

Proposal for amendments to UN Regulation No. 140 (ESC)

This document proposes amendments to the ESC prescribed test conditions for anticipating the development of future steering systems

1. Proposal

Paragraph 9.9.4., amend to read:

“9.9.4. 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.

If the above calculated steering amplitude of the final run is greater than the maximum operable steering wheel angle determined by design of the steering system, the final angle amplitude for the series test may be the maximum operable angle.”

2. Justifications

A. Background

UN R140 ESC prescribes that the “Sine with Dwell” series test of vehicle directional stability performance shall be conducted with;

- The initial steering wheel angle amplitude of 1.5A (paragraph 9.9.2),
- The steering wheel angle amplitude is increased by 0.5A from a test run to next run (paragraph 9.9.3),
- The final steering wheel angle amplitude of the greater of 6.5A or 270 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 (paragraph 9.9.4),

where "A" is the steering wheel angle that produces a steady state lateral acceleration of 0.3 g for the test vehicle, which is determined from the “Slowly Increasing Steer” test (paragraph 9.6).

In these test conditions, **the normalized angle “A” evacuates the influence of the steering gear ratio in relation to the steering wheel angle and vehicle behavior.** The lower the steering gear ratio is (i.e. the quicker the steering characteristic is), the smaller the angle “A” and steering angle amplitude for each test run are, to **provide constant steered wheel angle implying constant lateral movement of vehicle, regardless of the steering gear ratio**, for reasonable testing of ESC.

However, **the final steering wheel angle amplitude is fixed between 270 and 300 degrees, which are absolute values, not the normalized angles that exclude the influence of the steering gear ratio** of each vehicle.

B. Concern on future steering systems

There might appear in the future **some vehicles** which have significantly low steering gear ratio (i.e. quick steering characteristics) and **which may not be able to achieve the specified final absolute**

angle amplitude in the ESC test, then jeopardizing future beneficial improvement of steering equipment e.g. steering-by-wire system.

C. Justification to the proposal

The above proposal would be appropriate because:

(1) The original intention of the ESC regulation would not be prejudiced.

UN official document on UN GTR8 ESC, produced in parallel to the text of UN R140, mentions that the final steering wheel angle amplitude of 270 to 300 degrees was decided based on the investigation of an average driver's ability to operate steering wheel as fast as possible under the specified "Sine with Dwell" condition (ECE/TRANS/180/Add.8, paragraphs 190 and 191 of the Preamble). Thus, **the decision was based on maximum achievable steering wheel input.**

Without prejudice to the above intention, the final steering wheel angle amplitude for the series of tests could be decided to be the maximum operable steering wheel angle of the steering system if the maximum operable angle is less than 270 degrees. It is because **the maximum operable angle is equivalent to the maximum achievable steering input** in this case.

(2) ESC regulation is not intended to prescribe a maximum operable steering wheel angle.

It would not be reasonable to judge that a vehicle equipped with low geared steering system (i.e. quick steering characteristics) is incompliant with the ESC regulation for the simple reason that the operable steering wheel angle is less than 270 degrees, even though it is adequately safe in practical use with technical development and complies with UN R79 steering requirements.

D. Relevant extracts

UN R140 ELECTRONIC STABILITY CONTROL SYSTEMS

5. General requirements

5.1. Vehicles equipped with an ESC shall meet the functional requirements specified in paragraph 6. and the performance requirements in paragraph 7. under the test procedures specified in paragraph 9. and under the test conditions specified in paragraph 8. of this Regulation.

7. Performance requirements

During each test performed under the test conditions of paragraph 8. and the test procedure of paragraph 9.9., the vehicle with the ESC system engaged shall satisfy the directional stability criteria of paragraphs 7.1. and 7.2., and it shall satisfy the responsiveness criterion of paragraph 7.3. during each of those tests conducted with a commanded steering wheel angle of 5A or greater but limited as per paragraph 9.9.4., where A is the steering wheel angle computed in paragraph 9.6.1.

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7.1. 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 per cent 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.

- 7.2. The yaw rate measured 1.75 seconds after completion of the Sine with Dwell steering input shall not exceed twenty per cent 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.
- 7.3. 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 9.11.6.
- 7.3.1. 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.
- 7.3.2. 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 9.11.6.

9. Test Procedure

- 9.6. 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.
- 9.6.1. 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 9.11.3.) 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.
- 9.9. 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.
- 9.9.1. The steering motion is initiated with the vehicle coasting in high gear at 80 +/- 2 km/h.
- 9.9.2. The steering amplitude for the initial run of each series is 1.5 A, where A is the steering wheel angle determined in paragraph 9.6.1.

- 9.9.3. 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 9.9.4.
- 9.9.4. 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.
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