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Road vehicles — Passenger-car and trailer combinations — Lateral stability test

Véhicules routiers — Ensembles voiture particulière et remorque — Essai de stabilité latérale

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Foreword

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This document was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 33, *Vehicle dynamics, chassis components and driving automation systems testing*.

This fourth edition cancels and replaces the third edition (ISO 9815:2010), which has been technically revised.

The main changes are as follows:

— additions have been made to 6.2.1, 6.2.2 and 6.2.3;

— additions have been made to 7.2.1, 7.2.2, 7.2.3 and 7.2.4;

— references have been updated to ISO 4138:2021 and ISO 15037-1:2019.

Any feedback or questions on this document should be directed to the user’s national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The main purpose of this document is to provide repeatable and discriminatory test results.

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

Since this test method quantifies only one small part of the complete vehicle handling characteristics, the results of these tests 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 substantial 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 these tests in particular. Consequently, any application of this test method for regulation purposes requires proven correlation between test results and accident statistics.

Road vehicles — Passenger-car and trailer combinations — Lateral stability test

1 Scope

This document specifies a lateral stability test for passenger-car and trailer combinations. It is applicable to passenger cars in accordance with ISO 3833, and also to light trucks and their trailer combinations.

The lateral stability test determines the damping characteristic of the yaw oscillation of such towing-vehicle–trailer combinations excited by a defined steering impulse. The combination is initially driven in a steady-state, straight-ahead driving condition. Oscillation of the vehicle is then initiated by the application of a single impulse of steering, followed by a period in which steering is held fixed and the oscillation of the combination is allowed to damp out. Testing is conducted at several constant speeds. Where non-periodic instability is of interest, a steady-state circular test is specified.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 2416, *Passenger cars — Mass distribution*

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

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

ISO 15037-1:2019, *Road vehicles — Vehicle dynamics test methods — Part 1: General conditions for passenger cars*

3 Terms, definitions

For the purposes of this document, the terms and definitions given in ISO 3833, ISO 8855 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
yaw articulation angle
$\Delta\psi$
angle of the X_C axis relative to the X_T axis, i.e. angle between the X axes of each of the two units, with the polarity determined by the rotation of the towing vehicle relative to the trailer

Note 1 to entry: The letters “C” and “T” are used as subscripts to distinguish between variables associated with the towing vehicle (car or light truck) and the trailer, respectively. For example, the longitudinal axis of the intermediate axis system of the towing vehicle is designated as X_C, and the lateral acceleration of the trailer is designated as a_{YT}.

3.2
mean gradient of the test track
$\bar{G}$
change in elevation of the track surface between two points along the path of the vehicle divided by the horizontal distance between those points, where the two points are those that define, as closely as is practicable, that segment of the track travelled by the test vehicle between the times t_2 and $t_{\Delta\psi n}$, respectively for t_2 and $t_{\Delta\psi n}$, see 6.2.2 and 7.2.3, respectively

Note 1 to entry: This gradient is dimensionless and is positive for a test vehicle travelling uphill and negative for a test vehicle travelling downhill.

4 Measurement variables

When performing this test procedure, the following shall be measured:

— steering-wheel angle, δ_H,

— longitudinal velocity of the towing vehicle, v_X,

— lateral acceleration of the trailer, $a_{Y\mathrm{T}}$,

— yaw articulation angle between towing vehicle and trailer, $\Delta\psi$.

The following should be measured:

— yaw velocity of the towing vehicle, $\frac{\mathrm{d}\psi_C}{\mathrm{d}t}$;

— yaw velocity of the trailer, $\frac{\mathrm{d}\psi_T}{\mathrm{d}t}$.

NOTE These variables are not intended to comprise a complete list.

5 General conditions

5.1 Conformity

The general conditions of the test shall be in accordance with ISO 15037-1, with the additions and exceptions given in this clause.

5.2 Measuring equipment

The measurement variables given in Clause 4 shall be monitored using appropriate transducers. Typical operating ranges and recommended maximum errors for variables are given in Table 1.

A steering-wheel stop or marking may be used. The use of a steering machine is optional.

Table 1 — Variables, operating ranges and recommended maximum errors

Variable	Typical operating range	Recommended maximum error (of combined transducer/recorder system)
Articulation angle	±20°	±0,2°

5.3 Test track

In addition to the test track requirements of ISO 15037-1, the mean gradient of the test track along the path of the vehicle, $\bar{G}$, shall be within the range ±0,01. $\bar{G}$ shall be recorded for each test run. See 6.2.1 and 7.2.1 for related requirements. In addition, the test surface shall be maintained over a track with a minimum width of 8 m. An increased run-off area should be provided in addition to the specified test surface.

Yaw damping of articulated vehicles is sensitive to the longitudinal slope of the test track. The test should therefore be conducted in both directions whenever $\bar{G}$ approaches the allowed maximum.

5.4 Wind velocity

Wind velocity shall be in accordance with ISO 15037-1 and, in addition, should not exceed 2,5 m/s.

5.5 Loading conditions

5.5.1 Towing vehicle

The total mass of the towing vehicle shall consist of the complete vehicle kerb mass (ISO 1176, code ISO-M06) plus driver and instrumentation (combined mass should not exceed 150 kg). The location of the instrumentation shall be such as to minimize its effect on the yaw moment of inertia of the towing vehicle.

The tests should be repeated at a maximum loading condition of the towing vehicle, at other loading conditions of interest, or both. For the maximum loading condition, the total mass of a fully laden vehicle shall consist of the complete vehicle kerb mass plus 68 kg for each seat in the passenger compartment, with the static load at the coupling ball and the remaining maximum luggage mass equally distributed over the luggage compartment in accordance with ISO 2416. Loading of the passenger compartment shall be such that the actual wheel loads are equal to those obtained by loading each seat with 68 kg in accordance with ISO 2416. The mass of instrumentation shall be included in the vehicle mass. Care shall be taken to ensure that the moments of inertia are representative of the loading conditions of the vehicle in normal use.

The total mass of the fully laden towing vehicle, including the equivalent mass of the static load at the coupling ball, shall not exceed the maximum design total mass (ISO 1176, code ISO-MO7), nor shall the front and rear axle loads exceed their respective maximum design values with the load applied at the coupling ball. If a load-distributing coupling is used, these axle loads should be assessed after engagement of the load-distributing mechanisms (see 5.5.4), except where this is counter to the recommendations of the manufacturer of the towing vehicle.

5.5.2 Trailer

The trailer shall be loaded to its maximum authorized total mass (ISO 1176, code ISO-M08) or until the maximum design mass of vehicle combination (ISO 1176, code ISO-M18) is reached, whichever is the lesser of the two masses. If the type of trailer allows various load distributions, the load shall be distributed in such a way as to produce realistic and representative values of the yaw moment of inertia, centre-of-gravity height and the static load at the coupling ball (see 5.5.3).

Optionally, tests may also be carried out with any other towed mass of interest.

The mass, centre-of-gravity position and yaw moment of inertia of the trailer as tested shall be measured and noted in the general data (see Annex A). Alternatively, a description of the loading condition, adequate to reproduce these properties with reasonable accuracy, shall be provided.

5.5.3 Static load on the coupling ball

Tests shall be carried out with the maximum permissible static load on the coupling ball as determined by the maximum coupling load allowable for the towing vehicle, the trailer or the coupling itself, whichever is the smallest. However, it is necessary to reduce further the static load on the coupling ball if it causes the load on the rear axle of the towing vehicle to exceed the maximum design load as specified by the manufacturer of the towing vehicle. Unless it is counter to the recommendations of that manufacturer, the rear-axle load is to be assessed after the engagement of any load-distributing mechanism at the coupling.

The fraction of the weight of the trailer carried as static load on the hitch has an important influence on the yaw damping of the vehicle combination. Typically, damping decreases as static load on the hitch decreases. Therefore, tests should also be carried out with the minimum permissible static load at the coupling ball (see ISO 1176).

5.5.4 Adjustment of load-distributing coupling mechanisms

When trailer mass is large, load-distributing couplings are often used to restore the pitch angle exhibited by the towing vehicle prior to the application of a static load on the coupling. The addition of this moment redistributes some of the coupling static load from the rear tyres to the front tyres of the towing vehicle and the trailer tyres. This increases the articulation-angle damping but reduces the understeer of the towing vehicle with lateral acceleration.

The load-distributing coupling often includes a mechanism for adding articulation-angle damping. The coupling and auxiliary friction devices should be installed and adjusted according to the towing vehicle, trailer and coupling manufacturers' recommendations.

In the absence of manufacturers' recommendations for the use of load-distributing coupling, the following procedure should be followed: Before attaching the trailer, measure the vertical distance from points on the vehicle body to the ground at the centre lines of the front and rear axles of the towing vehicle, with the vehicle loaded as intended for testing. After attaching the trailer, adjust the coupling moment so the resulting overall changes in these two vertical distances are the same within 10 mm.

If recommendations for static loading conditions are not available for the load-distributing coupling, static load can be based upon the recommendation of Reference [3], which is that coupling load should be 8,4 % of the weight of the towing vehicle.

NOTE With multi-axle trailers, the force required to support the tongue can increase as the height of the tongue is increased. As a result, proper set-up of the static load on the coupling ball and coupling moment can be an iterative process.

The coupling moment should be recorded for the test configuration. For this, the front and rear axle loads of the towing vehicle should be measured once without the trailer attached (to determine the weight of the towing vehicle) and once with the trailer attached and the load-distributing coupling adjusted. The axle loads shall be measured with the trailer and towing vehicle on a flat surface. If the contact patches of the towing-vehicle and trailer tyres are not in the same plane, the coupling moment is altered.

The moment due to a load-distributing coupling, M_{Yeq}, can be calculated as follows:

$$M_{Yeq} = F_{ZwfC}(l_C + e_C) + F_{ZwrC}(e_C) + m_C(d_C + e_C)$$

where

- F_{ZwfC} is the sum of the loads on the front wheels of the towing vehicle with the trailer attached and load-distributing coupling engaged;
- F_{ZwrC} is the sum of the loads on the rear wheels of the towing vehicle with the trailer attached and load-distributing coupling engaged;
- g is the gravitational acceleration;
- m_C is the mass of the towing vehicle;
- l_C is the wheelbase of the towing vehicle;
- d_C is the longitudinal distance between the centre of gravity of the towing vehicle and the centreline of the rear axle of the towing vehicle;
- e_C is the rear overhang, the longitudinal distance between the spindle axis of the rear axle and the centre of the coupling ball.