INTERNATIONAL STANDARD

ISO 15037-3

First edition
2022-05

Road vehicles — Vehicle dynamics test methods —

Part 3: General conditions for passenger cars ride comfort tests

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

Partie 3: Conditions générales pour les essais de confort de conduite des voitures particulières

STANDARDSISO.COM : Click to view the full PDF of ISO 15037-3:2022

Reference number
ISO 15037-3:2022(E)

© ISO 2022

STANDARDSISO.COM : Click to view the full PDF of ISO 15037-3:2022

COPYRIGHT PROTECTED DOCUMENT

© ISO 2022

All rights reserved. Unless otherwise specified, or required in the context of its implementation, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

Page

STANDARDSISO.COM : Click to view the full PDF of ISO 15037-3:2022

© ISO 2022 – All rights reserved

STANDARDSISO.COM : Click to view the full PDF of ISO 15037-3:2022

 © ISO 2022 – All rights reserved

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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

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

A list of all parts in the ISO 15037 series can be found on the ISO website.

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.

STANDARDSISO.COM : Click to view the full PDF of ISO 15037-3:2022

Introduction

This document was developed to define general test conditions for passenger-cars ride comfort tests. Any given vehicle, together with its driver and the prevailing environment, constitutes a unique closed-loop system. 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 test results obtained at identical test conditions and environment are comparable.

STANDARDSISO.COM : Click to view the full PDF of ISO 15037-3:2022

© ISO 2022 – All rights reserved

Road vehicles — Vehicle dynamics test methods —

Part 3:
General conditions for passenger cars ride comfort tests

1 Scope

This document specifies the general conditions that apply to vehicle ride comfort test methods.

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 reports (general data and test conditions).

These items are of general significance, regardless of the specific vehicle ride comfort test method. They apply when vehicle ride comfort properties are determined, unless other conditions are required by the standard which is actually used for the test method.

This document is applicable to passenger cars as defined in ISO 3833 and light trucks.

NOTE The general conditions defined in existing vehicle dynamics standards are valid until a reference to this document is included.

This document mainly refers to road tests, but in many cases can be applied also for bench tests.

STANDARDSISO.COM : Click to view the full PDF of ISO 15037-3:2022

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 1176, *Road vehicles — Masses — Vocabulary and codes*

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*

3 Terms and definitions

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

© ISO 2022 – All rights reserved

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

4 Variables

4.1 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).

4.2 Variables to be determined

To describe the vehicle ride comfort in terms of vehicle response, the principal relevant variables are the following:

— general vehicle dynamics variables, as defined in ISO 8855:

  — longitudinal velocity (v_X);

  — roll velocity ($\mathrm{d}\varphi/\mathrm{d}t$);

  — pitch velocity ($\mathrm{d}\theta/\mathrm{d}t$);

  — roll angle (φ);

  — pitch angle (θ);

— whole-body vibrations (WBV), like accelerations on hands, feet, pelvis and back;

— accelerations on the unsprung masses (i.e. on hubs, etc.);

— accelerations on the sprung mass:

  — outside the cockpit (i.e. on suspension attachments points, etc.);

  — inside the cockpit (i.e. on steering wheel, seat rail, drive floor, etc.);

— accelerations in the engine compartment.

All standards that make reference to this document shall specify which variables apply. Depending on the specific standard, additional variables can be required or recommended.

NOTE These variables can be determined directly by measuring or by calculation from measured values.

5 Measuring equipment

5.1 Description

Time histories of the measured variables shall be recorded by a time-based multi-channel recording system by means of appropriate transducers (see Annex C). Typical operating ranges and recommended maximum errors of the transducer and recording system are shown in Table 1. The specified accuracies should be achieved whether the variables are measured or are calculated. In Table 1 there are also the typical temperature operating ranges and the recommended transducers' IP code (the classification of degrees of protection provided by enclosures for electrical equipment from external influences or conditions like dirt and water).

STANDARDSISO.COM : Click to view the full PDF of ISO 15037-3:2022

 © ISO 2022 – All rights reserved

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

Variable	Axes	Typical operating range	Recommended maximum "overall" error	Temperature operating range	Recommended IP (IEC 60529)
Velocity	X	0 km/h to 180 km/h	±1 km/h for v_X < 100 km/h ±2 km/h for v_X > 100 km/h	-10/+40 °C	1st digit: 5 or higher 2nd digit: 1 or higher
Pitch velocity	Y	−50°/s to 50°/s	±0,3°/s for $d\theta/dt$ < 20°/s ±1°/s for $d\theta/dt$ > 20°/s	-10/+40 °C	1st digit: 5 or higher 2nd digit: 1 or higher
Roll velocity	X	−50°/s to 50°/s	±0,3°/s for $d\varphi/dt$ < 20°/s ±1°/s for $d\varphi/dt$ > 20°/s	-10/+40 °C	1st digit: 5 or higher 2nd digit: 1 or higher
Roll angle	X	−15° to 15°	±0,15°	-10/+40 °C	1st digit: 5 or higher 2nd digit: 1 or higher
Pitch angle	Y	−15° to 15°	±0,15°	-10/+40 °C	1st digit: 5 or higher 2nd digit: 1 or higher
Accelerations WBV	X,Y,Z	−30 m/s² to 30 m/s²	±0,3 m/s²	-10/+40 °C	1st digit: 5 or higher 2nd digit: 1 or higher
Accelerations on sprung masses inside the cockpit	X,Y,Z	−15 m/s² to 15 m/s²	±0,15 m/s²	-10/+40 °C	1st digit: 5 or higher 2nd digit: 1 or higher
Accelerations on sprung masses outside the cockpit	X,Y,Z	−20 m/s² to 20 m/s²	±0,2 m/s²	-30/+70 °C	1st digit: 6 2nd digit: 2 or higher
Accelerations on the unsprung masses	X,Y,Z	−50 m/s² to 50 m/s²	±0,5 m/s²	-30/+70 °C	1st digit: 6 2nd digit: 5 or higher
Accelerations in the engine compartment	X,Y,Z	−50 m/s² to 50 m/s²	±0,5 m/s²	-10/+90 °C	1st digit: 6 2nd digit: 2 or higher
Increased measurement accuracy may be desirable for computation of some of the characteristic values. 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).					

Some of the variables included in Table 1 are measured directly on driver/vehicle interface, in particular accelerations WBV and some accelerations on sprung masses inside the cockpit such as steering wheel accelerations. For this reason, they are strongly influenced by the driver. When different vehicles are compared it is recommended to have the same driver in all the tests used in the comparison.

5.2 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, or the variables defined in this norm, can be determined.

If a transducer does not measure a variable in the defined position, appropriate transformation shall be carried out.

All the positions of the transducers shall be stated in Annex A.

NOTE The correct position of these transducers, that determinate the new variables, is in Annex C.

STANDARDSISO.COM : Click to view the full PDF of ISO 15037-3:2022

5.3 Data processing

The band of human sensitivity is between 0 Hz and 100 Hz (see ISO 2631/ISO 8041), but for the analysis, the frequency range relevant for tests on comfort dynamics of passenger cars is between 0 Hz and the maximum utilized frequency: f_{max} = 50 Hz.

The bandwidth of the entire, combined transducer/recording system shall be more than 500 Hz and amplitude errors shall be less than ±0,5 %.

If the time history has an offset, that is the time history is not centred around 0, it is important to cancel this offset calculating the mean value of the points of the time history (all or only a section) and subtract it from all the points. The signals also shall be filtered with a low-pass filter (like a Butterworth filter), with a gain in the passband of 1 ± 0,005 (100 ± 0,5 %) and in the stopband ±0,01 (±1 %) with the cut-off frequency not before 100 Hz. All the data have to be resampling at the same frequency, not less than 500 Hz.

See ISO 15037-1 for an example of filter.

6 Test conditions

6.1 General

Limits and specifications for the ambient conditions and vehicle test conditions are established in Clause 6. These shall be maintained during the specific test. Any deviations shall be shown in the test report (see Annexes A and B), including the individual diagrams of the presentation of results. For each test method, the test-specific conditions and those which cannot be kept constant (e.g. tread depths) shall be recorded in a separate test report in accordance with Annex B.

6.2 Test track

Ride comfort analysis is really sensitive to roughness and road profile. The track profile shall be added in the test report.

The track shall have different characteristics as a function of the type of the test: smooth road (like a highway), uneven road (like a rough country road) and urban obstacles (like cleats, humps, steps etc.).

6.3 Wind velocity

The ambient wind velocity shall not exceed 5 m/s and not have gusts during a test. For each test method, the climatic conditions shall be recorded in the test report (see Annex B).

The tests shall not be performed with heavy rain and puddles.

6.4 Test vehicle

6.4.1 General data

General data of the test vehicle shall be presented in the test report shown in Annex A. For any change of the vehicle's specification (e.g. load), the general data shall be documented again.

The test vehicle shall be a passenger car or light truck in accordance with ISO 3833. If a new vehicle is used, it is recommended to make an adequate run-in before starting the tests.

Since in certain cases the ambient temperature has a significant influence on test results, this should be taken into account when making comparisons between vehicles. Before the test start, it is recommended the have the vehicle in a garage with a temperature between 0 and 40 °C.

STANDARDSISO.COM : Click to view the full PDF of ISO 15037-3:2022

© ISO 2022 – All rights reserved

6.4.2 Tyres

For a general tyre condition, new tyres shall be fitted on the test vehicle according to the vehicle manufacturer's specifications. If not specified otherwise by the tyre manufacturer, they shall be run in for at least 150 km on the test vehicle or an equivalent vehicle without excessively harsh use, for example, braking, acceleration, cornering, hitting the kerb, etc. After being run in, the tyres shall be maintained in the same positions in the vehicle for the tests.

Tyres shall have a tread depth of at least 90 % of the original value across the whole breadth of the tread and around the whole circumference of the tyre.

Tyres shall not be manufactured more than one year before the test. The date of manufacturing shall be noted in the presentation of test conditions (see Annex B).

Tyres shall be inflated to the pressure as specified by the vehicle manufacturer for the test vehicle configuration at the ambient temperature of the test.

Inflation pressure and tread depth of the tyres determined before tyre warm-up shall be recorded in the test report (see Annex B).

Tests may also be performed under conditions other than general tyre conditions. The details shall be noted in the test report (see Annex B).

NOTE Tread breadth is the width of that part of the tread that, with the tyre correctly inflated, contacts the road in normal straight-line driving.

As the tread depth or uneven tread wear can have a significant influence on test results, it is recommended that it is taken into account when making comparisons between vehicles or between tyres.

6.4.3 Operating components

For the standard test condition, the type (e.g. part number or model number) and condition (e.g. shock-absorber settings and suspension-geometry adjustments) of all components likely to influence the test results shall be as specified by the manufacturer. Any deviations from manufacturer's specifications shall be noted in the presentation of general data (see Annex A).

6.4.4 Loading conditions of the vehicle

The test mass shall be between the complete vehicle kerb mass in accordance with ISO 1176 (code ISO-M06) plus driver and test equipment (combined mass should not exceed 150 kg) and the maximum authorized total mass in accordance with ISO 1176 (code ISO-M08).

The maximum authorized axle loads in accordance with ISO 1176 (code ISO-M13) shall not be exceeded.

Care shall be taken to generate a minimum deviation in the location of the centre of gravity and in the moments of inertia as compared to the loading conditions of the vehicle in normal use, in accordance with ISO 2416. The resulting wheel loads shall be determined and recorded in the test report (see Annex A).

6.4.5 Drivetrain conditions of the vehicle

For vehicles with regenerative braking capabilities, the specific vehicle configuration can alter the dynamic vehicle behaviour while releasing the accelerator pedal and/or while pressing the brake pedal. For these vehicles, the different dynamic vehicle behaviour with or without active regenerative braking shall be considered while performing the tests. The selected level of regenerative braking capability and the transmission lever position shall be documented in the test report.

STANDARDSISO.COM : Click to view the full PDF of ISO 15037-3:2022

© ISO 2022 – All rights reserved

6.4.6 Active systems

For vehicles with active systems influencing the test results, such as active suspensions, the different ride vehicle behaviours possible with different settings of the systems shall be considered while performing the tests. If the driver can choose between different settings of the system, e.g. by a “sport/comfort” switch, the settings chosen for the test shall be documented in the test report.

7 Test methods

7.1 General

Vehicle ride comfort testing is here divided into three different areas:

— primary ride which is low frequency excitation of the sprung mass (0-5) Hz, mainly evaluating control and balance of the sprung mass of the vehicle;

— secondary ride is evaluated in the range of the natural frequencies of the unsprung mass and secondary masses (e.g. steering wheel, powertrain) in the range of (5-25) Hz using random and periodic disturbances;

— impact isolation testing to evaluate the influence of discrete impacts.

Typically, primary and secondary ride analysis is performed in the frequency domain and impact isolation is evaluated in the time domain.

7.2 Primary ride

7.2.1 General

The purpose of evaluation of the primary ride is to quantify low frequency (0-5) Hz movements of the vehicle due to small or large continuous road undulations and periodic disturbances. Split results for small (class A-C) and large amplitude roads (class D-H). Primary ride is typically evaluated on body shake, control (heave, pitch and roll) and balance (travel, roll and abruptness). Control is evaluated as road copying at one end of the scale and “floating” the desired state. Balance in turn is evaluated as the front/rear ratio of travel, roll and abruptness to analyse if and how any part of the motion is dominated by the front or rear axle. Abruptness is here determined by if the body movements are not continuously fluent, round and harmonic, but interrupted by jerky transitions/acceleration peaks along with significant primary ride motion. Shake analysis in primary ride is focused on underdamped vibrations of the sprung mass.

7.2.2 Random disturbances

The test methods associated with evaluating primary ride should, based on the above, focus on testing the vehicle on roads that primarily excites the sprung mass with large and low amplitude motion (different amplitudes to evaluate the non-linear characteristics of the suspension). Typically, one wants to choose roads and test speeds that excite the heave, roll and pitch motion of the vehicle around the natural frequencies for the respective motion for a given motion amplitude.

7.3 Secondary ride

7.3.1 General

The test purpose is to quantify vibrations in the (5-25) Hz frequency range caused by road texture and various surface disturbances on smooth, coarse and rough roads. The ride comfort is typically evaluated as RMS values of acceleration within pre-specified frequency bands. Shake analysis in the secondary ride frequency range and focuses on undamped vibrations of the unsprung mass or secondary body vibrations such as the powertrain or the steering wheel.

STANDARDSISO.COM : Click to view the full PDF of ISO 15037-3:2022

 © ISO 2022 – All rights reserved

7.3.2 Random disturbances

Different road types are used to evaluate the choppiness (irregular motion), shake (undamped vibrations) and rolling plushness (tactile sensation of transmitted vibrations into the seat and steering wheel) of the vehicle response due to random disturbances. The test speed can be varied for the same stretch of road to excite different frequencies in the vehicle. Amplitude and frequencies do not have to follow the typical road classification in ISO 8608 since a road can have one classification in a certain spatial frequency interval and a different one in another. It is recommended to use the ISO 8608 approach to describe the severity of the road used in the test and to include it in the test report.

7.3.3 Periodic disturbances

Testing of the sensitivity to and isolation of vibration to periodic disturbances induced by suspension friction, wheel (rim and tire) and brake imperfections is important during development. For wheels the typical sensitivity is due to out of roundness (wheel runout), radial runout (wheel mounted off centre), and static (radial) and dynamic (axial) imbalance. Brakes vibrations can be caused by disc thickness variations or lateral runout (disc not parallel to the direction of rotation).

Testing of sensitivity due to these imperfections is typically done by starting with a disturbance free base-line test. Testing should then be performed on a smooth road (Class A or better) with well-balanced and round wheels. Ideally spindle balanced (on car wheel balancing) should be performed to minimize the effects of any remaining radial runout and to balance the imbalance from all rotating components. Tests should then be performed with a controlled disturbance (such as a predefined wheel imbalance) and with a slow increase in vehicle speed or at fixed speed intervals. The speed where the worst-case response occurs should be noted. Wheel imbalance weights should be large enough to “overrun” tire force variation with larger weights required for studies where the baseline (balanced, round wheels) cannot be satisfactorily controlled.

7.4 Impact isolation

Impact isolation testing is focused on evaluating the harshness caused by single events such as cleats (transverse or angled), speed humps (long) or bumps (short) and manhole covers or potholes that are indented below or raised above the road surface. The purpose of the test is to evaluate the intensity and damping of vibrations caused by the disturbance. Typically, short and low amplitude disturbances mainly excite the secondary ride of the vehicle. Examples of single events affecting (also) the primary motion of the unspring mass are speed humps or so-called freeway hop shake which may occur when the vehicle passes over the concrete joints of the freeway which impose in-phase harmonic road inputs.

STANDARDSISO.COM : Click to view the full PDF of ISO 15037-3:2022

8 Data analysis

8.1 Frequency weighting filters application (see ISO 2631, ISO 8041 and ISO 5349)

8.1.1 General

Frequency weighting filters (see ISO 2631, ISO 8041 and ISO 5349) represent a key tool to analyse and quantify the obtained data, as the vibration frequency content is responsible of how vibration affects health, comfort, perception and motion sickness. Therefore, the frequency weighting filters that are applied to analyse the obtained data shall be recorded in the test report (see Annex B).

Regarding frequency-weighted acceleration time history, the main applications are related to health, comfort, perception and motion sickness:

— w_k for the z direction and for vertical recumbent direction (except head);

— w_d for the x and y directions and for horizontal recumbent direction;

— w_f for the motion sickness.

© ISO 2022 – All rights reserved

Special cases can also be found with the following designations:

— w_c for seat-back measurements;

— w_e for rotational vibration;

— w_j for vibration under the head of a recumbent person;

— w_h for steering wheel vibrations.

8.1.2 Health application

Seated persons in standard health exposed to WBV during travel are influenced by the effects of periodic, random and transient vibration.

Vibration frequency range is fixed in 0,5 Hz to 80 Hz, considering that frequencies below 1 Hz are not relevant for the concerning field.

8.1.3 Comfort application

Persons in standard health exposed to WBV during travel are influenced by the effects of periodic, random and transient vibration.

Vibration frequency range is fixed in 0,5 Hz to 80 Hz concerning the three translational and rotational axes on the seat pan and the three translational axes on the seat-back and feet seated persons

8.1.4 Perception application

For the perception of vibration by standing, sitting and recumbent persons, periodic and random vibration in the three translational axes on the principal surface supporting the body is needed.

8.1.5 Motion sickness application

It concerns the effects of oscillatory motion on the incidence of travel sickness with vibrations at frequencies below 0,5 Hz, which may cause discomfort and motion sickness, mainly while standing or sitting.

8.2 Analysis techniques for random input tests: frequency domain

8.2.1 Power spectral density

Thanks to the deterministic inputs obtained during the comfort test, it is possible to measure the vibrational response of a vehicle in a wide frequency range of excitation. The power spectral density of a signal can be calculated in order to evaluate the frequency contents of it using the fast Fourier transform (*FFT*), as it generates the average power as a function of frequency. Therefore, the power spectral density, P_{xx}, can be expressed as:

$$P_{xx}(f) = \int_{-\infty}^{+\infty} r_{xx}(\tau) \cdot e^{-j2\pi f\tau} \, \mathrm{d}\tau$$

where $r_{xx}(\tau)$ is the auto-correlation function of the stochastic signal $x(t)$, expressed as:

$$r_{xx}(\tau) = \lim_{T \to \infty} \frac{1}{T} \int_{-T/2}^{T/2} x(t) x(t+\tau) \, \mathrm{d}t$$

where T is the signal duration.

STANDARDSISO.COM : Click to view the full PDF of ISO 15037-3:2022

 © ISO 2022 – All rights reserved

The FFT shall be in Hann window form, with not less than 2 000 points and with a 50 % of overlap. Useful parameters for the analysis are the RMS of the FFT signal, which is divided in 4 different parts:

— the body motions are usually from around (0,5 to 5) Hz;

— the suspensions from (5 to 20) Hz;

— the high frequency from (20 to 50) Hz;

— the overall RMS value from (0,5 to 50) Hz.

The peak values and its frequencies of body motion and suspension frequency range are useful to investigate the cause of unusual vibration.

On flat track and on high speed test (over 100 km/h), it is important to erase the tire pick contributions. It is possible to calculate a spectrum in which the contribution of the unbalance of the wheels has been erased in the whole frequency range. Every tire has a theoretical frequency of the contributions starting from tires characteristics. The closest peaks are in a 1 Hz window around the theoretical frequencies, where a linear interpolation it is needed. Consequently, it is possible to eliminate a part of energy which is not generated by the road.

8.2.2 Transfer function

Transfer function $H(p)$ is the result of a product of several factors as it will be shown below. It shall be known that between 2 different signals, modulus, phase and coherence of the transfer function shall be calculated.

Therefore, the transfer function $H(p)$ of the frequency weighting w_m is given by

$$H(p) = H_h(p) \cdot H_l(p) \cdot H_t(p) \cdot H_s(p)$$

where

$H_h(p)$ is the high-pass filter;

$H_l(p)$ is the low-pass filter;

$H_t(p)$ is the acceleration-velocity transition;

$H_s(p)$ is the upward step.

$H_h(p)$ and $H_l(p)$ are both band-limited using two-pole filter with Butterworth characteristic.

High pass filter $H_h(p)$ is expressed as following:

$$H_h(p) = \frac{1}{1+\sqrt{2}\cdot\omega_1/p+(\omega_1/p)^2}$$

$$|H_h(p)| = \sqrt{\frac{f^4}{f^4+f_1^4}}$$

where f_1 is the corner frequency.

Low pass filter $H_l(p)$ is expressed as following:

$$H_l(p) = \frac{1}{1+\sqrt{2}\cdot p/\omega_2+(p/\omega_2)^2}$$

STANDARDSISO.COM : Click to view the full PDF of ISO 15037-3:2022

$$|H_1(p)| = \sqrt{\frac{f_2^4}{f^4 + f_2^4}}$$

where f_2 is the corner frequency.

Acceleration-velocity transition $H_t(p)$ is expressed as following:

$$H_t(p) = \frac{1 + p/\omega_3}{1 + p/(Q_4\omega_4) + (p/\omega_4)^2}$$

$$|H_t(p)| = \sqrt{\frac{f^2 + f_3^2}{f_3^2}} \cdot \sqrt{\frac{f_4^2 \cdot Q_4^2}{f^4 \cdot Q_4^2 + f^2 \cdot f_4^2\left(1 - 2Q_4^2\right) + f_4^4 \cdot Q_4^2}}$$

where Q_4 is the resonant quality factor for i=4.

NOTE There is a proportionality to acceleration at lower frequencies and a proportionality to velocity at higher frequencies.

Upward step $H_s(p)$ is expressed as following:

$$H_s(p) = \frac{1 + p/(Q_5\omega_5) + (p/\omega_5)^2}{1 + p/(Q_6\omega_6) + (p/\omega_6)^2} \cdot \left(\frac{\omega_5}{\omega_6}\right)^2$$

$$|H_s(p)| = \frac{Q_6}{Q_5} \cdot \sqrt{\frac{f^4 \cdot Q_5^2 + f^2 \cdot f_5^2\left(1 - 2Q_5^2\right) + f_5^4 \cdot Q_5^2}{f^4 \cdot Q_6^2 + f^2 \cdot f_6^2\left(1 - 2Q_6^2\right) + f_6^4 \cdot Q_6^2}}$$

where Q_i are the resonant quality factors.

8.3 Analysis techniques for single events: time domain

8.3.1 Overall characterization - Global energy parameters

It is important to analyse the behaviour of both axles during their impact against an obstacle.

The RMS value of the accelerator signals, in the time domain, shall be calculated only on a window containing the transient event. The length has been fixed at 1 second. This analysis is usually performed on stationary signals in order to evaluate the energetic content of the acceleration signal. The analysis calculates the values of RMS, RMQ and Crest factor of the analysed signal, using the following formulae:

$$RMS = \sqrt{\sum_{n=1}^{N_{\mathrm{TOT}}} \frac{x(t_n)^2}{N_{\mathrm{TOT}}}}$$

$$RMQ = \sqrt{\sum_{n=1}^{N_{\mathrm{TOT}}} \frac{x(t_n)^4}{N_{\mathrm{TOT}}}}$$

$$C_{\mathrm{f}} = \frac{x_{\mathrm{peak}}}{RMS} \quad x_{\mathrm{peak}} = \max(\mathrm{abs}(x(t_n)))$$

where

$x(t)$ is the time history value at instant t;

t_n is the sampling instant;

STANDARDSISO.COM : Click to view the full PDF of ISO 15037-3:2022

 © ISO 2022 – All rights reserved

N_{TOT} is the samples number of the time history;

x_{peak} is the peak value obtained over the duration of measurement.

It is recommended to calculate the RMS as ΔRMS value, which indicates the energy increment of the signal during the transient of an obstacle impacting a vehicle (MAX RMS) with regard to the stationary RMS offset excitation.

8.3.2 Single axle characterization

Single event analysis has been implemented in order to characterize the different behaviour of front and rear axle independently.

8.3.2.1 Peak 1, peak 2 and valley

Peak 1 and peak 2 are two relative maximums on a curve of running RMS, calculated using a specific window of length depending on the vehicle speed. Between these two points there is a relative minimum, which is the valley. These points intervene in the peak to peak and peak to valley analysis.

The length used for the RMS is shorter than the one used for the overall characterization (in order to separate the behaviour of both axles).

8.3.2.2 Range front, range rear, dissipation time front, dissipation time rear

Each axle has its range of analysis with a particular dissipation time. The parameter of dissipation time value indicates the transient duration associated to an impulsive impact. It can be calculated through different forms thus it is requested to insert in the report the way of calculation.

STANDARDSISO.COM : Click to view the full PDF of ISO 15037-3:2022

© ISO 2022 – All rights reserved

Annex A
(normative)

Test report — General data

Vehicle identification	Vehicle identification number:	____________________	
	Type of vehicle:	____________________	
	Manufacturer:	____________________	
	Model:	____________________	
	Model year/first registration date:	____________________	
Drivetrain	Type:	☐ combustion	☐ electric ☐ hybrid
	Driven axle:	☐ front axle	☐ rear axle
	Type of 4WD:	____________________	
	Special features:	____________________	
Electric engine	Identification code:	____________________	
	Maximum power:		kW
	Maximum torque:		Nm
Combustion engine	Identification code:	____________________	
	Type of engine:	☐ spark ignition	☐ diesel
	Air/fuel mixture control:	☐ carburettor	☐ injection
	Charging system:	☐ turbo charger	☐ super-charger
	Ignition point control:	☐ mechanical	☐ electronic
	Fuel cut-off:	☐ yes	☐ no
	Displacement/number of cylinders:	cm^3	cylinders
	Maximum power/engine speed:	kW	1/min
	Maximum torque/engine speed:	Nm	1/min
Transmission	Identification code:		
	Type/number of forward gears:	☐ manual	gears
		☐ automatic	gears
		☐ continuously variable (e.g. CVT)	

STANDARDSISO.COM : Click to view the full PDF of ISO 15037-3:2022

© ISO 2022 – All rights reserved

	Gear ratios:	1st gear: : 1	2nd gear: : 1
		3rd gear: : 1	4th gear: : 1
		5th gear: : 1	6th gear: : 1
	Final drive ratio:	: 1	
Rear axle	Type of rear axle:	______________________	
	Suspension/damping:	______________________	
	Stabilizer/Anti-roll bar:	☐ yes	☐ no
	Active systems:	______________________	
Front axle	Type of front axle:	______________________	
	Suspension/damping:	______________________	
	Stabilizer/Anti-roll bar:	☐ yes	☐ no
	Active systems:	______________________	
Steering	Steered axle:	☐ front axle	☐ rear axle
	Active front axle steering:	☐ yes	☐ no
	Active rear axle steering:	☐ yes	☐ no
	Power assisted:	☐ yes	☐ no
	Type of steering assist:	☐ electric	☐ hydraulic
		☐ electro-hydraulic	
	Overall steering ratio on front axle:	______________________	
	Steering wheel diameter:		mm
Braking system	Power assisted:	☐ yes	☐ no
	Electronic stability control system:	☐ yes	☐ no
	Type:	______________________	
	Wheel brakes on front axle:	☐ drums	☐ discs
	Wheel brakes on rear axle:	☐ drums	☐ discs
Wheels	Rim size:	front:	rear:
Tyres	Size:	front:	rear:
	Tread depth (new):	front: mm	rear: mm
	Inflation pressure, according to the vehicle manufacturer's specifications:		
	— at complete vehicle kerb mass (ISO-M06):	front: kPa	rear: kPa

STANDARDSISO.COM : Click to view the full PDF of ISO 15037-3:2022

© ISO 2022 – All rights reserved

	— at maximum authorized total mass (ISO-M08):	front:	kPa	rear:	kPa
Masses	Complete vehicle kerb mass (ISO-M06):			kg	
	Maximum authorized total mass (ISO-M08):			kg	
	Maximum authorized axle load (ISO-M13):	front:	kg	rear:	kg
	Type of loads used for mass reproduction:				
	Measured wheel loads of test vehicle, including driver and instrumentation:	FL:	kg	FR:	kg
		RL:	kg	RR:	kg
Vehicle dimensions	Overall length:			mm	
	Overall width:			mm	
	Overall height at test mass:			mm	
	Wheelbase:			mm	
	Track:	front:	mm	rear:	mm
	Height of centre of gravity at complete vehicle kerb mass (ISO-M06):			mm	
Reference point coordinates for measured variables	X_V (from half wheel base): mm		Y_V (from half track): mm		Z_V (from ground): mm

General comments and/or other relevant details

____

____

____

STANDARDSISO.COM : Click to view the full PDF of ISO 15037-3:2022

© ISO 2022 – All rights reserved

Table A.1 — Sensor positions (referred to the reference point)

Variable	*X* mm	*Y* mm	*Z* mm
longitudinal velocity			
pitch velocity			
roll velocity			
roll angle			
pitch angle			
vertical acceleration on drive seat cushion			
longitudinal acceleration on drive back seat			
tangential acceleration on steering wheel			
radial acceleration on steering wheel			
longitudinal acceleration on seat slide			
vertical acceleration on seat slide			
vertical acceleration on drive floor			
longitudinal acceleration on cylinder head			
lateral acceleration on cylinder head			
vertical acceleration on cylinder head			
longitudinal acceleration on front left hub			
vertical acceleration on front left hub			
longitudinal acceleration on rear left hub			
vertical acceleration on rear left hub			
longitudinal acceleration on front left top mount			
vertical acceleration on front left top mount			
longitudinal acceleration on front right top mount			
vertical acceleration on front right top mount			
longitudinal acceleration on rear left top mount			
vertical acceleration on rear left top mount			
longitudinal acceleration on rear right top mount			
vertical acceleration on rear right top mount			

STANDARDSISO.COM : Click to view the full PDF of ISO 15037-3:2022

© ISO 2022 – All rights reserved

Annex B
(normative)

Test report — Test conditions

Test method	ISO	
Proving ground	Location:	
	Path radius:	
Ambient conditions	Road surface:	Type:
		Condition:
		Track temperature: °C
		Tyre-road peak friction coefficient:
		Friction measuring method:
	Climate:	Air temperature: °C
		Relative humidity: %
		Wind speed: m/s
		Wind direction:
Tyres	Date of manufacture:	front: rear:
	Tread depth:	
	— before warm-up:	FL: mm FR: mm
		RL: mm RR: mm
	Tyre pressure:	
	— before warm-up:	FL: kPa FR: kPa
		RL: kPa RR: kPa
Driving conditions	Manual transmission:	Engaged gear: gear
	Automatic transmission:	Transmission program:
		Gear selector position:
	Electric/hybrid mode:	
	State of charge at start of test:	%
	Active safety systems:	

STANDARDSISO.COM : Click to view the full PDF of ISO 15037-3:2022

© ISO 2022 – All rights reserved