INTERNATIONAL STANDARD

ISO 4138

Second edition
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Passenger cars — Steady-state circular driving behaviour — Open-loop test procedure

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

Reference number
ISO 4138:1996(E)

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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.

International Standard ISO 4138 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 9, *Vehicle dynamics and road-holding ability*.

This second edition cancels and replaces the first edition (ISO 4138:1982), which has been technically revised.

Annexes A and B form an integral part of this International Standard.

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Introduction

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

Since the steady-state circular test procedure quantifies only one small part of the complete handling characteristics, the results of this test 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 large 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 this test in particular. Therefore, it is not possible to use this procedure and test results for regulation purposes.

To describe the circular driving behaviour of passenger cars in steady-state condition there are four known different test methods:

— constant radius test;

— constant steer angle test;

— constant speed, variable steer angle test;

— constant speed, variable radius test.

ISO 4138 defines only the constant radius test method.

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

1 Scope

This International Standard defines an open-loop test procedure to determine the steady state directional control response of passenger cars by measuring the steady-state cornering behaviour which is one of the factors composing vehicle dynamics and road holding properties.

It applies to passenger cars as defined in ISO 3833.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 1176:1990, *Road vehicles — Masses — Vocabulary and codes.*

ISO 2416:1976, *Passenger cars — Mass distribution.*

ISO 3833:1977, *Road vehicles — Types — Terms and definitions.*

ISO 8855:1991, *Road vehicles — Vehicle dynamics and road-holding ability — Vocabulary.*

3 Principle

The purpose of this test procedure is to measure the steering-wheel angle as a function of lateral acceleration and to describe vehicle steering (for example, understeer/oversteer) behaviour for left-hand and right-hand turns.

This procedure requires the test vehicle to be driven at several constant (see 7.2) speeds on a path of known radius. The directional control response characteristics are determined from data obtained while driving the vehicle at successively higher speeds on the constant radius path (or path of sufficent length to attain steady state). This procedure can be conducted in a relatively small area. The procedure can be tailored to existing test track facilities by selecting a circle or path of appropriate radius. Often a constant radius (in plane) road will suffice for a test facility.

The variables of motion used to describe the steady state directional control response of the vehicle relate to the intermediate axis system X, Y, Z (see ISO 8855).

The location of the origin of the intermediate axis system, being the reference point, is independent from loading condition. It is fixed in the longitudinal plane of symmetry at half wheel base and at the same height above the ground as the centre of gravity of the vehicle at complete vehicle kerb mass (see ISO 1176).

4 Variables

The following variables corresponding to the terms and definitions of ISO 8855 shall be measured:

— steering-wheel angle, δ_H;

— lateral acceleration, a_Y.

NOTE 1 Alternatively, lateral acceleration may be determined from other variables.

NOTE 2 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 intermediate X-axis and not at right angles to the tangent of the vehicle path. To overcome this difficulty, lateral acceleration may be corrected for vehicle sideslip angle, which gives the quantity centripetal acceleration (see clause 8.3). However, the extent of this correction is not likely to exceed a few percent and can generally be neglected.

It is recommended to measure the following variables as well:

— sideslip angle, β;

If the whole procedure described in clause 9 is to be followed, the sideslip angle must be measured directly or calculatd from other measured variables.

— yaw velocity, $\dot{\Psi}$;

— longitudinal velocity, v_X;

— steering-wheel torque, M_H;

— vehicle roll angle, φ.

5 Measuring equipment

5.1 Description

The variables selected from those listed in clause 4 shall be measured by means of appropriate transducers and their time histories recorded by a multi-channel recorder. The typical operating ranges and recommended maximum errors of the transducer and recording system are shown in table 1. The values in table 1 are tentative and provisional until more experience and data are available.

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

Variable	Typical operating range	Recommended maximum error of the combined transducer and recorder system
Steering-wheel angle	− 360° to + 360°	± 2°, for angles < 180° ± 4°, for angles > 180°
Yaw velocity	− 50°/s to + 50°/s	± 0,5°/s
Sideslip angle	− 15° to + 15°	± 0,5°
Longidutinal velocity	0 m/s to 50 m/s	± 0,5 m/s
Lateral acceleration	− 15 m/s² to + 15 m/s²	± 0,15 m/s²
Steering-wheel torque	− 30 N·m to + 30 N·m	± 0,3 N·m
Roll angle	− 15° to + 15°	± 0,15°

NOTE — 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 (see annex A).

5.2 Transducer installation

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

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

5.3 Data processing

The frequency range relevant for this test is between 0 Hz and the maximum utilized frequency of f_{max} = 5 Hz. According to the chosen data processing method, analog or digital, the stipulations given in 5.3.1 or 5.3.2 shall be observed.

5.3.1 Analog data processing

The bandwidth of the entire combined transducer/recording system shall be no less than 8 Hz.

In order to execute the necessary filtering of signals, low-pass filters with order four or higher shall be employed. The width of the passband frequency f_0 at −3 dB shall not be less than 8 Hz. Amplitude errors shall be less than ± 0,5 % in the relevant frequency range of 0 Hz to 5 Hz. All analog signals shall be processed with filters, having sufficiently similar phase characteristics, in order to ensure that time delay differences due to filtering shall lie within the required accuracy for time measurement.

NOTE — Phase shifts may occur during analog filtering of signals with different frequency contents. Therefore a data processing method, as described in 5.3.2, is preferable.

5.3.2 Digital data processing

5.3.2.1 Preparation of analog signals

In order to avoid aliasing, the analog signals shall correspondingly be filtered before digitizing. In this case, low-pass filters with order four or higher shall be employed. The width of the passband (frequency f_0 at −3 dB) shall amount to roughly

$$f_0 \geqslant 5f_{max}$$

The amplitude error of the anti-aliasing filter should not exceed ± 0,5 % in the utilized frequency range from zero to f_{max}. All analog signals shall be processed with anti-aliasing filters having sufficiently similar phase characteristics in order to ensure that time delay differences lie within the required accuracy for time measurement.

Additional filters shall be avoided in the data acquisition string.

Amplification of the signals shall be such that, in relation with the digitizing process, the additional error is less than 0,2 %.

5.3.2.2 Digitizing

The sampling rate f_s shall be appropriate to the order of the filters being used and shall under no circumstances be less than $2f_0$.

NOTE — In common practice anti-aliasing filters of Butterworth type are used. For this type of filter the following specifications are recommended:

four pole filter: $f_s \geqslant 5f_0$

eight pole filter: $f_s \geqslant 3,6f_0$

5.3.2.3 Digital filtering

For filtering of sampled data in data evaluation, phaseless (zero phase shift) digital filters shall be used incorporating the following characteristics (see figure 1):

- passband range, ⩾ 0 Hz to ⩾ 5 Hz;
- start of stopband, ⩾ 10 Hz and ⩽ 15 Hz;
- filter gain in the passband, 1 ± 0,005 (100 % ± 0,5 %);
- filter gain in the stopband, ⩽ 0,01 (⩽ 1 %).

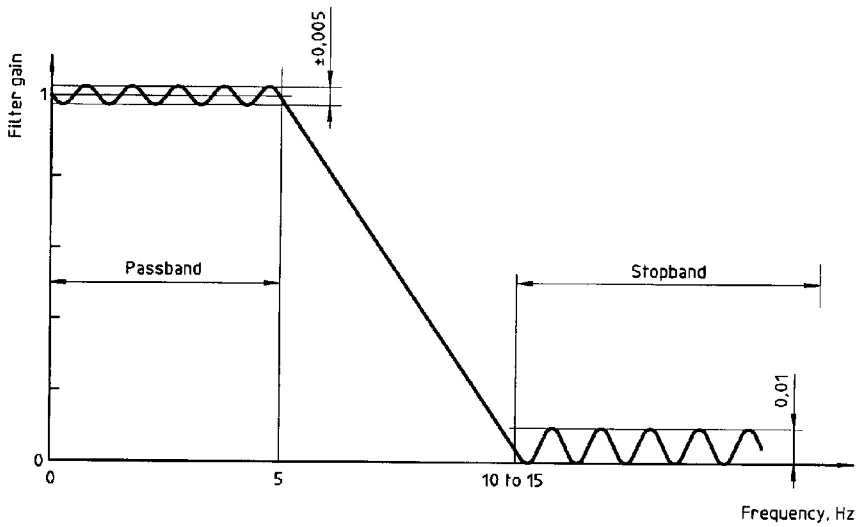

Figure 1 — Required characteristics of phaseless digital filters

6 Test conditions

Limits and specifications for the ambient and vehicle test conditions are established in 6.1 to 6.3, and shall be maintained during the test. Any deviations shall be shown in the test report (see annex A), including the individual diagrams of the presentation of results (see annex B).

NOTE — The ambient temperature may influence both the road friction and the tyre characteristics. Therefore the tests should be carried out without the ambient temperature varying too much.

6.1 Test track

All tests shall be carried out on a level, clean, dry and uniform hard road surface, which must not exceed a gradient of 2,5 % at any place. For standard test conditions, a smooth dry road surface of asphalt or concrete or a high friction test surface is recommended.

6.2 Wind velocity

The wind velocity shall not exceed 5 m/s and shall be recorded in the test report (annex A).

6.3 Test vehicle

6.3.1 Tyres

For standard tyre condition, new tyres shall be fitted on the test vehicle according to the manufacturer's specifications. They shall have a tread depth of at least 90 % of the original value and shall be manufactured not more than one year before the test. The date of manufacture shall be noted in the test report (see annex A).

Tyres shall be inflated to the pressure as specified by the vehicle manufacturer for the test vehicle configuration at the ambient temperature. The tolerance for setting the cold pressure is ± 5 kPa[1)] for pressures up to 250 kPa and ± 2 % for pressure above 250 kPa.

They shall be run in for at least 150 km without excessively harsh use, for example braking, acceleration, cornering, hitting the kerb, etc. After the tyres have been run in, they should remain in the same position on the vehicle for the test.

The test may also be performed with tyres in any state of wear as long as the end of the test they are in such a condition that a minimum of 1,6 mm of tread depth remains across the whole breadth of the tread (see note) and around the whole circumference of tyre.

NOTES

1 Tread breadth is the width of that part of the tread which with the tyre correctly inflated contacts the road in normal straight-line driving.

2 As in certain cases the tread depth has a significant influence on test results, it is recommended that it should be taken into account when making comparisons between vehicles or between tyres.

6.3.2 Operating components

For the standard test conditions, all operating components likely to influence the results of this test (for example condition, setting and temperature of shock absorbers, springs and other suspension components and suspension geometry) shall be as specified by the manufacturer. Any deviations from the manufacturer's specification shall be noted in the test report (see annex A).

6.3.3 Drivetrain

For the standard test conditions, the adjustment and condition of the drivetrain (especially the differentials, clutches, locks, free wheel shifts, etc.) shall correspond to the vehicle manufacturer's specifications.

6.3.4 Loading conditions of the vehicle

The test mass shall be between complete vehicle kerb mass (code: ISO-M06) plus driver's mass and maximum authorized total mass (code: ISO-M08). The instrumentation plus driver should not exceed 150 kg.

The maximum authorized total mass and the maximum design axle loads (code: ISO-M13) shall not be exceeded.

Care shall be taken to generate the minimum deviation in the location of the centre of gravity and in the values of the moments of inertia as compared to the loading conditions of the vehicle in normal use. The resulting wheel loads shall be determined and recorded in the test report (annex A).

1) 1kPa = 10^{-2} bar = 10^{3} N/m^{2}

7 Test procedure

7.1 Tyre warm-up

The tyres shall be warmed up in order to achieve a tyre temperature and pressure representative of normal driving conditions. This should be done by driving at a speed of 100 km/h over a distance of at least 10 km. However, if this is not practical, this can be done by driving 500 m at a lateral acceleration of 3 m/s^2 on the radius to be used for the tests. The tyre pressures after warm-up should be recorded.

7.2 Initial driving condition

During this procedure the vehicle is to be steered in such a manner that the reference point of the vehicle moves on a circular path. 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 vehicle shall be driven on the desired circle at the lowest possible speed. Data shall be recorded with the steering-wheel position and throttle position fixed.

The vehicle shall then be driven at the next speed at which data are to be taken. However, if the instrumentation requires to be reset between the tests, the vehicle may be stopped for this purpose. Data shall be taken in increments of the lateral acceleration of not more than 0,5 m/s^2. Where the data vary rapidly with lateral acceleration, it may be useful to take data in smaller increments.

At each lateral acceleration level, the steering-wheel position and throttle position shall be maintained as constant as possible while data are taken. Whatever radius is chosen, the path shall be followed to within 0,5 m of either side. Data shall be taken for at least 3 s at each steady-state lateral acceleration level. It is recommended that the highest gear compatible with the conditions of the test should be used.

NOTE — It may be possible to carry out the test by accelerating very slowly through the speed range and recording the variables continuously. Further work is required before this can be specified as an alternative procedure.

The value of the lateral acceleration shall be increased and data shall be taken until it is no longer possible to maintain steady-state conditions.

Data shall be taken for both left and right turns. All the data may be taken in one direction followed by all the data in the other direction. Alternatively, data may be taken successively in one direction and in the other for each acceleration level, going from the lowest to the highest. The method chosen shall be noted in the general data.

8 Data analysis

8.1 General

When analysing the data, the steady-state values for all the measured variables shall be established as the average values of these variables in the elapsed time during which the steady state was maintained.

8.2 Steering-wheel angle

If the steering-wheel angle varies by more than 10° from the average value, the data, if used, shall be so labelled.

8.3 Lateral acceleration

Steady-state levels of lateral acceleration in case of method a) below, or centripetal acceleration in case of methods b), c) and d) below, may be obtained by:

a) the corrected output of an accelerometer (see 5.2);

b) the product of the yaw velocity, corrected for vehicle roll angle, and the forward velocity corrected for sideslip angle;

c) the square of the forward velocity, corrected for sideslip angle, divided by the path radius;

d) the product of the square of the yaw velocity, corrected for vehicle roll angle, and the path radius.

9 Data evaluation and presentation of results

9.1 General

General data shall be presented in the test report as shown in annex A. For every change in equipment of the vehicle (e.g. load), the general data shall be documented again.

The primary purpose of further processing of the acquired data is to produce derived parameters which can be used when comparing different vehicles.

Measured data shall be plotted as shown in annex B as follows:

— steering-wheel angle data points (see figure B.1);

— sideslip angle data points, if measured (see figure B.2);

— vehicle roll angle data points, if measured (see figure B.3);

— steering-wheel torque data points, if measured (see figure B.4).

Curves may be fitted to the plotted points freehand, or by one of the many mathematical routines available. The method of curve fitting should be stated.

NOTE — There are a number of ways of further processing the data presented in this clause. These ways have been developed as conventions over many years and each can be justified in its own way; for example the division of steering-wheel angle data by a nominal overall steering ratio.

This is particularly true where the process involves fitting smooth curves to experimental data for the purpose of evaluating the gradients. The type of curve and the method of fitting will influence the results obtained and several different types of curves have been used.

Within the context of this International Standard it is not possible to recommend any one way as being better than any other.

The following specified variables represent examples for the evaluation of results, which describe vehicle steady-state behaviour. Any one of those ways may be used at the option of the user. If this evaluation is carried out, it will be necessary to determine the overall steering ratio.

9.2 Determination of overall steering ratio

The overall steering ratio (ISO 8855:1991, 4.1.5.8) shall be determined for each vehicle test configuration over the range of steering-wheel angles used during the test.

The overall steering ratio will not, in general, represent the dynamic situation because of additional steering system deflections caused by compliance and geometric effects. It is, however, suitable for removing the effect of different steering system lever and gears ratios from comparisons of measurements from different vehicles. The compliance and geometric effects referred to above are then quite properly regarded as part of the vehicle handling characteristics.

9.3 Evaluation of gradients — Differentiation

A common method of further treating basic experimental data is to derive the gradient of the curve fitted to the experimental points. The values of gradient thereby obtained are then plotted against the independent variable (in this case lateral acceleration) to give a response graph.

As mentioned in 9.1, curves may be fitted to the experimental data freehand or by a mathematical routine, but, if it is being done for the purpose of gradient evaluation, it is strongly recommended that the latter method should be used, otherwise the repeatability of the resulting gradients cannot be guaranteed. In addition, because each resulting curve will be described by a mathematical expression, it can be differentiated mathematically to produce the gradient as a continuous function of lateral acceleration.

NOTE — It has been found that the characteristics of some vehicles have discontinuities in slope which are not easily dealt with by standard curve fitting and differentiating techniques.

By this means the following derived gradients can be obtained and plotted as functions of lateral acceleration:

a) steering-wheel angle gradient (ISO 8855, 6.3.4);

b) sideslip angle gradient (ISO 8855, 6.3.7);

c) vehicle roll angle gradient (ISO 8855, 6.3.6.1);

d) steering-wheel torque gradient (ISO 8855, 6.3.5);

e) steering-wheel/sideslip angle gradient (ISO 8855, 6.3.8).

Whilst, in theory, the curve for case e) can be produced as the ratio of curves of steering-wheel angle gradient and sideslip angle gradient, this method is likely to lead to significant errors. It is preferable to fit a curve directly to the steering-wheel angle versus sideslip angle data and to differentiate it with respect to sideslip angle to produce steering-wheel angle/sideslip angle gradient versus sideslip angle and then to transform the latter variable into lateral acceleration by using the sideslip angle/lateral acceleration relationship in b).

NOTE — This curve is believed by some experts to relate strongly to the vehicle behaviour as perceived by the driver; that is, the relationship between the steering-wheel input and the resulting vehicle sideslip angle.

The above gradients are plotted against lateral acceleration using the convention: lateral acceleration on the abscissa, with left turns positive, right turns negative; and the gradients on the ordinate with normal sign convention.

9.4 Normalization of results — Comparison of results from different vehicles

9.4.1 Explanation

In any general case of a vehicle making a steady-state turn of given radius, the steer angle needed to do this will consist of two parts; that due to the Ackermann Effect, which for a given radius is proportional to the wheelbase, and that due to the "handling characteristic" of the vehicle. In addition, the steering-wheel angle corresponding to the required steer angle will depend on the overall steering ratio.

Thus, there are three quantities to be taken into account in the general case:

— wheelbase;

— overall steering ratio;

— steering-wheel angle gradient.

The units of the steering-wheel angle gradient will be degrees per metre per second squared and, by convention, a vehicle with zero steering-wheel angle gradient, that is to say one which needs no movement of its steering-wheel when changing speed on a curve of constant radius, is defined as a "neutral steer vehicle". The steering-wheel angle of a neutral steer vehicle becomes a function only of overall steering ratio and wheelbase.

The steering-wheel angle gradient of any vehicle can be normalized by dividing the measured responses of the actual vehicle by the product of its wheelbase and overall steering ratio.

The practical benefits from doing this are that the steering-wheel angle gradient of vehicles of widely different sizes and overall steering ratios can be compared analytically with each other by comparing their normalized measured responses.

Comparison of measurements which have not been normalized will not show, clearly, differences in steering-wheel angle gradient because they will contain also the effects of differences in wheelbase and overall steering ratio.

It should be noted that in this particular procedure the numerical value of the product of wheelbase and overall steering ratio is the same as the product of the test radius and the steering-wheel angle, in radians, required at zero speed on that radius. This steering-wheel angle is the intercept of the curve in figure B.1 with the zero lateral acceleration line and thus, the value of the product of overall steering ratio and wheelbase can be obtained without direct measurement.

9.4.2 Normalized responses

In the light of the explanation given in 9.4.1, it is possible to define normalized response parameters which correspond to the non-normalized parameters of clause 9.3. However, there does not appear to be any significance in normalized sideslip angle, roll angle or torque gradients, and therefore only normalized equivalents of steering-wheel/sideslip angle gradient are described.

9.4.2.1 Normalization with respect to overall steering ratio is useful only if results from vehicles of similar wheelbase are to be compared. The procedure for measuring overall steering ratio is given in 9.2.

a) understeer gradient (ISO 8855, 6.3.9)

Since the dynamic reference steer angle gradient in a constant radius test is zero the equation can be written as

$$\frac{\text{steering-wheel angle gradient}}{\text{steering ratio}}$$

b) understeer/oversteer/sideslip gradient

$$\frac{\text{steering-wheel/sideslip angle gradient}}{\text{steering ratio}}$$

9.4.2.2 Normalization with respect to overall steering ratio and wheelbase yields response values which can be used to compare vehicles of widely different sizes.

a) stability factor (ISO 8855, 6.3.10);

b) directional coefficient (ISO 8855, 6.3.11).

Annex A
(normative)

Test report — General data

Vehicle identification:

Vehicle identification number (VIN):		....
Type of vehicle:		....
Manufacturer:		....
Model:		....
Model year/1st registration date:		....

Drive configuration:

Front-wheel drive:		☐
Rear-wheel drive:		☐
Four-wheel drive; type of 4WD:		....
Special features:		....

Engine:

Identification code:		....

Transmission:

Identification code:		....

Steering:

Conventional (front-wheel) steering:		☐
Four-wheel steering:		☐
Power-assisted steering:		☐
Steering ratio overall on front axle:		.... : 1
Steering-wheel diameter:		.... mm

Tyres:

		Front	**Rear**
Size:		....	....
Make and type:		....	....
Date of manufacture:		....	....
Tread depth:	Right:	.... mm	.... mm
Tread depth:	Left:	.... mm	.... mm
Original tread depth (new condition)		.... mm	.... mm
Inflation pressure:			
— according to vehicle manufacturer			
at ISO-M06		.... kPa	.... kPa
at ISO-M08		.... kPa	.... kPa
— on vehicle test weight:		.... kPa	.... kPa
Rim size:		.... mm	.... mm

Masses:

Kerb mass (ISO-M06):		.... kg	
Gross mass (ISO-M08):		.... kg	
Maximum permissible axle load:		.... kg	.... kg
Measured wheel loads of test vehicle including driver's weight:	Right:	.... kg	.... kg
	Left:	.... kg	.... kg

Vehicle specifications:	Length overall:	.... mm
	Width overall:	.... mm
	Height overall at test mass:	.... mm
	Wheelbase:	.... mm
	Track width:	front .... mm rear .... mm
	Height of centre of gravity (ISO-M06):	.... mm
Wheel suspension:	Front	
	— Type:	....
	— stabilizer	☐
	— anti-roll bar	☐
	Rear	
	— Type:	....
	— stabilizer	☐
	— anti-roll bar	☐
	Suspension/damping	....
		....
Test conditions:	Engaged gear:	....
	Gear selector position:	....
	Transmission programme:	....
	Radius of circle:	.... m
	Reference point for sideslip angle and lateral velocity:	....
	Road surface condition (e.g. skid number, wet, dry):	....
	Ambient climate conditions:	
	— temperature:	.... °C
	— wind speed:	.... m/s
	Method for verifying the uniformity of initial conditions:	....
	standard deviation	☐
	mean value difference	☐
Staff:	Driver:	....
	Observer:	....
	Data analyst:	....

General comments and/or other relevant details:

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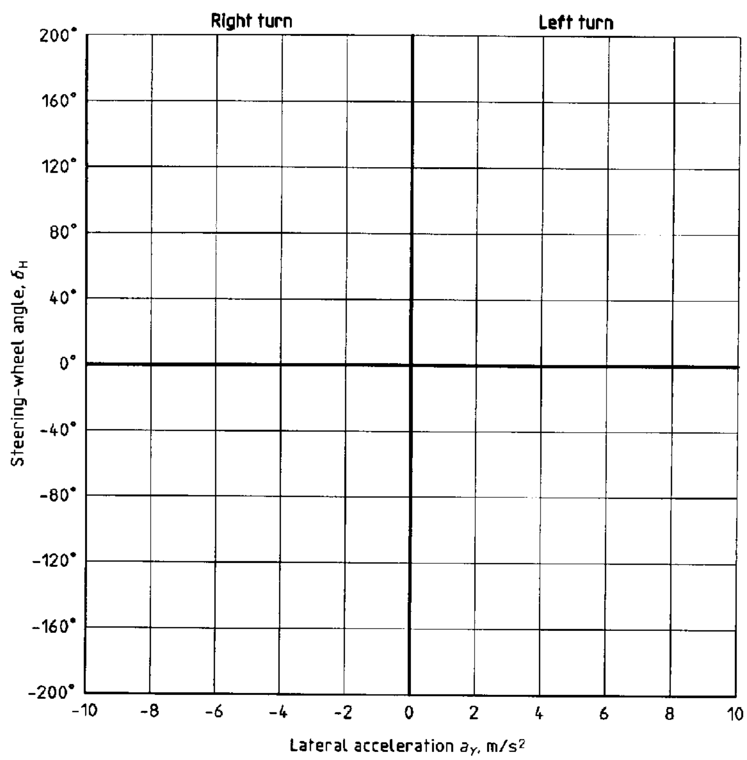
Annex B
(normative)

Test report — Presentation of results

The characteristic values of the vehicle dynamic reaction shall be presented as functions of the steady-state lateral acceleration, as shown in figures B.1 to B.4.

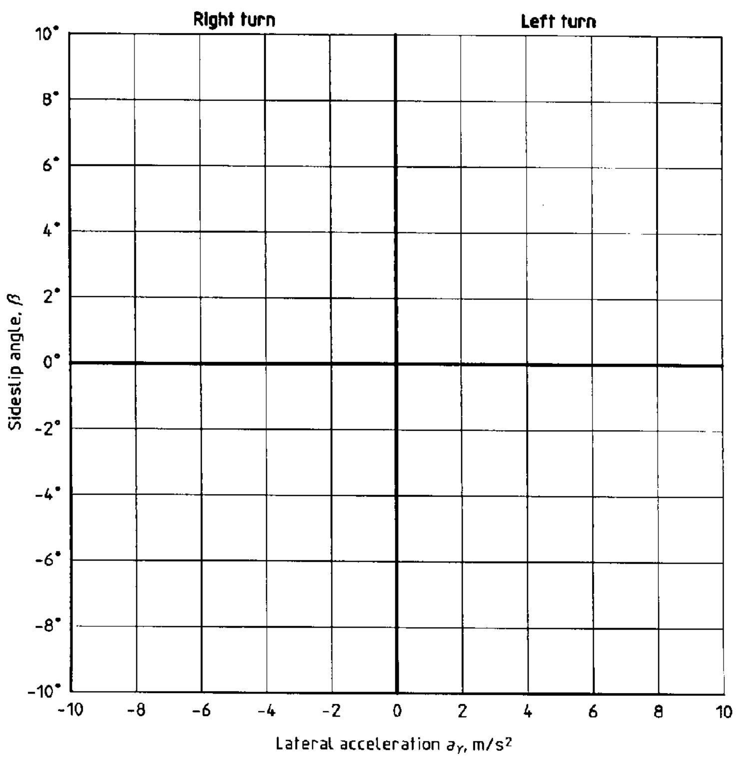


Vehicle: ....

Radius: ....

(for test conditions see annex A)

Figure B.1 — Steering-wheel angle characteristic

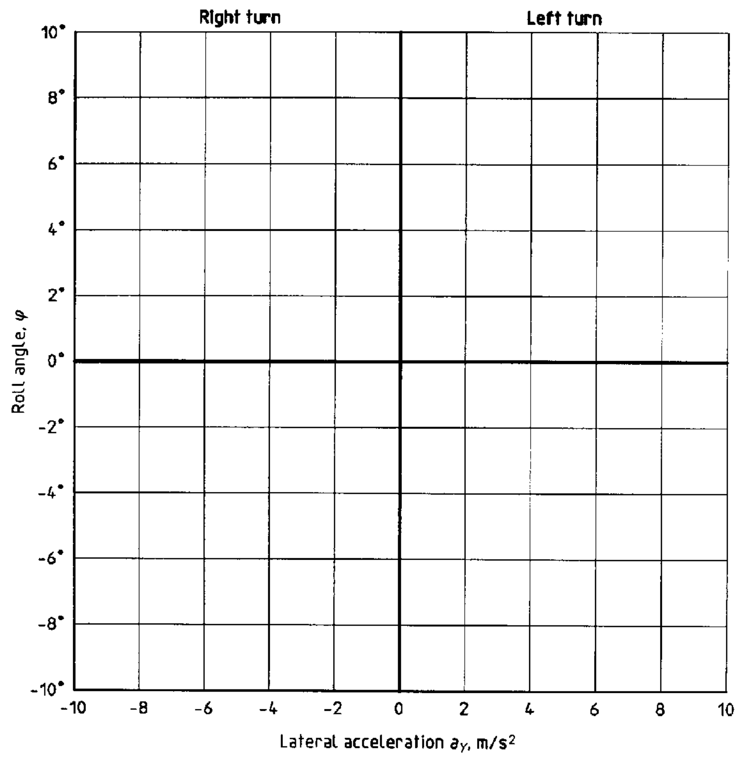


Vehicle: ....

Radius: ....

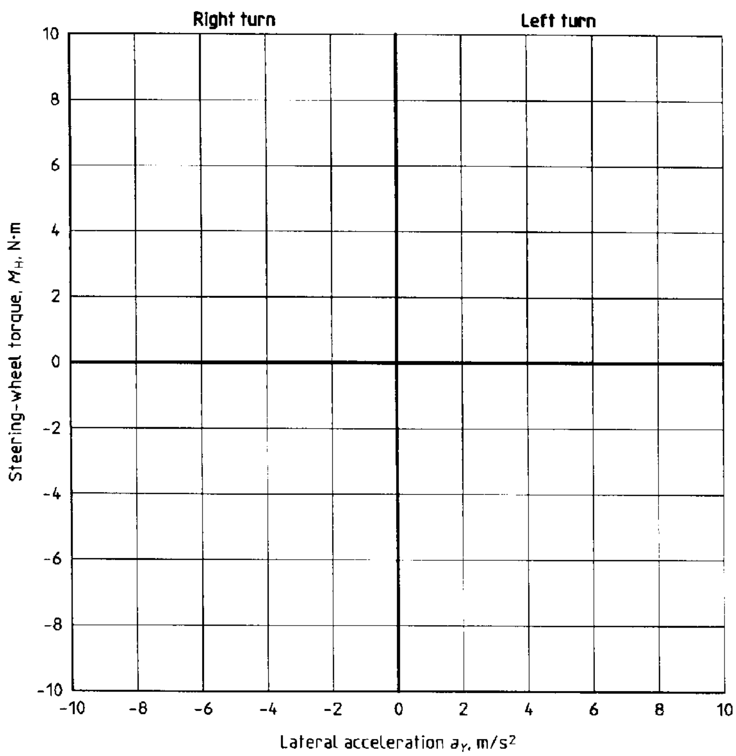
(for test conditions see annex A)

Figure B.2 — Sideslip angle characteristic



Vehicle: ....
Radius: ....
(for test conditions see annex A)

Figure B.3 — Vehicle roll angle characteristic



Vehicle: ....
Radius: ....
(for test conditions see annex A)

Figure B.4 — Steering-wheel torque characteristic

ICS 43 100

Descriptors: road vehicles, road safety, private cars, dynamic properties, road holding, tests, dynamic tests, stability tests, steady state, procedure, test report sheets.

Price based on 15 pages