## 85 Electronic stability control systems

Refer to: R140 00

### 85.1 Effective date and Scope:

85.1.1 Effective date from 2018/1/1, the new vehicle type of category symbols M1 and N1, and from 2022/1/1, the all vehicle types of category symbols M1 and N1, shall comply with this regulation.

85.1.1.1 Category symbols M1 and N1 that conformed to “42-3 Dynamic braking” of “Directions”, regard as has conformed to this regulation.

85.1.2 This regulation does not suitable for:

85.1.2.1 Vehicles with a design speed not exceeding 25km/hr.

85.1.3 The same applicant applying for low volume safety approval and the amounts of vehicle not exceed 3 at same year and the category symbols M1 or N1 of same type and specification, could exempt from regulation of “Electronic stability control systems”.

85.1.4 The same applicant applying for vehicle-by-vehicle low volume safety approval and the amounts of vehicle not exceed 20 at same year and small passenger vehicle of same type and specification, could exempt from regulation of “Electronic stability control systems”.

### 85.2 Definitions:

85.2.1 "Maximum mass" means the maximum mass stated by the vehicle manufacturer to be technically permissible (this mass may be higher than the "permissible maximum mass" laid down by the national administration).

85.2.2 "The distribution of mass among the axles" means the distribution of the effect of the gravity on the mass of the vehicle and/or its contents among the axles.

85.2.3 "Wheel/axle load" means the vertical static reaction (force) of the road surface in the contact area on the wheel/wheels of the axle.

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

85.2.5 "Electronic Stability Control (ESC) System" means a system that has all of the following attributes:

85.2.5.1 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 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;

85.2.5.2 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;

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

85.2.5.4 That has a means to monitor driver steering inputs; and

85.2.5.5 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.

85.2.6 "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.

85.2.7 "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 a result of the Ackerman steer angle.

85.2.8 "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.

85.2.9 "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 a result of the Ackerman steer angle.

85.2.10 "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.

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

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

85.2.13 "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 width 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.

85.3 Electronic stability control systems shall according to suitable type and range of principle：

85.3.1 The same brand and vehicle type.

85.3.2 Vehicle features which significantly influence the performances of the Electronic Stability Control system (e.g. maximum mass, centre of gravity position, track width, distance between axles, tyres dimension and the design of the braking system);

85.3.3 The design of the Electronic Stability Control system.

85.4 General requirements

85.4.1 Applicants apply for certification test shall provide at least one representative vehicle (or the essential part of vehicle for test) and submit the documents as below:

Applicants applying for low volume safety approval which could exempt from regulation of paragraph 85.4.1.1.2, 85.4.1.1.3 and paragraph 85.4.1.1.4.

85.4.1.1 Vehicle specification documents, drawings and / or photographs described in paragraph 85.3.

85.4.1.1.1 The numbers and/or symbols identifying the vehicle type and the engine type shall be specified;

85.4.1.1.2 A list of the components, duly identified, constituting the ESC system;

85.4.1.1.3 A diagram of the assembled ESC system and an indication of the position of its components on the vehicle;

85.4.1.1.4 Detailed drawings of each component to enable it to be easily located and identified.

85.4.1.1.5 Mass of vehicle.

85.4.1.1.5.1 Maximum mass of vehicle

85.4.1.1.5.2 Minimum mass of vehicle

85.4.1.1.6 Distribution of mass of each axle (maximum value)

85.4.1.1.7 Engine type

85.4.1.1.8 Number and ratios of gears

85.4.1.1.9 Final drive ratio(s)

85.4.1.1.10 If applicable, maximum mass of trailer which may be coupled

85.4.1.1.10.1 Unbraked trailer

85.4.1.1.11 Tyre dimension

85.4.1.1.12 Maximum design speed

85.4.1.1.13 Brief description of braking equipment

85.4.1.1.14 Mass of vehicle when tested:

| | **Load** *(kg)* |
|---|---|
| Axle No. 1 | |
| Axle No. 2 | |
| Total | |

85.4.1.1.15 The ESC system has been tested according to and fulfils the requirements of this Regulation. or:

The vehicle stability function has been tested according to and fulfils the requirements of “Dynamic braking”.

85.4.2 General requirements

Vehicles equipped with an ESC system shall meet the functional requirements specified in paragraph 85.5 and the performance requirements in paragraph 85.7 under the test procedures specified in paragraph 85.8 and under the test conditions specified in paragraph 85.6 of this section.

85.5 Functional requirements

If Technical service could not carry out the test due to related testing practical concern, then Technical service could base on the descriptive documents, which was provided by applicants to carry out the test.

85.5.1 Is capable of applying braking torques individually to all four wheels and has a control algorithm that utilizes this capability;

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

85.5.2.1 When the driver has disabled ESC;

85.5.2.2 When the vehicle speed is below 20 km/h;

85.5.2.3 While the initial start-up self test and plausibility checks are completed, not to exceed 2 minutes when driven under the conditions of paragraph 85.8.10.2;

85.5.2.4 When the vehicle is being driven in reverse.

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

85.6 Performance requirements

During each test performed under the test conditions of paragraph 85.7 and the test procedure of paragraph 85.8.9., the vehicle with the ESC system engaged shall satisfy the directional stability criteria of paragraphs 85.6.1 and 85.6.2, and it shall satisfy the responsiveness criterion of paragraph 85.8.9.4 during each of those tests conducted with a commanded steering wheel angle of 5A or greater but limited as per paragraph 85.6.3, where A is the steering wheel angle computed in paragraph 85.8.6.1.

Where a vehicle has been physically tested in accordance with paragraph 85.7, the compliance of versions or types of that same vehicle type may be demonstrated by a computer simulation, which respects the test conditions of paragraph 85.7 and the test procedure of paragraph 85.8.9. The use of the simulator is defined in paragraph 85.9.

85.6.1 The yaw rate measured 1 second after completion of the Sine with Dwell steering input (time $T_0$ + 1 in diagram 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) (in Figure 6) during the same test run.

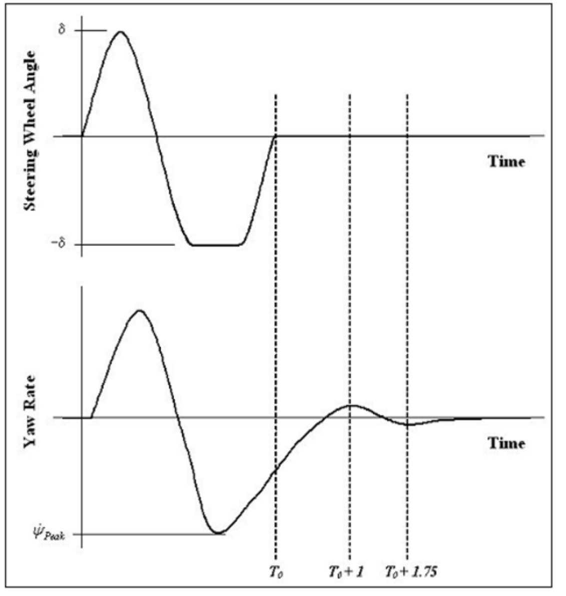


Diagram 1: Steering wheel position and yaw velocity information used to assess lateral stability

85.6.2 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.

85.6.3 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 85.11.6

85.6.3.1 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.

85.6.3.2 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 85.8.11.6.

85.6.4 ESC malfunction detection

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.

85.6.4.1 The ESC malfunction tell-tale:

85.6.4.1.1 Shall fulfil the relevant technical requirements of "The location and identification of hand controls, tell-tales and indicators";

85.6.4.1.2 Except as provided in paragraph 85.6.4.1.3, the ESC malfunction tell-tale shall illuminate when a malfunction exists and shall remain continuously illuminated under the conditions specified in paragraph 85.6.4 for as long as the malfunction exists, whenever the ignition locking system is in the "On" ("Run") position;

85.6.4.1.3 Except as provided in paragraph 85.6.4.2, 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;

85.6.4.1.4 Shall extinguish at the next ignition cycle after the malfunction has been corrected in accordance with paragraph 85.8.10.4;

85.6.4.1.5 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.

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

85.6.4.3 The requirement of paragraph 85.6.4.1.3 does not apply to tell-tales shown in a common space.

85.6.4.4 The manufacturer may use the ESC malfunction tell-tale in a flashing mode to indicate ESC operation intervention and/or the intervention of ESC-related systems (as listed in paragraph 85.6.4.1.5).

85.6.5 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 85.6, 85.6.1, 85.6.2 and 85.6.3. 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 85.6, 85.6.1, 85.6.2 and 85.6.3. are permitted, provided that the system also meets the requirements of paragraphs 85.6.5.1, 85.6.5.2 and 85.6.5.3.

85.6.5.1 The vehicle's ESC system shall always return to the manufacturer's original default mode that satisfies the requirements of paragraphs 85.5 and 85.6 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 85.6 through 85.6.3. at the initiation of each new ignition cycle if:

85.6.5.1.1 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, selected by the driver for low speed, off-road driving; or

85.6.5.1.2 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 85.6.1 and 85.6.2. under the test conditions specified in paragraph 85.7. However, if the system has more than one ESC mode that satisfies the requirements of paragraphs 85.6.1 and 85.6.2. 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.

85.6.5.2 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 85.6, 85.6.1,85.6.2 and 85.6.3, shall fulfil the relevant technical requirements of "The location and identification of hand controls, tell-tales and indicators";

85.6.5.3 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 85.6, 85.6.1,85.6.2 and 85.6.3, shall fulfil the relevant technical requirements of "The location and identification of hand controls, tell-tales and indicators";

Alternatively, in the case where the ESC system mode is controlled by a multifunctional control, the driver display shall identify clearly to the driver the control position for this mode using the "ESC OFF" symbol for electronic stability control system as defined in "The location and identification of hand controls, tell-tales and indicators".

85.6.5.4 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 85.6, 85.6.1, 85.6.2 and 85.6.3 need not be identified by the "ESC Off" symbol of paragraph 85.6.5.2.

85.6.6 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 85.6.5, the tell-tale requirements of paragraphs 85.6.6.1 to 85.6.6.4. 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 85.6.5.1.2.

85.6.6.1 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 85.6, 85.6.1, 85.6.2 and 85.6.3, if such a mode is provided.

85.6.6.2 The "ESC Off" tell-tale:

85.6.6.2.1 The "ESC Off" tell-tale shall fulfil the relevant technical requirements of "The location and identification of hand controls, tell-tales and indicators";

85.6.6.2.2 Shall remain continuously illuminated for as long as the ESC is in a mode that renders it unable to satisfy the requirements of paragraphs 85.6, 85.6.1, 85.6.2 and 85.6.3;

85.6.6.2.3 Except as provided in paragraphs 85.6.6.3 and 85.6.6.4 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.

85.6.6.2.4 Shall extinguish after the ESC system has been returned to the manufacturer's original default mode.

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

85.6.6.4 The requirement of paragraph 85.6.6.2.3 does not apply to tell-tales shown in a common space.

85.6.6.5 The manufacturer may use the "ESC Off" tell-tale to indicate an ESC level of function other than the manufacturer's original default mode even if the vehicle would meet paragraphs 85.6, 85.6.1, 85.6.2 and 85.6.3 of this annex at that level of ESC function.

85.7 Test conditions

85.7.1 Ambient conditions

85.7.1.1 The ambient temperature is between 0 degrees C and 45 degrees C.

85.7.1.2 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.

85.7.2 Road test surface

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

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

85.7.2.2.1 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

85.7.2.2.2 The k-test method specified in paragraph 43-1.6.2.5.1. of this “VSTD”.

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

85.7.3 Vehicle conditions

85.7.3.1 The ESC system is enabled for all testing.

85.7.3.2 Vehicle mass

The vehicle is loaded with the fuel tank filled to at least 90 per cent 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.

85.7.3.3 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.

85.7.3.4 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:

85.7.3.4.1.1 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 27 kg and a maximum roll moment of inertia of $27\ \text{kg}\cdot\text{m}^2$.

85.7.3.4.2 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 $35.9\ \text{kg}\cdot\text{m}^2$.

85.7.3.4.3 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 $40.7\ kg \cdot m^2$.

85.7.3.5 Automated steering machine

A steering robot programmed to execute the required steering pattern shall be used in paragraphs 85.8.5.2, 85.8.5.3, 85.8.6 and 85.8.9. 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.

85.8 Test procedure

85.8.1 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.

85.8.2 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 85.6.4.1.3, and if equipped, the "ESC Off" tell-tale shall also be illuminated as a check of lamp function, as specified in paragraph 85.6.6.2.3. The tell-tale bulb check is not required for a tell-tale shown in a common space as specified in paragraphs 85.6.4.3 and 85.6.6.4.

85.8.3 "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 85.6.6.2.

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" telltale has extinguished indicating that the ESC system has been restored as specified in paragraph 85.6.5.1.

85.8.4 Brake conditioning

Condition the vehicle brakes in the manner described in paragraphs 85.8.4.1 to 85.8.4.4.

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

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

85.8.4.3 When executing the stops in paragraph 85.8.4.2, 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.

85.8.4.4 Following completion of the final stop in 85.8.4.2, the vehicle is driven at a speed of 72 km/h for five minutes to cool the brakes.

85.8.5 Tyre Conditioning

Condition the tyres using the procedure of paragraphs 85.8.5.1 to 85.8.5.3 to wear away mould sheen and achieve operating temperature immediately before beginning the test runs of paragraphs 85.8.6 and 85.8.9.

85.8.5.1 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.

85.8.5.2 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.

85.8.5.3 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.

85.8.6 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 +/- 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.

85.8.6.1 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 85.8.11.3) 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.

85.8.7 After the quantity A has been determined, without replacing the tyres, the tyre conditioning procedure described in paragraph 85.8.5. is performed again immediately prior to conducting the Sine with Dwell test of paragraph 85.8.9. Initiation of the first Sine with Dwell test series shall begin within two hours after completion of the slowly increasing steer tests of paragraph 85.8.6.

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

85.8.9 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 diagram 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.

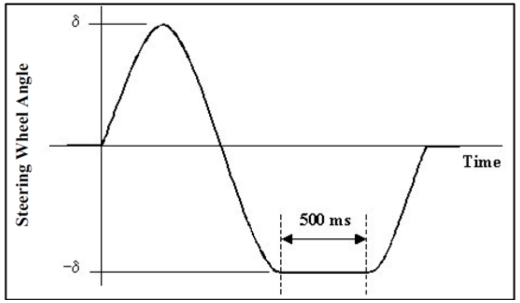


Diagram 2: Sine with Dwell

85.8.9.1 The steering motion is initiated with the vehicle coasting in high gear at 80 +/- 2 km/h.

85.8.9.2 The steering amplitude for the initial run of each series is 1.5 A, where A is the steering wheel angle determined in paragraph 85.8.6.1.

85.8.9.3 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 85.8.9.4.

85.8.9.4 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.

85.8.9.5 Upon completion of the two series of test runs, post processing of yaw rate and lateral acceleration data is done as specified in paragraph85.8.11.

85.8.10 ESC malfunction detection

85.8.10.1 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.

85.8.10.2 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 85.6.4 by the end of these manoeuvres.

85.8.10.3 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.

85.8.10.4 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 85.8.10.2 and verify that the tell-tale has extinguished within this time or immediately afterwards.

85.8.11 Post data processing - calculations for performance metrics

Yaw rate and lateral displacement measurements and calculations shall be processed utilizing the techniques specified in paragraphs 85.8.11.1 to 85.8.11.8.

85.8.11.1 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.

85.8.11.2 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.

85.8.11.3 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.

85.8.11.4 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.

85.8.11.5 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 85.8.11.5.1 and 85.8.11.5.2.

85.8.11.5.1 Using the steering wheel rate data calculated using the methods described in paragraph 85.11.4, 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.

85.8.11.5.2 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").

85.8.11.6 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.

85.8.11.7 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.

85.8.11.8 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.

85.8.11.9 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.

85.9 Use of the dynamic stability simulation

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

85.9.1 Use of the simulation

85.9.1.1 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 85.8.9.

85.9.1.2 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 T0 + 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.

85.9.1.3 The simulation shall be carried out with a validated modelling and simulation tool and using the dynamic manoeuvres of paragraph 85.8.9 under the test conditions of paragraph 85.7. The method by which the simulation tool is validated is given in paragraph 85.10.

85.10 Dynamic stability simulation tool and its validation

85.10.1 Specification of the simulation tool

85.10.1.1 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.

85.10.1.2 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.

85.10.2 Validation of the simulation tool

85.10.2.1 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 85.8.9.

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 (delta H);
(b) Longitudinal velocity (vX);
(c) Sideslip angle (beta) or lateral velocity (vY);(optional);
(d) Longitudinal acceleration (aX); (optional);
(e) Lateral acceleration (aY);
(f) Yaw velocity (d psi/dt);
(g) Roll velocity (d phi/dt);
(h) Pitch velocity (d theta/dt);
(i) Roll angle (phi);
(j) Pitch angle (theta).

85.10.2.2 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.

85.10.2.3 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 85.8.9. 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.

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

85.10.2.5 A simulator test report shall be produced, a model and a copy attached to the vehicle approval report.