BS ISO 9815:2010

BSI Standards Publication

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

National foreword

This British Standard is the UK implementation of ISO 9815:2010. It supersedes BS ISO 9815:2003 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee AUE/15, Safety related to vehicles.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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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

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 9815 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 9, *Vehicle dynamics and road-holding ability*.

This third edition cancels and replaces the second edition (ISO 9815:2003), which has been technically revised.

Introduction

The main purpose of this International Standard 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 International Standard 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 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 4138:2004, *Passenger cars — Steady-state circular driving behaviour — Open-loop test methods*

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

ISO 15037-1:2006, *Road vehicles — Vehicle dynamics test methods — Part 1: General conditions for passenger cars*

3 Terms, definitions and symbols

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

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 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 $t_{\Delta\psi m}$, respectively

For t_2 and $t_{\Delta\psi m}$, see 6.2.2 and 7.2.3, respectively.

NOTE 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_{XT},

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

The following should be measured:

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

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

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

5 General conditions

5.1 Compliance

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. The requirements of ISO 15037-1 regarding measurement and recording equipment shall be applied to both towing vehicle and trailer. Typical operating ranges and recommended maximum errors for variables not considered by ISO 15037-1 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 — Addendum to ISO 15037-1:2006, Table 1

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, $\overline{G}$, shall be within the range ± 0,01. $\overline{G}$ 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.

Inasmuch as yaw damping of articulated vehicles is known to be sensitive to the longitudinal slope of the test track, the test should be conducted in both directions whenever $\overline{G}$ 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 or at other loading conditions of interest or all these. 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/TR 4114[1]).

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. Prior to the attachment of 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 such that 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 [2], 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 may 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, $M_{Y\text{eq}}$, can be calculated as follows:

$$M_{Y\text{eq}} = F_{Z\text{wfC}}\,(l_\text{C} + e_\text{C}) + F_{Z\text{wrC}}\,(e_\text{C}) - m_\text{C} g\,(d_\text{C} + e_\text{C})$$

where

$F_{Z\text{wfC}}$ is the sum of the loads on the front wheels of the towing vehicle with the trailer attached and load-distributing coupling engaged;

$F_{Z\text{wrC}}$ 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 constant;

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.

6 Test method

6.1 General

Prior to testing, the vehicle shall be warmed up, and each test run shall be initiated from a steady-state, straight-ahead driving condition, in accordance with ISO 15037-1.

6.2 Test runs

6.2.1 Speed

The first specified test speed shall be 50 km/h. Thereafter, the specified test speed shall be increased incrementally. At speeds where damping (see 7.2.3) is $\geqslant$ 0,15, the increment shall be $\leqslant$ 10 km/h. In speed ranges where damping is less than 0,15, the increment shall be $\leqslant$ 5 km/h. The highest specified speed shall be at least 90 % of the calculated zero-damping speed (see 7.3).

Precautions should be taken with combinations expected to have low levels of damping. In such cases, initial exploratory test runs should be made at speeds lower than 50 km/h; when appropriate, the initial specified speed may be less than 50 km/h.

Test speeds shall be maintained in accordance with ISO 15037-1:2006, 6.2.1 throughout the run (i.e. from t_1 in accordance with ISO 15037-1 to $t_{\Delta\psi n}$ in accordance with 7.2.3 of this International Standard). Moreover, during the time period from t_2 (see 6.2.2) to $t_{\Delta\psi n}$ (see 7.2.3) of each test run, the mean of the longitudinal acceleration shall be between $\pm$ 0,1 m/s^2. See 5.3 and 7.2.1 for related requirements.

6.2.2 Steering impulse

The yaw oscillation of the towing vehicle and trailer combination shall be initiated by an impulse displacement of the steering wheel.

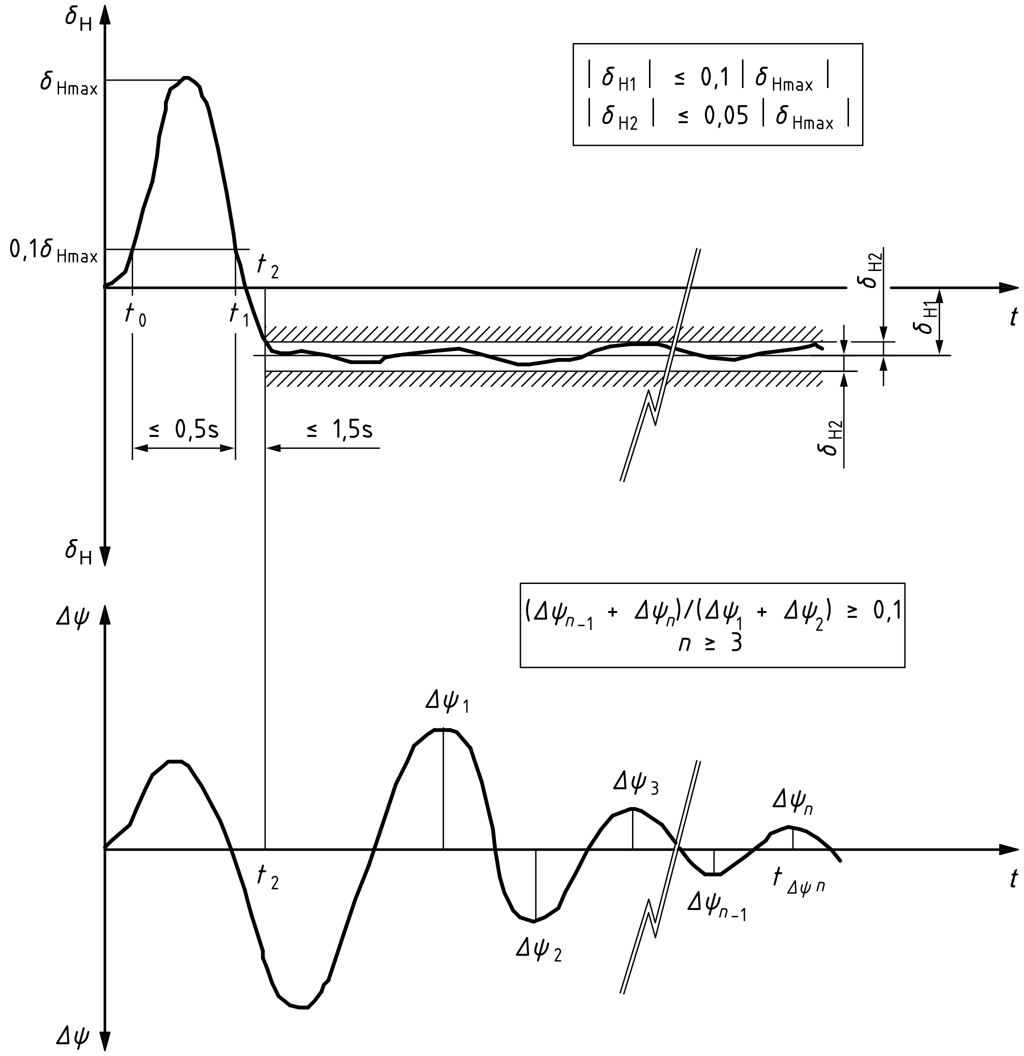
Wherever practical, the amplitude of the steering impulse shall be that required to produce a maximum amplitude of lateral acceleration at the centre of gravity of the trailer of (4 $\pm$ 1) m/s^2. In cases where it is not practical to attain (4 $\pm$ 1) m/s^2, the steering pulse should be that required to produce the maximum lateral acceleration reasonably attainable at the centre of gravity of the trailer. The maximum amplitude of lateral acceleration at the centre of gravity of the trailer that is actually attained shall be recorded in the test report (see Annex B).

Referring to the example time histories of steering-wheel angle presented in Figures 1 and 2:

t_0 is the time, in seconds, at which the amplitude of the steering-wheel angle first exceeds 10 % of its maximum amplitude;

t_1 is the time, in seconds, following the occurrence of the peak, at which the amplitude of the steering-wheel angle first decreases to 10 % of its maximum amplitude;

t_2 is the time, in seconds, after which the steering-wheel angle remains within the limits of the tolerance demand (i.e. $\pm\ \delta_{H2}$ about the mean).



Key

t time

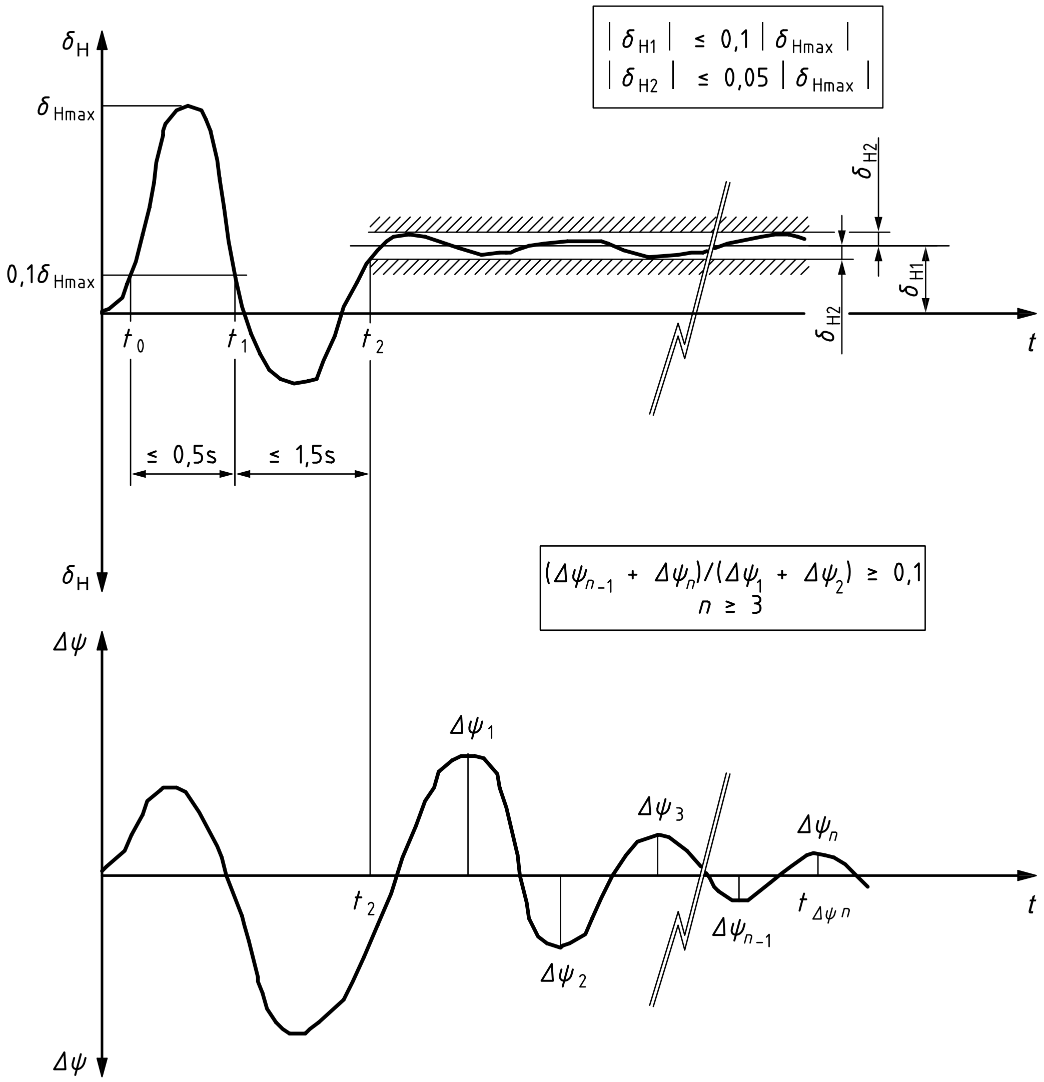
δ_H steering-wheel angle

$\Delta\psi$ articulation angle

Figure 1 — Time histories of steering-wheel and articulation angles — Type 1

The duration of the steering impulse (i.e. the time period from t_0 to t_1) shall not exceed 0,5 s.

The steering impulse may be completed by returning the steering wheel directly to its initial position as in Figure 1 or by applying a subsequent steering correction in the opposite direction as in Figure 2 in order that the towing vehicle may regain its initial path. After the steering impulse and any subsequent correction, the steering wheel shall be held fixed in the straight-ahead position. The duration ($t_2 - t_1$) of any steering correction shall not exceed 1,5 s. Starting from time t_2, the amplitude of the mean deviation of the steering-wheel angle from the straight-ahead position, $|\delta_{H1}|$, shall not exceed 10 % of the amplitude of the initial steering impulse. The maximum amplitude of the deviations about this mean, $|\delta_{H2}|$, shall not exceed 5 % of the amplitude of the initial steering impulse.



Key

t time

δ_H steering-wheel angle

$\Delta\psi$ articulation angle

Figure 2 — Time histories of steering-wheel and articulation angles — Type 2

6.2.3 Number of test runs

At least five valid test runs shall be carried out within each 10 km/h range between the minimum test speed and 90 % of the zero-damping speed, v_{zd} (see 7.3). At least three valid test runs shall be carried out at speeds $>$ 90 % of the actual v_{zd}.

7 Data analysis

7.1 General

Because of the large amount of data, computer analysis should be used.

The recorded time history of the articulation angle shall be displayed and examined visually. Results that are considered not to be representative shall be discarded.

7.2 Individual test runs

7.2.1 Effective longitudinal vehicle acceleration

The effective longitudinal vehicle acceleration, a_E, in metres per second per second, shall be determined for each test run. This quantity is the mean value of the sum of the longitudinal acceleration of the towing vehicle (i.e. the change in longitudinal velocity of the towing vehicle per unit time) and the mean longitudinal component of gravitational acceleration experienced by the vehicle due to the gradient of the test track. Effective longitudinal vehicle acceleration is determined as follows:

$$a_E = \frac{v_x\left(t_{\Delta\psi n}\right) - v_x\left(t_2\right)}{t_{\Delta\psi n} - t_2} + \bar{G}\, g$$

where

- g is the gravitational constant, in metres per second per second;
- $v_x(t_i)$ are the speeds, $\Delta\psi_n$, and $i = 2$, in metres per second per second, of the towing vehicle at times $t_{\Delta\psi n}$ and t_2, respectively;
- $t_{\Delta\psi n}$ is in accordance with 7.2.3.

The value of a_E shall be within the range of $\pm$ 0,1 m/s^2 for the test run to be valid. It is desirable that the average of the values of a_E for all runs at a given, predetermined test speed be within the range $\pm$ 0,05 m/s^2. In any case, the value of a_E shall be reported for each test.

7.2.2 Test speed

The test speed, $\bar{v}$, shall be determined for each test run using the equation:

$$\bar{v} = \frac{\int_{t=t_2}^{t_{\Delta\psi n}} v_x \mathrm{d}t}{t_{\Delta\psi n} - t_2}$$

7.2.3 Damping the oscillation of the articulation angle

Referring to the example time histories of the articulation angle presented in Figures 1 and 2:

- $\Delta\psi_1$ is the amplitude of the first peak occurring after the first zero crossing after the time t_2 (which is typically the third peak);
- $\Delta\psi_n$ is the amplitude of the last peak for which the value ($\Delta\psi_{n-1} \pm \Delta\psi_n$) is at least 10 % of the value ($\Delta\psi_1 \pm \Delta\psi_2$);
- $\Delta\psi_2$ to $\Delta\psi_{n-1}$ are the amplitudes of the successive peaks occurring between the peaks defining $\Delta\psi_1$ and $\Delta\psi_n$;
- $t_{\Delta\psi n}$ is the time, in seconds, at which $\Delta\psi_n$ occurs.

All amplitudes $\Delta\psi_1$ to $\Delta\psi_n$ and the time $t_{\Delta\psi n}$ shall be determined from the time history of the articulation angle.

NOTE All amplitudes from $\Delta\psi_1$ to $\Delta\psi_n$ are positive values.

The mean value of the amplitude ratios, $\bar{r}$, shall be calculated using the equation:

$$\bar{r} = \frac{1}{n-2}\left(\frac{\Delta\psi_1 + \Delta\psi_2}{\Delta\psi_2 + \Delta\psi_3} + \frac{\Delta\psi_2 + \Delta\psi_3}{\Delta\psi_3 + \Delta\psi_4} + \frac{\Delta\psi_3 + \Delta\psi_4}{\Delta\psi_4 + \Delta\psi_5} + \ldots + \frac{\Delta\psi_{n-2} + \Delta\psi_{n-1}}{\Delta\psi_{n-1} + \Delta\psi_n}\right)$$

The damping, D, is calculated according to

$$D = \frac{\ln\bar{r}}{\sqrt{\pi^2 + (\ln\bar{r})^2}}$$

The calculation of $\bar{r}$ should be based upon at least seven amplitudes (i.e. $n \geqslant 7$). If this is not practicable, it should be so noted and the value of n reported along with that of D.

7.2.4 Yaw velocity ratio

When the yaw velocity of the towing vehicle and of the trailer are measured, the mean yaw velocity ratio shall be calculated according to the equation:

$$R_{\mathrm{d}\psi/\mathrm{d}t} = \frac{1}{n-1}\left(\frac{\mathrm{d}\psi_{\mathrm{C}1}/\mathrm{d}t + \mathrm{d}\psi_{\mathrm{C}2}/\mathrm{d}t}{\mathrm{d}\psi_{\mathrm{T}1}/\mathrm{d}t + \mathrm{d}\psi_{\mathrm{T}2}/\mathrm{d}t} + \frac{\mathrm{d}\psi_{\mathrm{C}2}/\mathrm{d}t + \mathrm{d}\psi_{\mathrm{C}3}/\mathrm{d}t}{\mathrm{d}\psi_{\mathrm{T}2}/\mathrm{d}t + \mathrm{d}\psi_{\mathrm{T}3}/\mathrm{d}t} + \frac{\mathrm{d}\psi_{\mathrm{C}3}/\mathrm{d}t + \mathrm{d}\psi_{\mathrm{C}4}/\mathrm{d}t}{\mathrm{d}\psi_{\mathrm{T}3}/\mathrm{d}t + \mathrm{d}\psi_{\mathrm{T}4}/\mathrm{d}t} + \ldots + \frac{\mathrm{d}\psi_{\mathrm{C}(n-1)}/\mathrm{d}t + \mathrm{d}\psi_{\mathrm{C}n}/\mathrm{d}t}{\mathrm{d}\psi_{\mathrm{T}(n-1)}/\mathrm{d}t + \mathrm{d}\psi_{\mathrm{T}n}/\mathrm{d}t}\right)$$

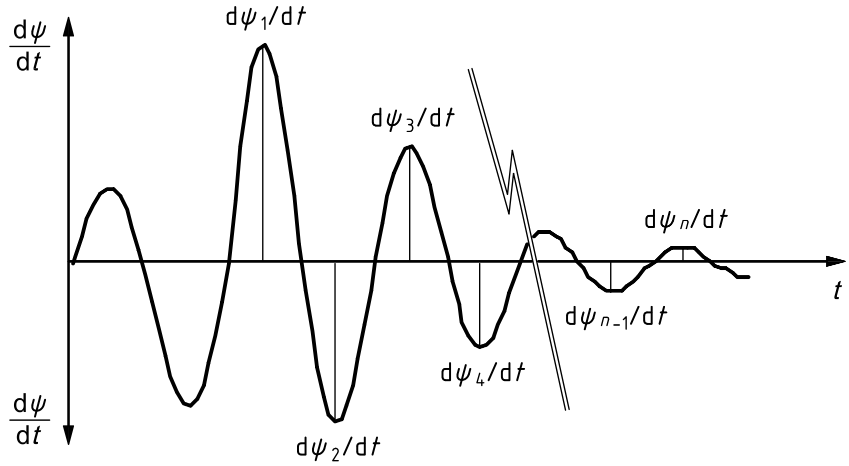
where

$\mathrm{d}\psi_{\mathrm{C}i}/\mathrm{d}t$ are the peak amplitudes, for $i = 1 \ldots n$, of the yaw velocity of the towing vehicle;

$\mathrm{d}\psi_{\mathrm{T}i}/\mathrm{d}t$ are the peak amplitudes, for $i = 1 \ldots n$, of the yaw velocity of the trailer.

The subscripts 1 to n imply amplitudes at successive peaks in the same manner as is shown in Figure 3.

NOTE All amplitudes $\mathrm{d}\psi_{\mathrm{C}i}/\mathrm{d}t$ and $\mathrm{d}\psi_{\mathrm{T}i}/\mathrm{d}t$ are positive values.



Key

t time

$\frac{d\psi}{dt}$ yaw velocity

Figure 3 — Time history of yaw velocity

7.3 Zero-damping speed

The zero-damping speed is the speed at which damping equals zero. It shall be determined from the plotted values of damping, D, versus test speed, $\bar{v}$, presented in the form of the figure given in Annex B. A straight line representing the best fit to the data shall be determined by regression of the data to the following form:

$$D = C_0 + C_1 \bar{v}$$

where

C_0 is a dimensionless regression coefficient;

C_1 is a regression coefficient, expressed in hours per kilometre.

The value of $\bar{v}$ corresponding to D = 0 is the zero-damping speed, v_{zd}, i.e.

$$v_{zd} = -\frac{C_0}{C_1}$$

At least three test runs shall have been performed in which the test speed, $\bar{v}$, was at least 90 % of the zero-damping speed resulting from this calculation. If this requirement is not met or if, for safety reasons, driving at 90 % of the zero-damping speed is not feasible, the designation “zero-damping speed” shall not be used in the presentation of results (see Annex B).

7.4 Reference-damping speed

Reference-damping speed is the speed that results in a damping level of 0,05. The value of $\bar{v}$ corresponding to $D = 0{,}05$ is the reference-damping speed, $v_{0,05}$. It shall be determined using the equation:

$$v_{0,05} = \frac{0{,}05 - C_0}{C_1}$$

7.5 Reference-speed damping

Reference-speed damping, D_{80}, is the damping that exists when the vehicle speed is 80 km/h. It shall be determined using the equation:

$$D_{80} = C_0 + 80C_1$$

8 Data presentation

8.1 General data

General data describing the test vehicles shall be reported in accordance with ISO 15037-1:2006, Annex A and Annex A of this International Standard. The relevant sections of ISO 15037-1:2006, Annex A shall be completed for the towing vehicle. The three items in that annex that are influenced by the loading condition, i.e. measured wheel loads, overall height at test mass (towing vehicle only) and height of the centre of gravity (towing vehicle only), shall be recorded twice — once as they exist for the towing vehicle without the trailer attached and once as they exist for the towing vehicle with the trailer attached.

8.2 Test conditions

The test conditions shall be reported in accordance with ISO 15037-1:2006, Annex B. The entries related to tyres in that annex shall be expanded to include the tyres of the trailer as well as the tyres of the towing vehicle.

8.3 Results

Results of the tests shall be presented in accordance with Annex B of this International Standard. This includes tabular presentation of the results from each run and graphical presentation of articulation-angle damping, D, as a function of test speed, $\overline{v}$.

Annex A
(normative)

Test report — General data
(supplement to ISO 15037-1:2006, Annex A)

Coupling device on towing vehicle

Identification

Manufacturer: ....

Model/year of manufacture: ....

Standard type/standards organization: ....

Masses and loads

Maximum permissible trailer mass: .... kg

Maximum permissible vertical load: .... N

Vertical load as tested: .... N

Coupling moment: .... N·m

Dimensions

Rear overhang (e_c)[1]: .... mm

Height of the centre of the coupling ball

on towing vehicle without trailer: .... mm

on towing vehicle with trailer: .... mm

General comments and other relevant details: ....

....

....

....

Trailer

Identification

Vehicle identification number: ....

Type of trailer: ....

Manufacturer: ....

Model: ....

Model year/1st registration date: ....

Suspension

Manufacturer/model: ....

Type: ....

....

Number of axles: ....

Axle spacing (axle 1 to 2; axle 2 to 3): .... mm

Springs: ....

Dampers: ....

Stabilizer/anti-roll bar: ....

1) This is the longitudinal distance between the spindle axis of the rear axle and the centre of the coupling ball.

Wheels	Number of wheels: ....
	Rim size: ....
Tyres	Size: ....
	Make and type: ....
	Tread depth (new): .... mm
	Inflation pressure, according to the trailer manufacturer's specifications
	— at trailer kerb mass: .... kPa
	— at maximum permissible total mass: .... kPa
Masses and loads	Trailer kerb mass: .... kg
	Maximum permissible trailer mass: .... kg
	Maximum permissible suspension load: .... N
	Maximum permissible coupler load: .... N
	Wheel loads as tested[2]: 1L .... N 1R .... N
	2L .... N 2R .... N
	3L .... N 3R .... N
	Coupler load as tested[2]: .... N
	Yaw moment of inertia: .... kgm^2
Dimensions	Overall length: .... mm
	Overall width: .... mm
	Overall height: .... mm
	Body length: .... mm
	Wheelbase[3]: .... mm
General comments and other relevant details:	....
	....
	....
	....

Coupling device on trailer

Identification	Manufacturer: ....
	Model/year of manufacture: ....
	Standard type/standards organization: ....
Masses and loads	Maximum permissible trailer mass: .... kg
	Maximum permissible vertical load: .... N
	Vertical load as tested: .... N
	Coupling moment: .... N·m

2) With trailer loaded and coupled to the loaded car.

3) The longitudinal distance from the centre of the coupling ball to the vertical plane equidistant between the first and last axles of the trailer.

General comments and other relevant details: ....

....

....

....

Annex B
(normative)

Test results

Table of results

Towing-vehicle identification: .... Date of testing: ....

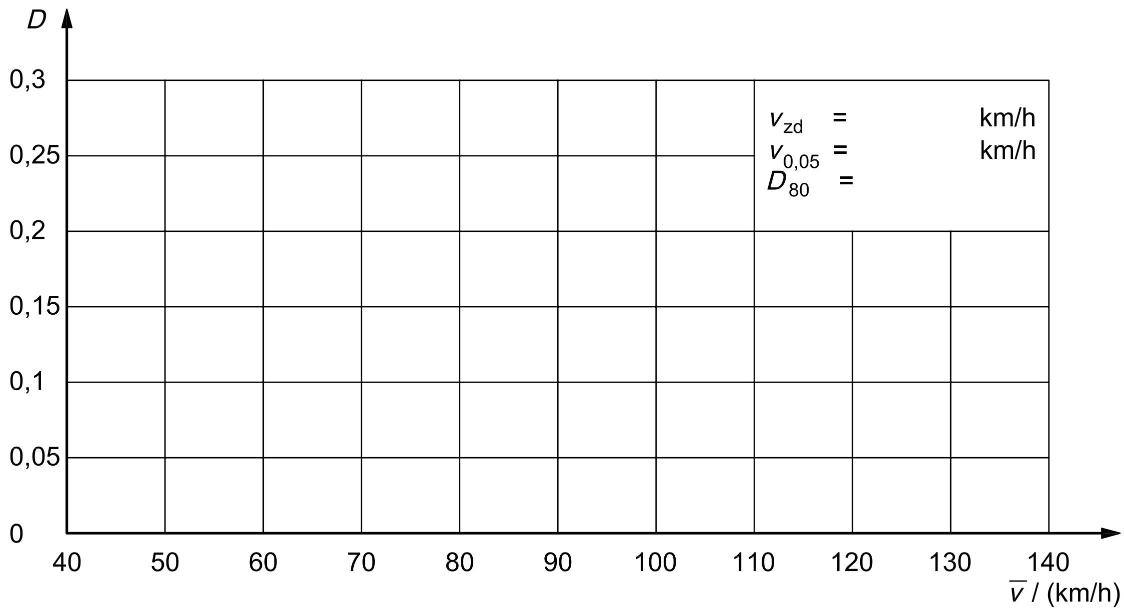
Trailer identification: ....

Run No.	$\overline{G}$	a_E m/s^2	$\overline{v}$ km/h	Max. $\lvert a_{YT} \rvert$ m/s^2	D	n	$R_{\psi\dot{Y}}$

Damping characteristics of articulation angle

Towing-vehicle identification: .... Date of testing: ....

Trailer identification: .... Run numbers: ....



Key

D damping

$\overline{v}$ test speed

Annex C
(normative)

Steady-state behaviour

Where non-periodic instability is of interest, a steady-state circular test shall be performed in accordance with ISO 4138.

In this case, the articulation angle between the towing vehicle and the trailer should be measured.

The combination shall be instrumented in accordance with Clause 4.

The trailer shall be loaded in accordance with 5.5.2 with a static load at the coupling ball as in 5.5.3. The data presentation shall include the articulation-angle data points, if measured. They shall be plotted in a figure corresponding to that in ISO 4138:2004, Annex A.

For presentation of general data, the forms of ISO 15037-1:2006, Annex A, and Annex A of this International Standard shall be used.

Bibliography

[1] ISO/TR 4114, *Road vehicles — Caravans and light trailers — Static load on ball couplings*

[2] KLEIN, R.H., SZOSTAK, H.T. Development of maximum allowable hitch load boundaries for trailer towing. Systems Technology, Inc., Hawthorne, California 1980, 10 p. *Recreational vehicle dynamics*, Warrendale: SAE, Feb 1980, pp. 53-62. Also, SAE paper 800157

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