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World Forum for Harmonization of Vehicle Regulations

Working Party on Brakes and Running Gear

REPORT OF THE WORKING PARTY ON BRAKES AND RUNNING GEAR ON ITS SIXTY-THIRD SESSION (4 – 8 February 2008)

Addendum 1

Annex VI

Proposal for draft Supplement 7 to Regulation No. 13-H (Braking)

The text reproduced below was adopted by GRRF at its sixty-third session (see para. 49 of this report) and contains a proposal to align Regulation No. 13-H with the new provisions on electronic stability control. It is mainly based on ECE/TRANS/WP.29/GRRF/2007/28. It takes also into account the decision by WP.29 at its March 2008 session regarding the transitional provisions and the remaining open issues (see WP.29 report ECE/TRANS/WP.29/1066, paras. 25 and 65, and informal document No. WP.29-144-28). The secretariat was requested to submit it to WP.29 and AC.1 for consideration at their November 2008 session, subject to a final review at the sixty-fourth GRRF session in September 2008. The modifications to ECE/TRANS/WP.29/GRRF/2007/28 are marked in **bold** characters.

Insert new paragraphs 2.24. to 2.32., to read:

"2.24. "Ackerman steer angle" means the angle whose tangent is the wheelbase divided by the radius of the turn at a very low speed.

2.25. "Electronic Stability Control System" or "ESC System" means a system that has all of the following attributes:

2.25.1. **That improves vehicle directional stability by at least having the ability to automatically control individually the braking torques of the left and right wheels on each axle 1/ to induce a correcting yaw moment based on the evaluation of actual vehicle behaviour in comparison with a determination of vehicle behaviour demanded by the driver;**

2.25.2. **That is computer controlled with the computer using a closed-loop algorithm to limit vehicle oversteer and to limit vehicle understeer based on the evaluation of actual vehicle behaviour in comparison with a determination of vehicle behaviour demanded by the driver;**

2.25.3. That has a means to determine **directly** the value of vehicle's yaw rate and to estimate its side-slip or side-slip derivative with respect to time;

2.25.4. That has a means to monitor driver steering inputs; **and**

2.25.5. That has an algorithm to determine the need, and a means to modify **propulsion torque**, as necessary, to assist the driver in maintaining control of the vehicle.

2.26. "Lateral acceleration" means the component of the acceleration vector of a point in the vehicle perpendicular to the vehicle x axis (longitudinal) and parallel to the road plane.

2.27. "Oversteer" means a condition in which the vehicle's yaw rate is greater than the yaw rate that would occur at the vehicle's speed as result of the Ackerman steer angle.

2.28. "Side-slip or side-slip angle" means the arctangent of the ratio of the lateral velocity to the longitudinal velocity of the centre of gravity of the vehicle.

2.29. "Understeer" means a condition in which the vehicle's yaw rate is less than the yaw rate that would occur at the vehicle's speed as result of the Ackerman steer angle.

1/ An axle group shall be treated as a single axle and dual wheels shall be treated as a single wheel.

2.30. "Yaw rate" means the rate of change of the vehicle's heading angle measured in degrees/second of rotation about a vertical axis through the vehicle's centre of gravity.

2.31. "Peak braking coefficient (PBC)": means the measure of tyre to road surface friction based on the maximum deceleration of a rolling tyre.

2.32. "Common space" means an area on which more than one tell-tale, indicator, identification symbol, or other message may be displayed but not simultaneously.

2.33. "Static stability factor" means one-half the track width of a vehicle divided by the height of its center of gravity, also expressed as SSF = T/2H, where: T = track width (for vehicles with more than one track widths the average is used; for axles with dual wheels, the outer wheels are used when calculating 'T') and H = height of the center of gravity of the vehicle.

Insert new paragraphs 4.4.3. and 4.4.4., to read:

"4.4.3. In the case of a vehicle complying with the Electronic Stability Control requirements of Annex 9 to this Regulation, the additional letters 'ESC' shall be placed immediately to the right of the letter 'R' mentioned in paragraph 4.4.2.

4.4.4. In the case of a vehicle complying with the Vehicle Stability Function requirements of Annex 21 to Regulation No. 13, the additional letters 'VSF' shall be placed immediately to the right of the letter 'R' mentioned in paragraph 4.4.2."

Insert new paragraphs 5.2.25. and 5.2.25.1., to read:

"5.2.25. Subject to the requirements of paragraphs 12.2. to 12.4., any vehicle **fitted with an ESC** system **complying with the definition of paragraph 2.25.** shall meet the equipment, performance and test requirements contained in Annex 9 to this Regulation.

5.2.25.1. As an alternative to the requirement of paragraph 5.2.25., vehicles of categories M_1 and N_1 with a mass in running order > 1,735 kg may be equipped with a vehicle stability function which includes roll-over control and directional control and meets the technical requirements of Annex 21 to Regulation No. 13."

Insert new paragraphs 12.2. to 12.3., to read:

"12.2. As from **1 November 2011, Contracting Parties applying this Regulation may refuse to grant new approvals if the vehicle type to be approved does not meet the requirements of this Regulation as amended by Supplement 7.**

12.3. As from **1 November 2013, Contracting Parties applying this Regulation may refuse first national registration of a vehicle which does not meet the requirements of this Regulation as amended by Supplement 7.**"

Annex 1

Insert a new item 21, to read:

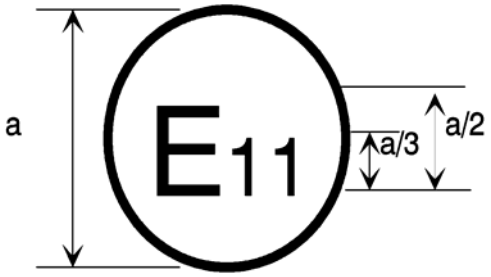
"21 The vehicle is equipped with **an ESC system**:..... Yes / No
If yes: The **ESC system** has been tested according to and fulfils the requirements of Annex 9 ..... Yes / No

or: The vehicle stability function has been tested according to and fulfils the requirements of Annex 21 to Regulation No. 13 ..... Yes / No"

Items 21 to 30 (former), renumber as items 22 to 31.

Annex 2, model 'A' and the accompanying text, amend to read:

"



13HRESC-002439 a/3

a= 8mm. min.

The above approval mark ..... in its original form. **The additional marking 'ESC' indicates that the vehicle meets the electronic stability control requirements of Annex 9 to this Regulation.**"

Insert a new Annex 9, to read (see next pages):

"Annex 9

ELECTRONIC STABILITY CONTROL SYSTEMS

1. GENERAL REQUIREMENTS

Vehicles equipped with an ESC system shall meet the functional requirements specified in paragraph 2. and the performance requirements in paragraph 3. under the test procedures specified in paragraph 4. and under the test conditions specified in paragraph 5. of this annex.

2. FUNCTIONAL REQUIREMENTS

Each vehicle to which this annex applies shall be equipped with an electronic stability control system that:

2.1. Is capable of applying **braking** torques individually to all four wheels 1/ and has a control algorithm that utilizes this capability;

2.2. Is operational over the full speed range of the vehicle, during all phases of driving including acceleration, coasting, and deceleration (including braking), except:

2.2.1. When the driver has disabled ESC;

2.2.2. When the vehicle speed is below **20 km/h**;

2.2.3. While the initial start-up self test and plausibility checks are completed, not to exceed 2 minutes when driven under the conditions of paragraph 5.10.2.;

2.2.4. When the vehicle is being driven in reverse.

2.3. Remains capable of activation even if the antilock braking system or traction control system is also activated.

3. PERFORMANCE REQUIREMENTS

During each test performed under the test conditions of paragraph 4. and the test procedure of paragraph 5.9., the vehicle with the ESC system engaged shall satisfy the directional stability criteria of paragraphs 3.1. and 3.2., and it shall satisfy the responsiveness criterion of paragraph 3.3. during each of those tests conducted with a

1/ An axle group shall be treated as a single axle and dual wheels shall be treated as a single wheel.

commanded steering wheel **2**/ angle of 5A or greater but limited as per paragraph 5.9.4., where A is the steering wheel angle computed in paragraph 5.6.1.

Where a vehicle has been physically tested in accordance with paragraph 4., the compliance of versions or variants of that same vehicle type may be demonstrated by a computer simulation, which respects the test conditions of paragraph 4. and the test procedure of paragraph 5.9. The use of the simulator is defined in Appendix 1 to this annex.

3.1. The yaw rate measured 1 second after completion of the Sine with Dwell steering input (time $T_0 + 1$ in Figure 1) shall not exceed 35 percent of the first peak value of yaw rate recorded after the steering wheel angle changes sign (between first and second peaks) ($\dot{\psi}_{Peak}$ in Figure 1) during the same test run.

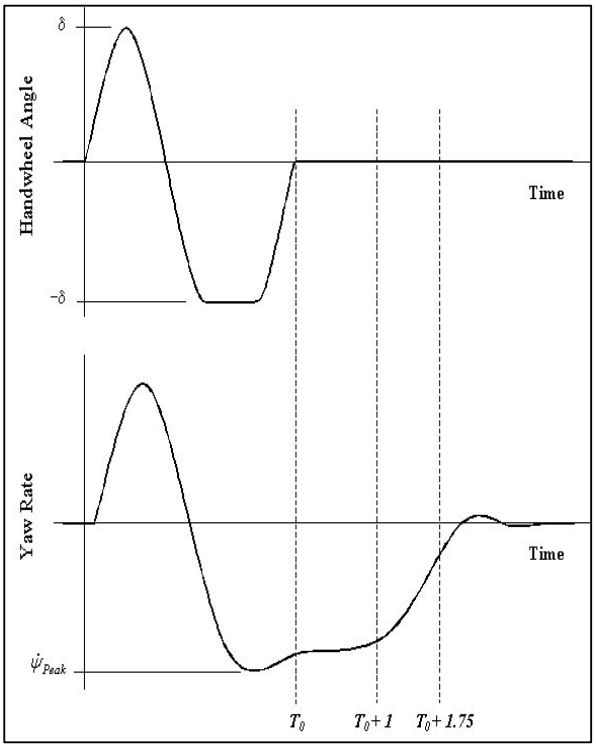


Figure 1 Steering wheel position and yaw velocity information used to assess lateral stability.

2/ The text in this annex assumes that the vehicle steering is controlled by means of a steering wheel. Vehicles using other types of steering control may also be approved to this annex provided the manufacturer is able to demonstrate to the technical service that the performance requirements of this annex can be met using equivalent steering inputs to the steering inputs stipulated under paragraph 5. of this annex.

3.2. The yaw rate measured 1.75 seconds after completion of the Sine with Dwell steering input shall not exceed 20 percent of the first peak value of yaw rate recorded after the steering wheel angle changes sign (between first and second peaks) during the same test run.

3.3. The lateral displacement of the vehicle centre of gravity with respect to its initial straight path shall be at least 1.83 m for vehicles with a GVM of 3,500 kg or less, and 1.52 m for vehicles with a **maximum mass** greater than 3,500 kg when computed 1.07 seconds after the Beginning of Steer (BOS). BOS is defined in paragraph 5.11.6.

3.3.1. The computation of lateral displacement is performed using double integration with respect to time of the measurement of lateral acceleration at the vehicle centre of gravity, as expressed by the formula:

$$\text{Lateral Displacement} = \iint a_{y_{C.G.}} dt$$

An alternative measuring method may be allowed for type approval testing, provided it demonstrates at least an equivalent level of precision as the double integration method.

3.3.2. Time t = 0 for the integration operation is the instant of steering initiation, known as the Beginning of Steer (BOS). BOS is defined in paragraph 5.11.6.

3.4. <u>ESC malfunction detection</u>

The vehicle shall be equipped with a tell-tale that provides a warning to the driver of the occurrence of **any malfunction that affects** the generation or transmission of control or response signals in the vehicle's electronic stability control system.

3.4.1. The ESC malfunction tell-tale:

3.4.1.1. Shall be displayed in direct and clear view of the driver, while **in the driver's designated seating position with the driver's seat belt fastened;**

3.4.1.2. **Shall appear perceptually upright to the driver while driving;**

3.4.1.3. Shall be identified by the symbol shown for "ESC Malfunction Tell-tale" below or the text "ESC":

3.4.1.4. Shall be yellow or amber in colour;

3.4.1.5. When illuminated must be sufficiently bright to be visible to the driver under both daylight and night-time driving conditions, when the driver has adapted to the ambient roadway light conditions;

3.4.1.6. Except as provided in paragraph **3.4.1.7.**, the ESC malfunction tell-tale shall illuminate when a **malfunction** exists and **shall** remain continuously illuminated under the conditions specified in paragraph 3.4. for as long as the malfunction exists, whenever the ignition locking system is in the "On" ("Run") position;

3.4.1.7. Except as provided in paragraph 3.4.2., each ESC malfunction tell-tale shall be activated as a check of lamp function either when the ignition locking system is turned to the "On" ("Run") position when the engine is not running, or when the ignition locking system is in a position between "On" ("Run") and "Start" that is designated by the manufacturer as a check position;

3.4.1.8. Shall extinguish **at the next ignition cycle after the malfunction has been corrected in accordance with paragraph 5.10.4.;**

3.4.1.9. May also be used to indicate the malfunction of related systems/functions, including traction control, trailer stability assist, corner brake control, and other similar functions that use throttle and/or individual torque control to operate and share common components with ESC.

3.4.2. The ESC malfunction tell-tale need not be activated when a starter interlock is in operation.

3.4.3. The requirement of paragraph 3.4.1.4. does not apply to tell-tales shown in a common space.

3.4.4. The manufacturer may use the ESC malfunction tell-tale in a flashing mode to indicate **ESC operation**.

3.5. ESC Off and other system controls

The manufacturer may include an "ESC Off" control, which shall be illuminated when the vehicle's headlamps are activated, **and which has a purpose** to place the ESC system in a mode in which it will no longer satisfy the performance requirements of paragraphs **3.,** 3.1., 3.2. and 3.3. Manufacturers may also provide controls for other systems that have an ancillary effect upon ESC operation. Controls of either kind that place the ESC system in a mode in which it **may** no longer satisfy the performance requirements of paragraphs **3.,** 3.1., 3.2. and 3.3. are permitted, provided that the system also meets the requirements of paragraphs 3.5.1., 3.5.2. and 3.5.3.

3.5.1. The vehicle's ESC system shall always return to **the manufacturer's original default** mode that satisfies the requirements of paragraphs 2. and 3. at the initiation of each new ignition cycle, regardless of what mode the driver had previously selected**. However, the vehicle's ESC system need not return to a mode that satisfies the requirements of paragraphs 3. through 3.3. at the initiation of each new ignition cycle if:**

3.5.1.1. The vehicle is in a four-wheel drive configuration which has the effect of locking the drive gears at the front and rear axles together and providing an additional gear reduction between the engine speed and vehicle speed of at least 1.6 or 2.0 3/, selected by the driver for low-speed, off-road driving; or

3.5.1.2. The vehicle is in a four-wheel drive configuration selected by the driver that is designed for operation at higher speeds on snow-, sand-, or dirt-packed roads and that has the effect of locking the drive gears at the front and rear axles together, provided that in this mode the vehicle meets the stability performance requirements of paragraphs 3.1. and 3.2. under the test conditions specified in paragraph 4. However, if the system has more than one ESC mode that satisfies the requirements of paragraphs 3.1. and 3.2. within the drive configuration selected for the previous ignition cycle, the ESC shall return to the manufacturer's original default ESC mode for that drive configuration at the initiation of each new ignition cycle.

3.5.2. A control, whose only purpose is to place the ESC system in a mode in which it will no longer satisfy the performance requirements of paragraphs **3.**, 3.1., 3.2. and 3.3., shall be identified by the symbol shown for "ESC Off" below or the text "ESC OFF".

3.5.3. **A control for an ESC system whose purpose is to place the ESC system in different modes, at least one of which may no longer satisfy the performance requirements of paragraphs 3., 3.1., 3.2., and 3.3., shall be identified by the symbol below with the text "OFF" adjacent to the control position for this mode.**

3/ The value of either 1.6 or 2.0 to be selected at the discretion of the Contracting Party.

3.5.4. A control for another system that has the ancillary effect of placing the ESC system in a mode in which it no longer satisfies the performance requirements of paragraphs **3.**, 3.1., 3.2. and 3.3. need not be identified by the "ESC Off" symbol of paragraph **3.5.2.**

3.6. ESC OFF tell-tale

If the manufacturer elects to install a control to turn off or reduce the performance of the ESC system under paragraph 3.5., the tell-tale requirements of paragraphs 3.6.1. to **3.6.4.** shall be met in order to alert the driver to the inhibited or reduced state of ESC system functionality. **This requirement does not apply for the driver-selected mode referred to in paragraph 3.5.1.2.**

3.6.1. The vehicle manufacturer shall provide a tell-tale indicating that the vehicle has been put into a mode that renders it unable to satisfy the requirements of paragraphs **3.**, 3.1., 3.2. and 3.3., if such a mode is provided.

3.6.2. The "ESC Off" tell-tale:

3.6.2.1. Shall be displayed in direct and clear view of the driver while in the driver's designated seating position with the driver's seat belt fastened;

3.6.2.2. Shall appear perceptually upright to the driver while driving;

3.6.2.3. Shall be identified by the symbol shown for "ESC Off" below or the text "ESC OFF",

or

Shall be identified with the English word "OFF" adjacent to either the control referred to in paragraph 3.5.2. or 3.5.3. or the illuminated malfunction tell-tale;

3.6.2.4. Shall be yellow or amber in colour;

3.6.2.5. When illuminated, shall be sufficiently bright to be visible to the driver under both daylight and night time driving conditions, when the driver has adapted to the ambient roadway light conditions;

3.6.2.6. Shall remain continuously illuminated for as long as the ESC is in a mode that renders it unable to satisfy the requirements of paragraphs 3., 3.1., 3.2. and 3.3;

3.6.2.7. Except as provided in **paragraphs 3.6.3. and 3.6.4. each "ESC Off"** tell-tale shall be activated as a check of lamp function either when the ignition locking system is turned to the "On" ("Run") position when the engine is not running, or when the

ignition locking system is in a position between "On" ("Run") and "Start" that is designated by the manufacturer as a check position.

3.6.2.8. **Shall** extinguish after the ESC system has been returned to its fully functional default mode.

3.6.3. **The "ESC Off" malfunction tell-tale need not be activated when a starter interlock is in operation.**

3.6.4. **The requirement of paragraph 3.6.2.7. of this annex does not apply to tell-tales shown in a common space.**

3.6.5. **The manufacturer may use the ESC malfunction tell-tale to indicate an ESC level of function other than the fully functional default mode even if the vehicle would meet paragraphs 3., 3.1., 3.2. and 3.3. of this annex at that level of ESC function.**

3.7. ESC system technical documentation

Further to the requirements defined in Annex 8 to this Regulation the documentation package shall, as confirmation that the vehicle is equipped with an ESC system that meets the definition of an "ESC System" as in paragraph 2.25. to this Regulation, include the vehicle manufacturer's documentation as specified in paragraphs 3.7.1. to 3.7.4. below.

3.7.1. System diagram identifying all ESC system hardware. The diagram shall identify those components that are used to generate brake torques at each wheel, determine vehicle yaw rate, estimated side-slip or the side-slip derivative and driver steering inputs.

3.7.2. **A brief** written explanation **sufficient to describe** the ESC system's basic operational characteristics. This explanation shall include **the outline description of** the system's capability to apply braking torques at each wheel and how the system modifies engine torque during ESC system **activation, and show that the vehicle yaw rate can be determined even under the conditions where no wheel speed information is available**. The explanation shall also specify the vehicle speed range and the driving phases (acceleration, deceleration, coasting, during activation of the ABS or traction control) under which the ESC system can activate.

3.7.3. Logic diagram. This diagram supports the explanation provided under paragraph 3.7.2.

3.7.4. Understeer information. **An outline description of the pertinent inputs to the computer that control ESC system hardware and how they are used to limit vehicle understeer.**

4. TEST CONDITIONS

4.1. Ambient conditions

4.1.1. The ambient temperature is between **0 °C and 45 °C.**

4.1.2. The maximum wind speed is no greater than 10 m/s for **vehicles with SSF > 1.25, and 5 m/s for vehicles with SSF ≤ 1.25.**

4.2. Road test surface

4.2.1. Tests are conducted on a dry, uniform, solid-paved surface. Surfaces with irregularities and undulations, such as dips and large cracks, are unsuitable.

4.2.2. The road test surface **has a nominal 4/ peak braking coefficient (PBC) of 0.9, unless otherwise specified, when measured using either**:

4.2.2.1. The American Society for Testing and Materials (ASTM) E1136 standard reference test tyre, in accordance with ASTM Method E1337-90, at a speed of 40 mph; or

4.2.2.2. The k-test method specified in Appendix 2 to Annex 6 of this Regulation.

4.2.3. The test surface has a consistent slope between level and 1 per cent.

4.3. Vehicle conditions

4.3.1. The ESC system is enabled for all testing.

4.3.2. Vehicle mass. The vehicle is loaded with the fuel tank filled to at least 75 percent of capacity, and a total interior load of 168 kg comprised of the test driver, approximately 59 kg of test equipment (**automated** steering machine, data acquisition system and the power supply for the steering machine), and ballast as required to make up for any shortfall in the weight of test drivers and test equipment. Where required, ballast shall be placed on the floor behind the passenger front seat or if necessary in the front passenger foot well area. All ballast shall be secured in a way that prevents it from becoming dislodged during testing.

4.3.3. Tyres. The tyres **are inflated to the vehicle manufacturer's** recommended cold inflation pressure(s) **e.g. as** specified on the vehicle's placard or the tyre inflation pressure label. Tubes may be installed to prevent tyre de-beading.

4/ The 'nominal' value is understood as being the theoretical target value.

4.3.4. Outriggers. **Outriggers may be used for testing if deemed necessary for test drivers' safety. In this case, the following applies for vehicles with a Static Stability Factor (SSF) ≤ 1.25:**

4.3.4.1. Vehicles with a mass in running order under 1,588 kg shall be equipped with "lightweight" outriggers. Lightweight outriggers shall be designed with a maximum mass of [XX] kg and a maximum roll moment of inertia of [XX] kg·m^2 [figures to be provided by USA].

4.3.4.2. Vehicles with a mass in running order between 1,588 kg and 2,722 kg shall be equipped with "standard" outriggers. Standard outriggers shall be designed with a maximum mass of 32 kg and a maximum roll moment of inertia of 35.9 kg·m^2.

4.3.4.3. Vehicles with a mass in running order equal to or greater than 2,722 kg shall be equipped with "heavy" outriggers. Heavy outriggers shall be designed with a maximum mass of 39 kg and a maximum roll moment of inertia of 40.7 kg·m^2.

4.3.5. Automated steering machine. A steering robot programmed to execute the required steering pattern shall be used in paragraphs 5.5.2., 5.5.3., 5.6. and 5.9. The steering machine shall be capable of supplying steering torques between 40 to 60 Nm. The steering machine shall be able to apply these torques when operating with steering wheel velocities up to 1,200 degrees per second.

5. Test Procedure

5.1. Inflate the vehicles' tyres to the **manufacturer's recommended** cold inflation pressure(s) **e.g. as** provided on the vehicle's placard or the tyre inflation pressure label.

5.2. Tell-tale bulb check. With the vehicle stationary and the ignition locking system in the "Lock" or "Off" position, switch the ignition to the "On" ("Run") position or, where applicable, the appropriate position for the lamp check. The ESC malfunction tell-tale shall be illuminated as a check of lamp function, as specified in paragraph 3.4.1.4., and if equipped, the "ESC Off" tell-tale shall also be illuminated as a check of lamp function, as specified in paragraph 3.6.6. The tell-tale bulb check is not required for a tell-tale shown in a message centre as specified in paragraphs 3.4.2. and 3.6.8.

5.3. "ESC Off" control check. For vehicles equipped with an "ESC Off" control, with the vehicle stationary and the ignition locking system in the "Lock" or "Off" position, switch the ignition locking system to the "On" ("Run") position. Activate the "ESC Off" control and verify that the "ESC Off" tell-tale is illuminated, as specified in paragraph 3.6.4. Turn the ignition locking system to the "Lock" or "Off" position. Again, switch the ignition locking system to the "On" ("Run") position and verify

that the "ESC Off" tell-tale has extinguished indicating that the ESC system has been restored as specified in paragraph 3.5.1.

5.4. Brake conditioning

Condition the vehicle brakes in the manner described in paragraphs 5.4.1. to 5.4.4.

5.4.1. Ten stops are performed from a speed of 56 km/h, with an average deceleration of approximately 0.5g.

5.4.2. Immediately following the series of ten 56 km/h stops, three additional stops are performed from 72 km/h at higher deceleration.

5.4.3. When executing the stops in paragraph 5.4.2., sufficient force is applied to the brake pedal to bring the vehicle's antilock braking system (ABS) into operation for a majority of each braking event.

5.4.4. Following completion of the final stop in 5.4.2., the vehicle is driven at a speed of 72 km/h for five minutes to cool the brakes.

5.5. Tyre Conditioning

Condition the tyres using the procedure of paragraphs 5.5.1. to 5.5.3. to wear away mould sheen and achieve operating temperature immediately before beginning the test runs of paragraphs 5.6. and 5.9.

5.5.1. The test vehicle is driven around a circle 30 meters in diameter at a speed that produces a lateral acceleration of approximately 0.5 to 0.6g for three clockwise laps followed by three anticlockwise laps.

5.5.2. Using a sinusoidal steering pattern at a frequency of 1 Hz, a peak steering wheel angle amplitude corresponding to a peak lateral acceleration of 0.5 to 0.6g, and a vehicle speed of 56 km/h, the vehicle is driven through four passes performing 10 cycles of sinusoidal steering during each pass.

5.5.3. The steering wheel angle amplitude of the final cycle of the final pass shall be twice that of the other cycles. The maximum time permitted between each of the laps and passes is five minutes.

5.6. Slowly increasing steer procedure

The vehicle is subjected to two series of runs of the slowly increasing steer test using a constant vehicle speed of 80 $\pm$ 2 km/h and a steering pattern that increases by 13.5 degrees per second until a lateral acceleration of approximately 0.5g is obtained. Three repetitions are performed for each test series. One series uses anticlockwise steering, and the other series uses clockwise steering. The maximum time permitted between each test run is five minutes.

5.6.1. From the slowly increasing steer tests, the quantity "A" is determined. "A" is the steering wheel angle in degrees that produces a steady state lateral acceleration (corrected using the methods specified in paragraph 5.11.3.) of 0.3g for the test vehicle. Utilizing linear regression, A is calculated, to the nearest 0.1 degrees, from each of the six slowly increasing steer tests. The absolute value of the six A values calculated is averaged and rounded to the nearest 0.1 degrees to produce the final quantity, A, used below.

5.7. After the quantity A has been determined, without replacing the tyres, the tyre conditioning procedure described in paragraph 5.5. is performed again immediately prior to conducting the Sine with Dwell test of paragraph 5.9. Initiation of the first Sine with Dwell test series shall begin within two hours after completion of the slowly increasing steer tests of paragraph 5.6.

5.8. Check that the ESC system is enabled by ensuring that the ESC malfunction and "ESC Off" (if provided) tell-tales are not illuminated.

5.9. Sine with Dwell test of oversteer intervention and responsiveness

The vehicle is subjected to two series of test runs using a steering pattern of a sine wave at 0.7 Hz frequency with a 500 ms delay beginning at the second peak amplitude as shown in Figure 2 (the Sine with Dwell tests). One series uses anticlockwise steering for the first half cycle, and the other series uses clockwise steering for the first half cycle. The vehicle is allowed to cool-down between each test runs for a period of 1.5 to 5 minutes, with the vehicle stationary.

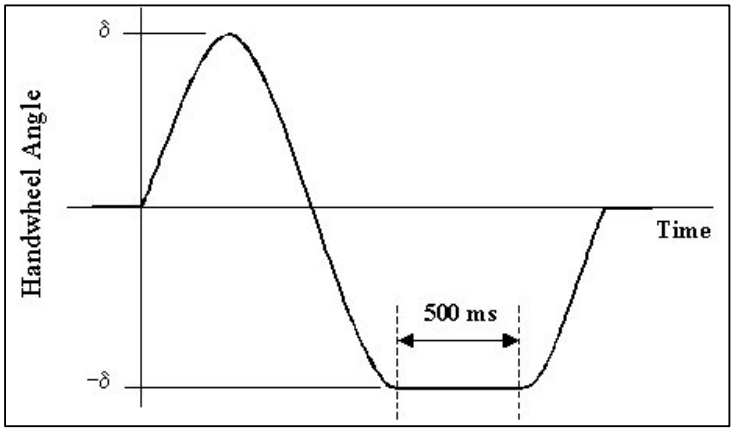


Figure 2 Sine with Dwell

5.9.1. The steering motion is initiated with the vehicle coasting in high gear at 80 ± 2 km/h.

5.9.2. The steering amplitude for the initial run of each series is 1.5 A, where A is the steering wheel angle determined in paragraph 5.6.1.

5.9.3. In each series of test runs, the steering amplitude is increased from run to run, by 0.5 A, provided that no such run will result in a steering amplitude greater than that of the final run specified in paragraph 5.9.4.

5.9.4. The steering amplitude of the final run in each series is the greater of 6.5 A or 270 degrees, provided the calculated magnitude of 6.5 A is less than or equal to 300 degrees. If any 0.5 A increment, up to 6.5 A, is greater than 300 degrees, the steering amplitude of the final run shall be 300 degrees.

5.9.5. Upon completion of the two series of test runs, post processing of yaw rate and lateral acceleration data is done as specified in paragraph 5.11.

5.10. ESC malfunction detection

5.10.1. Simulate one or more ESC malfunction(s) by disconnecting the power source to any ESC component, or disconnecting any electrical connection between ESC components (with the vehicle power off). When simulating an ESC malfunction, the electrical connections for the tell-tale lamp(s) **and/or optional ESC system control(s)** are not to be disconnected.

5.10.2. With the vehicle initially stationary and the ignition locking system in the "Lock" or "Off" position, switch the ignition locking system to the "Start" position and start the engine. **Drive the vehicle forward to obtain a vehicle speed of 48 ± 8 km/h. 30 seconds, at the latest, after the engine has been started and within the next two minutes at this speed, conduct at least one left and one right smooth turning manoeuvre without losing directional stability and one brake application. Verify that the ESC malfunction indicator illuminates in accordance with paragraph 3.4. by the end of these manoeuvres**.

5.10.3. Stop the vehicle, switch the ignition locking system to the "Off" or "Lock" position. After a five-minute period, switch the vehicle's ignition locking system to the "Start" position and start the engine. Verify that the ESC malfunction indicator again illuminates to signal a malfunction and remains illuminated as long as the engine is running or until the fault is corrected.

5.10.4. Switch the ignition locking system to the "Off" or "Lock" position. Restore the ESC system to normal operation, switch the ignition system to the "Start" position and start the engine. **Re-perform the manoeuvre described in paragraph 5.10.2. and verify that the tell-tale has extinguished within this time or immediately afterwards.**

5.11. Post data processing – calculations for performance metrics

Yaw rate and lateral displacement measurements and calculations shall be processed utilizing the techniques specified in paragraphs 5.11.1. to 5.11.8.

5.11.1. Raw steering wheel angle data is filtered with a 12-pole phaseless Butterworth filter and a cut-off frequency of 10 Hz. The filtered data is then zeroed to remove sensor offset utilizing static pre-test data.

5.11.2. Raw yaw rate data is filtered with a 12-pole phaseless Butterworth filter and a cut-off frequency of 6 Hz. The filtered data is then zeroed to remove sensor offset utilizing static pre-test data.

5.11.3. Raw lateral acceleration data is filtered with a 12-pole phaseless Butterworth filter and a cut-off frequency of 6 Hz. The filtered data is then zeroed to remove sensor offset utilizing static pre-test data. The lateral acceleration data at the vehicle centre of gravity is determined by removing the effects caused by vehicle body roll and by correcting for sensor placement via the use of coordinate transformation. For data collection, the lateral accelerometer shall be located as close as possible to the position of the vehicle's longitudinal and lateral centres of gravity.

5.11.4. Steering wheel velocity is determined by differentiating the filtered steering wheel angle data. The steering wheel velocity data is then filtered with a moving 0.1 second running average filter.

5.11.5. Lateral acceleration, yaw rate and steering wheel angle data channels are zeroed utilizing a defined "zeroing range." The methods used to establish the zeroing range are defined in paragraphs 5.11.5.1. and 5.11.5.2.

5.11.5.1. Using the steering wheel rate data calculated using the methods described in paragraph 5.11.4., the first instant that the steering wheel rate exceeds 75 deg/sec is identified. From this point, steering wheel rate shall remain greater than 75 deg/sec for at least 200 ms. If the second condition is not met, the next instant that the steering wheel rate exceeds 75 deg/sec is identified and the 200 ms validity check applied. This iterative process continues until both conditions are ultimately satisfied.

5.11.5.2. The "zeroing range" is defined as the 1.0 second time period prior to the instant the steering wheel rate exceeds 75 deg/sec (i.e., the instant the steering wheel velocity exceeds 75 deg/sec defines the end of the "zeroing range").

5.11.6. The Beginning of Steer (BOS) is defined as the first instance when the filtered and zeroed steering wheel angle data reaches -5 degrees (when the initial steering input is anticlockwise) or +5 degrees (when the initial steering input is clockwise) after a time defining the end of the "zeroing range." The value for time at the BOS is interpolated.

5.11.7. The Completion of Steer (COS) is defined as the time the steering wheel angle returns to zero at the completion of the Sine with Dwell steering manoeuvre. The value for time at the zero degree steering wheel angle is interpolated.

5.11.8. The second peak yaw rate is defined as the first local yaw rate peak produced by the reversal of the steering wheel. The yaw rates at 1.000 and 1.750 seconds after COS are determined by interpolation.

5.11.9. Determine lateral velocity by integrating corrected, filtered and zeroed lateral acceleration data. Zero lateral velocity at the BOS point. Determine lateral displacement by integrating zeroed lateral velocity. Zero lateral displacement at the BOS point. The lateral displacement measurement is made at 1.07 seconds after BOS point and is determined by interpolation."

Add new Appendices 1 to 3 to Annex 9, to read:

"**Annex 9 - Appendix 1**

USE OF THE DYNAMIC STABILITY SIMULATION

The effectiveness of the electronic stability control system may be determined by computer simulation.

1. USE OF THE SIMULATION

1.1. The vehicle stability function shall be demonstrated by the vehicle manufacturer to the Type Approval Authority or Technical Service by simulating the dynamic manoeuvres of paragraph 5.9. of Annex 9.

1.2. The simulation shall be a means whereby the vehicle stability performance shall be demonstrated with:

(a) The yaw rate, one second after completion of the Sine with Dwell steering input (time $T_0 + 1$);

(b) The yaw rate, 1.75 seconds after completion of the Sine with Dwell steering input;

(c) The lateral displacement of the vehicle centre of gravity with respect to its initial straight path.

1.3. The simulation shall be carried out with a validated modelling and simulation tool and using the dynamic manoeuvres of paragraph 5.9. of Annex 9 under the test conditions of paragraph 4. of Annex 9.

The method by which the simulation tool is validated is given in Appendix 2 to this annex.

Annex 9 - Appendix 2

DYNAMIC STABILITY SIMULATION TOOL AND ITS VALIDATION

1. SPECIFICATION OF THE SIMULATION TOOL

1.1. The simulation method shall take into account the main factors which influence the directional and roll motion of the vehicle. A typical model may include the following vehicle parameters in an explicit or implicit form:

(a) Axle/wheel
(b) Suspension
(c) Tyre
(d) Chassis/vehicle body
(e) Power train/driveline, if applicable
(f) Brake system
(g) Pay load

1.2. The Vehicle Stability Function shall be added to the simulation model by means of:

a) A subsystem (software model) of the simulation tool; or
b) The electronic control box in a hardware-in-the-loop configuration.

2. VALIDATION OF THE SIMULATION TOOL

2.1. The validity of the applied modelling and simulation tool shall be verified by means of comparisons with practical vehicle tests. The tests utilised for the validation shall be the dynamic manoeuvres of paragraph 5.9. of Annex 9.

During the tests, the following motion variables, as appropriate, shall be recorded or calculated in accordance with ISO 15037 Part 1:2005: General conditions for passenger cars or Part 2:2002: General conditions for heavy vehicles and buses (depending on the vehicle category):

(a) Steering-wheel angle (δ_H)
(b) Longitudinal velocity (v_X)
(c) Sideslip angle (β) or lateral velocity (v_Y);(optional)
(d) Longitudinal acceleration (a_X); (optional)
(e) Lateral acceleration (a_Y)
(f) Yaw velocity ($d\psi/dt$)
(g) Roll velocity ($d\varphi/dt$)
(h) Pitch velocity ($d\theta/dt$)
(i) Roll angle (φ)
(j) Pitch angle (θ)

2.2. The objective is to show that the simulated vehicle behaviour and operation of the vehicle stability function is comparable with that seen in practical vehicle tests.

2.3. The simulator shall be deemed to be validated when its output is comparable to the practical test results produced by a given vehicle type during the dynamic manoeuvres of paragraph 5.9. of Annex 9. The relationship of activation and sequence of the vehicle stability function in the simulation and in the practical vehicle test shall be the means of making the comparison.

2.4. The physical parameters that are different between the reference vehicle and simulated vehicle configurations shall be modified accordingly in the simulation.

2.5. A simulator test report shall be produced, a model of which is defined in Appendix 3 to this annex, and a copy attached to the vehicle approval report.

Annex 9 - Appendix 3

VEHICLE STABILITY FUNCTION SIMULATION TOOL TEST REPORT

Test Report Number: .....

1. Identification

1.1. Name and address of the simulation tool manufacturer.....

1.2. Simulation tool identification: name/model/number (hardware and software) .....

2. Scope of application

2.1. Vehicle type:.....

2.2. Vehicle configurations: .....

3. Verifying vehicle test

3.1. Description of vehicle(s):.....

3.1.1. Vehicle(s) identification: make/model/VIN.....

3.1.2. Vehicle description, including suspension/wheels, engine and drive line, braking system(s), steering system, with name/model/number identification: .....
.....

3.1.3. Vehicle data used in the simulation (explicit): .....

3.2. Description of location(s), road/test area surface conditions, temperature and date(s):.....

3.3. Results with the vehicle stability function switched on and off, including the motion variables referred to in Annex 9, Appendix 2, paragraph 2.1. as appropriate: .....
.....

4. Simulation results

4.1. Vehicle parameters and the values used in the simulation that are not taken from the actual test vehicle (implicit): .....

4.2. Yaw stability and lateral displacement according to paragraphs 3.1. to 3.3. of Annex 9: .....

5. This test has been carried out and the results reported in accordance with Appendix 2 of Annex 9 to Regulation No. 13-H, as last amended by the Supplement 7.

Technical Service conducting the test 1/ …….

Signed: …….. **Date: ……**

Approval Authority 1/ ……..

Signed: ……. **Date: ……**

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1/ To be signed by different persons if the Technical Service and the Approval Authority is the same organization."

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