recorded throughout the manoeuvre. Data shall be taken for both left and right turns. A minimum of three repetitions is recommended.

For tests utilizing discrete increments of speed, radius or steering-wheel angle, all of the test data may be taken in one turning direction followed by all the data in the other turning direction, as experience has shown that this minimizes data scatter. However, to obtain more even tyre wear and reduced tyre heating, data may be taken in alternating turning directions at each test speed/radius/steering-wheel angle.

The method chosen shall be noted on the test report, in the section on test-method-specific data for test conditions (see ISO 15037-1:2019, Annex B). At a minimum, data shall be taken at increments of lateral acceleration no larger than 0,5 m/s^2. Annex C provides general information for the test methods.

NOTE Where data vary rapidly with changes in lateral acceleration, it can be useful to decrease the speed/radius/steering-wheel angle increments.

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

Caution should be exercised during testing so that tyre heating is minimized as much as possible. Tyre heating is a particular concern for test methods using continuous speed increase, with attendant long periods of data acquisition, and for all test methods at high levels of lateral acceleration. The tyres should be cooled to normal operating temperatures between test runs.

8.4 Method 1 — Constant radius

8.4.1 Description

This test method requires driving the test vehicle at several speeds over a circular path of known radius. The standard radius of the path shall be 100 m, but larger and smaller radii may be used, with 40 m as the recommended lower value and 30 m as the minimum.

The directional-control response characteristics are determined from data obtained while driving the vehicle at successively higher speeds on the constant-radius path. This procedure can be conducted in a relatively small area. The procedure can be adapted to existing test track facilities by selecting a circle or path of appropriate radius. A constant-radius (in plane) road will often suffice for a test facility.

The constant-radius test exists in two variations. In the first, the vehicle is driven on the circular path at discrete constant speeds. Data are taken when steady-state is attained. The test can be run on any level constant-radius path of sufficient length to attain and hold on-radius steady-state for at least a 3 s measurement period. In the second, the vehicle remains on the circle with a continuous, slow speed increase, during which data are taken.

