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Heavy commercial vehicles and buses — Vehicle dynamics simulation and validation — Lateral dynamic stability of vehicle combinations

Véhicules utilitaires lourds et autobus — Dynamique du véhicule simulation et validation — Stabilité latérale des véhicules articulés

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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 and chassis components*.

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Introduction

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

The dynamic behaviour of a road vehicle is a most important aspect 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 is therefore very complicated, since the significant interaction of these driver-vehicle-road elements are each complex in themselves. A complete and accurate description of the behaviour of the road vehicle will inevitably involve information obtained from a number of different tests.

Since this test method quantifies only one small part of the complete handling characteristics, the results of this test can only be considered significant for a correspondingly small part of the overall dynamic behaviour.

Moreover, insufficient knowledge is available to correlate overall vehicle dynamic properties with accident prevention. A substantial amount of work is necessary to acquire sufficient and reliable data on the correlation between accident prevention and vehicle dynamic properties in general and the results of this test in particular. Consequently, proven correlation between test results and accident statistics is used for any application of this test method for regulation purposes.

Test conditions and tyres have a strong influence on test results. Therefore, only results obtained under comparable test and tyre conditions are comparable.

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Heavy commercial vehicles and buses — Vehicle dynamics simulation and validation — Lateral dynamic stability of vehicle combinations

1 Scope

This document specifies a method for comparing simulation results from a vehicle model to measured test data for an existing vehicle combination's lateral stability according to driving tests as specified in ISO 14791. The comparison is made for the purpose of validating the simulation model for this type of test. A complete validation comprises the comparison for at least one tested vehicle and one variant of this vehicle, covered by a parameter variation in the vehicle model.

The document applies to heavy vehicles, including commercial vehicles, commercial vehicle combinations, buses and articulated buses as defined in ISO 3833 (trucks and trailers with maximum weight above 3,5 tonnes and buses and articulated buses with maximum weight above 5 tonnes, according to ECE and EC vehicle classification, categories M3, N2, N3, O3 and O4).

2 Normative references

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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.

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ISO 14791:2000, *Road vehicles — Heavy commercial vehicle combinations and articulated buses — Lateral stability test methods*

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

ISO 15037-2:2002, *Road vehicles — Vehicle dynamics test methods — Part 2: General conditions for heavy vehicles and buses*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 8855, ISO 15037-2 and the following apply.

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

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

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

3.1
simulation
calculation of motion variables of a vehicle from equations in a mathematical model of the vehicle system

3.2
basic vehicle parameters
parameters not subject to model fitting, which are directly and accurately measurable on the test vehicle

EXAMPLE Masses and dimensions.

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3.3
estimated vehicle parameters
parameters that may be used for model fitting, which are typically hard to be determined

EXAMPLE Mass moment of inertia and tyre characteristics.

3.4
vehicle model validity range
basic vehicle parameters (3.2) which may be changed if the type of vehicle combination and tyre type are maintained

Note 1 to entry: For example, when wheel base is modified some of the estimated parameters may need to be updated accordingly.

4 Principle

The pseudo random and the single sine wave steering input according to ISO 14791 is used to determine lateral stability by calculating the rearward amplification (RA) and yaw damping (D) of heavy commercial vehicles and buses as defined in ISO 3833. Within this document, the purpose of the test is to demonstrate that a vehicle model can predict the vehicle behaviour within specified tolerances. The vehicle model is used to simulate a specific existing vehicle running tests as specified in ISO 14791. The maximum lateral acceleration in the first vehicle unit is limited to a conservative value to assure linear behaviour of the vehicle combination. The characteristic values from model results and physical testing are compared for validating the model. In this document a tolerance is given for when the model is valid. The tolerance depends upon the physical testing variation in repeatable results and the uncertainty in the input data to the model. The validated model can also be used for the single sine wave lateral acceleration input as specified in ISO 14791. The experimental variation sets the bounds within which the model is validated.

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When the vehicle model is used outside its validity range, for example changing vehicle combination type or changing tyre parameters, a new validation is required. For proving good reliability of the simulation results, it is recommended to repeat the process of comparing simulation and measurement results for different vehicle parameters, for example laden conditions and vehicle longitudinal velocity.

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5 Variables

The variables of motion used to describe the behaviour of the vehicle shall be related to the reference axis system (X, Y, Z) of the first vehicle unit (see ISO 8855) with the reference point as described in 3.1. The variables that shall be determined for conformance with this document are:

— longitudinal velocity, v_x;

— steering-wheel angle, δ_H;

— yaw velocity of the first vehicle unit and yaw velocity of each vehicle unit, ω_z;

— lateral acceleration of the front axle of the first vehicle unit at or below the height of the wheel centre, a_y.

It is recommended that the following variables are also determined:

— yaw angle of the first vehicle unit, ψ;

— lateral acceleration in the centre of gravity of each vehicle unit, a_y;

— articulation angles, $\Delta\psi$.

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6 Minimum vehicle model parameters and requirements

6.1 General

In this document, the vehicle model shall be able to predict lateral dynamic behaviour in the linear range, well below physical limits of performance as specified in ISO 14791. The minimum level of complexity is a single-track model with lateral slip behaviour. This clause will define a minimum level of requirements for the model's parameters. More detailed vehicle models can be used but they shall show that they meet the parameter requirements as specified in this document.

6.2 Basic vehicle parameters

The basic vehicle parameters shall not have larger errors between the vehicle model and the physical vehicle combination than the errors shown in Table 1.

Table 1 — Parameters, typical usage ranges and recommended maximum estimation errors between vehicle model and physical vehicle combination

Basic vehicle model parameter	Recommended maximum error between model and physical vehicle combination
Axle and coupling positions with front axle as reference	±0,02 m
Axle and coupling loads	±100 kg
Vehicle unit mass	±200 kg

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To receive an accurate centre of gravity position in longitudinal direction, each vehicle unit in the vehicle combination with significant vertical force in joint couplings between units, such as fifth wheel on tractor or converter dolly, shall also be measured separately on the weighting scale.

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6.3 Estimated vehicle parameters

The critical vehicle parameters shall be within the error range as shown in Table 2. The recommended method for estimating the yaw inertia is to use evenly distributed payload on the load carrying vehicle units. In combination with chassis inertia, the total yaw inertia per vehicle unit can be derived with Steiner's theorem.

The lateral tyre characteristics are an important vehicle model parameter when calculating lateral dynamics. The nominal value is usually provided by tyre supplier or measured. The lateral tyre characteristics shall be normal load dependent to allow basic vehicle parameter change of axle load.

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