

**MODIFICATIONS IN THE TILTING TEST PROPOSED FOR THE
DETERMINATION OF THE CENTRE OF GRAVITY IN REGULATION 66**

(presented by Spain)

Document TRANS/WP.29/GRSG/2001/5 proposes the inclusion of a new annex 7 in Regulation 66, in order to incorporate the method for determination of the centre of gravity of the vehicle. Two different methods are considered, the lifting and the tilting method.

In case of tilting test, the suspension is required to be blocked. The proposed test may present some problems, which are discussed next.

- To block suspension, specific restraints are to be made in each type of vehicle. Those devices may become complicated in some cases, as the independent suspension buses. Sometimes, adaptations or modifications in the vehicle may be required to anchor the tensile and compressive devices. Then, the restraints and adaptations should be made by the vehicle manufacturer.
- Configuration and looseness of the devices used by different laboratories will influence the test results.
- With a free suspension test, no operations or modifications in the vehicle are required. The test is easier, and requires less time and cost.
- In a tilting test with unblocked suspension, the centre of gravity height can be precisely determined, just using some displacement sensors to measure the movement of the bodywork, and carrying out the suitable calculations (see the method proposed later).
- A free suspension test allows to obtain the height of the CG in the stationary position of the vehicle, with the initial deformation of the springs, as well as the real height of the CG in the instability point, which may be more unfavourable.
- The draft European Directive related to buses and coaches includes a free suspension tilting test, to measure the rollover angle of the vehicles. The possibility of use a similar test for the CG determination in Regulation 66 shall facilitate the whole process for the approval of buses and coaches.
- The height of the wheel supports in the tilting tests should be specified. The European Directive proposes less than 2/3 of the tyre sidewall height, while in the full scale rollover test of the R66 a height of 80 mm is being proposed.
- The padded heads included to avoid rollover in the tilting test, should never touche the vehicle body, until the unstable position is reached and the contact of the wheels in one side is loosen. Their position should then be variable to not influence the result of the test.

Next, some amendments are proposed for the annex 7 of R66, to solve the aforementioned problems, and include the possibility of making free suspension tilting tests for determinate the centre of gravity of the vehicle.

In order to specify the wheel supports height, paragraph 7.1 of annex 7 should be amended to read:

“ 7.1. The vehicle shall be placed parallel to the tilting axis on the tilting platform. The wheels should be supported against side slip, and wheel support height should be maximum 2/3 of tyre sidewall height. Three side supporting frames with padded heads should be applied to avoid rollover. “

In order to avoid the interference of padded heads with the results of the tilting test with blocked suspension, paragraphs 7.2 and 7.4 of annex 7 should be amended to read:

“ 7.2. The distances between the padded heads and the side wall of the vehicle should be short enough to avoid rollover, but contact with the vehicle should be avoided until the instability point. Their position may be varied during the test to avoid it. “

“ 7.4. The tilting shall be done very slowly, until the unstable position of the vehicle. This position is reached, when the wheels on one side do not touch the tilting platform anymore, the side supporting load on that side is zero. “

In order to involve the manufacturer in making the fixing devices in case of blocked suspension tilting test, paragraph 7.3 of annex 7 should be amended to read:

“ 7.3. All axles of the vehicle should be fixed, the spring system blocked. The restraint devices and adaptations required should be made by the vehicle manufacturer. “

In order to include a free suspension tilting test in the methods for the determination of the centre of gravity, next amendments will be required in the annex 7:

➤ Paragraph 2.2 should be amended to read:

“ 2.2. There are three options to determine the height of the centre of gravity (h)

2.2.1. *lifting method (see figure 2)*

2.2.2. *tilting method with blocked suspension (see figure 3)*

2.2.3. *tilting method with unblocked suspension (see figures 5 to 7)*

The manufacturer can choose between the three options. ”

➤ Paragraph 7 should be amended to read:

“ 7. *Tilting test with blocked suspension to determine the height of the centre of gravity (see figure 3). ”*

➤ A new paragraph 8 should be included, to read:

“ 8. *Tilting test with unblocked suspension to determine the height of the centre of gravity (see figures 5, 6 and 7.)*

8.1. *The vehicle shall be placed parallel to the tilting axis on the tilting platform. The wheels should be supported against side slip, and wheel support height should be maximum 2/3 of tyre sidewall height. Three side supporting frames with padded heads should be applied to avoid rollover.*

8.2. *The distances between the padded heads and the side wall of the vehicle should be short enough to avoid rollover, but contact with the vehicle should be avoided until the instability point. Their position may be varied during the test to avoid it.*

8.3. *The spring system should remain unblocked.*

8.4. *Displacement sensors should be placed in fixed points of the platform for positioning the bodywork side wall. The transversal section in which this sensors should be placed will be coincident with CG's longitudinal position (see Figure 5).*

8.5. *The tilting shall be done very slowly, until the unstable position of the vehicle. This position is reached, when the wheels on one side do not touch the tilting platform anymore, the side supporting load on that side is zero.*

- 8.6. Measure precisely the tilting angle (α) and the bodywork rotation (θ) and displacement of the unstable position.
- 8.7. Tilting test shall be made on both directions.
- 8.8. In both left and right side tilting test, the CG's height shall be graphically determined as follows:

8.8.1. Following parameters have to be known, and should be provided by the manufacturer:

- unsprung mass (m_u).
- unsprung mass CG vertical position (h_u) and transversal eccentricity (e_u).

8.8.2. Then, the sprung mass (m_s) and its transversal eccentricity (e_s) are obtained from 4.5 and 5.2 using following expressions:

$$m_s = m_k - m_u$$

$$e_s = e_u + (e - e_u) \left(1 + \frac{m_u}{m_s}\right)$$

8.8.3. The bodywork position must be drawn at the instability point, just before rollover occurs, as shown in figure 6. Assumed the total CG being in the vertical of the wheel support point, the sprung mass CG position in a reference fixed in the bodywork (h_s'), is graphically obtained as the one making true next relation:

$$a = \frac{m_u}{m_s} \cdot c$$

The real CG's height of the vehicle at the unstable position (h_{up}) may be obtained too.

8.8.4. Once the CG's position of the sprung and unsprung masses are known, the bodywork must be drawn at the horizontal steady position (figure 7). The CG's height of the vehicle in its stationary position, with the initial deformation of springs, is then obtained using the expression:

$$h_i = \frac{h_s m_s + h_u m_u}{m_s + m_u}$$

Two values for that height should be obtained from both the left and right side tilting tests.

8.9. The CG's height for the vehicle in the horizontal steady position is calculated as the mean of both values obtained from the two tests:

$$h = \frac{h_l + h_r}{2}$$

Nevertheless, the CG's height in the unstable position (h_{up}) may be different depending on the tilting side. “

➤ New figures 5, 6 and 7 should be inserted, to read:

FIGURE 5

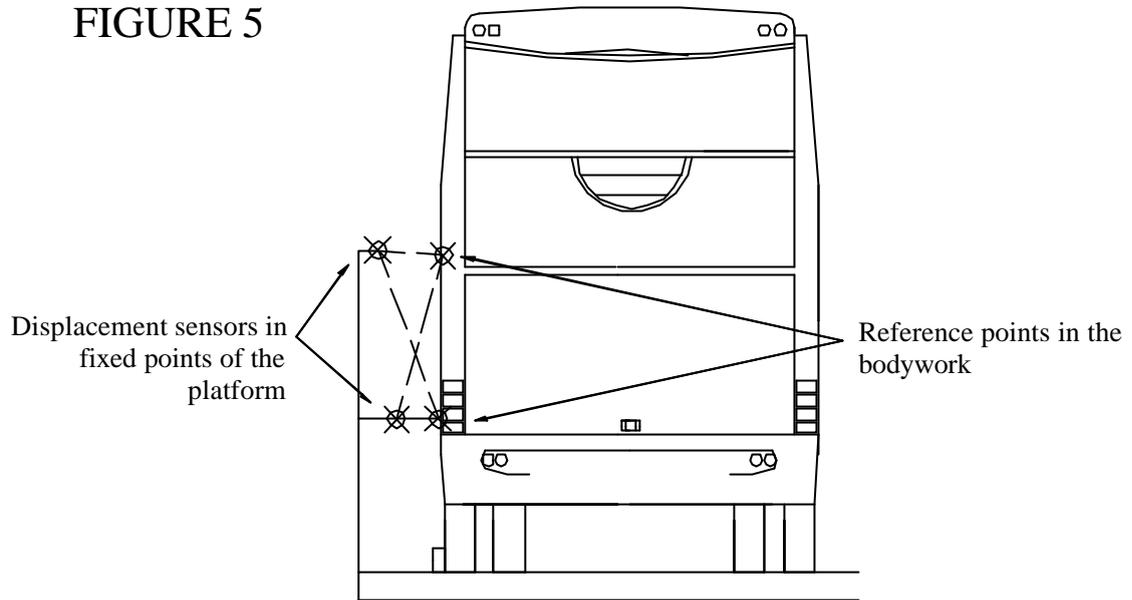


FIGURE 6

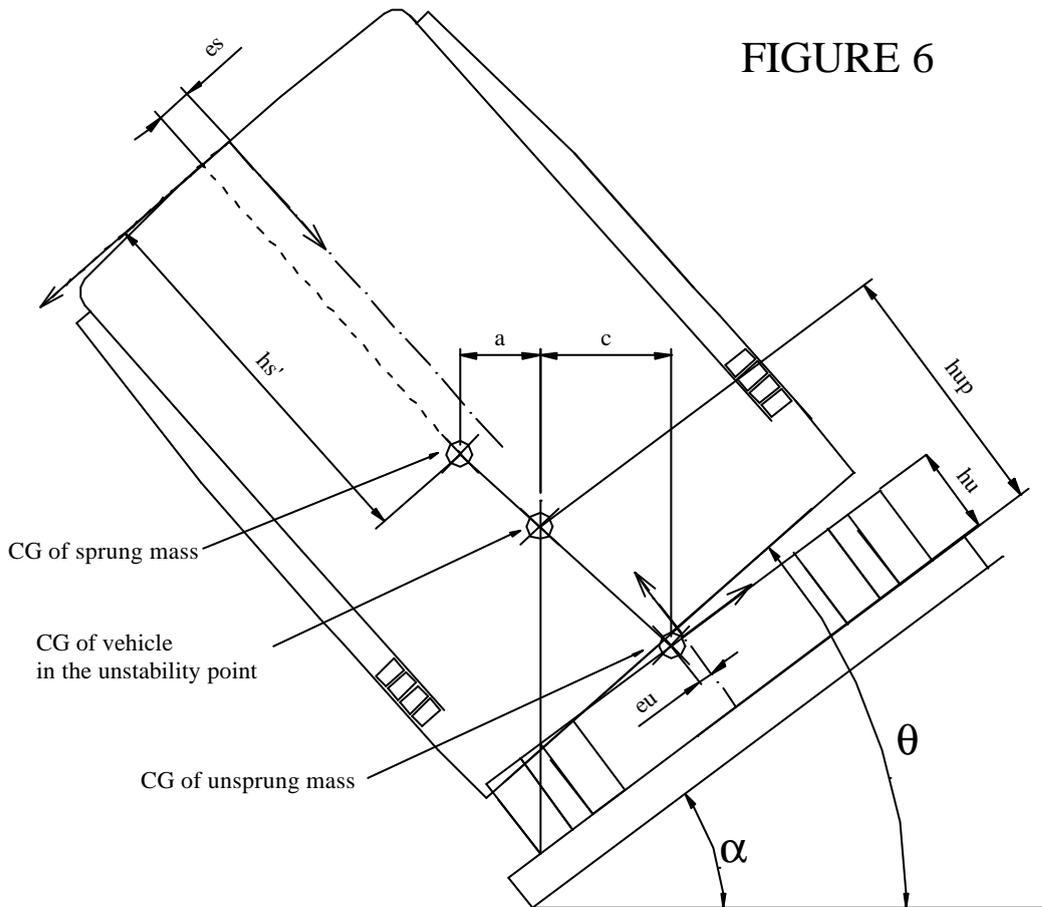


FIGURE 7

