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Road vehicles — Test method for the quantification of on-centre handling —

Part 2: Transition test

Véhicules routiers — Méthode d'essai pour la quantification du centrage —

Partie 2: Essai de la transition

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Foreword

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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 13674-2 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 9, *Vehicle dynamics and road holding ability*.

ISO 13674 consists of the following parts, under the general title *Road vehicles — Test method for the quantification of on-centre handling*:

— *Part 1: Weave test*

— *Part 2: Transition test*

Introduction

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

Because they quantify only a small part of the whole handling field, the results of these tests can be considered significant only for a correspondingly small part of the overall dynamic behaviour.

Moreover, insufficient knowledge is available concerning the relationship between accident avoidance and the dynamic characteristics evaluated by these tests. A substantial amount of effort 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.

Therefore, it is not presently possible to use these methods and test results for regulation purposes. The best that can be expected is that these on-centre handling tests are used as some among many other tests, which together describe an important part of the field of vehicle dynamic behaviour.

Finally, the role of the tyres is important and test results can be strongly influenced by the type and condition of tyres.

Road vehicles — Test method for the quantification of on-centre handling —

Part 2: **Transition test**

1 Scope

This part of ISO 13674 specifies a test schedule that addresses a particular aspect of the transition test, the on-centre handling characteristics of a vehicle. It is applicable to passenger cars in accordance with ISO 3833, and to light trucks.

NOTE The manoeuvre specified in this test method is not representative of real driving conditions, but is useful for obtaining measures of vehicle on-centre handling behaviour in response to a specific type of steering input under closely controlled test conditions. Other aspects of on-centre handling are addressed in the companion ISO 13674-1 and ISO/TS 20119.

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

ISO 2416, *Passenger cars — Mass distribution*

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

ISO 8855, *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*

3 Terms, definitions and symbols

For the purposes of this document, the terms, definitions and symbols of ISO 1176, ISO 2416, ISO 3833, ISO 8855 and the following apply.

3.1
on-centre handling
description of the steering “feel” and precision of a vehicle during nominally straight-line driving and in negotiating large radius bends at high speeds but low lateral accelerations

3.2
ordinate threshold
value of a parameter plotted as the ordinate on a graph and defined as the minimum threshold of human perception

3.3
abscissa deadband
horizontal separation between the pair of straight-line fits at ordinate threshold values

3.4
gradient
ratio of change in the ordinate with respect to a unit change in the abscissa, for a straight-line fit to a pair of recorded variables plotted one against the other on Cartesian coordinates

4 Principle

On-centre handling represents that part of the straight-line directional stability characteristics of the vehicle existing at lateral acceleration levels, typically no greater than 1 m/s^2. On-centre handling is concerned primarily with features that directly influence the driver's steering input, such as steering system and tyre characteristics. Thus, test schedules for the evaluation of on-centre handling behaviour seek to minimize other factors that influence the wider aspects of straight line directional stability, such as disturbance inputs due to ambient winds and road irregularities.

This part of ISO 13674 defines test schedules that involve driving the vehicle in a nominally straight line at a constant forward speed. During the tests, driver inputs and vehicle responses are measured and recorded. From the recorded signals, characteristic values are calculated.

5 Variables

5.1 Reference system

The variables of motion used to describe vehicle behaviour in a test-specific driving situation relate to the intermediate axis system (X, Y, Z) (see ISO 8855).

The location of the origin of the vehicle axis system (X_V, Y_V, Z_V) is the reference point and therefore should be independent of the loading condition. The origin is therefore fixed in the longitudinal plane of symmetry at half-wheelbase and at the same height above ground as the centre of gravity of the vehicle at complete vehicle kerb mass (see ISO 1176).

5.2 Variables to be measured

When using this test method, the following variables shall be measured:

— steering-wheel angle, δ_H;

— steering-wheel torque, M_H;

— yaw velocity, $d\psi/d_t$;

— longitudinal velocity, v_x;

— lateral acceleration, a_y (see the NOTE to Clause 6.2).

The following variables should be measured:

— steering-wheel angular velocity, $d\delta_H/d_t$.

The variables are defined in ISO 8855.

6 Measuring equipment

6.1 Description

All variables shall be measured by means of appropriate transducers and their time histories shall be recorded by a multi-channel recording system. Typical operating ranges and recommended maximum errors of the combined transducer and recording system are shown in Table 1.

Table 1 — Variables, typical operating ranges and recommended maximum errors

Variable	Typical operating range[a]	Recommended maximum error of the combined transducer and recorder system[b]
Steering-wheel angle	± 50°	± 0,1°
Steering-wheel torque	± 10 Nm	± 0,1 Nm
Yaw velocity	± 10 °/s	± 0,1 °/s
Longitudinal velocity	0 - 50 m/s	± 0,5 m/s
Lateral acceleration	± 5 m/s^2	± 0,1 m/s^2
Steering-wheel angular velocity	± 100 °/s	± 1 °/s
Transducers for measuring some of the listed variables are not widely available and are not in general use. Many such instruments are developed by users. If any system error exceeds the recommended maximum value, this and the actual maximum error shall be stated in the test report (ISO 15037-1:1998, Annex A).		

[a] These transducer ranges are appropriate for the standard test conditions and may not be suitable for non-standard test conditions.

[b] The values for maximum errors are provisional until more experience and data are available.

6.2 Transducer installations

The transducers shall be installed according to the manufacturers' instructions where such instructions exist, so that the variables corresponding to the terms and definitions of ISO 8855 can be determined.

If a transducer does not measure a variable directly, appropriate transformations into the specified reference system shall be carried out.

NOTE Lateral acceleration, as defined, is measured in the intermediate XY plane. However, for the purpose of this test procedure, measurement of "sideways" acceleration in the vehicle $X_V Y_V$ plane (i.e. corrupted by vehicle roll) is typically adequate, provided that the roll angle versus lateral acceleration characteristic for the vehicle is known and an appropriate correction in respect of roll angle can be made to the "sideways" acceleration.

6.3 Data processing

See ISO 15037-1:1998, 4.3.

7 Test conditions

7.1 General

General comments relating to test conditions are given in ISO 15037-1:1998, Clause 5.

7.2 Test track

The test track requirements shall be in accordance with those of ISO 15037-1:1998, 5.2. In addition, the lateral gradient of the test surface should not exceed 1 %.

7.3 Wind velocity

During a test, the ambient wind velocity shall not exceed 5 m/s when measured at a height above ground of not less than 1 m. Ideally, the maximum ambient wind velocity should not exceed 1,5 m/s. If this cannot be achieved, then conditions of significant “gusting” should be avoided, i.e. testing should be avoided in conditions where changes in wind velocity exceed a range of 1,5 m/s. In the event that the ambient velocity exceeds 1,5 m/s or the range of “gusting” exceeds 1,5 m/s, or both, the vehicle should be tested in a direction such that the ambient wind is a tail wind. For each test, the climatic conditions shall be recorded in the test report (see ISO 15037-1:1998, Annex B).

Where measurement of wind velocity is not possible, estimation by use of the Beaufort scale is suggested (see Table 2).

Table 2 — Estimation scale for wind intensity for observer without measuring instrument (Beaufort scale)

Wind intensity (Beaufort scale)	0	1	2	3	4
Name	calm	light air	light breeze	gentle breeze	moderate breeze
Velocity in m/s	0 - 0,2	0,3 - 1,5	1,6 - 3,3	3,4 - 5,4	5,5 - 7,9
Identification sign	smoke rises vertically in a straight line	wind direction indicated only by smoke	leaves rustle, wind felt in face	leaves and thin twigs move	moves twigs and thin branches, dust rises

7.4 Test vehicle

7.4.1 General Data

Refer to ISO 15037-1:1998, 5.4.1.

7.4.2 Tyres

For general information regarding tyres used for test purposes, see ISO 15037-1:1998, 5.4.2. In addition, the following recommendations are offered for guidance.

Since tyre characteristics can have a profound effect upon the vehicle behaviour being measured in this procedure, it is recommended that only tyres with known characteristics be used if possible. Failing this, original equipment rather than replacement market tyres should be used.

For similar reasons, caution should be exercised if worn tyres are to be used. For example, it is known that some tyre characteristics, which affect vehicle on-centre handling, change significantly during the early wear life (up to several thousand kilometres) of the tyre, but continue to change throughout the life of the tyre. In any event, tyres without a known history should be avoided.

All wheel/tyre assemblies should be balanced before use. Assemblies exhibiting large run-out or imbalance (detectable as vibration at roadwheel rotational frequency) should be avoided.

7.4.3 Operating components

See ISO 15037-1:1998, 5.4.3.

7.4.4 Loading conditions of the vehicle

See ISO 15037-1:1998, 5.4.4.

8 Test procedure

8.1 Warm-up

See ISO 15037-1:1998, 6.1.

8.2 Initial driving condition

The initial driving condition is that described in ISO 15037-1:1998, 6.2 for the steady-state straight-ahead run condition (with the time intervals as defined in Figure 2 of ISO 15037-1:1998). The allowable variations for yaw velocity should be adopted rather than those for lateral acceleration.

An additional requirement is that, for a time interval starting no later than time t_1 and ending at time t_2, the steering-wheel shall be subject to zero steer torque input. The recommended method to achieve this is to drive the vehicle under free steering control (i.e. hands free) during this specified time interval.

At time t_0, the steering input specified in 8.3 shall be applied. The user may find it useful to end the procedure specified in 8.3 by re-establishing the steady state straight ahead condition at the end of the test run.

See ISO 15037-1:1998, 6.2 for guidance on selection of the appropriate transmission gear for performing the test.

NOTE This test procedure is not suitable for any vehicle that, under free steering control, is not able to remain within the limits of yaw velocity variation given in ISO 15037-1:1998, 6.2.2 for the time interval t_1 to t_2. Any such vehicle and its tyres should be examined for causes of excessive lateral deviation.

8.3 Transition test procedure

The transition test is an open-loop procedure and is conducted from an initial straight-line path. The vehicle is driven at a nominally constant longitudinal velocity. The standard test velocity is 100 km/h. Other longitudinal velocities may be used; these should be decremented or incremented by 20 km/h from the standard velocity. Details shall be recorded in the test report (see ISO 15037-1:1998, Annex B, under *Test method specific data*).

The transducer signals shall be recorded throughout the initial driving condition and for the duration of the test; to ensure that the required data are not affected by the instrumentation system, it is recommended to continue recording for a further 1s after the test run.

Whereas the weave test (ISO 13674-1) examines the outer edge of the response hysteresis loop, this test examines the transition from straight line running to the edge of the hysteresis loop.

Continuing from the initial driving condition specified in 8.2, the steering-wheel shall be subjected to a ramp input (that is one that increases in amplitude with a nominally constant angular velocity). To ensure a smooth transition of the vehicle path from the straight-ahead condition onto a curve of diminishing radius, the steering input shall be applied with an angular velocity that increases smoothly from zero up to the nominally constant value. Commencing at time t_0, the steering input shall be applied for a minimum duration of 3 seconds, and at an angular velocity not exceeding 5 degrees/second, until the lateral acceleration achieved by the vehicle reaches a minimum of 1,5 m/s^2. The test shall be performed a sufficient number of times in each turn direction (see 9.2 below), using, nominally, the same steer input profile.

Details of the steering input, angular velocity and duration of application shall be recorded in the test report (see ISO 15037-1:1998, Annex B, under *Test method specific data*).

The longitudinal velocity during the test runs to be used for data analysis shall not vary from the nominal value by more than ± 3 %.

NOTE To quantify the effects of any lateral wind or lateral gradient of the test track, it is recommended that the test be performed in both turn directions for each direction of travel along the test track.

9 Data evaluation and presentation of results

9.1 General

General data shall be presented in the test report as shown in ISO 15037-1:1998, Annex A and Annex B. For every change in vehicle loading or configuration, the general data shall be documented again.

9.2 Time histories

Time histories serve to monitor correct test performance and functioning of the transducers. In particular, the time histories of steering angle amplitude, steering-wheel angular velocity, vehicle longitudinal velocity and vehicle lateral acceleration are examined to identify valid data for evaluation. For each turn direction, a minimum of five consistent test runs, for which the control criteria are best met, shall be selected for data analysis. Time histories of the variables listed in Clause 5 shall be presented for the data selected for analysis.

9.3 Characteristic values

9.3.1 Presentation of results

For all the test runs selected for data analysis, the recorded variables are taken in pairs (as detailed below) and plotted one against the other on Cartesian coordinates. For each pair of variables, this produces a series of overlaid traces of the form shown in Figure 1.

NOTE Since separate sets of data are used for the two turn directions, the data plots are not continuous through the origin as apparently depicted in Figure 1.

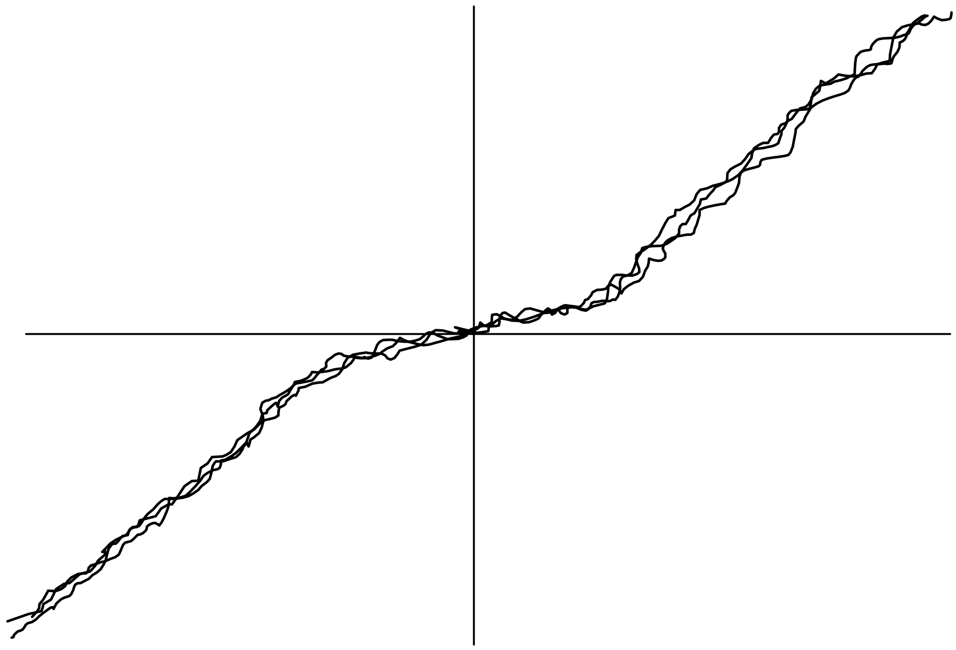
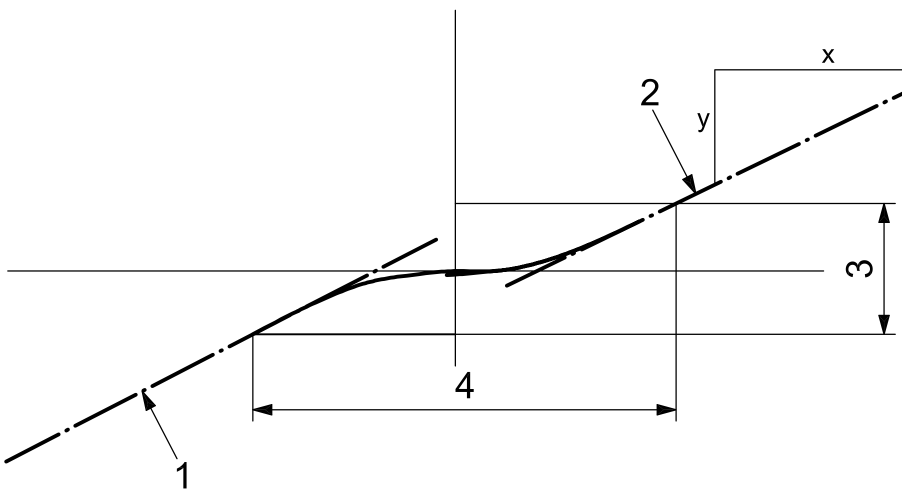


Figure 1 — Cartesian plots of data obtained from several test runs

On each Cartesian plot, a separate best straight-line fit is made to the data for each turn direction (see Figure 2). Each straight-line fit should exclude either data that is severely non-linear, such as that in the on-centre region (typically that obtained in the lateral acceleration range ± 0,5 m/s^2), or data obtained at lateral accelerations in excess of ± 1,2 m/s^2. The data range that is used to make each straight-line fit shall be recorded in the test report (see ISO 15037-1:1998, Annex B).

NOTE The upper bound of ± 1,2 m/s^2 is advisory; if linear characteristics are not apparent at lateral accelerations below this value, then an alternative data range may be chosen following prudent examination of the characteristic shape.



Key

1 straight-line fit to right-turn data

2 straight-line fit to left-turn data

3 ordinate threshold

4 abscissa deadband

Gradient = y/x

Figure 2 — Definition of parameters

From each Cartesian plot and the pair of straight-line fits to the data, the following parameters are evaluated:

- abscissa deadband; and
- gradient.

At the present level of knowledge, it is not yet known which variables best represent the subjective feeling of the driver and which variables, i.e. which characteristic values best describe the dynamic reactions of vehicles. Therefore, the specified variables listed below represent only examples for the evaluation of results.

The following lists the pairs of variables that are plotted (ordinate given first) and the characteristics that may be evaluated.

9.3.2 Steering-wheel torque versus steering-wheel angle (M_H vs. δ_H)

Steering stiffness	–	gradient of straight-line fit to data for each turn direction.

9.3.3 Yaw velocity versus steering-wheel angle ($d\psi/d_t$ vs. δ_H)

Yaw velocity response gain reference steering-wheel angle	–	gradient of straight-line fit to data for each turn direction;
Steering-wheel angle deadband reference yaw velocity	–	abscissa deadband at ordinate threshold of ± 1,1°/s.

9.3.4 Yaw velocity versus steering-wheel torque ($d\psi/d_t$ vs. M_H)

Yaw velocity response gain reference steering-wheel torque	–	gradient of straight-line fit to data for each turn direction;
Steering-wheel torque deadband reference yaw velocity	–	abscissa deadband at ordinate threshold of ± 1,1°/s,

9.3.5 Lateral acceleration versus steering-wheel angle (a_y vs. δ_H)

Lateral acceleration response gain reference steering-wheel angle	–	gradient of straight-line fit to data for each turn direction;
Steering-wheel angle deadband reference lateral acceleration	–	abscissa deadband at ordinate threshold of ± 0,6 m/s^2.

9.3.6 Lateral acceleration versus steering-wheel torque (a_y vs. M_H)

Lateral acceleration response gain reference steering-wheel torque	–	gradient of straight-line fit to data for each turn direction;
Steering-wheel torque deadband reference lateral acceleration	–	abscissa deadband at ordinate threshold of ± 0,6 m/s^2.

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