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ISO 15037-1

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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

ISO 15037-1:1998(E)

Foreword

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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 15037-1 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 9, *Vehicle dynamics and road-holding ability*.

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 commercial vehicles*

Annexes A and B form and integral part of this part of ISO 15037. Annex C is for information only.

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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 closed-loop system which is unique. 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 vehicle dynamic properties 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 (see annex C).

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,

— test report (general data and test conditions),

which 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.

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 standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 15037. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 15037 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 2416:1992, *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 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 therefore should be independent of the loading condition. The origin is therefore 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).

3.2 Variables to be measured

To describe the horizontal dynamics of a vehicle, the following variables are relevant:

— longitudinal velocity (v_X);

— sideslip angle (β) or lateral velocity (v_Y);

— longitudinal acceleration (a_X);

— lateral acceleration (a_Y);

— yaw velocity ($\mathrm{d}\psi/\mathrm{d}t$);

— roll angle (φ);

— pitch angle (θ).

To describe the input of the driver, it is necessary to measure the variable

— steering wheel angle (δ_H).

These variables are defined in ISO 8855. All standards that make reference to this part of ISO 15037 shall specify which variables apply.

4 Measuring equipment

4.1 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 transducer and recording system are shown in Table 1.

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 directly, appropriate transformations into the reference system 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. According to the chosen data processing method, analogue or digital data processing, the requirements given in 4.3.2 or 4.3.3 apply.

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

Variables range system	Typical operating of the combined transducer	Recommended maximum errors and recording
Longitudinal velocity	0 m/s to + 50 m/s	± 0,5 m/s
Lateral velocity	–10 m/s to + 10 m/s	± 0,4 m/s
Sideslip angle	–15° to +15°	± 0,5°
Longitudinal acceleration	–15 m/s² to + 15 m/s²	± 0,15 m/s²
Lateral acceleration	–15 m/s² to + 15 m/s²	± 0,15 m/s²
Yaw velocity	– 50°/s to + 50°/s	± 0,5°/s
Roll angle	–15° to +15°	± 0,15°
Pitch angle	–15° to +15°	± 0,15°
Steering wheel angle	–360° to + 360°	± 2° for angles ≤ 180° ± 4° for angles > 180°

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).

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 with order 4 or higher 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 ± 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 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 includes 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 ± 0,5 %.

4.3.3.2 Aliasing errors

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 attenuation is less than the resolution of the data acquisition system; 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 system 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.

NOTE For a Butterworth filter the attenuation is given by

$$A^2 = \frac{1}{1 + \left(f_{max} / f_0 \right)^{2n}} \quad \text{and} \quad A^2 = \frac{1}{1 + \left(f_N / f_0 \right)^{2n}}$$

where

n is the order to filter;

f_{max} is the relevant frequency range (5 Hz);

f_0 is the filter cut-off frequency;

f_N is the Nyquist or "folding" frequency.

For a fourth order filter

for A = 0,999 5: $f_0 = 2{,}37 \times f_{max}$ = 11,86 Hz;

for A = 0,000 5: $f_s = 2 \times (6{,}69 \times f_0)$ = 158 Hz, where f_s is the sampling frequency = $2 \times f_N$.

4.3.3.3 Filter phase shifts and time delays for anti-aliasing filtering

Excessive analogue filtering shall be avoided, and all filters shall have sufficiently similar phase characteristics to ensure that time delay differences lie within the required accuracy for the time measurement.

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 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.

NOTE In the frequency range in which the filter amplitude characteristics remain flat, the phase shift Φ of a Butterworth filter can be approximated by

$\Phi = 81 \times (f/f_0)$ degrees for second order;

$\Phi = 150 \times (f/f_0)$ degrees for fourth order;

$\Phi = 294 \times (f/f_0)$ degrees for eighth order.

The time delay for all filter orders is: $t = (\Phi/360°) \times (1/f_0)$.

4.3.3.4 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. All pairs or sets of data samples to be compared shall be taken simultaneously or over a sufficiently short time period.

4.3.3.5 System requirements

The data system shall have a resolution of 12 bits (± 0,05 %) or more and an accuracy of 2 LSB (± 0,1 %). Anti-aliasing filters shall be of order 4 or higher and the relevant data range f_{max} shall be 0 Hz to 5 Hz.

For fourth order filters the passband frequency f_0 (from 0 Hz to frequency f_0) shall be greater than $2,37 \times f_{max}$ if phase errors are subsequently adjusted in digital data processing, and greater than $5 \times f_{max}$ otherwise. For fourth order filters the data sampling frequency f_s shall be greater than $13,4 \times f_0$.

For filters having orders different from fourth order, f_0 and f_s shall be selected for adequate flatness and alias error prevention.

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

Sampling or digitizing time for each data channel sampled shall be less than 32 µs.

4.3.3.6 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%).

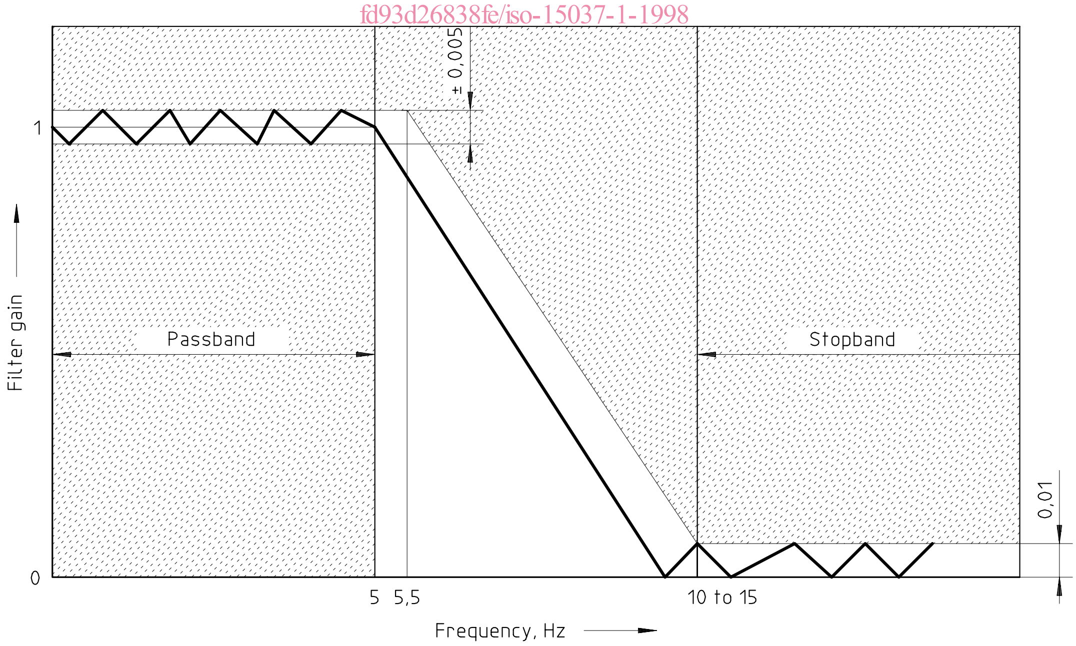

Figure 1 — Required characteristics of phaseless digital filters