

Methods of

Test for lateral transient response behaviour of passenger cars

[ISO title: Road vehicles — Lateral transient response test
methods]

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Committees responsible for this British Standard

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- Association of Trailer Manufacturers
- Caravan Club
- Department of Transport
- Metropolitan Police
- Motor Industry Research Association
- National Caravan Council Limited
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National foreword

This British Standard has been prepared under the direction of the Automobile Standards Policy Committee and is identical with ISO 7401:1988 “*Road vehicles — Lateral transient response test methods*” prepared by Technical Committee ISO/TC 22, Road vehicles, and published by the International Organization for Standardization (ISO).

Terminology and conventions. The text of the International Standard has been approved as suitable for publication as a British Standard without deviation. Some terminology and certain conventions are not identical with those used in British Standards; attention is drawn especially to the following.

The comma has been used as a decimal marker. In British Standards it is current practice to use a full point on the baseline as the decimal marker.

Wherever the words “International Standard” appear, referring to this standard, they should be read as “British Standard”.

Cross-reference

International Standard	Corresponding British Standard
ISO 4138:1982	BS AU 189:1983 <i>Method of test for steady state cornering behaviour for road vehicles</i> (Identical)

The Technical Committee has reviewed the provisions of ISO 1176, ISO 2416 and ISO 3833, to which reference is made in the text, and has decided that they are acceptable for use in conjunction with this standard.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 16, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

0 Introduction

0.1 General

The road-holding ability 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 road-holding ability 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 only be considered significant for a correspondingly small part of the overall vehicle handling behaviour.

Moreover, nothing is known about the relationship between the results of these tests and accident avoidance. Considerable work is necessary to acquire sufficient and reliable data on the correlation between handling properties in general, and accident avoidance.

It is therefore not possible to use these procedures and test results for regulation purposes at the moment. The best that can be expected is that the transient response tests are used as some among many other mostly transient tests, which together cover the field of vehicle dynamic behaviour.

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

0.2 Object of tests

The primary object of these tests is to determine the transient response behaviour of a vehicle.

Characteristic values and functions in the time domain and frequency domain are considered necessary to characterize the transient response of vehicles.

Important criteria in the time domain are:

- time lags between steering-wheel angle, lateral acceleration and yaw velocity;
- response times of lateral acceleration and yaw velocity (see 6.1.1);
- lateral acceleration gain (lateral acceleration divided by steering-wheel angle);
- yaw velocity gain (yaw velocity divided by steering-wheel angle);

- overshoot values (see 6.1.3);
- vehicle TB factor (see 7.1.1.2).

The criteria listed above show some correlation with subjective evaluation during road driving.

Important criteria in the frequency domain are the frequency responses of

- lateral acceleration related to steering-wheel angle;
- yaw velocity related to steering-wheel angle;
- phase between input and output functions.

There are several test methods to obtain these criteria, the applicability of which depends in part on the size of the test track available, in the domains of time and frequency:

- a) Time domain:
 - step input;
 - sinusoidal input (one period).
- b) Frequency domain:
 - step input;
 - random input;
 - pulse input;
 - continuous sinusoidal input.

These test methods are optional. At least one of each domain type shall be performed. The methods chosen shall be indicated in the general data presentation (see Annex A) and in the presentation of test results (see Annex B).

It is necessary to measure

- steering-wheel angle;
- lateral acceleration;
- yaw velocity;
- steady-state sideslip angle;¹⁾
- longitudinal velocity.

It is desirable to measure

- lateral velocity or transient sideslip angle;²⁾
- vehicle roll angle;
- steering-wheel torque.

The variables listed are not intended to comprise a complete list.

NOTE Strictly speaking, test results based on lateral acceleration should not be used for comparison of the performance of different vehicles. This is because lateral acceleration, as precisely defined, is measured at right angles to the vehicle x -axis³⁾ and not at right angles to the tangent of the vehicle path.

¹⁾ Steady-state sideslip angle is only necessary in the step input test.

²⁾ Alternatively this may be determined from other variables.

³⁾ As referred to an axis system defined as follows:

axis system: Right-hand orthogonal axis system fixed in the vehicle such that its origin is at the centre of gravity of the vehicle. The x' -axis is longitudinal forward, the y' -axis is lateral and the z' -axis is vertical upwards.

To overcome this difficulty, lateral acceleration may be corrected for vehicle sideslip angle, which gives the quantity “centripetal acceleration”. However, the extent of this correction is not likely to exceed a few percent and can generally be neglected.

1 Scope and field of application

This International Standard specifies test methods to determine transient response behaviour: it applies to passenger cars as defined in ISO 3833. The measurement of steady-state properties is defined in ISO 4138.

The open-loop manoeuvres specified in these test methods are not representative of real driving conditions but are useful to obtain measures of vehicle transient behaviour in response to several specific types of steering input under closely controlled test conditions.

NOTE It is important to remember that the method of data analysis in the frequency domain is based on the assumption that the vehicle has a linear response. Over the whole range of lateral acceleration this may not be the case; the standard method of dealing with such a situation is to restrict the range of the input so that linear behaviour can be assumed, and if necessary to perform more than one test at different ranges of inputs which together cover the total input range that is of interest.

2 References

- ISO 1176, *Road vehicles — Weights — Vocabulary*.
- ISO 2416, *Passenger cars — Load distribution*.
- ISO 3833, *Road vehicles — Types — Terms and definitions*.
- ISO 4138, *Road vehicles — Steady state circular test procedure*.
- ISO/TR 8725, *Road vehicles — Transient open-loop response test procedure with one period of sinusoidal input*.
- ISO/TR 8726, *Road vehicles — Lateral transient response test procedure — Explanatory report on the random steering input method⁴⁾*.

3 Instrumentation

3.1 Description

Those of the variables listed in 0.2 which are selected for test purposes shall be monitored, using appropriate transducers, and the data shall be recorded on a multi-channel recorder with a time base. The normal operating ranges and recommended maximum errors of the transducer/recording system are as shown in Table 1.

NOTE Some of the transducers listed are neither widely available nor in general use. Many such instruments are developed by users. If any system error exceeds the maximum values recommended, this fact and the actual maximum error shall be stated in the general data (see Annex A).

The values in Table 1 are tentative and provisional until more experience is available. To cover all the tests outlined in this International Standard, the minimum overall bandwidth of the entire measurement system including transducers and recorder shall be 8 Hz. If digitization is performed, it shall be at a rate sufficient for the required analysis.

3.2 Installation

Transducer installation and orientation will vary according to the type of instrumentation used. However, if a transducer does not measure the required variable directly, appropriate corrections for linear and angular displacement shall be made to its signals so as to obtain the required level of accuracy.

3.2.1 Steering-wheel angle

A transducer shall be installed as specified by the manufacturer so as to obtain the steering-wheel angle relative to the sprung mass.

3.2.2 Lateral acceleration

A transducer shall be installed as specified by the manufacturer and mounted either

- a) on the sprung mass at the whole vehicle centre of gravity and aligned with the vehicle *y*-axis. In this case, it will measure “side acceleration” and its output shall be corrected for the component of gravity on the transducer axis due to both the vehicle roll angle and any track surface inclination; or
- b) on the sprung mass at any position and aligned parallel to the vehicle *y*-axis. In this case, its output shall be corrected for its position relative to the centre of gravity, which will give “side acceleration”, which in turn shall be corrected for the component of gravity on the transducer axis due to both vehicle roll angle and any track surface inclination.

3.2.3 Yaw velocity

A transducer shall be installed as specified by the manufacturer with its axis aligned with or parallel to the vehicle *z*-axis.

3.2.4 Sideslip angle

A transducer shall be installed as specified by the manufacturer so as to determine sideslip angle at the centre of gravity. If it does not measure directly at the centre of gravity, an appropriate correction shall be made. Its output shall also be corrected for roll motion influences.

Sideslip angle can be calculated from coincident measurements of other variables, for example, yaw, lateral and longitudinal velocity at any point on the vehicle.

⁴⁾ At present at the stage of draft.

Table 1 — Variables

Variable	Range	Recommended maximum error of the combined transducer/recorder system
Steering-wheel angle	$\pm 360^\circ$ ^a	$\pm 2^\circ$ for angles $\leq 180^\circ$ $\pm 4^\circ$ for angles $> 180^\circ$
Lateral acceleration	$\pm 15 \text{ m/s}^2$	$\pm 0,15 \text{ m/s}^2$
Yaw velocity	$\pm 50^\circ/\text{s}$	$\pm 0,5^\circ/\text{s}$
Sideslip angle	$\pm 15^\circ$	$\pm 0,5^\circ$
Forward velocity	0 to 50 m/s	$\pm 0,5 \text{ m/s}$
Lateral velocity	$\pm 10 \text{ m/s}$	$\pm 0,1 \text{ m/s}$
Vehicle roll angle	$\pm 15^\circ$	$\pm 0,15^\circ$
Steering-wheel torque	$\pm 30 \text{ N m}$	$\pm 0,3 \text{ N m}$

^a Assuming a conventional steering system.

The vehicle point to which the output of the transducer⁵⁾ is referred shall be indicated in the general data presentation (see Annex A).

3.2.5 Forward velocity

A velocity transducer shall be installed as specified by the manufacturer. If it is not aligned so as to operate in the x - z plane, and parallel to the test track surface, its output shall be corrected for any linear or angular displacement from this.

3.2.6 Lateral velocity

A velocity transducer shall be installed as specified by the manufacturer. If it is not aligned so as to operate in the y - z plane, and parallel to the test track surface, its output shall be corrected for any linear or angular displacement from this, especially for roll motion influences.

The vehicle point to which the output of the transducer⁵⁾ is referred shall be indicated in the general data presentation (see Annex A).

3.2.7 Vehicle roll angle

A transducer shall be installed as specified by the manufacturer so as to measure the angle between the vehicle y -axis and the track surface.

3.2.8 Steering-wheel torque

A transducer shall be installed, as specified by the manufacturer, so as to measure the torque applied to the steering-wheel about its axis of rotation.

3.2.9 Steering machine

If a steering machine is used, it shall be installed as specified by the manufacturer.

3.2.10 Steering-wheel stop

For step input tests (see 5.4), a steering-wheel stop may be used.

4 Test conditions

4.1 Test track

All tests shall be carried out on a uniform hard surface which is free of contaminants and has no more than 2 % gradient as measured over a distance between 5 and 25 m in any direction. For standard test conditions, a smooth dry pavement of asphalt or cement concrete or a high-friction test surface is recommended.

For the random input test, the test surface shall be maintained over a track of 8 m minimum width for a length sufficient to permit at least 30 s running at the test speed, in addition to the run-up and stopping requirements.

The ambient wind speed shall not exceed 7 m/s. For test speeds above 30 m/s, a lower maximum wind speed is desirable. If the lateral component exceeds 4 m/s it shall be noted in the general data presentation (see Annex A).

4.2 Tyres

The tests may be performed with tyres in any state of wear so long as a minimum of 1,5 mm of tread depth remains over the whole width and circumference of the tyres at the end of the tests (see note).

However, for standard tyre conditions, new tyres shall be used after being run-in for 150 to 200 km in the appropriate position on the test car without excessive harsh use, for example braking, accelerating, cornering, hitting the kerb, etc.

⁵⁾ It is recommended that the centre of gravity or the point of intersection between a line connecting the rear wheel centres and the vehicle longitudinal median plane is used as a reference point.