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Heavy commercial vehicles and buses — Test method for steering effort measurement when manoeuvring at low speed or with stationary vehicle

Véhicule utilitaires lourds et autobus — Méthode d'essai pour la mesure des efforts de direction lors de braquage à basse vitesse ou sur place

Reference number
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Foreword

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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).

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For an explanation of 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*.

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.

Heavy commercial vehicles and buses — Test method for steering effort measurement when manoeuvring at low speed or with stationary vehicle

1 Scope

This document specifies a test method for steering effort measurement when manoeuvring a vehicle at low speed or with the vehicle stationary. It is mainly applicable to trucks having a mass exceeding 3,5 tonnes and buses and articulated buses having a mass exceeding 5 tonnes, according to ECE and EC vehicle classification, i.e. categories M3, N2, N3.

This document can also be applicable to trucks having a mass not exceeding 3,5 tonnes and buses and articulated buses having a mass not exceeding 5 tonnes, i.e. categories M2, N1.

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

ISO 15037-2, *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 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
rim offset
distance of a rim from its hub mounting surface to the centreline of the wheel

Note 1 to entry: A positive rim offset is when the hub mounting surface is more toward the outside of the centreline of the wheel.

3.2
catch up
point when the steering-wheel torque abruptly increases while increasing the steering-wheel speed

Note 1 to entry: (See Figure 3).

Note 2 to entry: On a hydraulic or an electric-hydraulic system this is usually the point when the steering servo fluid pump reaches the limit when the fluid flow is no longer sufficient to give the required output torque to turn the steering wheel.

3.3
catch up steering-wheel torque limit
predetermined level of steering-wheel torque limit for the specific application

Note 1 to entry: The catch-up steering-wheel torque limit level corresponds to the torque when a driver depending on application is no longer able to apply or is no longer comfortable with the torque needed to turn the steering-wheel. (See Figure 3).

3.4
steering-wheel straight forward position
δ_{H0}
steering-wheel angle resulting in vehicle zero course angle

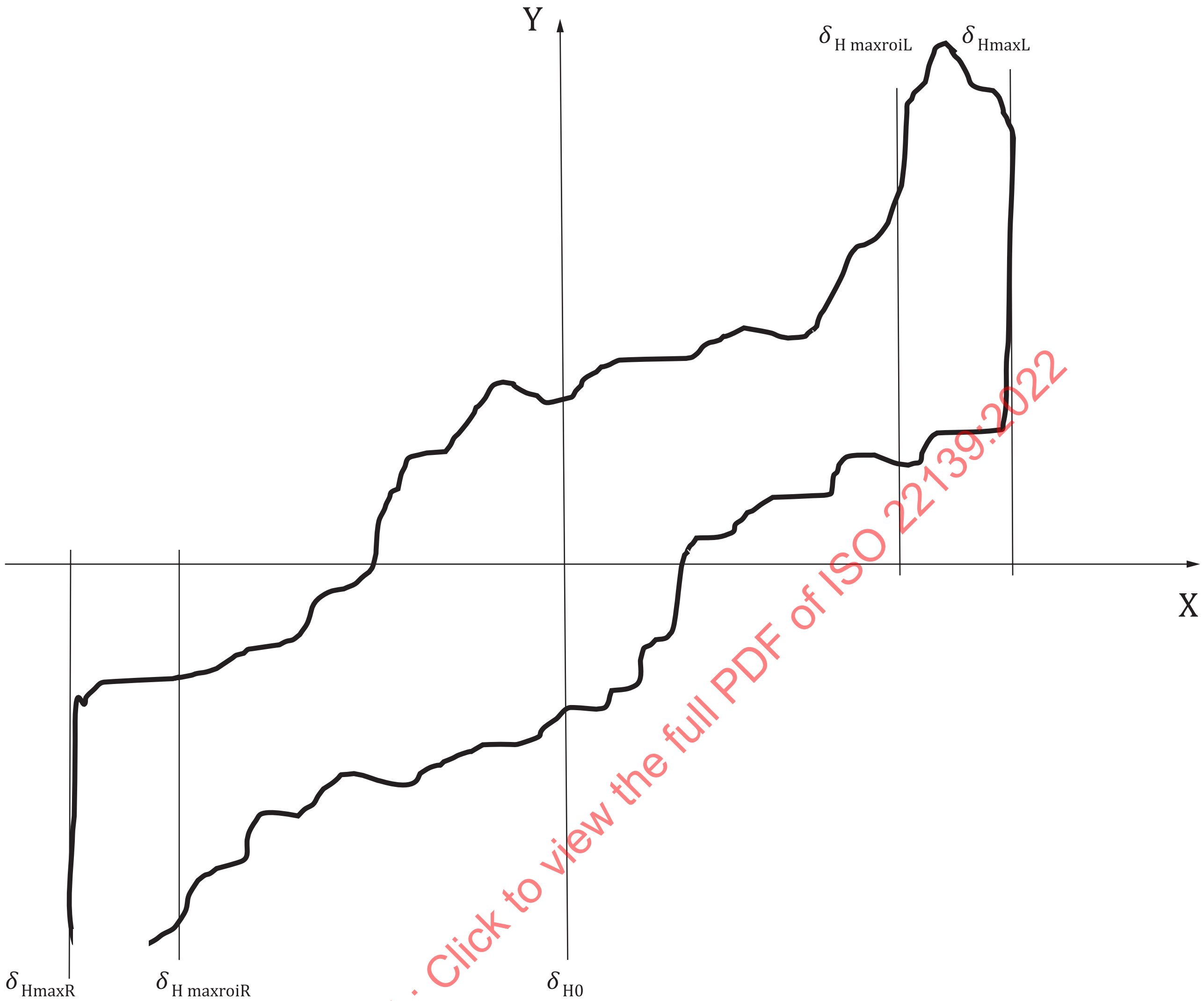
Note 1 to entry: See Figure 1.

3.5
maximum steering-wheel angles
δ_{HmaxL}
δ_{HmaxR}
steering-wheel angles (left and right) that due to mechanically limitations are the maximum that can be reached in the steering system

Note 1 to entry: In order not to overload the steering components when reaching the maximum steering wheel angles, vehicles with power steering system are equipped with a mechanism for lowering the boost torque before reaching the maximum steering wheel angles e.g. a hydraulic relief pressure valve. (See Figure 1 and 8.1).

3.6
maximum steering-wheel angles range of interest
$\delta_{H\ maxroiL}$
$\delta_{H\ maxroiR}$
range of steering wheel angles (left and right) of interest for the test and that are used while collecting data

Note 1 to entry: See Figure 1 and 8.1.



Key

X	steering-wheel angle	δ_H (°)
Y	steering-wheel torque	M_H (Nm)
δ_{H0}	steering-wheel straight forward position (°)	
δ_{HmaxR}	maximum steering-wheel angles in right direction (°)	
$\delta_{H\ maxroiR}$	maximum steering-wheel angles range of interest in right direction (°)	
δ_{HmaxL}	maximum steering-wheel angles in left direction (°)	
$\delta_{H\ maxroiL}$	maximum steering-wheel angles range of interest in left direction (°)	

Figure 1 — Maximum steering wheel angles and maximum steering wheel angles range of interest

3.7
remaining steering wheel angles

$\delta_{H\ remL}$
$\delta_{H\ remR}$
left and right steering-wheel angles when steering-wheel torque changes sign and is passing zero after reversing the steering-wheel inwards towards the *steering-wheel straight forward position* (3.4)

Note 1 to entry: See Figure 8.

3.8
steering-wheel work
W_H
work needed to turn the steering-wheel between two defined steering-wheel angles

Note 1 to entry: See Figures 5 and 7.

3.9
steering-wheel return ability
ability of the steering-wheel to return towards the *steering-wheel straight forward position* (3.4) without applying any torque to the steering-wheel

Note 1 to entry: See 9.9.

3.10
steering-wheel torque variation
ΔM_{Hmax}
M_{Hmax}
variation in steering-wheel torque

Note 1 to entry: The variation can result, e.g. from non-optimum phasing of steering column intermediate shaft universal joints.

Note 2 to entry: See 9.10.

4 Principle

The purpose of the test method is to objectively evaluate and quantify the **driver's perception** of the **steering feel** and **effort** while manoeuvring a vehicle at low speed or with the vehicle stationary.

The method is not intended to specify how to measure and evaluate mechanical or electrical properties in a steering system, e.g. pressure, flow, temperature, electrical current.

The driver's perception is quantified by calculating and evaluating characteristics parameters from the measured variables.

The main characteristic parameters are:

— steering-wheel torque;

— steering-wheel work;

— steering-wheel return ability;

— steering-wheel torque variation.

See Clause 9 for detailed characteristic parameters.

5 Variables

The following variables shall be determined:

— steering-wheel angle δ_H (°);

— steering-wheel torque M_H (Nm);

— steering-wheel speed $d\delta_H/dt$ (°/s).

If not directly available, the steering-wheel speed may be calculated from the time signal of steering wheel angle, i.e. $d\delta_H/dt$.

6 Measuring equipment

6.1 Description

The measuring equipment shall be in accordance with ISO 15037-2.

The variables listed in Clause 5 shall be monitored using appropriate transducers and the data shall be recorded on a multi-channel recorder with time base. Typical operating ranges and recommended maximum errors of the combined transducer and recording system are shown in Table 1.

A steering machine including driver emergency override functionality is preferred to be used to turn the steering wheel while collecting data.

The steering machine shall be able to perform triangular wave steering angle input with a steering-wheel torque, steering-wheel speed and maximum steering wheel angles corresponding to the test needs.

Care shall be taken to ensure that friction and inertia added to the system by steering machine or steering transducers does not improperly influence the measurement of steering-wheel torque. For example, any friction added by the steering-wheel torque sensor shall be estimated and compensated for if this is not done in the measuring equipment.

The steering input may be done manually without the help of a steering machine but with a risk of loss of accuracy in the results as it can be hard to maintain a constant steering-wheel speed during the manoeuvres. See 8.3 and 8.4.

Table 1 — Variables, typical operating ranges and recommended maximum errors. Not listed in or changed from ISO 15037-2

Variable	Typical operating range[a]	Recommended maximum error of the combined transducer and recorder system
Vehicle, axle or track mass:	Up to 40 000 kg	±0,2 %
Steering-wheel angle	±1 000°	±1°
Steering-wheel torque	±30 Nm	±0,3 Nm
Steering-wheel speed	±600°/s [b]	±2°/s

Transducers for measuring some of the listed variables are not widely available and are not in general use. Some such instruments are developed by users. If any system error exceeds the recommended maximum value, this and the actual maximum error shall be stated in the test report as shown in Annex B.

[a] These transducer ranges are appropriate for the standard test conditions and may not be suitable for non-standard test conditions.

[b] Steering-wheel speeds above ±600°/s are usually not of interest for a normal driver.

6.2 Transducer installations

The transducers shall be installed according to the manufacturers' instructions, where such instructions exist, so that the variables in Clause 5 corresponding to the terms and definitions in Clause 3 and ISO 8855 can be determined.

If a transducer does not measure a variable directly, appropriate transformations into the specified reference system shall be carried out. For example, if not directly available the steering-wheel speed should be calculated from the time signal of steering wheel angle, i.e. $d\delta_H/dt$.

6.3 Data processing

See Clause 9.

7 Test conditions

7.1 General

For each test the surface characteristics, paving material and ground (or ambient) temperature shall be recorded and documented in the test report. See Annex B.

If possible, the coefficient of friction should be estimated and documented. See Annex B.

7.2 Test track when manoeuvring at low speed

For measurements when manoeuvring the vehicle at low speed a large, smooth, flat and hard asphalt or concrete area of minimum size of 50 m × 150 m is preferred. Then a complete test while increasing the steering-wheel speed can be performed without interruption.

However, if this area is not available the test should be adapted and divided into smaller parts.

The lateral gradient of the test surface shall not exceed 2 %.

7.3 Test track with stationary vehicle

For measurements with stationary vehicle the steering effort is quite dependant on the tyre to road surface friction. It is recommended to perform the test on a surface with a stable coefficient of friction during the test.

On some surfaces the coefficient of friction can vary with the ground temperature and on some surfaces the coefficient of friction can change due to, e.g. polishing when steering multiple times at the same spot.

Due to this the vehicle may have to be moved a little bit between each set of measurements not to change the coefficient of friction or to damage the tyres and /or the surface.

In stationary tests with vehicles with more than one steerable axle, all steerable axles shall be on the same type of surface.

7.4 Test vehicle

7.4.1 General data

General data of the test vehicle shall be presented in the test report shown in Annex A.

7.4.2 Operating components

For the standard test conditions, all operating components likely to influence the test results shall be according to specification. Any deviations from specification shall be noted in the presentation of general data. See Annex A.

7.4.3 Tyres and rims

For general information regarding tyres used for test purposes, see ISO 15037-1:2019, 6.4.2.

Rim offset can have a significant influence and shall be reported in the test report-general data. See Annex A.

7.4.4 Vehicle loading conditions

See ISO 15037-1:2019, 6.4.4.

Depending on the purpose of the test it may be performed in any load condition of the vehicle even if a test at maximum design total mass for the vehicle is usually included.

The axle loads shall be documented in the test report-general data. See Annex A.

8 Test procedure

8.1 Preparation of test vehicle

Load the vehicle to the desired axle loads.

Check and adjust tyre pressure to the load.

Find the maximum steering-wheel angles and if applicable choose the maximum steering-wheel angles range of interest to be used in the measurement.

In many test cases measuring the steering-wheel torque all the way out to maximum steering-wheel angles is not necessary or even desirable. The reason being that the level of rise in torque when getting close to maximum steering wheel angles usually is irrelevant for the driver as there is no practical use to try to steer close to or beyond this point. Also, if using a steering machine to perform the manoeuvre going all the way out to maximum steering wheel angles can cause unwanted terminations of the measurements due to the sudden rise in torque exceeding the physical or pre-set torque limit for the machine.

In many cases the absolute values of the maximum steering-wheel angles range of interest left and right will be equal. For example, ±600 (°) as in examples in 9.5 to 9.10.

If there is a special interest in the behaviour of the system close to maximum steering-wheel angles, the measurement could be extended to these angles.

If available, activate the steering machine steering-wheel torque limit. This is the limit when the machine automatically stops the tests. It is recommended to set the value to a maximum of (30 to 40) Nm not to get too high forces in the machine attachment and also to have an automatic stop of the test when torque values become too high to be of any interest to measure, i.e. too high of a torque for a driver to handle.

Higher steering-wheel torque limit values can be used for special test cases.

As the servo fluid temperature in a hydraulic steering system can have a significant influence on the performance of the steering system it is recommended to have control of the temperature and report it together with the corresponding test results.

8.2 Warm-up

All relevant vehicle components shall be warmed up prior to the test in order to achieve a temperature representative for the purpose of the test.

8.3 Measurement with a stationary vehicle

The engine should normally be at idle speed, but the engine speed may be increased to check any change in performance.

The parking brake shall be released, and no foot brake applied.

Use the steering machine to give input on the steering-wheel starting at steering-wheel straight forward position and then performing complete cycles of triangular waves at constant steering-wheel speed going to maximum steering-wheel angles range of interest right, then to the maximum left and back to the maximum right again at a constant turning speed starting at 30 (°/s).

In this position increase steering-wheel speed to 60 (°/s) and going to the maximum left and back to maximum right again.

Continue in the same way while increasing the steering-wheel speed in 30 (°/s) increments until reaching the catch-up steering-wheel torque limit or when reaching the pre-set steering machine torque limit or when reaching a decided maximum steering-wheel speed, e.g. 120 (°/s).

Depending on the specific test and test object other ranges and increments of turning speeds may be used.

The tests can be repeated with either parking or foot brake, or both, applied.

Make sure not to exceed maximum temperatures specified by the manufacturer as this can damage the system.

If the steering input is done by hand, it is very important to keep a constant steering-wheel speed throughout the test and a minimum of five consistent test runs shall be made where the time histories are checked.

The test runs for which the control criteria steering-wheel speed are best met shall be selected for data analysis.

8.4 Measurement when manoeuvring at low speed

This test can be done at any chosen engine r/min but will typically start with engine at idle, e.g. 600 r/min and then the test should be repeated with increased engine speeds e.g. (800, 1 000, 1 200 and 1 400) r/min. Other engine speeds can be used depending on vehicle and test purpose.

Choose a gear to keep the vehicle speed between 5 km/h and 10 km/h at the chosen engine r/min.

The exact vehicle speed is not very critical for the result as long as the speed is between 5 km/h and 10 km/h which is for making sure that when performing the manoeuvres, no significant dynamic side forces are acting on the tyres and that the vehicle dynamic yaw behaviour is not influencing the result in a significant way.

With the vehicle placed at the end of the test surface area, start driving at steering-wheel straight forward position while keeping the engine speed constant at the chosen r/min.

Use the steering machine to give input on the steering-wheel starting at steering-wheel straight forward position and then perform complete cycles of triangular waves with constant steering-wheel speed going to the maximum steering-wheel angles range of interest right, then to the maximum left and back to maximum right again at a constant turning speed starting at 120 (°/s). In this position increase to 180 (°/s) going to the maximum left and back to maximum right again. Continue in the same way while increasing the steering-wheel speed in 60 (°/s) increments until reaching the catch-up steering-wheel torque limit or when reaching the pre-set steering machine torque limit or when reaching a decided maximum steering-wheel speed, e.g. 600 (°/s).

Depending on the specific test and test object other ranges and increments of turning speeds may be used.

The test can be repeated while reversing the vehicle at low speed.

If the steering input is done by hand, it is very important to keep a constant steering-wheel speed. A minimum of five consistent test runs at each steering-wheel speed shall be made where the time histories are checked. The test runs for which the control criteria steering-wheel speed is best met shall be selected for data analysis.

Performing the test at higher vehicle speeds (>10 km/h) may be done if for some reason this is of interest, but it has to be taken into consideration that with increasing vehicle speeds the dynamic yaw behaviour of the vehicle, for example, under/over steering and the corresponding time delays between time signals will have increasingly influence on the test results, e.g. between steering-wheel speed and steering-wheel torque time signals.

Especially when comparing steering characteristics between vehicles with different specifications or when changing the load case on a specific vehicle it is important to understand if any changes in observed steering characteristics are due to changes in the actual steering system or is coming partly or fully from a difference in dynamic yaw behaviour between the tested vehicles or load cases.

9 Data evaluation and presentation of results

General data shall be presented as shown in the test report. See Annex A.

Test conditions shall be presented as in ISO 15037-2. See Annex B.

Any changes in general data or test conditions shall be documented.

9.1 Time histories

The measured variables shall be plotted versus time in a diagram. See example in Figure 2.

The time histories shall be examined to identify valid data for evaluation.

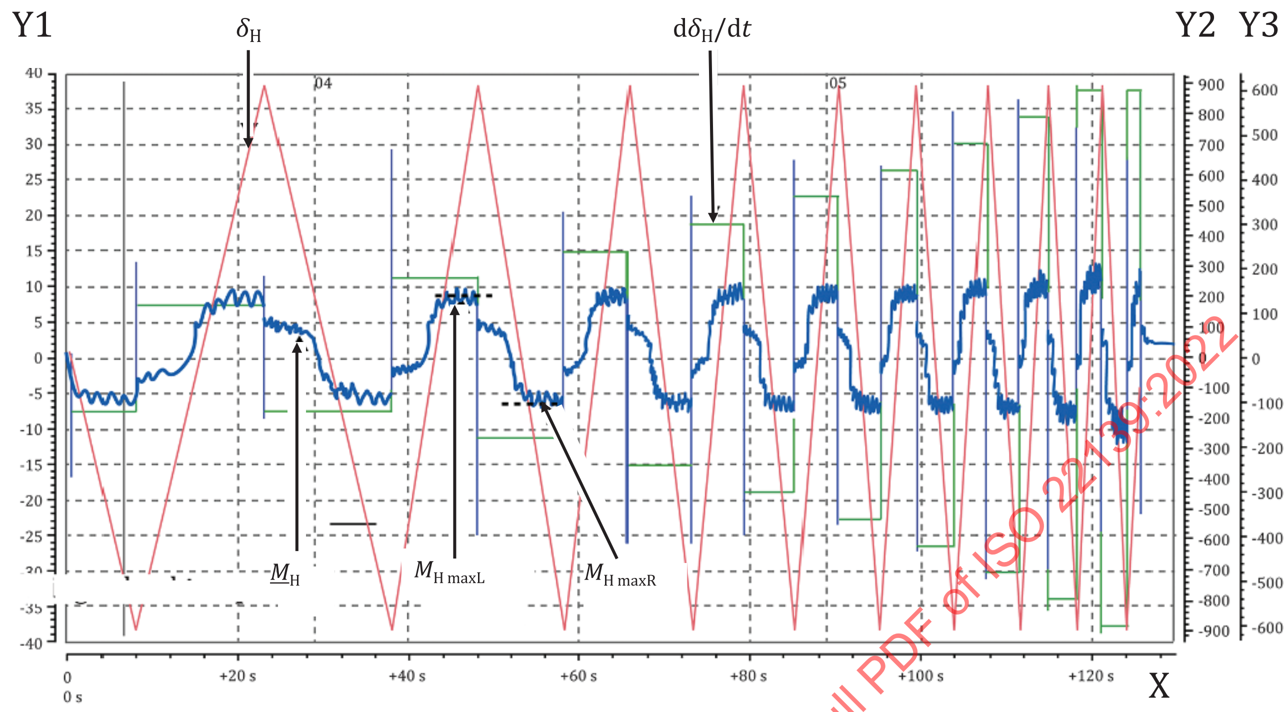
If any time signal has too much high frequency noise, the signal should be low pass filtered or smoothed by one of the mathematical curve fitting routines available.

Curves may also be fitted by freehand.

The low pass filter used, or the method of curve fitting used shall be stated in the test report. See Annex B.

Some characteristic values, e.g. M_{HmaxL} and M_{HmaxR} representing the maximum steering-wheel torque in the left and right direction at the various steering-wheel speeds can be taken directly from the time signal plot. See Figure 2.

For further definition of the maximum steering-wheel torque in the left and right direction, see 9.5.



Key

X	time (s)		
Y1	steering-wheel torque	M_H	(Nm)
Y2	steering-wheel angle	δ_H	(°)
Y3	steering-wheel speed	$d\delta_H/dt$	(°/s)
$M_{H\ maxL}$	maximum steering-wheel torque in left direction (Nm)		
$M_{H\ maxR}$	maximum steering-wheel torque in right direction (Nm)		

Figure 2 — Time histories

9.2 Maximum steering-wheel torque vs. steering-wheel speed

With input from the time histories, as in example in Figure 2, the maximum steering-wheel torque can be plotted in a diagram versus each measured and plotted steering-wheel speed. See Figure 3.

Usually, the average values from left and right steering shall be calculated and plotted but if the asymmetry between left and right steering is to be evaluated, the individual left and right values shall be plotted.

The type of diagram shown in Figure 3 will also visualize any sensitivity for catch up of the steering system.

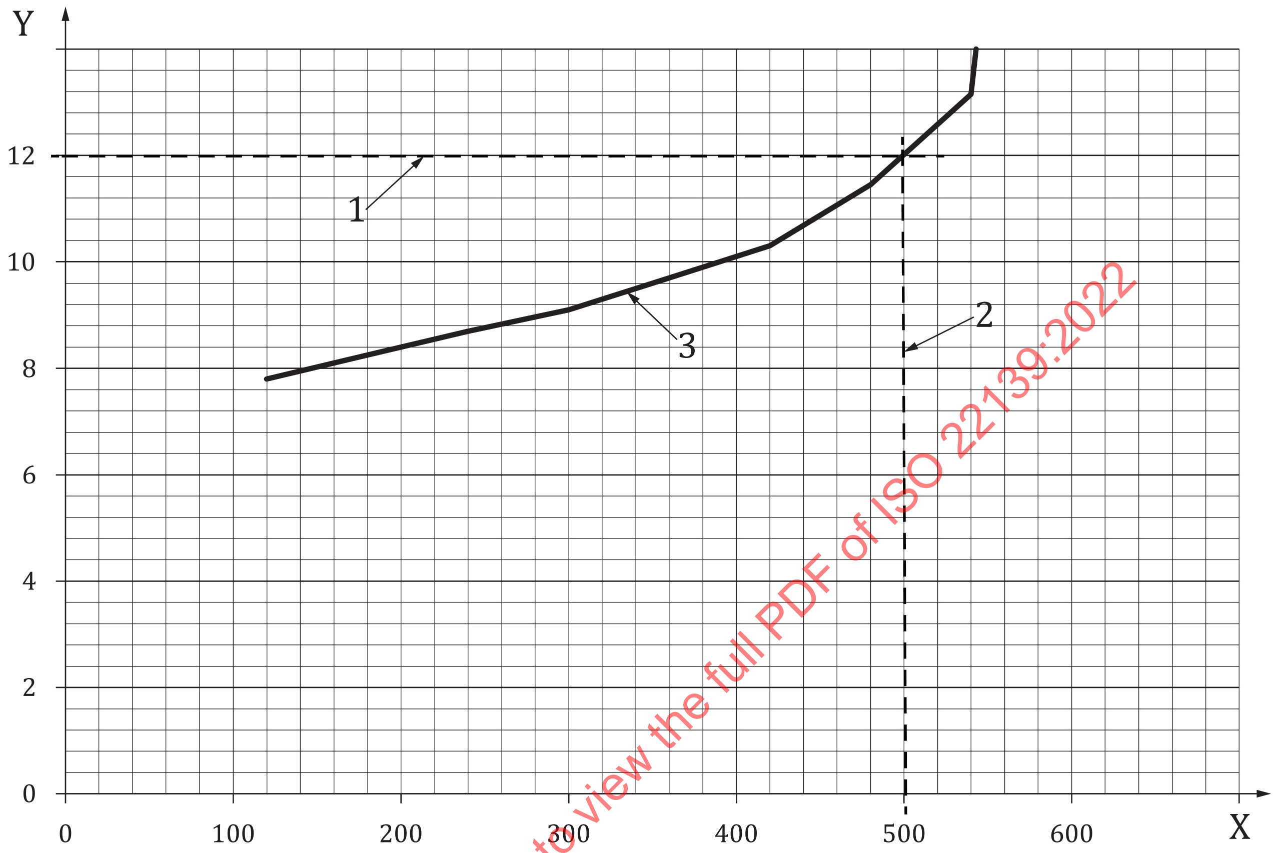
If the average of the left and right maximum steering-wheel torque or the individual left and right values are plotted in any diagram, these shall be stated in the diagram and the test report. See Annex B.

The diameter of the steering-wheel is influencing the steering forces to be handled by the driver. Therefore, the size of the steering-wheel shall be stated in the test report. See Annex A. However, the steering work is not influenced by the steering-wheel diameter.

If of interest, any of the other variables presented in 9.5 to 9.10 can also be plotted versus each measured steering-wheel speed in the same type of diagram as shown in Figure 3.

9.3 Catch up steering-wheel speed

Figure 3 shows the steering-wheel speed when the catch up steering-wheel torque limit is reached.



Key

X steering-wheel speed $d\delta_H/dt$ (°/s)

Y average of the left and right maximum steering-wheel torque ($M_{H\ maxL}$+ $M_{H\ maxR}$) /2 (Nm)

1 example of catch-up steering wheel torque limit (level to be determined depending on application)

2 example of catch-up steering wheel speed at the point where catch-up steering wheel torque limit is reached

3 example of measured relation between steering wheel speed and Maximum steering wheel torque

Figure 3 — Maximum steering-wheel torque vs. steering-wheel speed

9.4 Cartesian coordinates

For ease of understanding and for further analysis, the time signals or parts of the time signals may also be presented in Cartesian coordinates of steering-wheel torque versus steering-wheel angle. See 9.5 to 9.10 and Figures 4 to 9.

The plotting in Cartesian coordinates and the analysis may be repeated for all steering-wheel speeds if desired.

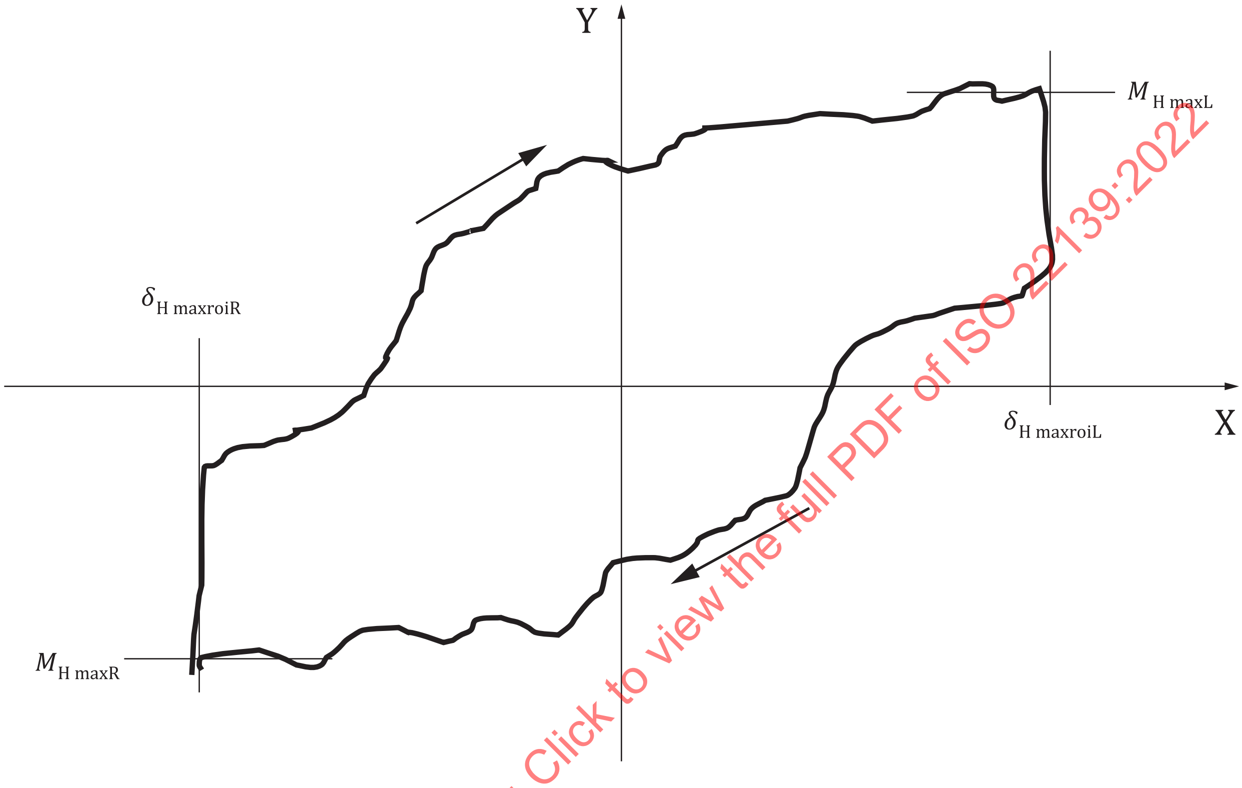
NOTE For simplicity only a **part of the total time signal** containing the data for left and right steering-wheel angles at **one single steering-wheel speed** is plotted as examples in the Figures 4 to 9.

9.5 Maximum steering-wheel torque (M_{HmaxL} and M_{HmaxR})

This characteristic parameter is the steering-wheel torque in the left and right direction at maximum steering-wheel angles range of interest when steering OUT from steering-wheel straight forward position. See Figures 2 and 4.

This characteristic parameter is meant to resemble the maximum torque a driver needs to apply to the steering wheel during slow speed manoeuvring while turning the steering wheel outwards at various steering wheel speeds.

Usually, the average torque around maximum steering-wheel angles range of interest shall be estimated and used. See Figure 4. If also the variation in torque in this area is to be evaluated, it shall be done according to 9.10. The way of evaluating maximum steering wheel torque shall be stated in the test report. See Annex B.



Key

X	steering-wheel angle	δ_H (°)
Y	steering-wheel torque	M_H (Nm)
$\delta_{H\ maxroiR}$	maximum steering-wheel angles range of interest in right direction (°)	
$\delta_{H\ maxroiL}$	maximum steering-wheel angles range of interest in left direction (°)	
$M_{H\ maxL}$	steering-wheel torque at $\delta_{H\ maxroiL}$ in left direction (Nm)	

Figure 4 — Steering-wheel torque vs. steering-wheel angle

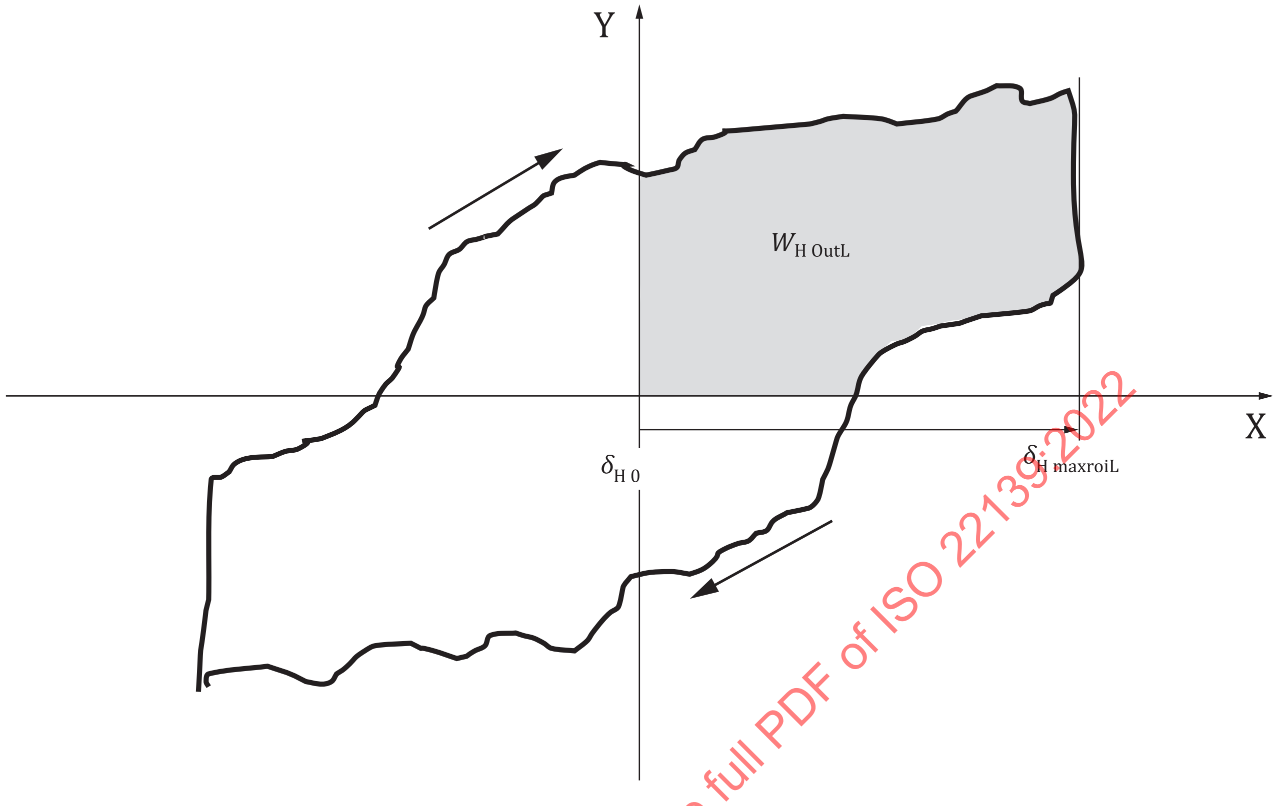
9.6 Steering-wheel work when steering OUT ($W_{H\ OutL}$ and $W_{H\ OutR}$)

This characteristic parameter is the steering-wheel work in the left and right direction needed when steering out with increasing steering-wheel angles from steering-wheel angle straight forward position (δ_{H0}) to maximum steering-wheel angles range of interest ($\delta_{Hmaxroi}$).

Figure 5 is showing an example with steering in the left direction.

This characteristic parameter is meant to resemble the work a driver needs to apply on the steering wheel during slow speed manoeuvring while turning the steering wheel outwards at various steering wheel speeds.

The work is represented by the area covered by steering-wheel torque and steering-wheel angle (in radians). From the raw data this work can be calculated by summarizing the work for each increment of angle between the two defined angles $\sum dW_H = \sum(d\delta_H \times M_H)$.



Key

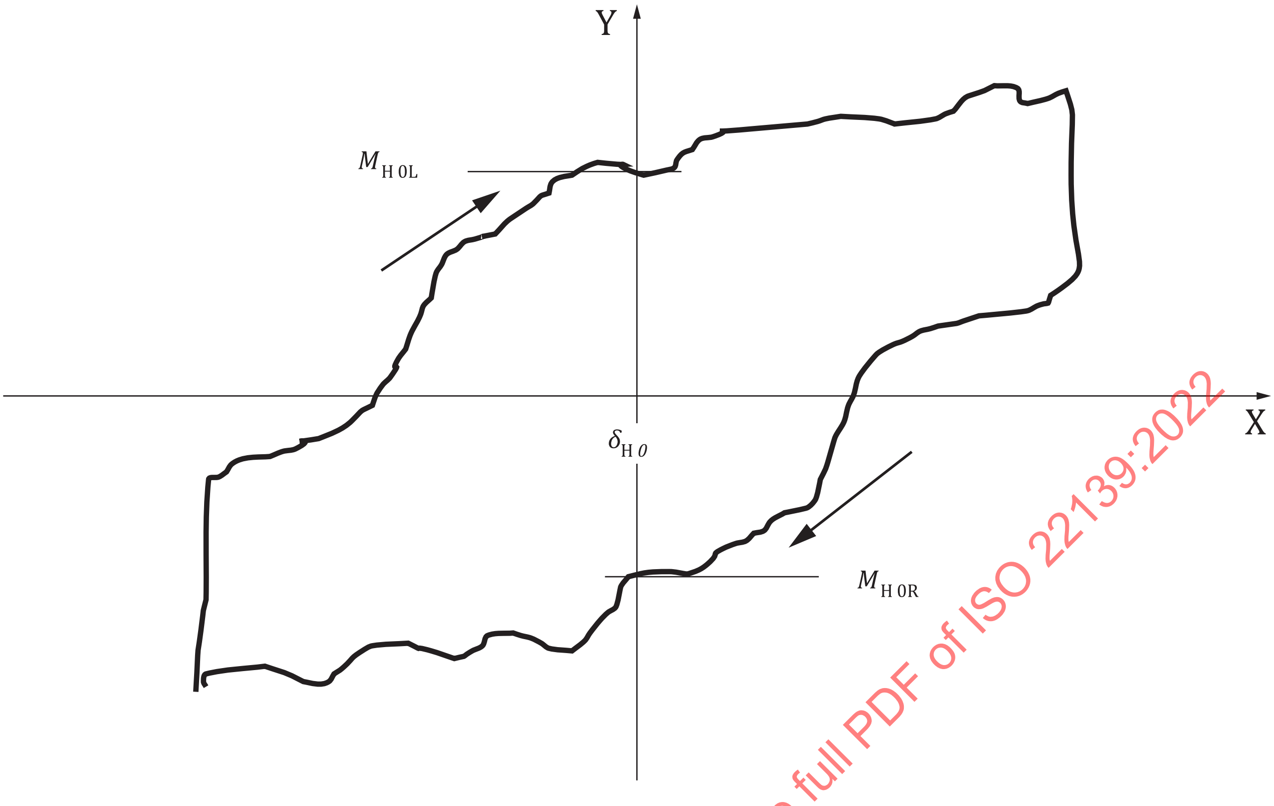
X	steering-wheel angle	δ_H(°)
Y	steering-wheel torque	M_H (Nm)
$\delta_{H\ maxroiL}$	maximum steering-wheel angles range of interest in left direction (°)	
$\delta_{H\ 0}$	steering-wheel angle straight forward position (°)	
$W_{H\ OutL}$	steering-wheel work needed when steering out in left direction (Nm)	

Figure 5 — Steering wheel work when steering OUT

9.7 Steering-wheel torque when steering IN ($M_{H\ 0L}$ and $M_{H\ 0R}$)

This characteristic parameter is the steering-wheel torque while passing steering-wheel straight forward position (δ_{H0}) while steering IN towards steering-wheel straight forward position. See Figure 6.

This characteristic parameter is meant to resemble the forces/torque a driver needs to apply to the steering wheel during slow speed manoeuvring while turning the steering wheel inwards at various steering wheel speeds.



Key

X	steering-wheel angle	δ_H (°)
Y	steering-wheel torque	M_H (Nm)
$\delta_{H\,0}$	steering-wheel angle straight forward position (°)	
$M_{H\,0L}$	steering-wheel torque while passing steering-wheel straight forward position when steering in left direction (°)	
$M_{H\,0R}$	steering-wheel torque while passing steering-wheel straight forward position when steering in right direction (°)	

Figure 6 — Steering wheel torque when steering IN

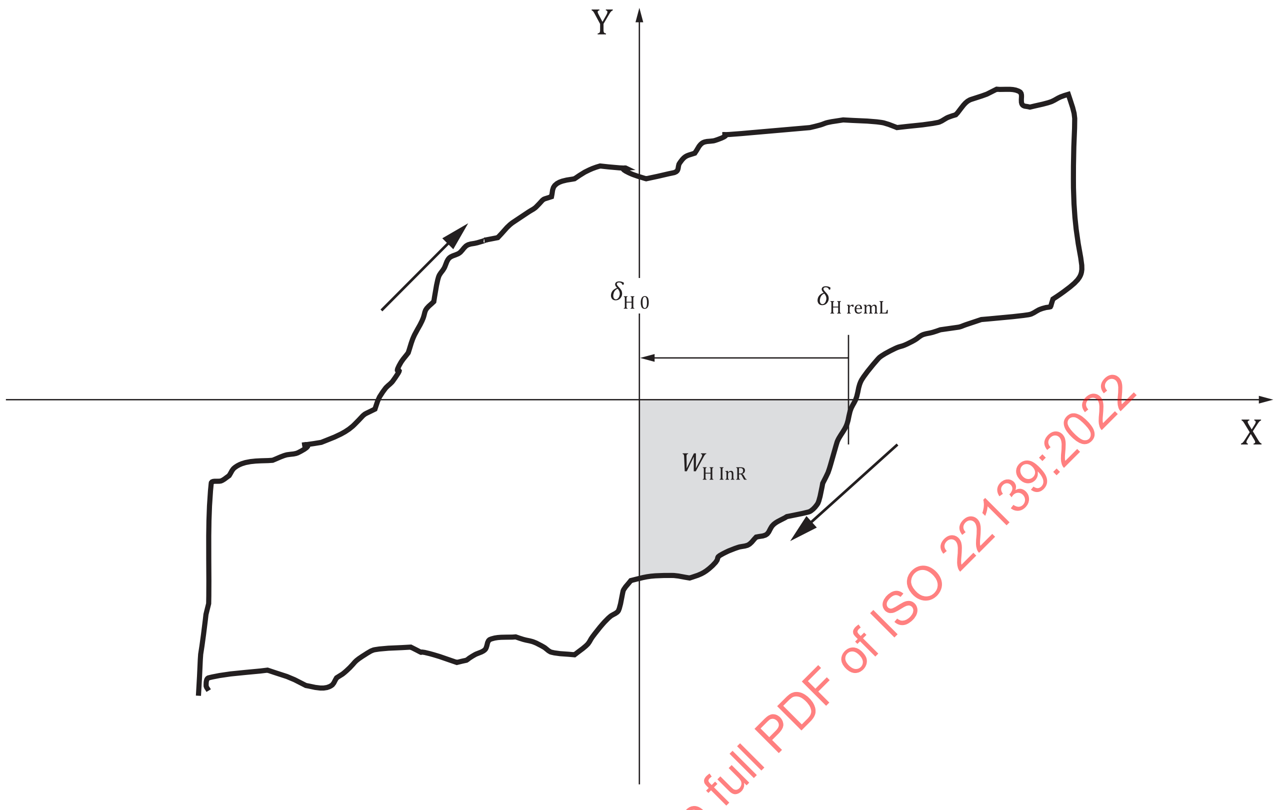
9.8 Steering work when steering IN ($W_{H\,InL}$ and $W_{H\,InR}$)

This characteristic parameter is the steering work in the left and right direction needed when steering inwards with decreasing steering-wheel angles from remaining steering wheel angle (δ_{Hrem}) to steering-wheel straight forward position (δ_{H0}).

The remaining steering wheel angle (δ_{Hrem}) is the angle where the driver needs to start applying torque to move the steering wheel inwards to on-centre position. See Figure 7 for an example when steering from left to right direction.

This characteristic parameter is meant to resemble the work a driver needs to apply on the steering wheel during slow speed manoeuvring while turning the steering wheel inwards at various steering wheel speeds.

This work is represented by the area covered by steering-wheel torque and steering-wheel angle (in radians). From the raw data the work can be calculated by summarizing the work for each increment of angle between the two defined angles $\delta_{H\,rem}$ and δ_{H0} $\sum \mathrm{d}W_{H\,InR} = \sum(\mathrm{d}\delta_H \times M_H)$.



Key

X	steering-wheel angle	δ_H (°)
Y	steering-wheel torque	M_H (Nm)
$\delta_{H\,0}$	steering-wheel angle straight forward position (°)	
$\delta_{H\,remL}$	remaining steering wheel angle when steering inwards from left to right direction (°)	
$W_{H\,InR}$	steering-wheel work needed when steering in the right direction inwards towards steering-wheel angle straight forward position (Nm)	

Figure 7 — Steering work when steering IN

9.9 Steering return ability

The steering-wheel return ability can be quantified by, either:

— the remaining steering wheel angle (see 9.9.1. and Figure 8); or

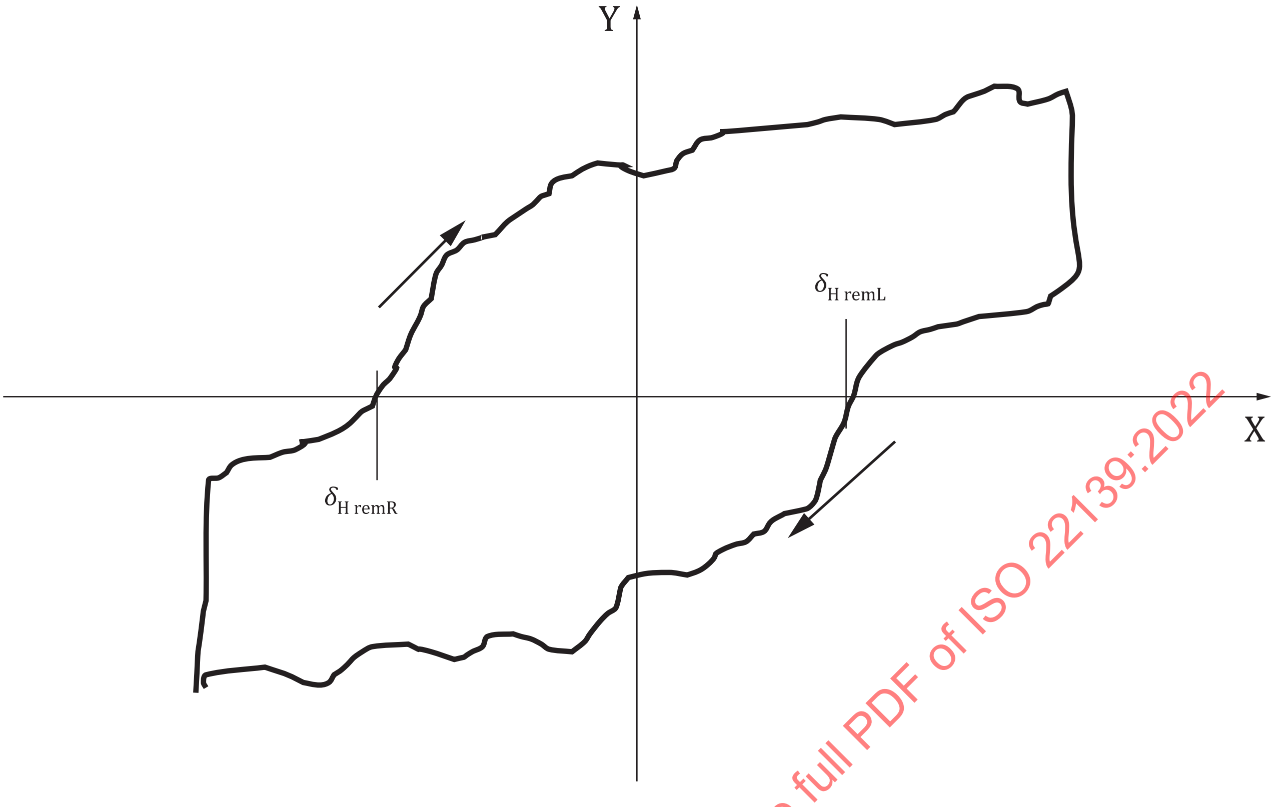
— the steering wheel speed after releasing the applied steering-wheel torque (see 9.9.2);

or both.

These characteristic parameters are meant to resemble how the steering wheel returns towards the on-centre position when at slow speed making a tight turn and then going straight in a new direction.

9.9.1 Remaining steering-wheel angle ($\delta_{H\,remL}$ and $\delta_{H\,remR}$)

The remaining steering wheel angle is the angle where the driver needs to start applying torque to move the steering wheel inwards to on-centre position. See Figure 8.



Key

X	steering-wheel angle	δ_H (°)
Y	steering-wheel torque	M_H (Nm)
$\delta_{H\ remL}$	remaining steering wheel angle when steering inwards from left to right direction (°)	
$\delta_{H\ remR}$	remaining steering wheel angle when steering inwards from right to left direction (°)	

Figure 8 — Remaining steering wheel angle

9.9.2 Steering-wheel speed when returning to steering-wheel straight forward position

This characteristic parameter is the average steering-wheel return speed during a predefined time period after release of steering wheel.

— Define vehicle speed, radius and time period after release to be used for the test.

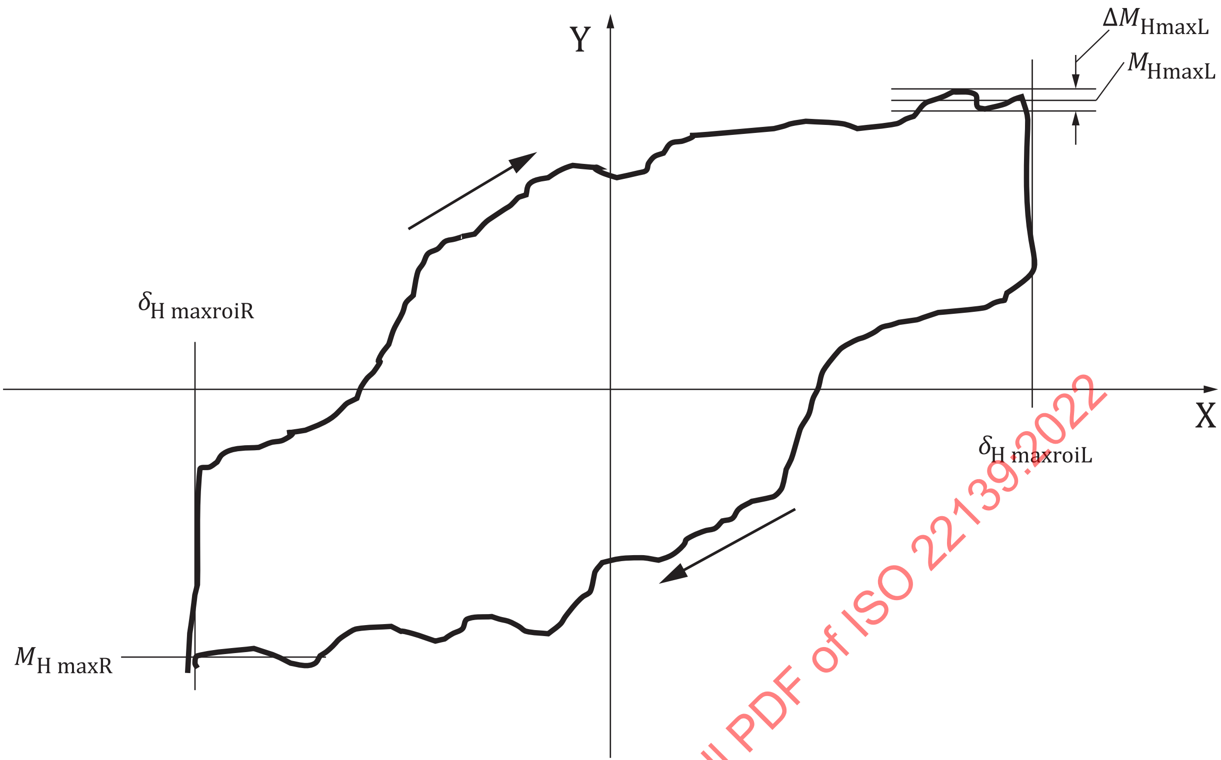
EXAMPLE 15 (km/h), 10 (m) radius and 2 (s) after release.

— Drive in the predefined vehicle speed in the predefined curve radius and let go of the steering-wheel.

— Measure the steering-wheel speed and calculate the average steering-wheel return speed during the predefined time period after release.

9.10 Steering-wheel torque variation ΔM_{Hmax} / M_{Hmax} (%)

This characteristic parameter is meant to resemble the variation in torque a driver experiences in the steering wheel during slow speed manoeuvring while turning the steering wheel at various steering wheel speeds. This variation can be evaluated between any chosen steering wheel angles. In the example in Figure 9 the evaluation is done at maximum steering-wheel angles range of interest in left direction, $\delta_{H\ maxroiL}$.



Key

X	steering-wheel angle	δ_H (°)
Y	steering-wheel torque	M_H (Nm)
ΔM_{HmaxL}	remaining steering wheel angle when steering inwards from left to right direction (°)	
M_{HmaxL}	remaining steering wheel angle when steering inwards from right to left direction (°)	
$\delta_{H\ maxroiL}$	maximum steering-wheel angles range of interest in right direction (°)	
$\delta_{H\ maxroiR}$	maximum steering-wheel angles range of interest in right direction (°)	

Figure 9 — Steering-wheel torque variation

Annex A
(normative)

Test report — General data

Test method for steering effort measurement when manoeuvring at low speed or with stationary vehicle

Vehicle or vehicle combination type

Vehicle identification

Type of vehicle: ....

Vehicle identification number: ....

Make, year, model, type: ....

Odometer reading: ....

Engine Identification code ....

Transmission Identification code ....

Axle 1 (front)

Suspension type: ....

Type of axle: ....

Model: ....

Load rating: ....

Stabilizer type: ....

Number of wheels: ....

Track: ....

Rim size: ....

Rim offset ....

Tyres

Type: ....

Make (retread): ....

Date: ....

Size: ....

