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Road vehicles — Vehicle dynamics test methods —

Part 2:
General conditions for heavy vehicles and buses

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

Partie 2: Conditions générales pour véhicules lourds et autobus

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Contents

Page

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.

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 15037-2 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 vehicles and buses*

Introduction

The dynamic behaviour of heavy vehicles 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. Each of these elements is individually complex in themselves.

Moreover, the knowledge of the relationship between overall vehicle dynamic properties and accident avoidance is insufficient. The number of variants of heavy vehicles is enormous and each vehicle is itself unique. Therefore, the measured results are valid only for the actual vehicle tested, and the application of results to other, apparently similar, vehicles is not permissible.

Test conditions have a strong influence on test results. Only vehicle dynamic properties obtained under virtually identical test conditions are comparable.

Road vehicles — Vehicle dynamics test methods —

Part 2:
General conditions for heavy vehicles and buses

1 Scope

This part of ISO 15037 specifies the general conditions that apply when vehicle dynamics properties are determined according to ISO test methods carried out on heavy vehicles. These are commercial vehicles, combinations, buses and articulated buses, as defined in ISO 3833 for trucks and trailers above 3,5 t and buses above 5 t maximum weight, and in UNECE (United Nations Economic Commission for Europe) and EC vehicle classification, categories M3, N2, N3, O3 and O4.

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 reporting (general data and test conditions),

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

NOTE The general conditions defined in existing vehicle dynamics standards are valid up until the point when a respective 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 1176:1990, *Road vehicles — Masses — Vocabulary and codes*

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

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

UNECE Regulation No. 13, *Uniform provisions concerning the approval of vehicles of categories M, N and O with regard to braking* (Series 09: 28 August 1996 and supplements 1 to 4: 4 February 1999)

UNECE Regulation No. 30, *Uniform provisions concerning the approval of pneumatic tyres for motor vehicles and their trailers*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 8855 and the following apply.

3.1
vehicle unit
unit of vehicle combination connected with a yaw-articulation joint

EXAMPLE Tractor, semitrailer or dolly.

NOTE The number of vehicle units is one more than the number of articulation joints.

3.2
offtracking
lateral deviation between the path of the centre-line point of the front axle of the vehicle and the path of the centre-line point of some other part of the vehicle

NOTE 1 If a single number is given, it becomes the maximum offtracking.

NOTE 2 In a single-lane-change manoeuvre where the path of the other part is farther from the projection of the original path of the vehicle than the path of the front axle, the path of the other part is said to “overshoot” the path of the front axle at that point. In the opposite case, the path of the other part is said to “undershoot” the path of the front axle.

3.3
rearward amplification
ratio of the maximum value of the motion variable of interest (e.g. lateral acceleration or yaw velocity) of a following vehicle unit to that of the first vehicle unit during a specified manœuvre

3.4
zero damping speed
speed at which the damping coefficient of the free oscillatory yaw movements of the vehicle combination equals zero

3.5
reference damping speed
speed at which the damping coefficient of the free oscillatory yaw movements of the vehicle combination equals 0,05

3.6
centre-line point
point at the intersection of the ground plane and the x–z plane of symmetry of the part of interest, which point lies directly below a longitudinal reference position

NOTE For an axle, the longitudinal reference point is the wheel-spin axis. For other parts, the longitudinal reference point needs to be stated.

3.7
yaw articulation angle
yaw angle of the X axis of the intermediate axis system of a more forward vehicle unit in the intermediate axis system of a following vehicle unit, i.e. the angle between the X axes of the two units, with polarity determined by the rotation of the leading unit in the axis system of the following unit

NOTE The units involved are usually adjacent, but not necessarily so.

4 Variables

4.1 Reference system

The variables of motion used to describe the 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 intermediate axis system of a vehicle unit is the reference point for that unit. The location is at ground level in the plane of symmetry at the longitudinal position of the rearmost non-lifting axle of the unit.

4.2 Variables to be measured

To describe the horizontal dynamics of a vehicle or vehicle–driver system, the following variables are relevant (but are not intended to comprise a complete list):

— lateral acceleration of each vehicle unit (a_Y);

— roll angle of each vehicle unit at relevant points (φ);

— sideslip angle of each vehicle unit (β);

— articulation angle ($\Delta\psi$);

— wheel load (F_Z);

— yaw velocity of each vehicle unit ($\dot{\Psi}$);

— longitudinal velocity (v_X);

— offtracking of points of interest (Δ_r);

— longitudinal acceleration (a_X);

— steering wheel angle (δ_H);

— steering wheel torque ($M_{\Delta H}$).

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

5 Measuring equipment

5.1 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 given in Table 1.

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

Variable	Typical operating range	Recommended maximum error of combined system
Steering wheel angle	± 360°	± 2° for angles < 180°
		± 4° for angles > 180°
Longitudinal velocity	0 to 35 m/s	± 0,3 m/s
Lateral acceleration	± 15 m/s^2	± 0,15 m/s^2
Articulation angle between vehicle units	± 50°	± 0,5°
Yaw velocity of each vehicle unit	± 50°/s	± 0,5°/s
Lateral displacement of points of interest	± 10 m	± 0,05 m
Wheel load	0 to rated axle load	± 2 % of full scale
Roll angle of each vehicle unit at relevant points	± 15°	± 0,2°
Lateral velocity	± 10 m/s	± 0,2 m/s
Sideslip angle of each vehicle unit	± 10°	± 0,5°
Articulation angular velocity	± 50°/s	± 0,5°/s
Steering wheel torque in case of no power steering	± 50 Nm	± 0,5 Nm
Steering wheel torque in case of power steering	± 20 Nm	± 0,2 Nm
Longitudinal acceleration	± 15 m/s^2	± 0,15 m/s^2

5.2 Transducer installations

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 a transducer does not measure a variable directly, appropriate transformations shall be carried out.

5.3 Data processing

5.3.1 General

The frequency range relevant for tests on horizontal dynamics of heavy vehicles is between 0 Hz and the maximum utilized frequency f_{max} = 2 Hz. Depending on the chosen data-processing method (analog or digital data processing), the provisions of 5.3.2 or 5.3.3 are to be observed.

For lighter trucks it could be necessary to increase f_{max} to 3 Hz, in which case the following requirements concerning the frequency f_{max} may be modified correspondingly.

5.3.2 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 of 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 2 Hz. All analog signals shall be processed with filters having phase characteristics sufficiently similar to ensure that time delay differences due to filtering lie within the required accuracy for time measurement.

NOTE During analog filtering of signals with different frequency contents, phase shifts can occur. Because of this, a digital data processing method such as that given in 5.3.3 is preferable.

5.3.3 Digital data processing

5.3.3.1 General considerations

Preparation of analog 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 presampling amplification of signals to minimize digitization errors, number of bits per sample, number of samples per cycle, sample and hold amplification, 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, as well as correction of antialias filter phase lags. Each of these factors must be considered if an overall data acquisition accuracy of ± 0,5 % is to be achieved.

5.3.3.2 Aliasing errors

In order to avoid aliasing errors that cannot be corrected, the analog 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} = 2 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 12-bit data acquisition systems with a resolution of 0,05 %, the filter attenuation shall be less than 0,05 % to 2 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

$$A^2 = \frac{1}{1 + \left(\frac{f}{f_0}\right)^{2n}}$$

where

n is the order of filter;

f_0 is the filter cut-off frequency.

The above is such that

$A \big/ f - f_{max} \geqslant 0{,}999\,5$, and

$A \big/ f - f_N \leqslant 0{,}000\,5$

where

f_{max} is the highest frequency (2 Hz) in the relevant frequency range;

f_N is the Nyquist or "folding" frequency;

f_s is the sampling frequency = $2 \times f_N$.

