

**AMENDMENT NO. 1
TO
AIS-031
Automotive Vehicles – The Strength of Superstructure of
Large Passenger Vehicles**

1. Page No. 1/17, cl. No. 1.0, Scope:

Substitute following text for existing text:

“ 1. SCOPE

- 1.1 This standard applies to single-deck rigid or articulated vehicles designed and constructed for the carriage of more than 22 passengers, whether seated or standing, in addition to the driver and crew.
- 1.2 It does not apply to the vehicles of Type I category as defined in AIS-052: Code of Practice for Bus Body Design and Approval in para 1.1.5.”

PRINTED BY
THE AUTOMOTIVE RESEARCH ASSOCIATION OF INDIA
P.B. NO. 832, PUNE 411 004
ON BEHALF OF
AUTOMOTIVE INDUSTRY STANDARDS COMMITTEE
UNDER
CENTRAL MOTOR VEHICLE RULES – TECHNICAL STANDING COMMITTEE
SET-UP BY
MINISTRY OF SHIPPING, ROAD TRANSPORT & HIGHWAYS
(DEPARTMENT OF ROAD TRANSPORT & HIGHWAYS)
GOVERNMENT OF INDIA

September 2008

AUTOMOTIVE INDUSTRY STANDARD

**Automotive Vehicles –
The Strength of Superstructure of
Large Passenger Vehicles**

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December 2004

Status chart of the Standard to be used by the purchaser
for updating the record

Sr. No.	Corr-igenda.	Amend-ment	Revision	Date	Remark	Misc.

General Remarks:

INTRODUCTION

The Government of India felt the need for a permanent agency to expedite the publication of standards and development of test facilities in parallel when the work on the preparation of the standards is going on, as the development of improved safety critical parts can be undertaken only after the publication of the standard and commissioning of test facilities. To this end, the Ministry of Surface Transport (MOST) has constituted a permanent Automotive Industry Standards Committee (AISC) vide order No.RT-11028/11/97-MVL dated September 15, 1997. The standards prepared by AISC will be approved by the permanent CMVR Technical Standing Committee (CTSC). After approval, the Automotive Research Association of India, (ARAI), Pune, being the Secretariat of the AIS Committee, has published this standard. For better dissemination of this information ARAI may publish this document on their Web site.

The super - structure of the bus shall be so designed and constructed as to eliminate to the greatest possible extent the risk of injury to the occupants in the event of an accident. This standard specifies the requirement of strength of the bus superstructure for the protection of occupants of the bus. This standard forms a part of the Bus Body Code.

While preparing this AIS considerable assistance is derived from ECE Regulation No. 66: Uniform provisions concerning the approval of Large Passenger Vehicles with regard to the Strength of their Superstructure - (Revision 2, including the amendments entered into force on October 16, 1995) Addendum 65: Regulation No. 66, Amendment 1, Supplement 1 to the original version of the Regulation - Date of entry into force: September 3, 1997 (ISSUE: 1 Jul/1999).

The Automotive Industry Standards Committee responsible for preparation of this standard is given in Annexure: 6 .

Automotive Vehicles -The Strength of Superstructure of Large Passenger Vehicles

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Automotive Vehicles -The Strength of Superstructure of Large Passenger Vehicles

1. SCOPE

This AIS Standard applies to single-decked vehicles constructed for the carriage of more than 13 passengers or above excluding driver.

2. REFERENCES

IS:11849-1986 Method of determination of centre of gravity of automotive vehicles

IS:9211-1979 Denominations and definitions of weights of road vehicles

3. DEFINITIONS

For the purposes of this AIS Standard:

- 3.1 **"Approval of a vehicle"** means the approval of a vehicle type with regard to the construction features specified in this AIS Standard;
- 3.2 **"Vehicle type"** means a category of vehicles which do not differ essentially in respect of the constructional features specified in this AIS Standard;
- 3.3 **"Passenger compartment"** means the space intended for passengers' use excluding any space occupied by fixed appliances such as bars, kitchenettes or toilets;
- 3.4 **"Driver's compartment"** means the space intended for the driver's exclusive use and containing the driver's seat, the steering wheel, controls, instruments and other devices necessary for driving the vehicle;
- 3.5 **" Vehicle kerb weight "** (MK) (kg) means, "complete vehicle kerb weight" as defined in IS: 9211:1979 with an addition of 75kg for mass of the driver
- 3.6 **"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 paragraph 6 of this AIS Standard;
- 3.7 **"Superstructure"** means the parts of a vehicle structure, which contribute to the strength of the vehicle in the event of a roll-over accident;
- 3.8 **"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;

3.9 "Total energy" means the energy assumed to be absorbed by the complete structure of the vehicle. This may be determined as shown in Appendix 1 of Annex 3 to this AIS Standard.

4. APPLICATION FOR APPROVAL

4.1 The application for approval of a vehicle type with regard to the strength of its superstructure shall be submitted by the vehicle/bus body manufacturer to the Test Agency.

4.2 It shall be accompanied the under mentioned documents giving the following particulars:

4.2.1 a detailed description of the superstructure of the vehicle type including its dimensions, configuration and constituent materials and its attachment to any chassis frame;

4.2.2 drawings of the vehicle and those parts of its interior arrangement which have an influence on the strength of the superstructure or on the residual space;

4.2.3 particulars of:

4.2.3.1 the complete vehicle kerb weight (kg) as defined in IS: 9211-1979 (In the case of an articulated bus this information shall be given separately for the two rigid portions);

4.2.3.2 the vehicle kerb weight for each axle (kg) as defined in IS: 9211-1979

4.2.3.3 the position of the centre of gravity of the unladen vehicle in the longitudinal, transverse and vertical directions as defined in IS: 11849-1986;

4.2.3.4 the maximum distance between the centre lines of the outboard passenger seats.

4.3. The vehicle/bus body manufacturer may either offer a complete vehicle or one or more sections of the superstructure representative of the type to be approved shall be submitted to the Test Agency for conducting the approval tests unless the approval is to be conducted by means of calculation, in which case the calculation shall be submitted to the Test Agency.

5. APPROVAL

5.1 If the vehicle submitted for approval to this AIS Standard meets the requirements of paragraph 6 below, approval of that vehicle type shall be granted.

6. GENERAL SPECIFICATIONS AND REQUIREMENTS

- 6.1** 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 7 :
- 6.1.1 No displaced part of the vehicle intrudes into the residual space, as specified in paragraph 7, and
- 6.1.2 No part of the residual space projects outside the deformed structure.
- 6.2** The requirements of paragraph 6.1. above shall apply to the vehicle including all its structural parts, members and panels and all projecting rigid parts such as luggage racks, on-the roof 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 6.1.
- 6.3** In the case of an articulated vehicle each part of the vehicle shall comply with the requirements specified in paragraph 6.1. above.

7. TEST METHODS

- 7.1** 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:
- 7.1.1 A roll-over test on a complete vehicle in accordance with the procedure set out in Annex 1 to this AIS Standard;
- 7.1.2 A roll-over test on a body section or sections representative of a complete vehicle in accordance with Annex 2 of this AIS Standard;
- 7.1.3 A pendulum test on a body section or sections in accordance with Annex 3 to this AIS Standard; or
- 7.1.4 A verification of strength of superstructure by calculation in accordance with Annex 4 to this AIS Standard.
- 7.2** If the methods prescribed in paragraphs 7.1.2., 7.1.3. or 7.1.4. 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 Test Agency. In the absence of such additional information the vehicle may be required to undergo the method of test prescribed in paragraph 7.1.1.

8. RESIDUAL SPACE

8.1 For the purpose of paragraph 6.1. of this AIS Standard, the residual space means the volume within the passenger compartment which is swept when the transverse vertical plane defined in Figure 1 (a) of this AIS Standard 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 seat.

8.2 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.

9. INTERPRETATION OF TEST RESULTS

9.1 If body sections are tested, the Test Agency for conducting the test shall ensure that the vehicle complies with the conditions specified in Appendix 2 of Annex 3 to this AIS Standard which contains requirements for the distribution of the main energy absorbing parts of the superstructure of a vehicle.

10. MODIFICATIONS OF THE VEHICLE TYPE AND EXTENSION OF APPROVAL

10.1 Every modification of the vehicle type shall be notified to the Test Agency which granted the type-approval. The Test Agency may then either :

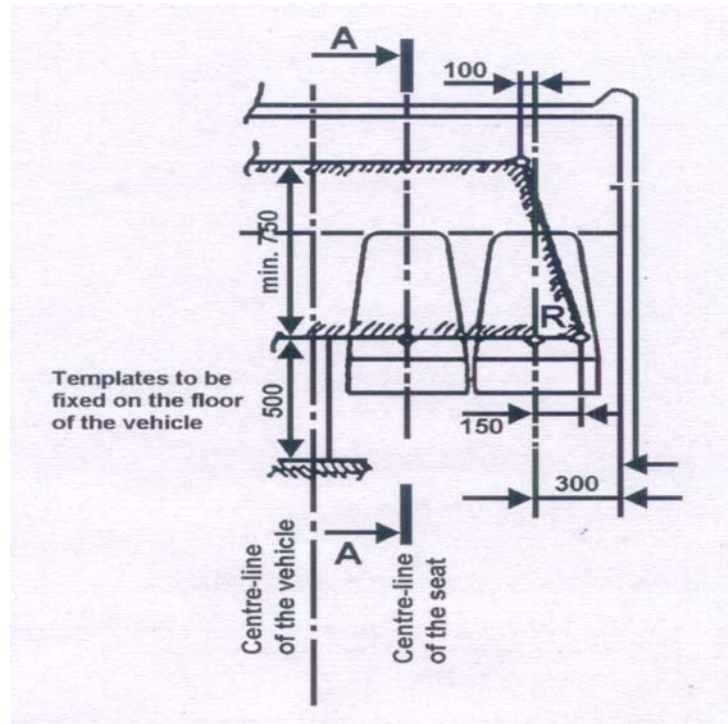
10.1.1 consider that the modifications made are unlikely to have an appreciable adverse effect and that in any case the vehicle still complies with the requirements; or

10.1.2 require a further test report from the Test Agency.

10.1.3 the criteria for extension of approval (CEA) are given in Annex 5

11. COP will be introduced along with Bus Body Code

1 (a) LATERALLY



1 (b) LONGITUDINALLY

Section A-A of the vehicle in the vertical plane of the centre-line of the inboard seats.

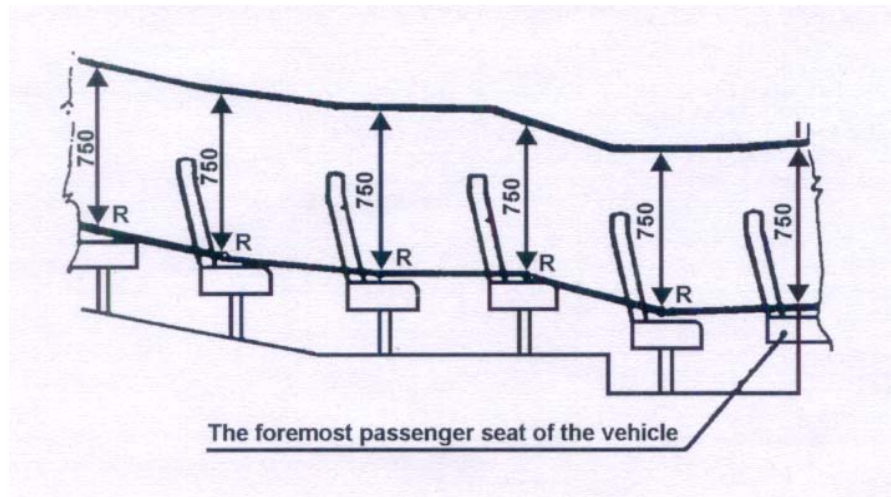


Figure 1

Residual Space

(All dimensions in millimetres)

Note: See requirements of paragraph 8.2 of the AIS Standard.

ANNEX 1
(see para. 7.1.1)

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 vehicle kerb weight , centre of gravity and distribution of mass as declared by the vehicle/bus body 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 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 springs shall be ensured. Any automatic leveling 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 above are met.
- 1.6 The impact area shall consist of concrete or other rigid material.

2. TEST PROCEDURE (See Figure 1 of this Annex)

- 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 - 200 mm from the vertical step between the two levels,
 - 2.2.3 the axis of rotation is 0 - 100 mm from the side of the tyre at the widest axle,

- 2.2.4 the axis of rotation is 0 - 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 it 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 6.1. of this AIS Standard 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.

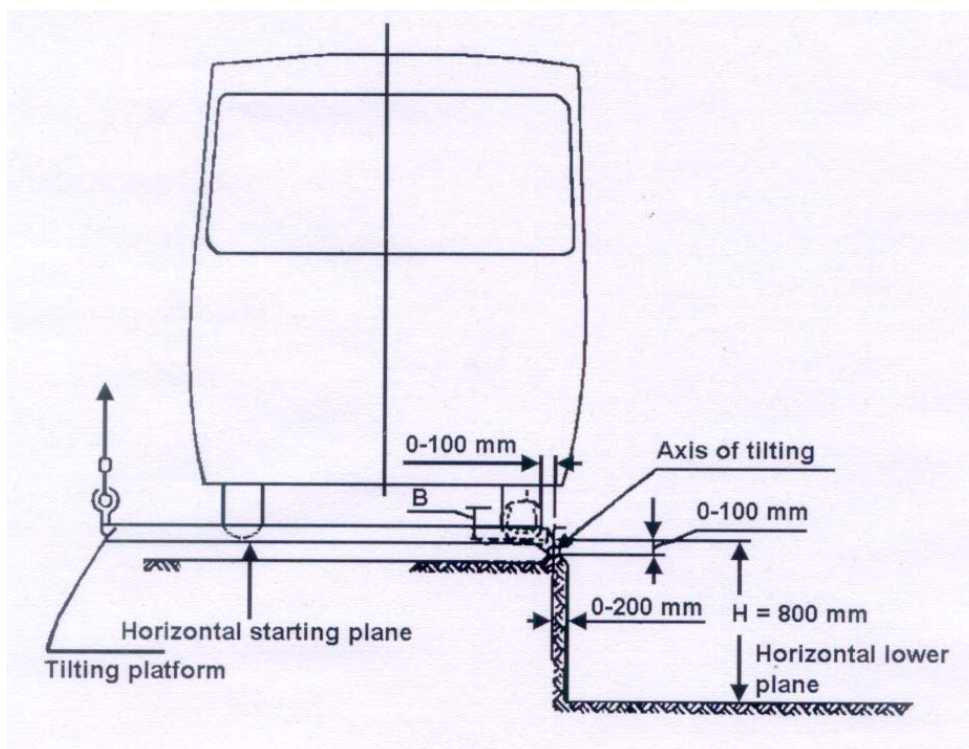


Figure 1

ANNEX 2
(See para. 7.1.2)

ROLL-OVER TEST ON A BODY SECTION

TEST CONDITIONS

- 1.1 The body section shall represent a section of the unladen vehicle.
- 1.2 The geometry of the body 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 body section, expressed as a percentage of the vehicle kerb weight of the vehicle, shall be specified by the vehicle/ bus body manufacturer.
- 1.4 The energy to be absorbed by the body section, expressed as a percentage of the total energy which would be absorbed by a complete vehicle, shall be specified by the vehicle/ bus body manufacturer.
- 1.5 The percentage of total energy described in paragraph 1.4. shall not be less than the percentage of total kerb mass described in Paragraph 1.3.
- 1.6 The test conditions specified in paragraph 1.6. of Annex 1 and in paragraphs 2.1. to 2.6. of Annex 3 shall apply.

2. TEST PROCEDURE

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

ANNEX 3
(See para. 7.1.3)

PENDULUM TEST ON A BODY SECTION

- 1. ENERGY LEVEL AND DIRECTION OF IMPACT**
 - 1.1** The energy to be transmitted to a particular body 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 body section.
 - 1.2** The appropriate proportion of the energy prescribed in Appendix 1 to this Annex shall be applied to the body section by the pendulum such that at the moment of impact the direction of motion of the pendulum makes an angle of 25° (+ 0°; - 5°) to the central longitudinal vertical plane of the body section. The precise angle within this range may be specified by the vehicle manufacturer.
- 2. TEST CONDITIONS**
 - 2.1** A sufficient number of tests shall be carried out for the Test Agency conducting the test to be satisfied that the requirement specified in paragraph 6.1. of this AIS Standard has been met.
 - 2.2** For the purposes of the test body sections shall have sections of the normal structure fitted between the pillars in relation to the floor, under frame, sides and roof. Sections of such items as luggage racks, ventilation ducting etc., where fitted, shall also be included.
 - 2.3** Every door and opening window of the body 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 body 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 the highest position.
 - 2.5** The side of the body section to be impacted shall be at the discretion of the manufacturer. Where more than one body 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 6.1 of this AIS Standard has been met. Templates shall be fixed to a substantially non-deformable part of the structure.

2.7 The body 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 body section at a speed of between 3 and 8 m/s.

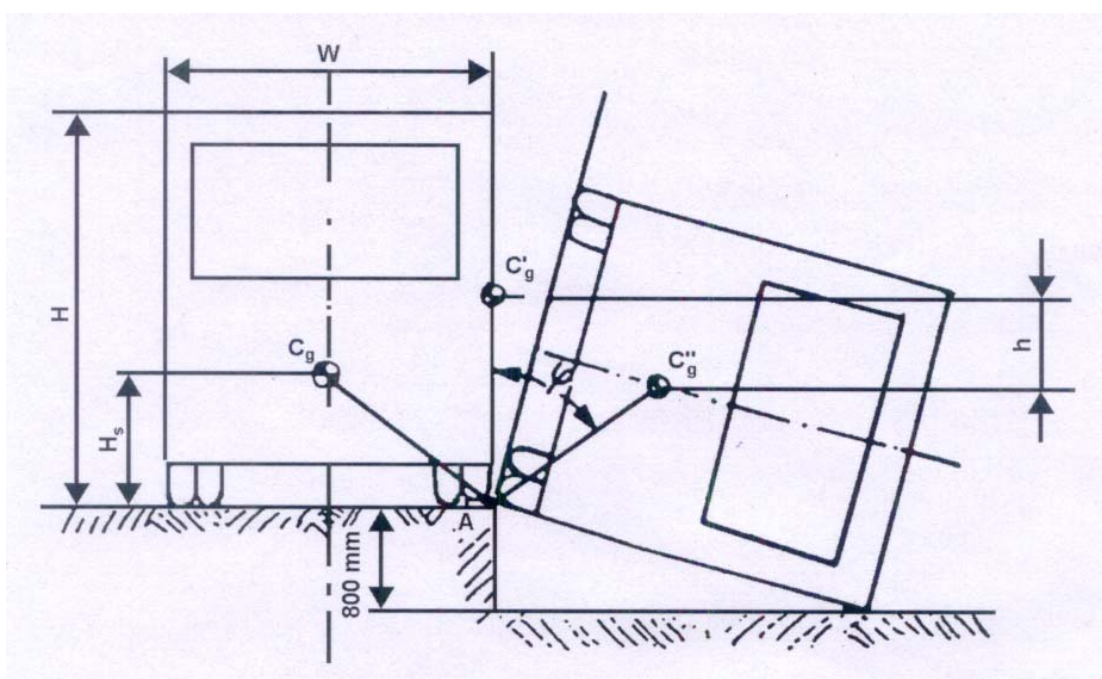
3. DESCRIPTION OF THE PENDULUM

3.1 The striking face of the pendulum shall be made of steel, or plywood 20 mm \pm 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 body 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.

ANNEX 3 - APPENDIX 1
(See para. 3.9)

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 body 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:

$$E^* = 0.75 M.g.h. \text{ (Nm)}$$

Alternatively, E* may be calculated by the formula:

$$E^* = 0,75 M.g. \left(\sqrt{\left(\frac{W}{2}\right)^2 + H_s^2} - \frac{W}{2H} \sqrt{H^2 - 0.8^2} + 0.8 \frac{H_s}{H} \right) \text{ (Nm)}$$

where:

M = the vehicle kerb weight of the vehicle (kg)

g = 9.8 m/s²

W = the overall width of the vehicle (m)

Hs = the height of the centre of gravity of the unladen vehicle (m)

H = the height of the vehicle (m)

ANNEX 3 - APPENDIX 2
(See para. 9.1)

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 Test Agency to be satisfied that the complete vehicle meets the requirements of paragraph 6.1. of this AIS Standard. This shall not necessarily require more than one test.
2. Calculations based on data obtained from a test on a body section may be used to demonstrate the acceptability of another body section which is not identical with the body section already tested if it has many structural features in common with it.
3. The vehicle/bus body 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)

$$\sum_{i=1}^m E_i > E^*$$

Where m is the total number of declared pillars

(2)

$$(a) \sum_{i=1}^n E_{iF} \geq 0.4 E^*$$

Where n is the number of declared pillars forward of the centre of gravity of the vehicle

$$(b) \sum_{i=1}^p E_{iR} \geq 0.4 E^*$$

Where p is the number of declared pillars to the rear of the centre of gravity of the vehicle

$$(3) L_F \geq 0.41 f$$

$$(4) L_R \geq 0.41 f$$

$$(5) \frac{d_{\max}}{d_{\min}} \leq 2.5$$

This shall apply only where d_{max} is greater than 0.8 x 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 body 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 body 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

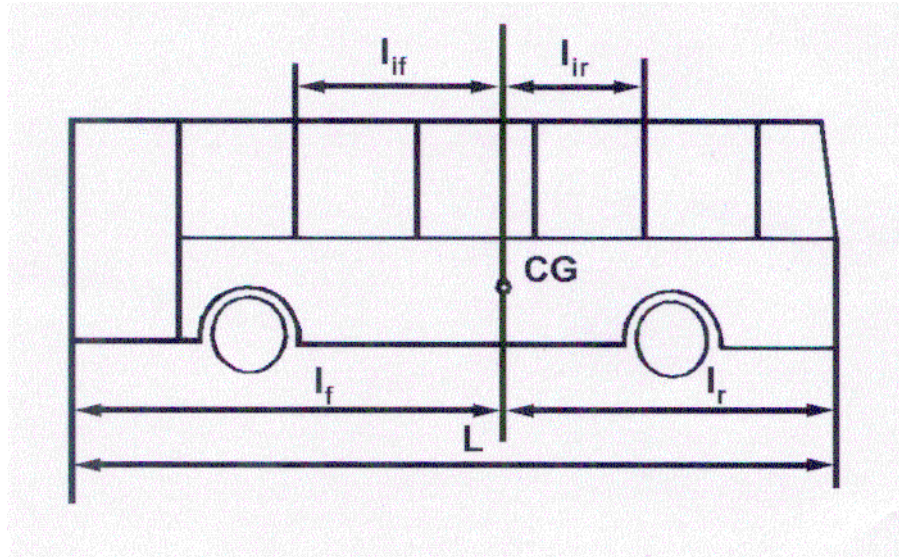
Where

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.



ANNEX 4
(See para. 7.1.4)

**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 6.1. of this AIS Standard by a calculation method approved by the Test Agency 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 Test Agency 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 with a significant fracture will occur it will be essential to determine, by experiment, separate analyses or appropriate dynamic tests that significant fractures will not occur. The assumed 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 sequence 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 Annex 3. 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 SECTIONS 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.

ANNEX 5
(See para 10.1.3)

CRITERIA FOR EXTENSION OF APPROVAL

Parameter	Change	Test Required
Roll Over test		
Body mountings on chassis i) Number of mountings ii) Quality of fasteners iii) Position of mountings	i) Decreased ii) Superior quality or equivalent iii) Any change	i) Test ii) No test iii) Test
Pillar pitch	i) Increase ii) Decrease	i) Test ii) No test
Number of gussets at joints	Increase	No test
Number of reinforcements	Increase	No test
Cross sectional area of the body structure	Increase	No test
Sheet metal thickness with same material	Increase	No test
Sheet materials	Superior Quality or equivalent	No test
Centre of gravity	Increase more than 10%.	Test
Total energy	Increase more than 10%	Test

Annex: 6
(See Introduction)
COMMITTEE COMPOSITION
Automotive Industry Standards Committee

Chairman	
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