Directive 2001/85/EC of the European Parliament and of the Council of 20 November 2001 relating to special provisions for vehicles used for the carriage of passengers comprising more than eight seats in addition to the driver's seat, and amending Directives 70/156/EEC and 97/27/EC (repealed)

ANNEX IV

STRENGTH OF SUPERSTRUCTURE

1. Scope

This Annex applies to all single deck Class II and III vehicles.

2. Definitions

For the purposes of this Annex:

2.1. ‘residual space’ means the space to be preserved in the passenger compartment during and after the structure has been subjected to one of the tests prescribed in this Annex;

2.2. ‘superstructure’ means the part(s) of a vehicle structure which contribute to the strength of the vehicle in the event of a roll-over accident;

2.3. ‘body section’ means a section containing at least two identical vertical pillars on each side representative of a part or parts of the structure of the vehicle;

2.4. ‘total energy’ means the energy assumed to be absorbed by the complete structure of the vehicle. This may be determined as shown in this Annex.

3. General specifications and requirements

If the superstructure has obtained the approval according to the Regulation UN/ECE No 66 of the Economic Commission for Europe, it is considered that it complies with these general specifications and requirements.

3.1. The superstructure of the vehicle shall be of sufficient strength to ensure that during and after it has been subjected to one of the methods of test or calculation prescribed in paragraph 4:

3.1.1. no displaced part of the vehicle intrudes into the residual space, as specified in paragraph 5, and

3.1.2. no part of the residual space projects outside the deformed structure.

3.2. The requirements of paragraph 3.1 shall apply to the vehicle including all its structural parts, members and panels and all projecting rigid parts such as baggage racks, ventilation equipment, etc. However, bulkheads, partitions, rings or other members reinforcing the superstructure of the vehicle and fixed appliances, such as bars, kitchenettes or toilets, shall be ignored for the purposes of paragraph 3.1.

3.3. In the case of an articulated vehicle each part of the vehicle shall comply with the requirements specified in paragraph 3.1.

4. Test methods

4.1. Each type of vehicle shall be verified according to one of the following methods at the discretion of the manufacturer or according to an alternative method approved by the competent authority:

4.1.1. a roll-over test on a complete vehicle in accordance with the procedure set out in Appendix 1;

4.1.2. a roll-over test on a body section or sections representative of a complete vehicle in accordance with Appendix 2;

4.1.3. a pendulum test on a body section or sections in accordance with Appendix 3; or

4.1.4. a verification of strength of superstructure by calculation in accordance with Appendix 4.

4.2. If the methods prescribed in paragraphs 4.1.2, 4.1.3 or 4.1.4 cannot take account of a significant variation between one section of the vehicle and another, for example an air-conditioning installation on the roof, additional test methods or calculations shall be submitted to the technical service. In the absence of such additional information the vehicle may be required to undergo the method of test prescribed in paragraph 4.1.1.

5. Residual space

5.1. For the purpose of paragraph 2.1, the residual space means the volume within the passenger compartment which is swept when the transverse vertical plane defined in figure 1(a) is moved in a straight line or lines so that the point ‘R’ in figure 1(a) passes from the ‘R’ point of the rearmost outer seat, through the ‘R’ point of every intermediate outer seat to the ‘R’ point of the foremost outer passenger seats.

5.2. The position of the ‘R’ point shown in figure 1(b) shall be assumed to be 500 mm above the floor under the passengers' feet, 300 mm from the inside surface of the side of the vehicle and 100 mm in front of the seat back in the centre line of the outboard seats.

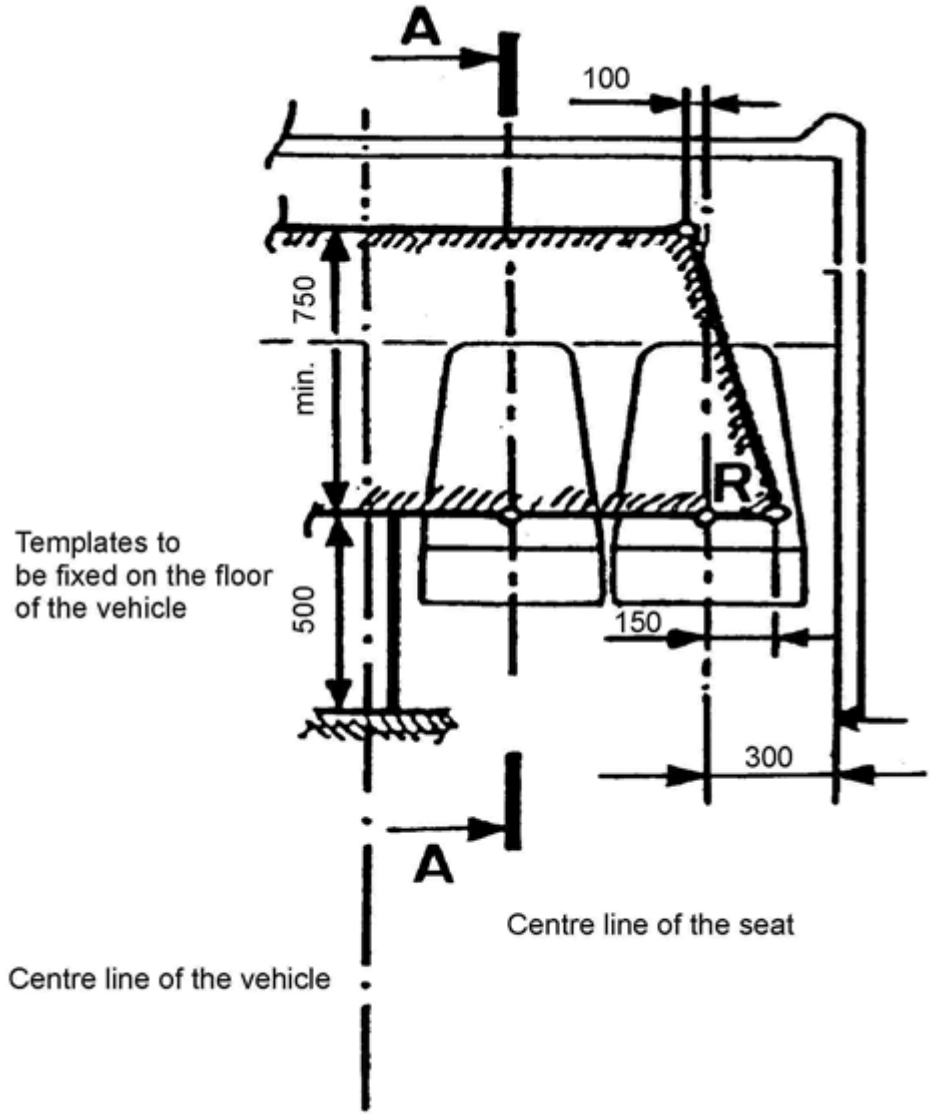
6. Interpretation of test results

6.1. If body sections are tested, the technical service responsible for conducting the test shall ensure that the vehicle complies with the conditions specified in Subappendix 2 of Appendix 3, which contains requirements for the distribution of the main energy absorbing parts of the superstructure of a vehicle.

Figure 1

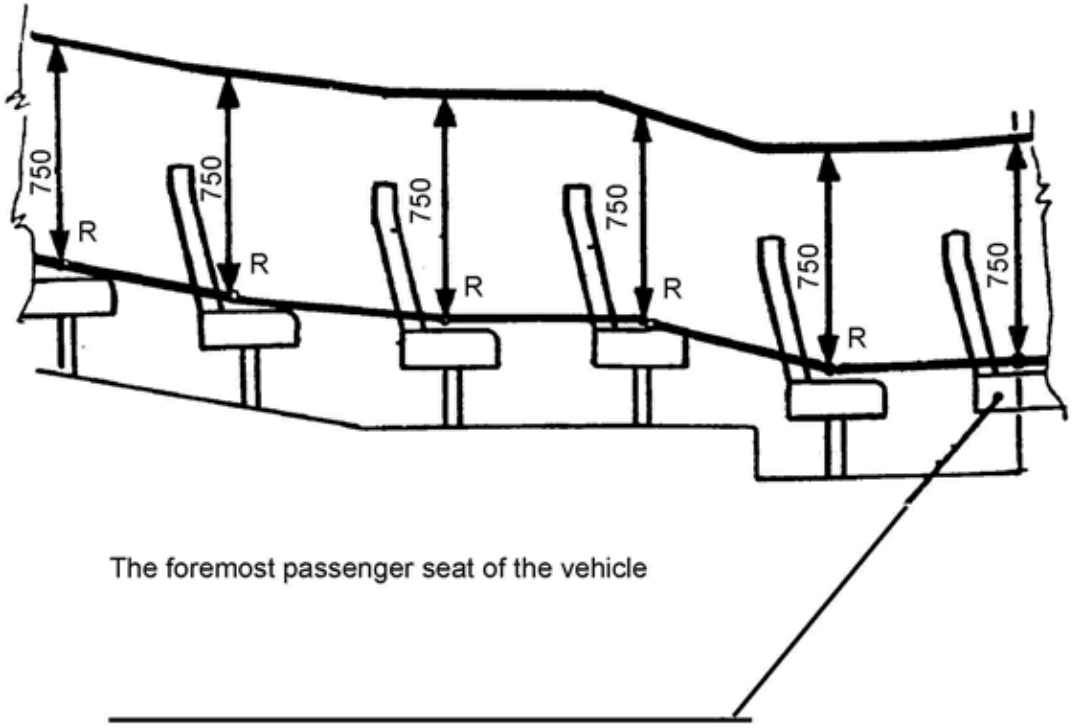
Residual space

(All dimensions in millimetres)



Note:

See requirement of paragraph 5.1.



Note:

See requirement of paragraph 5.2.

Appendix 1

ROLL-OVER TEST ON A COMPLETE VEHICLE

1. Test condition

1.1. While the vehicle need not be in a fully finished condition, it shall be representative of production vehicles in respect of the mass of the vehicle in running order, centre of gravity and distribution of mass as declared by the manufacturer.

1.2. Driver and passenger seats shall be placed with their backs, if adjustable, in their most upright position. The height of the seats, if adjustable, shall be in the highest position.

1.3. Every door and opening window of the vehicle shall be closed and latched but not locked. Windows and glazed bulkheads or screens may be glazed or unglazed at the applicant's discretion. If they are unglazed, an equivalent weight shall be imposed on the vehicle at the appropriate positions.

1.4. Tyres shall be inflated to the pressure prescribed by the vehicle manufacturer and, if the vehicle has an air-spring suspension system, the air supply to the air spring shall be ensured. Any automatic levelling system shall be adjusted with the vehicle on a flat, horizontal surface to the level specified by the manufacturer. Shock absorbers shall operate normally.

1.5. Fuel, battery acid and other combustible, explosive or corrosive materials may be substituted by other materials, provided that the conditions prescribed in paragraph 1.1 are met.

1.6. The impact area shall consist of concrete or other rigid material.

2. Test procedure (see figure 1)

2.1. The vehicle shall be placed on a platform in order to be rolled over on one side. This side shall be specified by the manufacturer.

2.2. The position of the vehicle on the platform shall be such that when the platform is horizontal:

2.2.1. the axis of rotation is parallel to the longitudinal axis of the vehicle,

2.2.2. the axis of rotation is 0 to 200 mm from the vertical step between the two levels,

2.2.3. the axis of rotation is 0 to 100 mm from the side of the tyre at the widest axle,

2.2.4. the axis of rotation is 0 to 100 mm below the horizontal starting plane on which the tyres stand, and

2.2.5. the difference between the height of the horizontal starting plane and the horizontal lower plane on which impact takes place shall be not less than 800 mm.

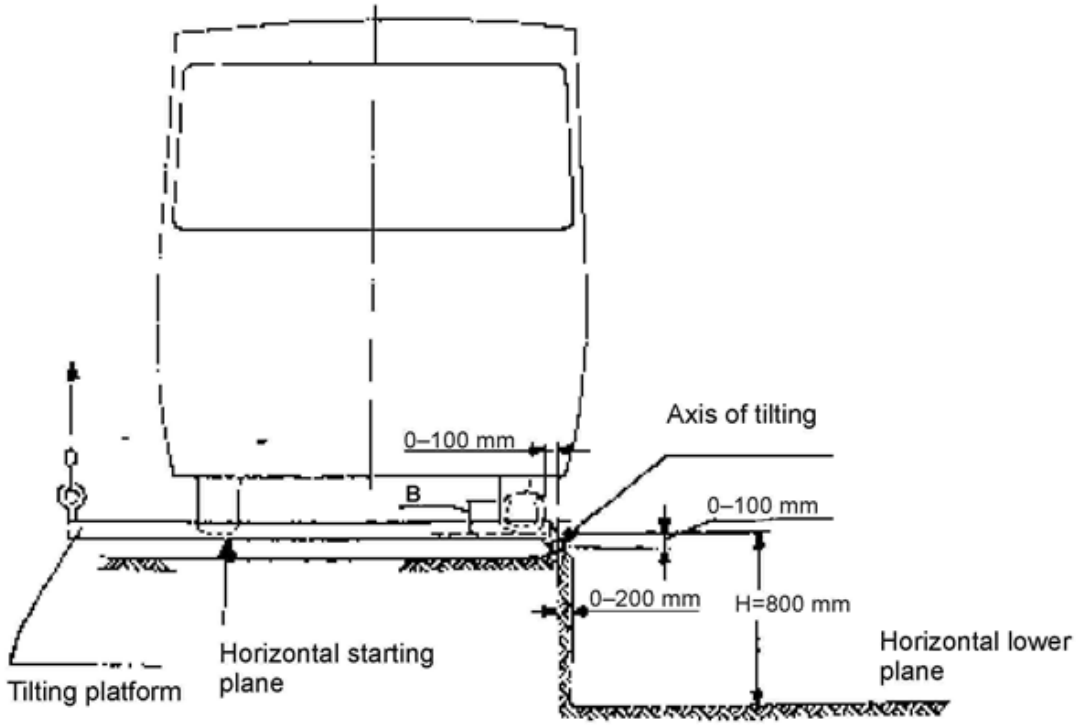
2.3. Means shall be provided to prevent the vehicle moving along its longitudinal axis.

2.4. The test apparatus shall prevent the tyres from sliding sideways in the direction of roll-over by means of side walls.

2.5. The test apparatus shall ensure the simultaneous lifting of the axles of the vehicle.

2.6. The vehicle shall be tilted without rocking and without dynamic effects until its rolls over. The angular velocity shall not exceed 5 degrees per second (0,087 rad/sec).

2.7. High-speed photography, deformable templates or other suitable means shall be used to determine that the requirement of paragraph 3.1 of this Annex has been met. This shall be verified at not less than two positions, nominally at the front and rear of the passenger compartment, the exact positions being at the discretion of the technical service. Templates shall be fixed to substantially non-deformable parts of the structure.



Appendix 2

ROLL-OVER TEST ON A BODYWORK SECTION

1. Test conditions

1.1. The bodywork section shall represent a section of the unladen vehicle.

1.2. The geometry of the bodywork section, the axis of rotation and the position of the centre of gravity in the vertical and lateral directions shall be representative of the complete vehicle.

1.3. The mass of the bodywork section, expressed as a percentage of the unladen mass of the vehicle in running order, shall be specified by the manufacturer.

1.4. The energy to be absorbed by the bodywork section, expressed as a percentage of the total energy which would be absorbed by a complete vehicle, shall be specified by the manufacturer.

1.5. The percentage of total energy described in paragraph 1.4 shall not be less than the percentage of the total mass of the vehicle in running order described in paragraph 1.3.

1.6. The test conditions specified in paragraph 1.6 of Appendix 1 and in paragraphs 2.1 to 2.6 of Appendix 3 shall apply.

2. Test procedure

2.1. The test procedure shall be the same as the procedure described in Appendix 1, except that the bodywork section described above shall be used instead of a complete vehicle.

Appendix 3

PENDULUM TEST ON A BODYWORK SECTION

1. Energy level and direction of impact

1.1. The energy to be transmitted to a particular bodywork section shall be the sum of the energies declared by the manufacturer to be allocated to each of the cross-sectional rings included in that particular bodywork section.

1.2. The appropriate proportion of the energy prescribed in Subappendix 1 to this Appendix shall be applied to the bodywork section by the pendulum such that at the moment of impact the direction of motion of the pendulum makes an angle of 25 degrees (+ 0°; - 5°) to the central longitudinal vertical plane of the bodywork section. The precise angle within this range shall be specified by the vehicle manufacturer.

2. Test conditions

2.1. A sufficient number of tests shall be carried out for the technical service conducting the test to be satisfied that the requirement specified in paragraph 3.1 of this Annex has been met.

2.2. For the purposes of the test, bodywork sections shall have sections of the normal structure fitted between the pillars in relation to the floor, underframe, sides and roof. Sections of such components as baggage racks, ventilation ducting, etc., where fitted, shall also be included.

2.3. Every door and opening window of the bodywork section shall be closed and latched but not locked. Windows and glazed bulkheads or screens may be glazed or unglazed at the applicant's discretion.

2.4. Where appropriate, seats may also be included, at the option of the manufacturer, in their normal positions in relation to the structure of the bodywork section. The normal fixings and joints between all members and attachments shall be incorporated. The backrests if adjustable shall be in their most upright position and the height of the seats, if adjustable, shall be in the highest position.

2.5. The side of the bodywork section to be impacted shall be at the discretion of the manufacturer. Where more than one bodywork section is required to be tested, both shall be impacted on the same side.

2.6. High speed photography, deformable templates or other suitable means shall be used to determine that the requirement specified in paragraph 3.1 of this Annex has been met. Templates shall be fixed to a substantially non-deformable part of the structure.

2.7. The bodywork section to be tested shall be firmly and securely attached to the mounting frame through the cross-bearers or parts which replace these in such a way that no significant energy is absorbed in the support frame and its attachments during the impact.

2.8. The pendulum shall be released from such a height that it strikes the bodywork section at a speed of between 3 and 8 m/s.

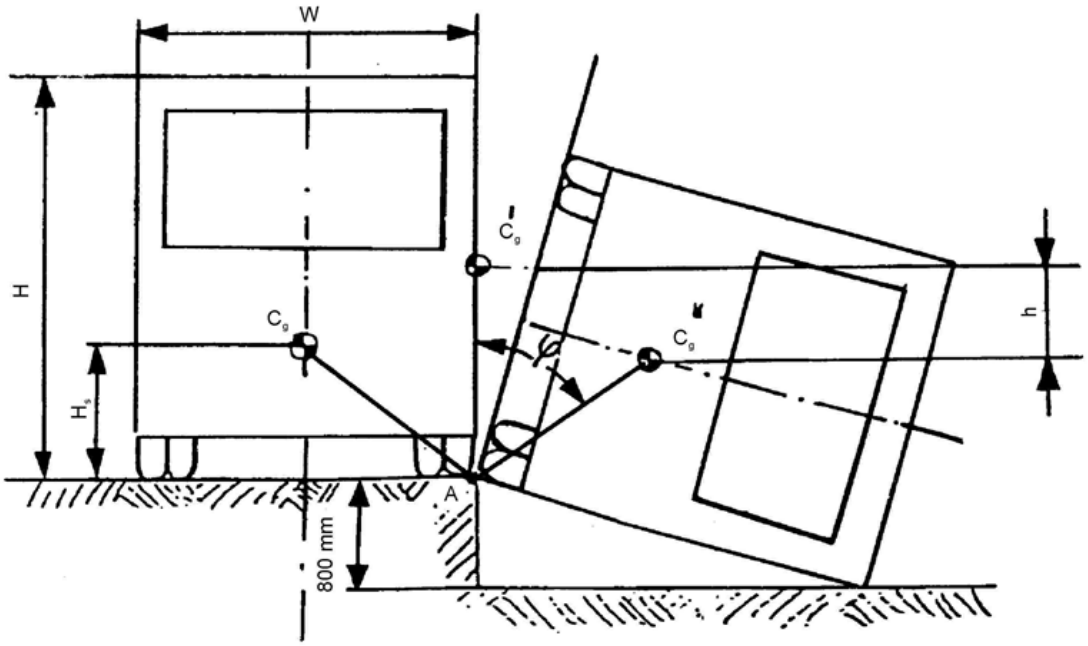
3. Description of the pendulum

3.1. The striking face of the pendulum shall be made of steel, or plywood 20 mm-5 mm thick, and the mass of the pendulum shall be evenly distributed. Its striking face shall be rectangular and flat, having a width of not less than the width of the bodywork section being tested and a height of not less than 800 mm. Its edges shall be rounded to a radius of curvature of not less than 15 mm.

3.2. The body of the pendulum shall be rigidly attached to two rigid bars. The axis of the bars shall be not less than 3 500 mm from the geometric centre of the body of the pendulum.

Subappendix 1

Calculation of total energy (E*)



Assumptions:

1. the shape of the cross-section of the body is assumed to be rectangular;

2. the suspension system is assumed to be rigidly fixed;

3. the movement of the bodywork section is assumed to be pure rotation about point ‘A’.

Calculation of total energy (E*)

If the fall of the centre of gravity (h) is determined by graphical methods, E* may be taken to be given by the formula:

$$E^* = 0{,}75\ M.g.h(Nm)$$

Alternatively, E* may be calculated by the formula:

$$E^* = 0{,}75\ M.g.\left[\sqrt{\left(\frac{W}{2}\right)^2 + H_s^2} - \frac{W}{2H}\sqrt{H^2 - 0{,}8^2} + 0{,}8H_s H\right](Nm)$$

where:

M	=	the unladen mass of the vehicle (kg),
g	=	9,8 m/s^2,
W	=	the overall width of the vehicle (m),
H_s	=	the height of the centre of gravity of the unladen vehicle (m),
H	=	the height of the vehicle (m).

Subappendix 2

Requirements for the distribution of the main energy absorbing parts of the superstructure

1. A sufficient number of tests shall be carried out for the technical service to be satisfied that the complete vehicle meets the requirements of paragraph 3.1 of this Annex. This shall not necessarily require more than one test.

2. Calculations based on data obtained from a test on a bodywork section may be used to demonstrate the acceptability of another bodywork section which is not identical with the bodywork section already tested if it has many structural features in common with it.

3. The manufacturer shall declare which pillars of the superstructure are considered as contributing to its strength and shall also declare the amount of energy (E_i) that each pillar is intended to absorb. These declarations shall meet the following criteria: 1)Σi = li = m Ei > E*where m is the total number of declared pillars.2) (a)Σi = li = n EiF ≥ 0,4 E*where n is the number of declared pillars forward of the centre of gravity of the vehicle;(b)Σi = li = p EiR ≥ 0,4 E*where p is the number of declared pillars to the rear of the centre of gravity of the vehicle.3)LF ≥ 0,4 lf4)LR ≥ 0,4 lr5)dmaxdmin ≤ 2,5this shall only apply where dmax is greater than 0,8 × maximum deflection permitted without intrusion of the residual space,

where:

E_i is the declared amount of energy that can be absorbed by i^{th} pillar of the superstructure,

E_{iF} is the declared amount of energy that can be absorbed by the i^{th} pillar forward of the centre of gravity of the vehicle,

E_{iR} is the declared amount of energy that can be absorbed by the i^{th} pillar to the rear of the centre of gravity of the vehicle,

E^* is the total energy to be absorbed by the complete structure of the vehicle,

d_{max} is the greatest amount of deflection measured in the direction of impact of any section of the bodywork structure after it has absorbed its own declared impact energy,

d_{min} is the least amount of deflection, measured in the direction of impact and at the same point on the bay as d_{max}, of any section of the bodywork structure after it has absorbed its own declared impact energy.

$L_F = \frac{\sum_{i=1}^{i=n}(E_{iF} l_{iF})}{\sum_{i=1}^{i=n} E_{iF}}$ = weighted mean distance of the declared pillars in front of the centre of gravity of the vehicle.

$L_R = \frac{\sum_{i=1}^{i=p}(E_{iR} l_{iR})}{\sum_{i=1}^{i=p} E_{iR}}$ = weighted mean distance of the declared pillars to the rear of the centre of gravity of the vehicle.

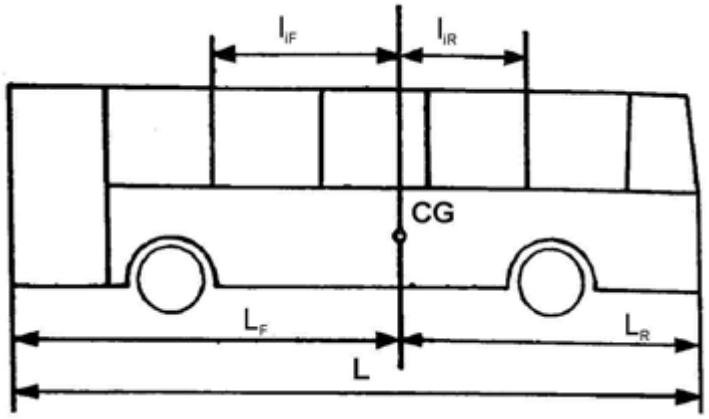
where:

l_{iF} is the distance from the centre of gravity of the vehicle of the i^{th} pillar forward of the centre of gravity,

l_{iR} is the distance from the centre of gravity of the vehicle of the i^{th} pillar rearward of the centre of gravity,

L_F is the distance of the front of the vehicle from the centre of gravity of the vehicle,

L_R is the distance of the rear of the vehicle from the centre of gravity of the vehicle.



Appendix 4

VERIFICATION OF STRENGTH OF SUPERSTRUCTURE BY CALCULATION

1. A superstructure or sections of a superstructure may be shown to meet the requirement specified in paragraph 3.1 of this Annex by a calculation method approved by the technical service responsible for conducting the tests.

2. If the structure is likely to be subject to deformations beyond the elastic limit of the materials used, then the calculations shall simulate the behaviour of the structure when undergoing large plastic deformations.

3. The technical service responsible for conducting the tests may require tests to be carried out on joints or parts of the structure to verify the assumptions made in the calculation.

4. Preparations for calculation

4.1. Calculations cannot be started until the structure has been analysed and a mathematical model of it produced. This will define the separate members to be considered and identify the points at which plastic hinges may develop. The dimensions of the members and the properties of material used must be stated. Physical tests must be made on the hinge points to determine the force (moment of rotation)-deformation characteristics in the plastic mode as this is essential data for the calculations. The strain rate and the dynamic yield stress appropriate for this strain rate must be determined. If the calculation method will not indicate when a significant fracture will occur, it will be essential to determine, by experiment, separate analyses or appropriate dynamic distribution. Distribution of loading along the length of a vehicle shall be stated.

4.2. The calculation method shall include the deformations up to the elastic limits of the materials followed by the identification of where plastic hinges will form and the subsequent formation of other plastic hinges unless the position and sequences of formation of plastic hinges is known from previous experience. The method shall accommodate the changes of geometry of the structure that take place, at least up to the stage where the deformations have passed the acceptable limits. The calculations shall simulate the energy and the direction of impact which would occur if that particular superstructure were to be submitted to the roll-over tests prescribed in Appendix 1. The validity of the calculation method shall have been established by comparison with the results of physical tests, which need not necessarily have been made in connection with the vehicle now being approved.

5. Tests of section of superstructure

When a calculation method is used for a section of the complete superstructure, the same conditions shall apply as stated above for the complete vehicle.