INTERNATIONAL STANDARD

ISO 15037-1

Second edition
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Road vehicles — Vehicle dynamics test methods —

Part 1: General conditions for passenger cars

Véhicules routiers — Méthodes d'essai de la dynamique des véhicules —

Partie 1: Conditions générales pour voitures particulières

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Contents

Page

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 15037-1 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 15037-1:1998), which has been technically revised. It also incorporates the Technical Corrigendum ISO 15037-1:1998/Cor. 1:2001.

ISO 15037 consists of the following parts, under the general title *Road vehicles — Vehicle dynamics test methods*:

— *Part 1: General conditions for passenger cars*

— *Part 2: General conditions for heavy vehicles and buses*

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, constitutes a unique closed-loop system. The task of evaluating the dynamic behaviour of the vehicle is therefore very difficult since there is significant interaction between these driver-vehicle-environment elements, and each of these elements is individually complex in itself.

The test conditions exert large influence on the test results. Only test results obtained at identical test conditions are comparable.

Road vehicles — Vehicle dynamics test methods —

Part 1: General conditions for passenger cars

1 Scope

This part of ISO 15037 specifies the general conditions that apply when vehicle dynamics properties are determined according to ISO test methods.

In particular, it specifies general conditions for

- variables,
- measuring equipment and data processing,
- environment (test track and wind velocity),
- test vehicle preparation (tuning and loading),
- initial driving, and
- test reports (general data and test conditions).

These items are of general significance, independent of the specific vehicle dynamics test method. They apply when vehicle dynamics properties are determined, unless other conditions are required by the standard which is actually used for the test method.

This part of ISO 15037 is applicable to passenger cars as defined in ISO 3833 and light trucks.

NOTE The general conditions defined in existing vehicle dynamics standards are valid until a reference to this part of ISO 15037 is included.

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*

3 Variables

3.1 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 this position shall be reported (see Annex A).

NOTE Useful positions for the reference point include (1) the centre of gravity of the vehicle and (2) a fixed point of geometry such as the point in the longitudinal plane of symmetry at the height of the centre of gravity and at mid-wheelbase. Locating the reference point at the centre of gravity is very useful for analytical evaluation of the test results of individual vehicles, but may cause difficulty in comparing results for different vehicles. Locating the reference point at the geometrical position is more convenient for comparing results from different tests, but may complicate theoretical analysis.

3.2 Variables to be determined

To describe the vehicle dynamics in terms of driver input and vehicle response, the principal relevant variables are the following:

- steering-wheel angle (δ_H);
- steering-wheel torque (M_H);
- longitudinal velocity (v_X);
- sideslip angle (β) or lateral velocity (v_Y);
- longitudinal acceleration (a_X);
- lateral acceleration (a_Y);
- yaw velocity ($d\psi/dt$);
- roll velocity ($d\varphi/dt$);
- pitch velocity ($d\theta/dt$);
- roll angle (φ); and
- pitch angle (θ).

These variables are defined in ISO 8855.

All standards that make reference to this part of ISO 15037 shall specify which variables apply. Depending on the specific standard, additional variables can be required or recommended.

NOTE These variables can be determined directly by measuring or by calculation from measured values.

4 Measuring equipment

4.1 Description

Time histories of the measured variables shall be recorded by a time-based multi-channel recording system by means of appropriate transducers (see Annex C). Typical operating ranges and recommended maximum errors of the transducer and recording system are shown in Table 1. The specified accuracies shall be achieved whether the variables are measured or are calculated.

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

Variable	Typical operating range	Recommended maximum "overall" error
Steering-wheel angle	−360° to 360°	± 1° for $\delta_H < 50°$ ± 2° for $\delta_H > 50°$ and < 180° ± 4° for $\delta_H > 180°$
Steering-wheel torque	−30 Nm to 30 Nm	± 0,1 Nm for $M_H < 10$ Nm ± 0,3 Nm for $M_H > 10$ Nm
Longitudinal velocity	0 km/h to 180 km/h	± 1 km/h for $v_X < 100$ km/h ± 2 km/h for $v_X > 100$ km/h
Lateral velocity	−10 m/s to 10 m/s	± 0,2 m/s
Sideslip angle	−20° to 20°	± 0,3°
Longitudinal acceleration	−15 m/s2 to 15 m/s2	± 0,15 m/s^2
Lateral acceleration	−15 m/s2 to 15 m/s2	± 0,15 m/s^2
Yaw velocity	−50 °/s to 50 °/s	± 0,3 °/s for $d\psi/dt < 20$ °/s ± 1 °/s for $d\psi/dt > 20$ °/s
Pitch velocity	−50 °/s to 50 °/s	± 0,3 °/s for $d\theta/dt < 20$ °/s ± 1 °/s for $d\theta/dt > 20$ °/s
Roll velocity	−50 °/s to 50 °/s	± 0,3 °/s for $d\varphi/dt < 20$ °/s ± 1 °/s for $d\varphi/dt > 20$ °/s
Roll angle	−15° to 15°	± 0,15°
Pitch angle	−15° to 15°	± 0,15°

Increased measurement accuracy may be desirable for computation of some of the characteristic values. 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).

4.2 Transducer installations

The transducers shall be installed according to the manufacturer's instructions when 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 in the defined position, appropriate transformation shall be carried out.

4.3 Data processing

4.3.1 General

The frequency range relevant for tests on horizontal dynamics of passenger cars is between 0 Hz and the maximum utilized frequency f_{max} = 5 Hz. Based on whether analogue or digital data processing methods are used, the requirements given in 4.3.2 or in 4.3.3 apply.

4.3.2 Analogue 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 shall be employed. The width of the passband (from 0 Hz to frequency f_0 at -3 dB) shall not be less than 9 Hz. Amplitude errors shall be less than $\pm$ 0,5 % in the relevant frequency range of 0 Hz to 5 Hz. All analogue signals shall be processed with filters having sufficiently similar phase characteristics to ensure that time delay differences due to filtering lie within the required accuracy for time measurement.

NOTE During analogue filtering of signals with different frequency contents, phase shifts can occur. Therefore, a digital data processing method, as described in 4.3.3, is preferable.

4.3.3 Digital data processing

4.3.3.1 General considerations

Preparation of analogue signals includes consideration of filter amplitude attenuation and sampling rate to avoid aliasing errors, and filter phase lags and time delays. Sampling and digitizing considerations include pre-sampling amplification of signals to minimize digitizing errors; number of bits per sample; number of samples per cycle; sample and hold amplifiers; and timewise spacing of samples. Considerations for additional phaseless digital filtering include selection of passbands and stopbands and the attenuation and allowable ripple in each; and correction of filter phase lags. Each of these factors shall be considered in order to achieve a relative overall data acquisition accuracy of $\pm$ 0,5 %.

Attenuation and phase shift information for a Butterworth filter is provided in Annex D.

4.3.3.2 Aliasing errors and anti-aliasing filters

In order to avoid uncorrectable aliasing errors, the analogue signals shall be appropriately filtered before sampling and digitizing. The order of the filters used and their passband shall be chosen according to both the required flatness in the relevant frequency range and the sampling rate.

The minimum filter characteristics and sampling rate shall be such that:

a) within the relevant frequency range of 0 Hz to f_{max} = 5 Hz, the maximum attenuation of the analogue signal is less than the resolution of the digitized signal; and

b) at one-half the sampling rate (i.e. the Nyquist or “folding” frequency), the magnitudes of all frequency components of signal and noise are reduced to less than the digital resolution.

For 0,05 % resolution, the filter attenuation shall be less than 0,05 % to 5 Hz, and the attenuation shall be greater than 99,95 % at all frequencies greater than one-half the sampling frequency.

It is recommended that anti-aliasing filters be of order four or higher (see Annex D).

Although filtering for anti-aliasing is required, excessive analogue filtering shall be avoided. Moreover, all filters shall have sufficiently similar phase characteristics to ensure that differences in time delays between signals are compatible with the required accuracy for the time measurement.

NOTE Phase shifts are especially significant when measured variables are multiplied together to form new variables, because, while amplitudes multiply, phase shifts and associated time delays add. Phase shifts and time delays are reduced by increasing the filter cut-off frequency, f_0. Whenever equations describing the pre-sampling filters are known, it is practical to remove their phase shifts and time delays by simple algorithms performed in the frequency domain.

4.3.3.3 Data sampling and digitizing

At 5 Hz, the signal amplitude changes by up to 3 % per millisecond. To limit dynamic errors caused by changing analogue inputs to 0,1 %, sampling or digitizing time shall be less than 32 µs. Each pair or set of data samples to be compared shall be taken simultaneously or within a sufficiently short time period.

The digitizing system shall have a resolution of 12 bits (± 0,05 %) or more and an accuracy of 2 LSB (± 0,1 %). Amplification of the analogue signal before digitizing shall be such that, in the digitizing process, the combined error due to the finite resolution and inaccuracy of digitizing is less than 0,2 %.

4.3.3.4 Digital filtering

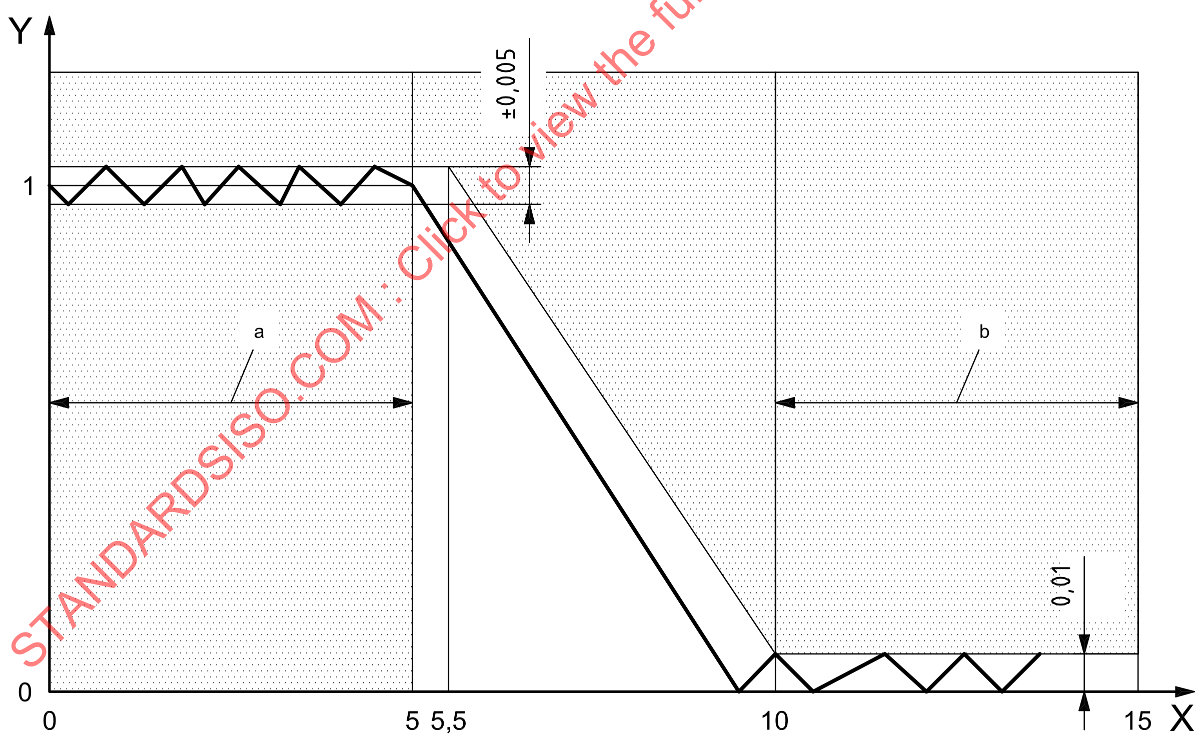
For filtering of sampled data in data evaluation, phaseless (zero phase shift) digital filters shall be used incorporating the following characteristics (see Figure 1):

— passband shall range from 0 Hz to 5 Hz;

— stopband shall begin between 10 Hz and 15 Hz;

— the filter gain in the passband shall be 1 ± 0,005 (100 ± 0,5 %);

— the filter gain in the stopband shall be ± 0,01 (± 1%).



Key

X frequency, f (Hz)

Y filter gain

[a] Passband.

[b] Stopband.

Figure 1 — Required characteristics of phaseless digital filters

5 Test conditions

5.1 General

Limits and specifications for the ambient conditions and vehicle test conditions are established below. These shall be maintained during the specific test. Any deviations shall be shown in the test report (see Annexes A and B), including the individual diagrams of the presentation of results. For each test method, the test-specific conditions and those which may not be kept constant (e.g. tread depths) shall be recorded in a separate test report in accordance with Annex B.

5.2 Test track

All tests shall be carried out on a smooth, clean, dry and uniform paved road surface. The gradient of the paved test surface to be used shall not exceed 2 % (recommended 1,5 %) in any direction when measured over any distance interval between that corresponding to the vehicle track and 25 m. For each test, the road surface conditions and paving material shall be recorded in the test report (see Annex B).

5.3 Wind velocity

The ambient wind velocity shall not exceed 5 m/s during a test. For each test method, the climatic conditions shall be recorded in the test report (see Annex B).

5.4 Test vehicle

5.4.1 General data

General data of the test vehicle shall be presented in the test report shown in Annex A. For any change of vehicle specification (e.g. load), the general data shall be documented again.

If a new vehicle is used, it is recommended to make an adequate run-in before starting the tests.

Since in certain cases the ambient temperature has a significant influence on test results, this should be taken into account when making comparisons between vehicles.

5.4.2 Tyres

For a general tyre condition, new tyres shall be fitted on the test vehicle according to the vehicle manufacturer's specifications. If not specified otherwise by the tyre manufacturer, they shall be run in for at least 150 km on the test vehicle or an equivalent vehicle without excessively harsh use, for example braking, acceleration, cornering, hitting the kerb, etc. After run in, the tyres shall be maintained at the same vehicle positions for the tests.

Tyres shall have a tread depth of at least 90 % of the original value across the whole breadth of the tread and around the whole circumference of the tyre.

Tyres shall not be manufactured more than one year before the test. The date of manufacturing shall be noted in the presentation of test conditions (see Annex B).

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

Inflation pressure and tread depth of the tyres determined before tyre warm-up shall be recorded in the test report (see Annex B).

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

Tests may also be performed under conditions other than general tyre conditions. The details shall be noted in the test report (see Annex B).

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

As the tread depth or uneven tread wear may have a significant influence on test results, it is recommended that they be taken into account when making comparisons between vehicles or between tyres.

5.4.3 Operating components

For the standard test condition, the type (e.g. part number or model number) and condition (e.g. shock-absorber settings and suspension-geometry adjustments) of all components likely to influence the test results shall be as specified by the manufacturer. Any deviations from manufacturer's specifications shall be noted in the presentation of general data (see Annex A).

5.4.4 Loading conditions of the vehicle

The test mass shall be between the complete vehicle kerb mass (ISO 1176, code ISO-M06) plus driver and test equipment (combined mass should not exceed 150 kg) and the maximum authorized total mass (ISO 1176, code ISO-M08).

The maximum authorized axle loads (ISO 1176, code ISO-M13) shall not be exceeded.

Care shall be taken to generate a minimum deviation in the location of the centre of gravity and in the moments of inertia as compared to the loading conditions of the vehicle in normal use (refer to ISO 2416). The resulting wheel loads shall be determined and recorded in the test report (see Annex A).

6 Test method

6.1 Warm-up

All relevant vehicle components shall be warmed up prior to the tests in order to achieve component temperatures representative of normal driving conditions. Tyres shall be warmed up prior to the tests to achieve an equilibrium temperature and pressure representative of normal driving conditions.

A procedure equivalent to driving at the test speed for a distance of 10 km or driving 500 m at a lateral acceleration of 3 m/s^2 (both left and right turns) may be appropriate for warming up the tyres.

6.2 Initial driving condition

6.2.1 General

The initial driving condition is specified in most of the vehicle dynamics test methods. It can either be a steady-state straight-ahead run or a steady-state circular run.

If there is no specific requirement defined in a test method standard, the tests shall be performed in the highest suitable gear for vehicles with manual transmission and for vehicles with automatic transmission in drive D. The position of the transmission lever and the selected driving programme shall be recorded in the test report (see Annex B).

The position of the steering wheel and the accelerator pedal shall be kept as constant as possible during the initial driving condition. The moment of observation t_{ss} to evaluate steady-state conditions is defined as the point in time which usually is between 0,5 s and 0,8 s before the reference point in time t_0 of the specific test method (see note below). The initial condition is considered to be sufficiently constant if for the moment of observation t_{ss} the requirements of 6.2.2 and 6.2.3 are fulfilled (see Figure 2, which also introduces the definition of t_1 and t_2).

NOTE For test methods which are used to determine only steady-state values (e.g. ISO 4138) the moment of observation t_{ss} and the reference time t_0 will be identical.

6.2.2 Steady-state straight-ahead run

The longitudinal velocity in the initial driving condition shall not deviate by more than ± 1 km/h (± 2 km/h for velocities above 100 km/h) from the nominal value during the time interval from t_1 to t_2 and the mean value of lateral acceleration shall be within a range from –0,3 m/s^2 to +0,3 m/s^2. As an alternative to the limits of lateral acceleration, the mean value of the yaw velocity shall be within a range from –0,5 °/s to +0,5 °/s.

For the time interval from t_1 to t_2, the standard deviation of the lateral acceleration shall not exceed 0,3 m/s^2. As an alternative to the limits on lateral acceleration, the standard deviation of the yaw velocity shall not exceed 0,5 °/s.

The difference between the mean values of the longitudinal velocity during the time intervals t_1 to t_{ss} and t_{ss} to t_2 shall not exceed ± 1 km/h (± 2 km/h for velocities above 100 km/h).

6.2.3 Steady-state circular run

The initial radius R_0 shall be calculated as follows:

— $R_0 = v_{X,0}/(\mathrm{d}\psi_0/\mathrm{d}t)$

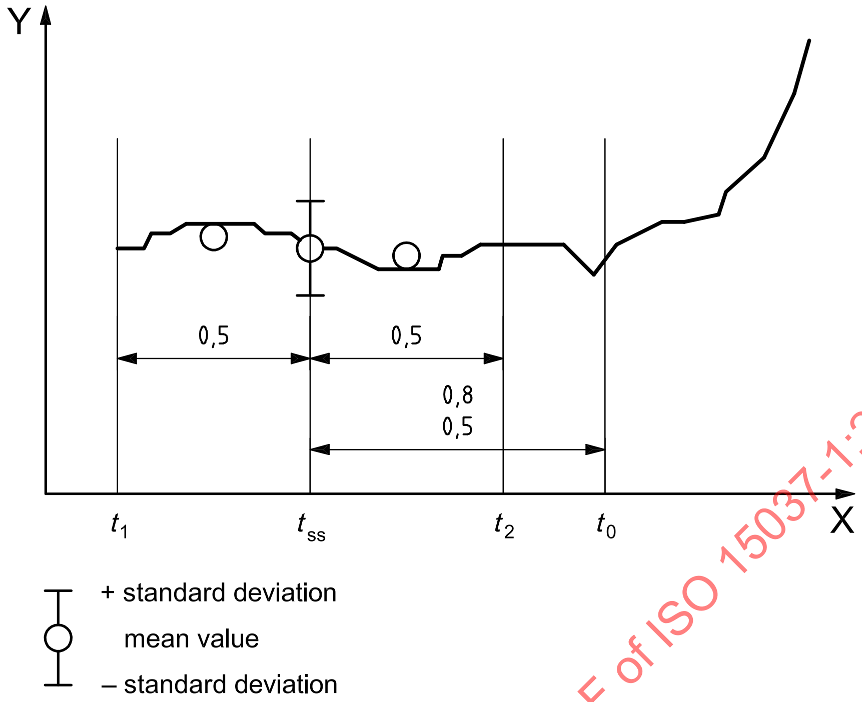
— $R_0 = v_{X,0}^2/a_{Y,0}$

The radius in the initial driving condition shall not deviate by more than 2 % or ± 2 m from the nominal value during the time interval from t_1 to t_2.

For the time interval from t_1 to t_2, the standard deviation of the lateral acceleration shall not exceed 5 % of its mean value and the standard deviation of the longitudinal velocity shall not exceed 3 % of its mean value.

The difference between the mean values of lateral acceleration during the time intervals t_1 to t_{ss} and t_{ss} to t_2 shall not exceed the nominal value of lateral acceleration by more than 5 %. The difference between the mean values of longitudinal velocity during the time intervals t_1 to t_{ss} and t_{ss} to t_2 shall not exceed the nominal value of longitudinal velocity by more than 3 %.

For the time interval from t_1 to t_2, the mean value of the lateral acceleration shall not deviate from the nominal value by more than ± 3 %.



Key

X time, s

Y measured variable

t_0 reference point in time of the specific test method

t_1 time measurement 1

t_2 time measurement 2

t_{ss} moment of observation to evaluate steady state conditions

Figure 2 — Definition of times

Annex A
(normative)

Test report — General data

Vehicle identification	Vehicle identification number:	....
	Type of vehicle:	....
	Manufacturer:	....
	Model:	....
	Model year/first registration date:	....
Drive train	Driven axle:	❒ front axle ❒ rear axle
	Type of 4WD:	....
	Special features:	....
Engine	Identification code:	....
	Type of engine:	❒ spark ignition ❒ diesel
	Air/fuel mixture control:	❒ carburettor ❒ injection
	Charging system:	❒ turbo charger ❒ super-charger
	Ignition point control:	❒ mechanical ❒ electronic
	Fuel cut-off:	❒ yes ❒ no
	Displacement/number of cylinders:	.... cm^3 .... cylinders
	Maximum power/engine speed:	.... kW 1/min
	Maximum torque/engine speed:	.... Nm 1/min
Transmission	Identification code:	
	Type/number of forward gears:	❒ manual .... gears
		❒ automatic .... gears
		❒ continuously variable (e.g. CVT)
	Gear ratios:	1st gear: .... : 1 2nd gear: .... : 1
		3rd gear: .... : 1 4th gear: .... : 1
		5th gear: .... : 1 6th gear: .... : 1
	Final drive ratio:	.... : 1
Rear axle	Type of rear axle:	....
	Suspension/damping:	....
	Stabilizer/Anti-roll bar:	❒ yes ❒ no
Front axle	Type of front axle:	....
	Suspension/damping:	....
	Stabilizer/Anti-roll bar:	❒ yes ❒ no

Steering	Steered axle:	❒ front axle	❒ rear axle
	Power assisted:	❒ yes	❒ no
	Overall steering ratio on front axle:	....	
	Steering wheel diameter:	.... mm	
Braking system	Power assisted:	❒ yes	❒ no
	Anti-lock braking system:	❒ yes	❒ no
	Type:	....	
	Wheel brakes on front axle:	❒ drums	❒ discs
	Wheel brakes on rear axle:	❒ drums	❒ discs
Wheels	Rim size:	front:	rear: ....
Tyres	Size:	front:	rear: ....
	Tread depth (new):	front: .... mm	rear: .... mm
	Inflation pressure, according to the vehicle manufacturer's specifications:		
	— at complete vehicle kerb mass (ISO-M06):	front: .... kPa	rear: .... kPa
	— at maximum authorized total mass (ISO-M08):	front: .... kPa	rear .... kPa
Masses	Complete vehicle kerb mass (ISO-M06):	.... kg	
	Maximum authorized total mass (ISO-M08):	.... kg	
	Maximum authorized axle load (ISO-M13):	front: .... kg	rear: .... kg
	Type of loads used for mass reproduction:		
	Measured wheel loads of test vehicle, including driver and instrumentation:	FL: .... kg	FR: .... kg
		RL: .... kg	RR: .... kg
Vehicle dimensions	Overall length:	.... mm	
	Overall width:	.... mm	
	Overall height at test mass:	.... mm	
	Wheelbase:	.... mm	
	Track:	front: .... mm	rear: .... mm
	Height of centre of gravity at complete vehicle kerb mass (ISO-M06):	.... mm	

Reference point coordinates for measured variables	X_V (from half wheel base):	Y_V (from half track):	Z_V (from ground):
	.... mm	.... mm	.... mm

General comments and/or other relevant details

....

....

....

Sensor positions (referred to the reference point)

Variable	X (mm)	Y (mm)	Z (mm)
Longitudinal velocity			
Lateral velocity			
Sideslip angle			
Longitudinal acceleration			
Lateral acceleration			
Yaw velocity			
Pitch velocity			
Roll velocity			
Roll angle			
Pitch angle			

Annex B
(normative)

Test report — Test conditions

Test method	ISO	....
Proving ground	Location:	....
	Path radius:	....
Ambient conditions	Road surface:	Type: ....
		Condition: ....
		Track temperature: .... °C
		Tyre-road peak friction coefficient:
		....
		Friction measuring method:
		....
	Climate:	Air temperature: .... °C
		Relative humidity: .... %
		Wind speed: .... m/s
		Wind direction: ....
Tyres	Date of manufacture:	front: .... rear: ....
	Tread depth:	
	— before warm-up:	FL: .... mm FR: .... mm
		RL: .... mm RR: .... mm
	Tyre pressure:	
	— before warm-up:	FL: .... kPa FR: .... kPa
		RL: .... kPa RR: .... kPa
Driving conditions	Manual transmission:	Engaged gear: .... gear
	Automatic transmission:	Transmission program: ....
		Gear selector position: ....
Staff	Driver:	....
	Observer:	....
	Data analyst:	....
Test method specific data	....	

Annex C
(informative)

Transducers and their installations

C.1 General

Transducers of various types, some commercially available and some specially fabricated, are used in measuring the required and optional variables. If a transducer does not directly measure the required variable, appropriate adjustments shall be made to its signal to obtain the required variable with a sufficient level of accuracy.

Because of the variety of instrumentation possibilities, the type of each instrument used shall be recorded; and where applicable, its location on the vehicle shall be entered on the test data sheets (see Annex A).

Typical errors for various direct measurement transducers are given in following clauses. Net percentage error for a variable computed from the output signals of several transducers is found by taking the differential of the computed variable and dividing it by the computed variable.

As sensor performance is rapidly changing, the information contained in the following clauses should be considered as general requirements referred to in the last revision of this part of ISO 15037.

C.2 Steering-wheel angle

Steering-wheel angle is measured relative to the sprung mass. Typical transducers are multi-turn potentiometers or digital shaft encoders, geared to the back of the steering wheel or attached to a “second steering wheel”.

C.3 Longitudinal velocity

A longitudinal velocity transducer should be installed as close as possible to the reference point position on the vehicle. The location of the velocity transducer shall be recorded and its signal corrected as necessary during data processing to provide longitudinal velocity at the reference point. Typical transducers are fifth wheels with accuracies to 0,2 km/h, and “contactless” velocity transducers based upon optical or Doppler principles, with optical accuracies to 0,1 km/h and Doppler accuracies to 0,5 km/h. The steady-state fifth-wheel signal is very close to horizontal velocity, while optical transducers measure longitudinal velocity (the component of horizontal velocity in the X direction, equal to horizontal velocity multiplied by the cosine of the sideslip angle). An additional way to measure the longitudinal velocity is by Global Positioning System (GPS) sensor (see C.11).

C.4 Lateral velocity and sideslip angle

Lateral velocity at a given point can be measured directly by means of a bipolar velocity transducer based upon optical principles, installed according to the manufacturer’s specifications. The location of the transducer must be recorded. Lateral velocity at any other point can be obtained by interpolation between two lateral velocity transducers or by extrapolation from the lateral velocity at the point of measurement, by adding the product of yaw velocity times the distance to the desired point. Sideslip angle is computed as the angle whose tangent is lateral velocity divided by longitudinal velocity. Commercially available bipolar velocity transducers have full-scale range of ± 10 m/s and ± 1 % full-scale steady-state accuracy.

Sideslip angle can be measured directly by a castered trolley, attached to the vehicle through gimbals and loading springs to keep the caster axis vertical. The sideslip angle measured is that which exists at the caster