Attachment 95 Pedestrian safety

Refer to: UN R127 02

95.1 Effective date and Scope:

95.1.1 Effective date from 2025/7/1, new vehicles of category symbols M1 and N1, and from 2028/1/1, all vehicles of category symbols M1 and N1, shall comply with this regulation, except for following vehicles:

95.1.1.1 Vehicles of category N1 where the driver's position "R-point" is either forward of the front axle or longitudinally rearwards of the front axle transverse centreline by a maximum of 1,100 mm.

95.1.1.2 Vehicles of category M1 above 2,500 kg maximum mass

95.1.1.2.1 Vehicles of category M1 which are derived from N1 category vehicles

95.1.1.2.2 Vehicles of category M1 where the driver's position "R-point" is either forward of the front axle or longitudinally rearwards of the front axle transverse centreline by a maximum of 1,100 mm.

95.1.2 Except for child-only vehicle, application for low volume or vehicle-by-vehicle safety approval may be exempt from this regulation.

95.1.3 Technical Service can carry out test according to UN Regulations that this direction harmonized with: UN R127 02 Series of amendments and following amendments of above-mentioned regulations.

95.2 Definitions：

When performing measurements as described in this Part, the vehicle should be positioned in its normal ride attitude.

If the vehicle is fitted with a badge, mascot or other structure, which would bend back or retract under an applied load of maximum 100 N, then this load shall be applied before and/or while these measurements are taken.

Any vehicle component which could change shape or position, other than suspension components or active devices to protect pedestrians, shall be set to their stowed position.

95.2.1 "Adult headform test area" is an area on the outer surfaces of the front structure. The area is bounded:

(a) In the front, by a Wrap Around Distance (WAD) of 1,700 or a line 82.5 mm rearward of the bonnet leading edge reference line, whichever is most rearward at a given lateral position;

(b) At the rear, by a WAD 2,100 or a line 82.5 mm forward of the bonnet rear reference line, whichever is most forward at a given lateral position; and

(c) At each side, by a line 82.5 mm inside the side reference line.

The distance of 82.5 mm is to be set with a flexible tape held tautly along the outer surface of the vehicle.

95.2.2 "Assessment interval" (AI) of the flexible lower legform impactor is defined and limited by the time of first contact of the flexible lower legform impactor with the vehicle and the timing of the last zero crossing of all femur and tibia segments after their first local maximum subsequent to any marginal value of 15 Nm, within their particular common zero crossing phases. The AI is identical for all bone segments and knee ligaments. In case of any bone segment not having a zero crossing during the common zero crossing phases, the time history curves for all bone segments are shifted downwards until all bending moments are crossing zero. The downwards shift is to be applied for the determination of the AI only.

95.2.3 "A-pillar" means the foremost and outermost roof support extending from the chassis to the roof of the vehicle.

95.2.4 "Bonnet leading edge" means the edge of the front upper outer structure of the vehicle, including the bonnet and wings, the upper and side members of the headlight surrounds and any other attachments. The reference line identifying the position of the bonnet leading edge is defined by its height above the ground reference plane and by the horizontal distance separating it from the bumper (bumper lead).

95.2.5 "Bonnet leading edge height" means, at any point on the bonnet leading edge, the vertical distance between the ground reference plane and the bonnet leading edge reference line at that point.

95.2.6 "Bonnet leading edge reference line" means the geometric trace of the points of contact between a straight edge 1,000 mm long and the front surface of the bonnet, when the straight edge, held parallel to the vertical longitudinal plane of the car and inclined rearwards by 50 deg. from the vertical and with the lower end 600 mm above the ground, is traversed across and in contact with the bonnet leading edge (see Figure 1).

For vehicles having the bonnet top surface inclined at 50 deg., so that the straight edge makes a continuous contact or multiple contacts rather than a point contact, the reference line is determined with the straight edge inclined rearwards at an angle of 40 deg. from the vertical.

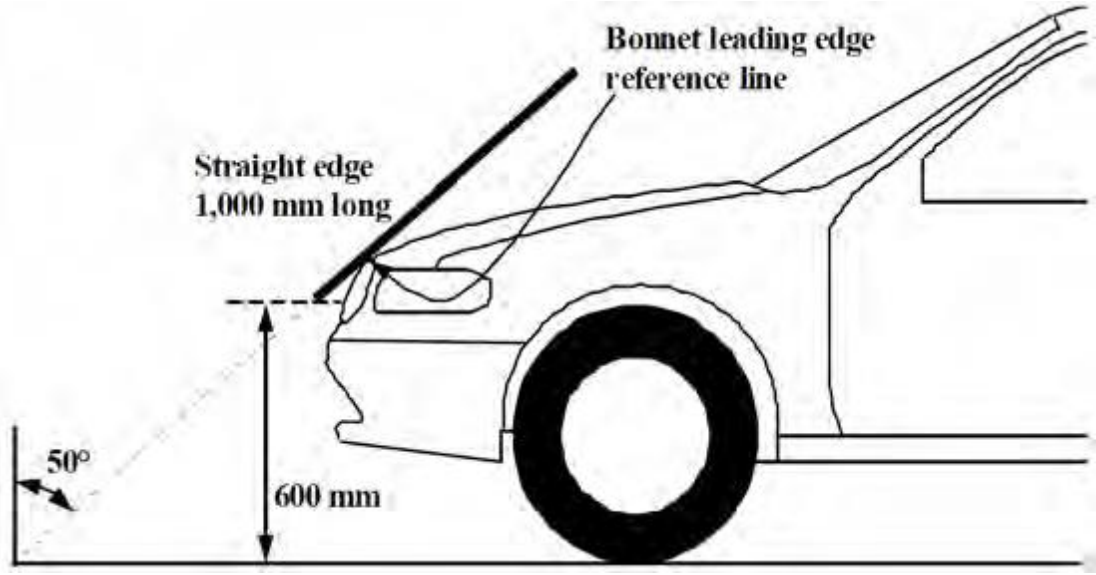
For vehicles of such shape that the bottom end of the straight edge makes first contact, then that contact is taken to be the bonnet leading edge reference line, at that lateral position.

For vehicles of such shape that the top end of the straight edge makes first contact with the vehicle, then the geometric trace of 1,000

mm wrap around distance will be used as the bonnet leading edge reference line at that lateral position.

The top edge of the bumper shall also be regarded as the bonnet leading edge for the purposes of this Regulation, if it is contacted by the straight edge during this procedure.

Figure 1: Bonnet leading edge reference line



95.2.7 "Bonnet rear reference line" means the geometric trace of the most rearward points of contact between a 165 mm diameter sphere and the front structure of the vehicle when the sphere is traversed across the front structure of the vehicle while maintaining contact with the windscreen (see Figure 2). The wiper blades and arms are removed during this process.

Where the bonnet rear reference line and the side reference line do not intersect, the bonnet rear reference line should be extended and/or modified using a semi-circular template, of radius 100 mm. The template should be made of a thin flexible sheet material that easily bends to a single curvature in any direction. The template should, preferably, resist double or complex curvature where this could result in wrinkling. The recommended material is a foam backed thin plastic sheet to allow the template to "grip" the surface of

the vehicle.

The template should be marked up with four points "A" through "D", as shown in Figure 3, while the template is on a flat surface.

The template should be placed on the vehicle with Corners "A" and "B" coincident with the side reference line. Ensuring these two corners remain coincident with the side reference line, the template should be slid progressively rearwards until the arc of the template makes first contact with the bonnet rear reference line. Throughout the process, the template should be curved to follow, as closely as possible, the outer contour of the vehicle's bonnet top, without wrinkling or folding of the template. If the contact between the template and bonnet rear reference line is tangential and the point of tangency lies outside the arc scribed by points "C" and "D", then the bonnet rear reference line is extended and/or modified to follow the circumferential arc of the template to meet the bonnet side reference line, as shown in Figure 4.

If the template cannot make simultaneous contact with the bonnet side reference line at points "A" and "B" and tangentially with the bonnet rear reference line, or the point at which the bonnet rear reference line and template touch lies within the arc scribed by points "C" and "D", then additional templates should be used where the radii are increased progressively in increments of 20 mm, until all the above criteria are met.

Figure 2: Bonnet rear reference line

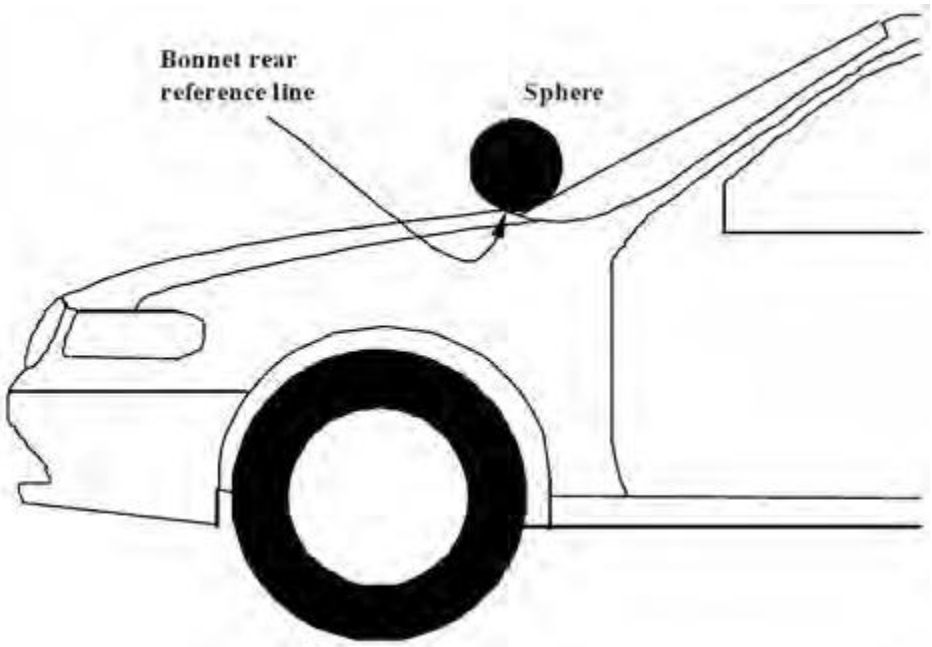


Figure 3: Template

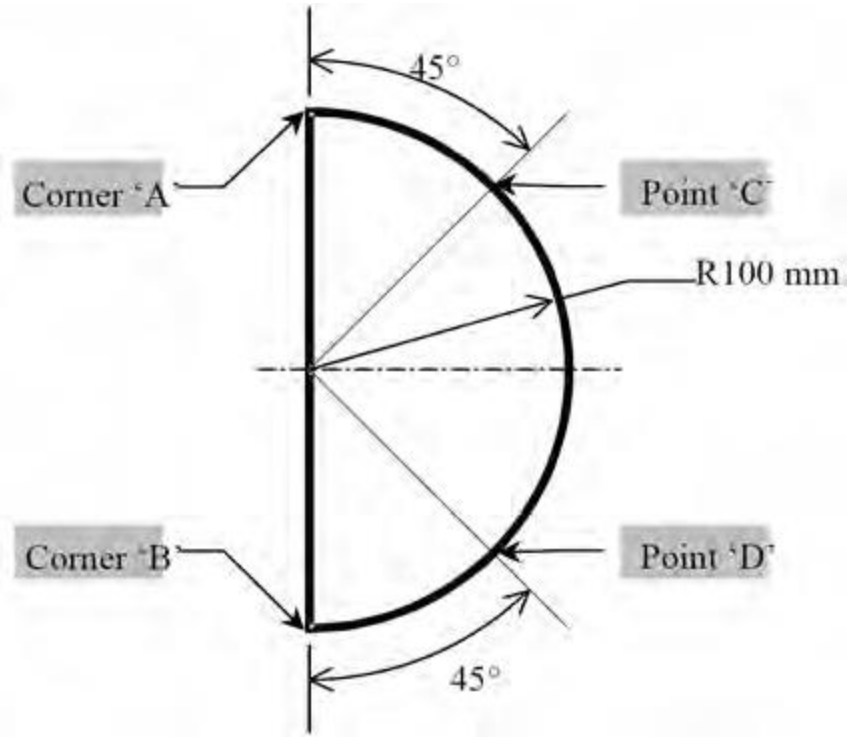
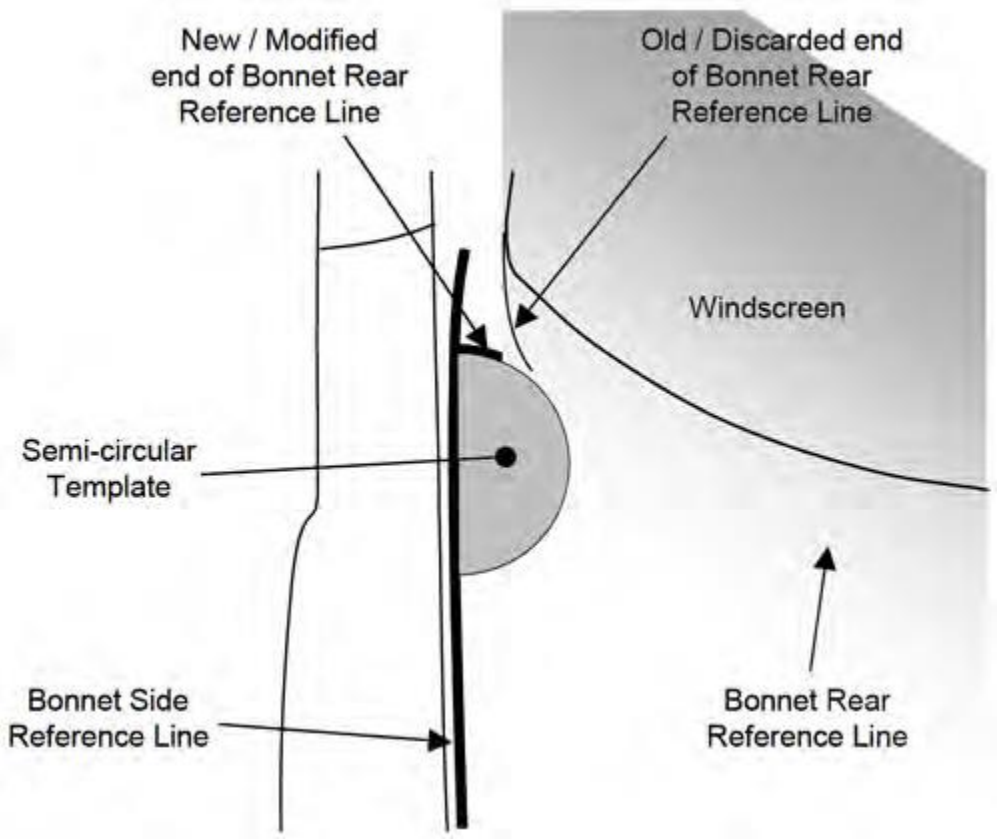


Figure 4: Marking of intersection between bonnet rear and side reference lines



95.2.8 "Bonnet top" is the area which is bounded by (a), (b) and (c) as follows:

(a) The bonnet leading edge reference line;

(b) The bonnet rear reference line;

(c) The side reference lines.

95.2.9 "Bonnet top test area" is composed of the child headform test area and the adult headform test area as defined in paragraphs 95.2.15. and 95.2.1. respectively.

95.2.10 "Bumper" means the front, lower, outer structure of a vehicle. It includes all structures that are intended to give protection to a vehicle when involved in a low speed frontal collision and also any attachments to this structure. The reference height and lateral limits of the bumper are identified by the corners and the bumper reference lines.

95.2.11 "Bumper beam" means the structural cross member, rearward of the bumper fascia if present, protecting the front of the vehicle. The beam does not include foam, cover support or any pedestrian protection devices.

95.2.12 "Bumper lead" means for any longitudinal section of a vehicle, the horizontal distance measured in any vehicle vertical longitudinal plane between the upper bumper reference line and the bonnet leading edge reference line.

95.2.13 "Bumper test area" means either the front vehicle fascia between the left and right corner of bumper as defined in paragraph 95.2.17., minus the areas covered by the distance of 42 mm inboard of each corner of bumper as measured horizontally and perpendicular to the longitudinal median plane of the vehicle, or between the outermost ends of the bumper beam as defined in paragraph 95.2.12. (see Figure 5D), minus the areas covered by the distance of 42 mm inboard of each end of the bumper beam, as measured horizontally and perpendicular to the longitudinal median plane of the vehicle, whichever area is wider.

95.2.14 "Centre of the knee" of the lower legform impactor is defined as the point about which the knee effectively bends.

95.2.15 "Child headform test area" is an area on the outer surfaces of the front structure. The area is bounded:

(a) In the front, by a WAD 1,000 or a line 82.5 mm rearward of the bonnet leading edge reference line, whichever is most rearward at a given lateral position,

(b) At the rear, by a WAD 1,700 or a line 82.5 mm forward of the bonnet rear reference line, whichever is most forward at a given lateral position, and

(c) At each side, by a line 82.5 mm inside the side reference line.

The distance of 82.5 mm is to be set with a flexible tape held tautly along the outer surface of the vehicle.

95.2.16 "Corner of bumper" means the transversal position of the vehicle's point of contact with a corner gauge as defined in Figure 5B.

For determination of the corner of bumper, the front surface of the corner gauge is moved parallel to a vertical plane with an angle of 60 deg. to the vertical longitudinal centre plane of the vehicle (see Figures 5A and 5C) at any height of the centre point of the corner gauge between:

(a) Equal to and above the point found on the vertical line intersecting the Lower Bumper Reference Line at the assessment position

in transversal direction or at 75 mm above the ground reference plane, whichever is higher.

(b) Equal to and below the point found on the vertical line intersecting the Upper Bumper Reference Line at the assessment position in transversal direction or at 1,003 mm above the ground reference plane, whichever is lower.

For determination of the corner of bumper, the gauge is moved to contact the outer contour/front fascia of the vehicle touching at the vertical centre line of the gauge. The horizontal centre line of the gauge is kept parallel to the ground plane.

The corners of bumper on both sides are subsequently defined as the outermost points of contact of the gauge with the outer contour/front fascia of the vehicle as determined in accordance with this procedure. Any points of contact on the top and the bottom edges of the gauge are not taken into account. The external devices for indirect vision and the tyres shall not be considered.

Figure 5A: Corner of bumper example (see paragraph 95.2.16., note that the corner gauge is to be moved in vertical and horizontal directions to enable contact with the outer contour/front fascia of the vehicle)

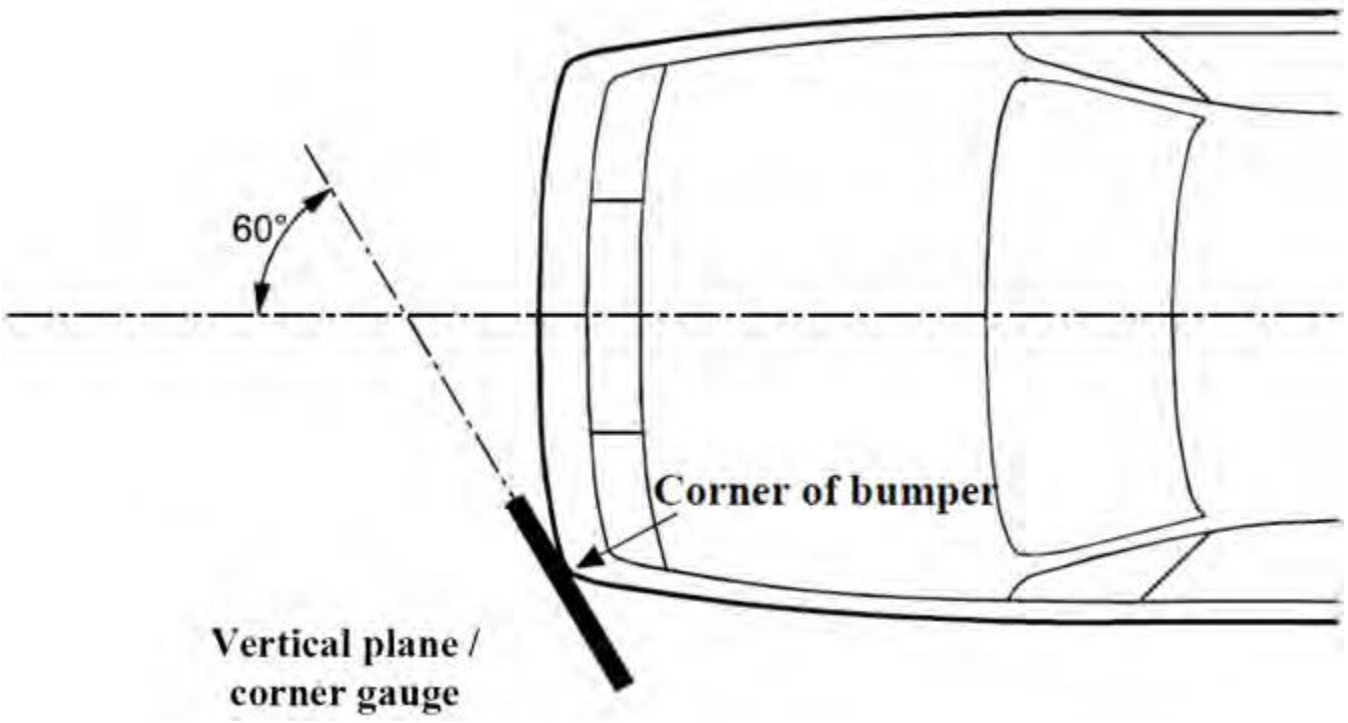
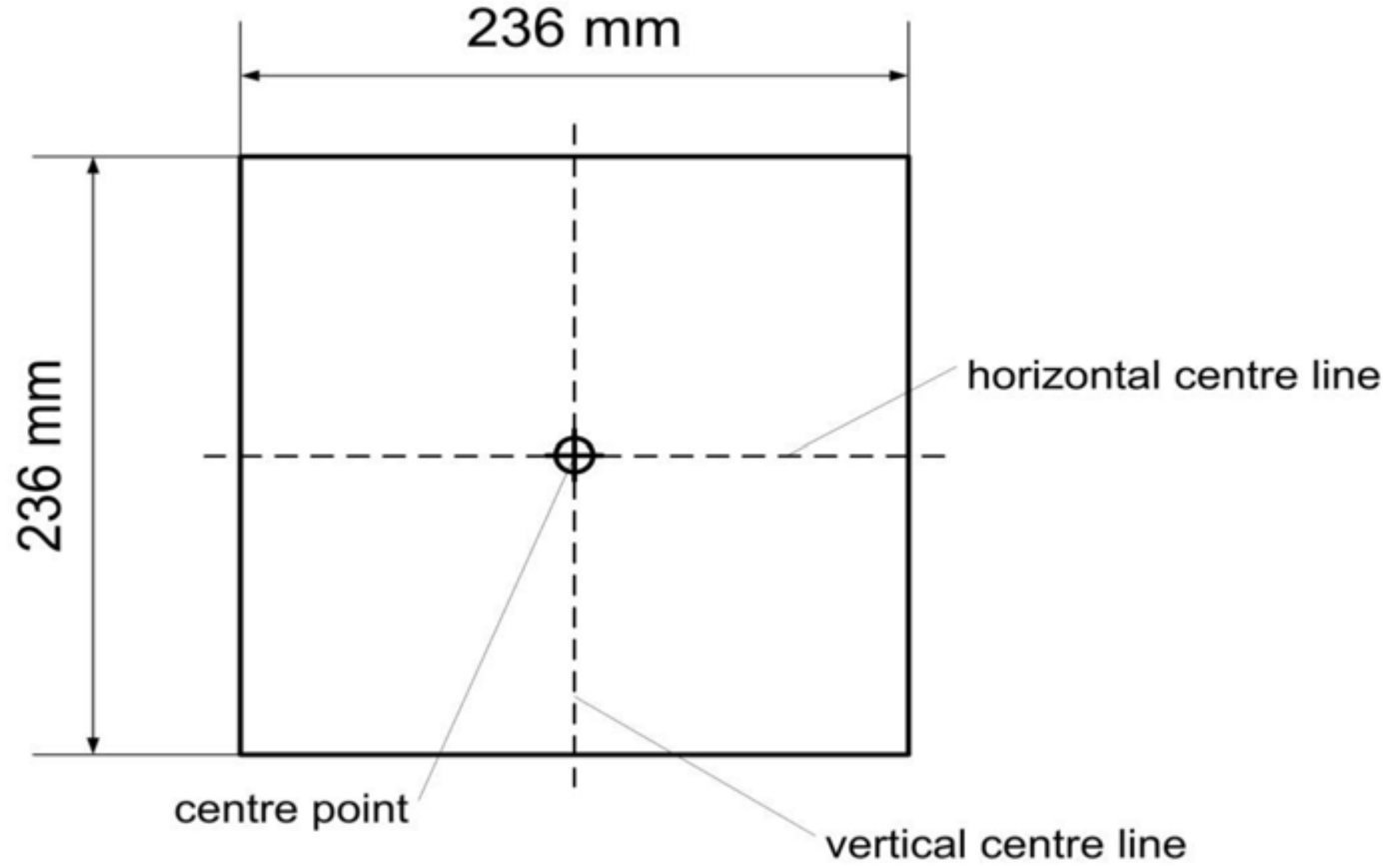


Figure 5B: Corner gauge



The front surface of the corner gauge is flat.

The centre point is the intersection of the vertical and horizontal centre lines on the front surface.

Figure 5C: Determination of the corner of bumper with the corner gauge (shown in random location)

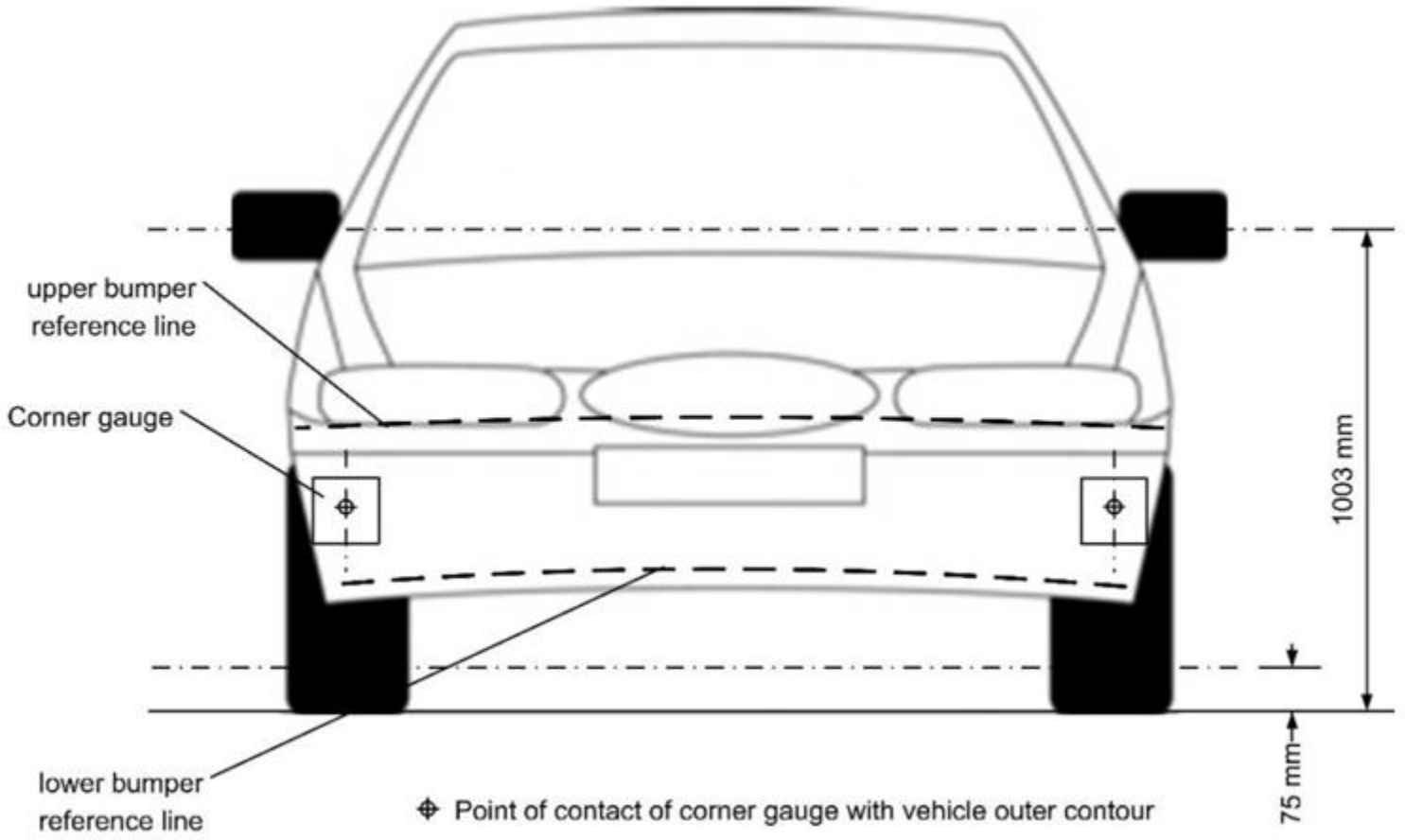
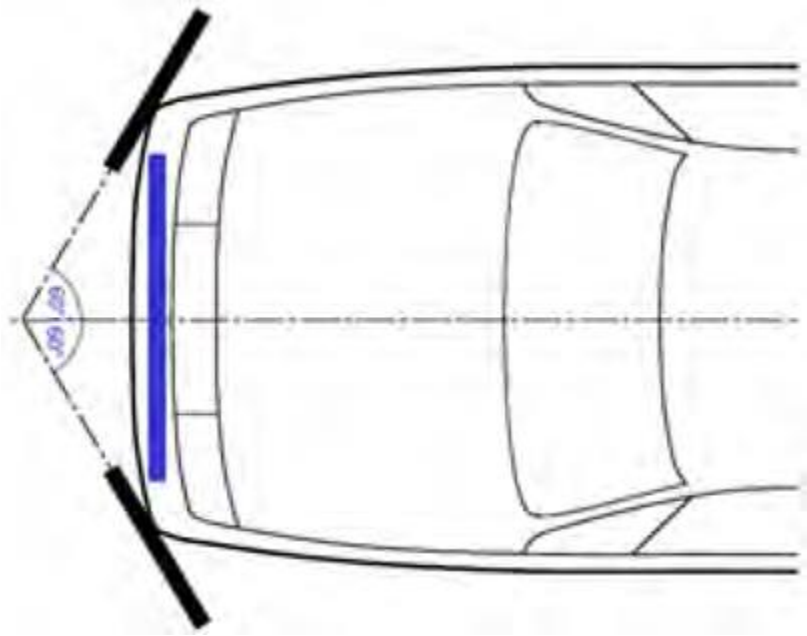
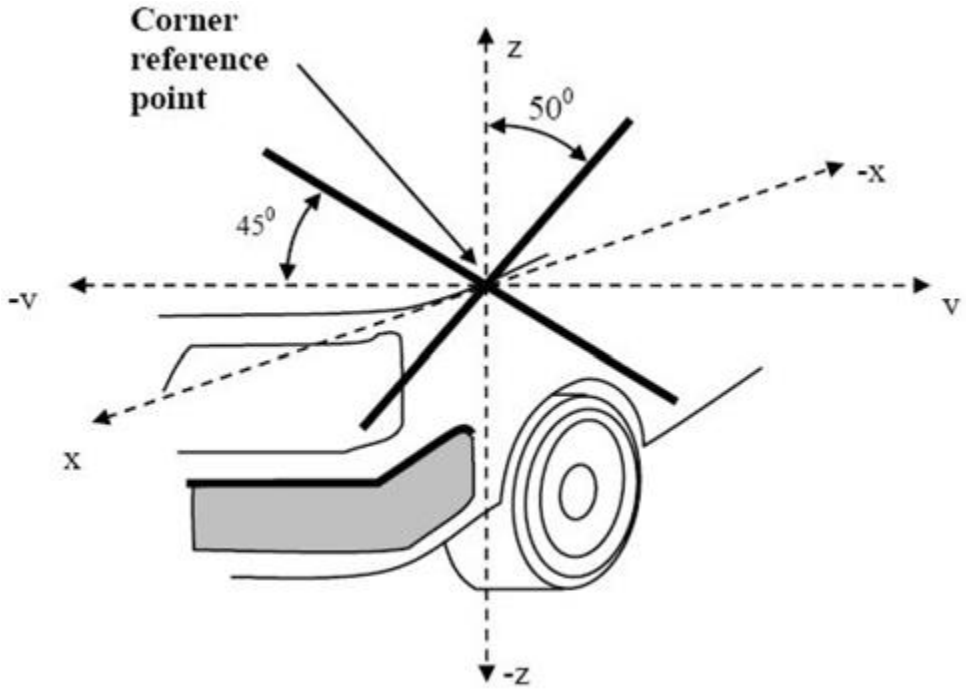


Figure 5D: Determination of bumper test area (note that the corner gauges are to be moved in vertical and horizontal directions to enable contact with the outer contour/front fascia of the vehicle)



95.2.17 "Corner reference point" means the intersection of the bonnet leading edge reference line and of the bonnet side reference line (see Figure 6).

Figure 6: Determination of corner reference point; intersection of the bonnet leading edge reference line and the bonnet side reference line



95.2.18 "Driver mass" means the nominal mass of a driver that shall be 75 kg (subdivided into 68 kg occupant mass at the seat and 7 kg luggage mass in accordance with ISO standard 2416-1992).

95.2.19 "Femur" of the lower legform impactor is defined as all components or parts of components (including flesh, skin covering, damper, instrumentation and brackets, pulleys, etc. attached to the impactor for the purpose of launching it) above the level of the centre of the knee.

95.2.20 "Front reference line for child headform" means the geometric trace as described on the vehicle front structure using a WAD1000 line. In the case of vehicles where the wrap around distance to the bonnet leading edge reference line, is more than 1,000 mm at any point, then the bonnet leading edge reference line will be used as the front reference line for child headform at that point.

95.2.21 "Front structure" means all outer structures of the vehicle except the windscreen, the windscreen header, the A-pillars and structures

rearward of these. It therefore includes, but is not limited to, the bumper, the bonnet, wings, scuttle, wiper spindles and lower windscreen frame.

95.2.22 "Ground reference plane" means a horizontal plane, either real or imaginary, that passes through the lowest points of contact for all tyres of a vehicle while the vehicle is in its normal ride attitude. If the vehicle is resting on the ground, then the ground level and the ground reference plane are one and the same. If the vehicle is raised off the ground such as to allow extra clearance below the bumper, then the ground reference plane is above ground level.

95.2.23 "Head Injury Criterion (HIC)" means the calculated result of accelerometer time histories using the following formula:

$$\text{HIC} = \left[\frac{1}{t_2 - t_1}\int_{t_1}^{t_2} a\,dt\right]^{2.5}(t_2 - t_1)$$

Where:

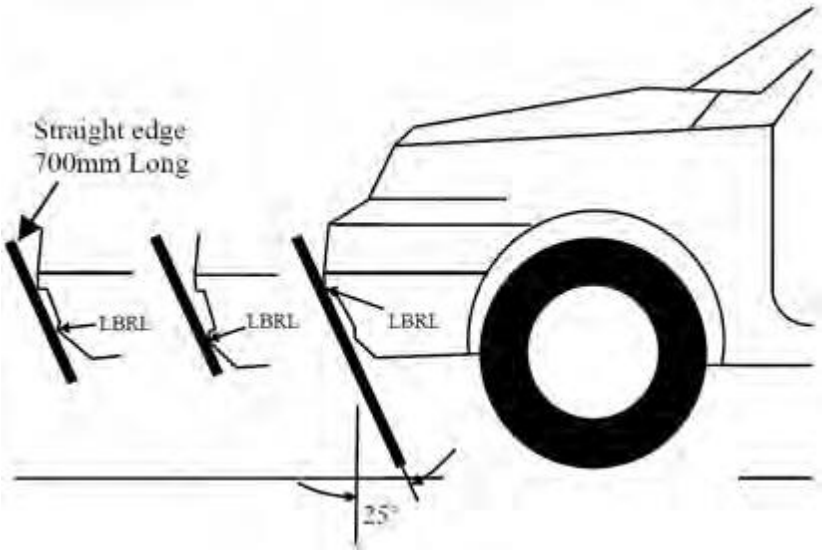
"a" is the resultant acceleration measured in units of gravity "g" (1 g = 9.81 m/s^2);

"t_1" and "t_2" are the two time instants (expressed in seconds) during the impact, defining an interval between the beginning and the end of the recording period for which the value of HIC is a maximum (t_2 - t_1 < 15 ms).

95.2.24 "Lower bumper height" means the vertical distance between the ground reference plane and the lower bumper reference line, with the vehicle positioned in its normal ride attitude.

95.2.25 "Lower bumper reference line" means the lower limit to significant points of pedestrian contact with the bumper. It is defined as the geometric trace of the lowermost points of contact between a straight edge 700 mm long and the bumper, when the straight edge, held parallel to the vertical longitudinal plane of the vehicle and inclined forwards by 25 deg. from the vertical, is traversed across the front of the vehicle, while maintaining contact with the ground and with the surface of the bumper (see Figure 7).

Figure 7: Lower Bumper Reference Line (LBRL)



95.2.26 "Mass in running order" means the nominal mass of a vehicle as determined by the sum of unladen vehicle mass and driver's mass.

95.2.27 "Measuring point"

The measuring point may also be referred to as "test point" or "impact point". In all cases, the result of the test shall be attributed to this point, independent of where first contact occurs.

95.2.27.1 "Measuring point" for the headform test means a point on the vehicle's outer surface selected for assessment. The measuring point is where the headform's profile contacts the vehicle's outer surface cross section in a vertical longitudinal plane through the centre of gravity of the headform (see Figure 8A).

95.2.27.2 "Measuring point" for the lower legform to bumper test and the upper legform to bumper test is located in the vertical longitudinal plane through the central axis of the impactor (see Figure 8B).

Figure 8A: Measuring point in the vertical longitudinal plane through the center of the headform impactor

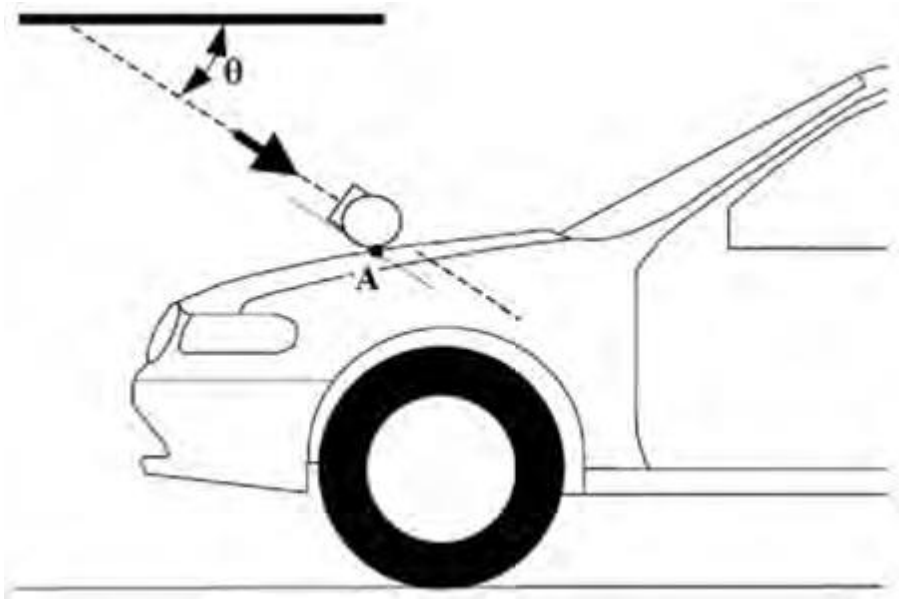
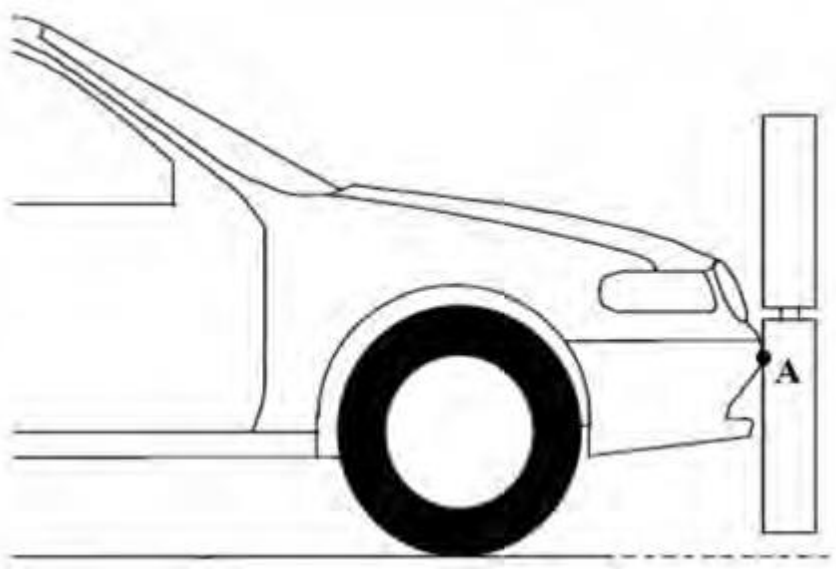


Figure 8B: Measuring point in the vertical longitudinal plane through the central axis of the legform impactor



95.2.28 "Normal ride attitude" means the vehicle positioned on a flat horizontal surface with its mass in running order, with the tyres inflated to manufacturer recommended pressures, the front wheels in the straight-ahead position and with a passenger mass placed on the front passenger seat. The front seats are placed at the nominal mid-track position. The suspension shall be set in normal running condition as specified by the manufacturer for a speed of 40 km/h.

95.2.29 "Passenger mass" means the nominal mass of a passenger that shall be 68 kg, with in addition a 7 kg provision for luggage which shall be located in the luggage compartment(s) in accordance with ISO standard 2416-1992.

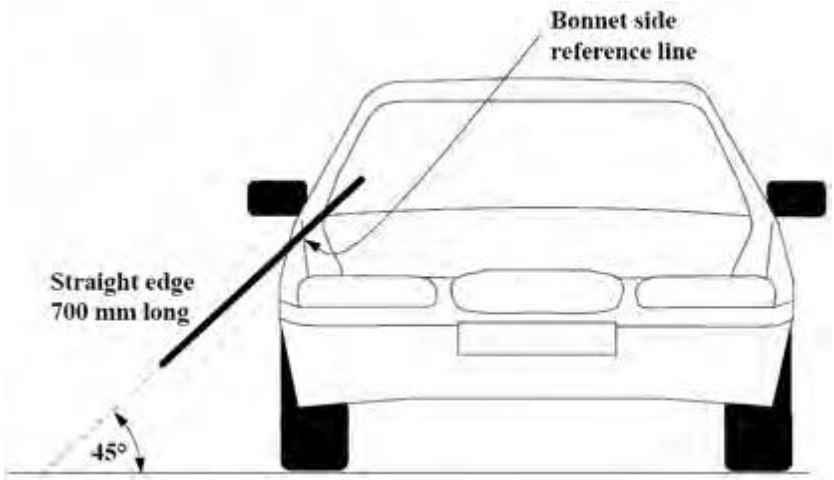
95.2.30 "Primary reference marks" means holes, surfaces, marks and identification signs on the vehicle body. The type of reference mark used and the vertical (Z) position of each mark relative to the ground shall be specified by the vehicle manufacturer according to the running conditions specified in paragraph 95.2.26. These marks shall be selected so as to be able to easily check the vehicle front and rear ride heights and vehicle attitude.

If the primary reference marks are found to be within +/- 25 mm of the design position in the vertical (Z) axis, then the design position shall be considered to be the normal ride height. If this condition is met, either the vehicle shall be adjusted to the design position, or

all further measurements shall be adjusted, and tests performed, to simulate the vehicle being at the design position.

95.2.31 "Side reference line" means the geometric trace of the highest points of contact between a straight edge 700 mm long and the sides of the vehicle, when the straight edge, held parallel to the transverse vertical plane of the vehicle and inclined inwards by 45 deg., is traversed down, and maintains contact with the sides of the front structure (see Figure 9).

Figure 9: Side reference line



95.2.32 "Third of the bonnet leading edge" means the geometric trace between the corner reference points, measured with a flexible tape following the outer contour of the leading edge, divided in three equal parts.

95.2.33 "Third of the bonnet top" means the geometric trace of the area between the bonnet side reference lines, measured with a flexible tape following the outer contour of the bonnet top on any transverse section, divided in three equal parts.

95.2.34 "Third of the bumper" means the geometric trace between the corners of the bumper, measured with a flexible tape following the outer contour of the bumper, divided in three equal parts.

95.2.35 "Tibia" of the lower legform impactor is defined as all components or parts of components (including flesh, skin covering, instrumentation and brackets, pulleys, etc. attached to the impactor for the purpose of launching it) below the level of the centre of

the knee. Note that the tibia as defined includes allowances for the mass, etc., of the foot.

95.2.36 "Unladen vehicle mass" means the nominal mass of a complete vehicle as determined by the following criteria:

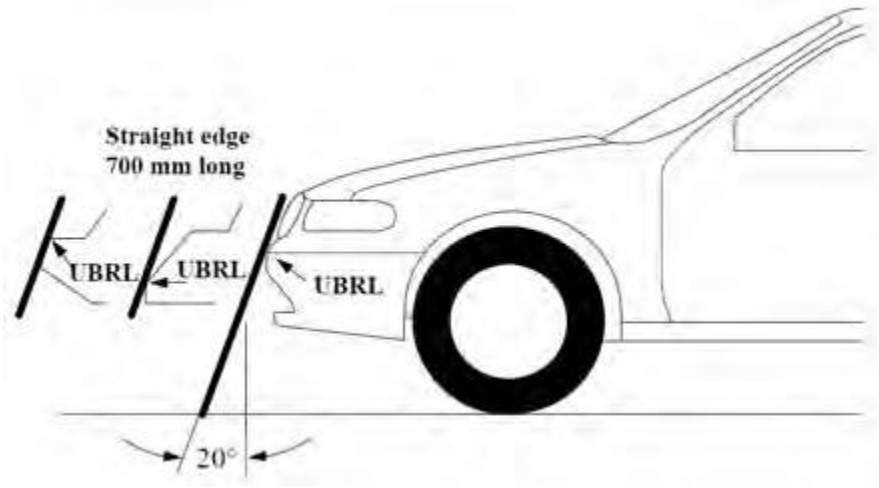
95.2.36.1 Mass of the vehicle with bodywork and all factory fitted equipment, electrical and auxiliary equipment for normal operation of vehicle, including liquids, tools, fire extinguisher, standard spare parts, chocks and spare wheel, if fitted.

95.2.36.2 The fuel tank shall be filled to at least 90 per cent of rated capacity and the other liquid containing systems (except those for used water) to 100 per cent of the capacity specified by the manufacturer

95.2.37 "Upper bumper reference line" means a line which identifies the upper limit to significant points of pedestrian contact with the bumper. It is defined as the geometric trace of the upper most points of contact between a straight edge 700 mm long and the bumper, when the straight edge, held parallel to the vertical longitudinal plane and inclined rearwards by 20 deg., is traversed across the front of the vehicle, while maintaining contact with the ground and with the surface of the bumper (see Figure 10).

Where necessary the straight edge shall be shortened to avoid any contact with structures above the bumper.

Figure 10: Upper Bumper Reference Line (UBRL)



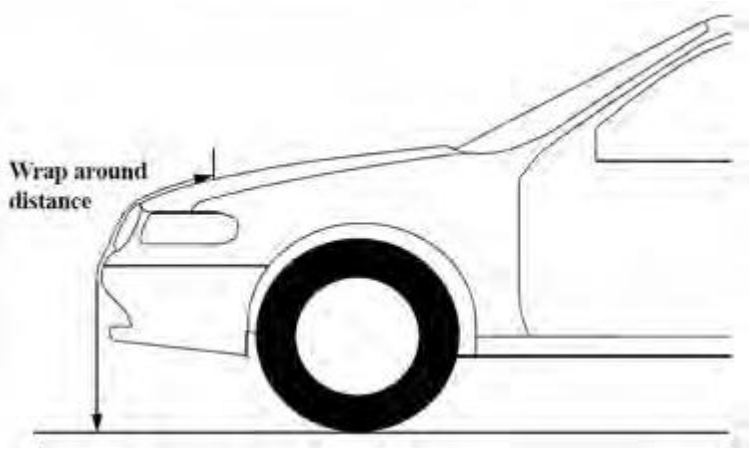
95.2.38 "Vehicles of category M1 derived from N1" means those vehicles of M1 category which, forward of the A-pillars, have the same general structure and shape as a pre-existing N1 category vehicle.

95.2.39 "Windscreen" means the frontal glazing of the vehicle situated between the A-pillars.

95.2.40 "Wrap Around Distance (WAD)" means the geometric trace described on the outer surface of the vehicle front structure by one end of a flexible tape, when it is held in a vertical longitudinal plane of the vehicle and traversed across the front structure. The tape is held taut throughout the operation with one end held at the same level as the ground reference plane, vertically below the front face of the bumper and the other end held in contact with the front structure (see Figure 11). The vehicle is positioned in the normal ride attitude.

This procedure shall be followed, using alternative tapes of appropriate lengths, to describe wrap around distances of 1,000 mm (WAD1000), of 1,700 mm (WAD1700) and of 2,100 mm (WAD2100).

Figure 11: Wrap around distance measurement



95.2.41 "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).

95.3 Pedestrian safety shall according to suitable variants and range of principle as below：

95.3.1 If use completed vehicle

95.3.1.1 Same brand and vehicle type.

95.3.1.2 Forward of the A-pillars of vehicle, do not differ in such essential respects as:

95.3.1.2.1 The structure.

95.3.1.2.2 The main dimensions.

95.3.1.2.3 The materials of the outer surfaces of the vehicle.

95.3.1.2.4 The component arrangement (external or internal).

95.3.2 If use chassis vehicle

95.3.2.1 Same chassis brand and same chassis vehicle type.

95.3.2.2 Forward of the A-pillars of vehicle, do not differ in such essential respects as:

95.3.2.2.1 The structure.

95.3.2.2.2 The main dimensions.

95.3.2.2.3 The materials of the outer surfaces of the vehicle.

95.3.2.2.4 The component arrangement (external or internal).

95.4 Specifications

95.4.1 Legform test to bumper:

For vehicles with a lower bumper height at the test position of less than 425 mm the requirements of paragraph 95.4.1.1. shall be applied.

For vehicles with a lower bumper height at the test position which is greater than, or equal to, 425 mm and less than 500 mm the requirements of either paragraph 95.4.1.1. or 95.4.1.2., at the choice of the manufacturer, shall be applied.

For vehicles with a lower bumper height at the test position of greater than, or equal to, 500 mm the requirements of paragraph 95.4.1.2. shall be applied.

95.4.1.1 Flexible Lower legform to bumper

When tested in accordance with paragraph 95.7.1. (Flexible lower legform to bumper), the absolute value of the maximum

dynamic medial collateral ligament elongation at the knee shall not exceed 22 mm, and the maximum dynamic anterior cruciate ligament and posterior cruciate ligament elongation shall not exceed 13 mm. The absolute value of dynamic bending moments at the tibia shall not exceed 340 Nm. In addition, the manufacturer may nominate bumper test widths up to a maximum of 264 mm in total where the absolute value of the tibia bending moment shall not exceed 380 Nm. A Contracting Party may restrict application of the relaxation zone requirement in its domestic legislation if it decides that such restriction is appropriate.

The flexible lower legform impactor shall be certified pursuant to paragraph 95.8.1.

95.4.1.2 Upper legform to bumper

When tested in accordance with paragraph 95.7.2. (upper legform to bumper), the instantaneous sum of the impact forces with respect to time shall not exceed 7.5 kN and the bending moment on the test impactor shall not exceed 510 Nm.

The upper legform impactor shall be certified pursuant to paragraph 95.8.2.

95.4.2 Headform tests

95.4.2.1 Child and adult headform tests

When tested in accordance with paragraphs 95.7.3., 95.7.4., and 95.7.5., the HIC recorded shall not exceed 1,000 over two thirds of the bonnet top test area. The HIC for the remaining areas shall not exceed 1,700 for both headforms.

In case there is only a child headform test area, the HIC recorded shall not exceed 1,000 over two thirds of the test area. For the remaining area the HIC shall not exceed 1,700.

95.4.2.2 Child headform impact

When tested in accordance with paragraphs 95.7.3. and 95.7.4., the HIC recorded shall not exceed 1,000 over a minimum of one half of the child headform test area. The HIC for the remaining areas shall not exceed 1,700.

95.4.2.3 The headform impactors shall be certified pursuant to paragraph 95.8.3.

95.5 General test conditions

95.5.1 Temperature and humidity

95.5.1.1 At the time of testing, the test facility and the vehicle or sub-system shall have a relative humidity of 40 +/-30 per cent and stabilized temperature of 20 +/- 4 deg. C.

95.5.2 Impact test site

95.5.2.1 The test site shall consist of a flat, smooth and hard surface with a slope not exceeding 1 per cent.

95.5.3 Preparation of the vehicle

95.5.3.1 Either a complete vehicle, or a cut-body, adjusted to the following conditions shall be used for the test.

95.5.3.1.1 The vehicle shall be in its normal ride attitude, and shall be either securely mounted on raised supports or at rest on a flat horizontal surface with the parking brake applied.

95.5.3.1.2 The cut-body shall include, in the test, all parts of the vehicle front structure, all underbonnet components and all components behind the windscreen that may be involved in a frontal impact with a vulnerable road user, to demonstrate the performance and interactions of all the contributory vehicle components. The cut-body shall be securely mounted in the normal vehicle ride attitude.

95.5.3.2 All devices designed to protect vulnerable road users when impacted by the vehicle shall be correctly activated before and/or be active during the relevant test. It shall be the responsibility of the manufacturer to show that any devices will act as intended in a pedestrian impact.

95.5.3.3 For vehicle components which could change shape or position, other than active devices to protect pedestrians, and which have more than one fixed shape or position shall require the vehicle to comply with the components in each fixed shape or position.

95.6 Test impactor specifications

95.6.1 Flexible lower legform impactor

95.6.1.1 The flexible lower legform impactor shall consist of flesh and skin, flexible long bone segments (representing femur and tibia), and a knee joint as shown in Figure 12. The assembled impactor shall have a total mass of 13.2 +/- [0.4] kg. The dimensions of the fully assembled impactor shall be as defined in Figure 12.

Brackets, pulleys, protectors, connection parts, etc. attached to the impactor for the purposes of launching and/or protection may extend beyond the dimensions and tolerances shown in Figure 12 and Figures 13(a) and (b).

95.6.1.2 The cross-sectional shape of the femur main body segments, the tibia main body segments and their impact faces shall be as defined in Figure 13(a).

95.6.1.3 The cross-sectional shape of the knee joint and its impact face shall be as defined in Figure 13 (b).

95.6.1.4 The masses of the femur and the tibia without the flesh and skin, including the connection parts to the knee joint, shall be 2.46 +/- 0.12 kg and 2.64 +/- 0.13 kg respectively. The mass of the knee joint without the flesh and skin shall be 4.28 +/- 0.21 kg. The assembled mass of the femur, the knee joint and the tibia without the flesh and skin shall be 9.38 +/- [0.3] kg.

The centres of gravity of the femur and tibia without the flesh and skin, including the connection parts to the knee joint, shall be as defined in Figure 12. The centre of gravity of the knee joint shall be as defined in Figure 12.

The moment of inertia of the femur and the tibia without the flesh and skin, including the connection parts inserted to the knee joint, about the X-axis through the respective centre of gravity shall be 0.0325 +/- 0.0016 kgm^2 and 0.0467 +/- 0.0023 kgm^2 respectively. The moment of inertia of the knee joint about the X-axis through the respective centre of gravity shall be 0.0180 +/- 0.0009 kgm^2

95.6.2 Lower legform instrumentation

95.6.2.1 Four transducers shall be installed in the tibia to measure bending moments at the locations within the tibia. Three transducers shall be installed in the femur to measure bending moments applied to the femur. The sensing locations of each of the transducers are as defined in Figure 14. The measurement axis of each transducer shall be the X-axis of the impactor.

95.6.2.2 Three transducers shall be installed in the knee joint to measure elongations of the medial collateral ligament (MCL), anterior cruciate ligament (ACL), and posterior cruciate ligament (PCL). The measurement locations of each transducer are shown in Figure 14. The measurement locations shall be within +/- 4 mm along the X-axis from the knee joint centre.

95.6.2.3 The instrumentation response value channel frequency class (CFC), as defined in ISO 6487:2002, shall be 180 for all transducers. The CAC response values, as defined in ISO 6487:2002, shall be 30 mm for the knee ligament elongations and 400 Nm for the tibia and femur bending moments. This does not require that the impactor itself be able to physically elongate or bend until these values.

95.6.2.4 The determination of all flexible lower legform impactor peak tibia bending moments and ligament elongations shall be limited to the assessment interval (AI) as defined in paragraph 95.2.2.

Figure 12: Flexible lower legform impactor

Dimensions and centre of gravitiy locations of femur, knee joint and tibia (Side view)

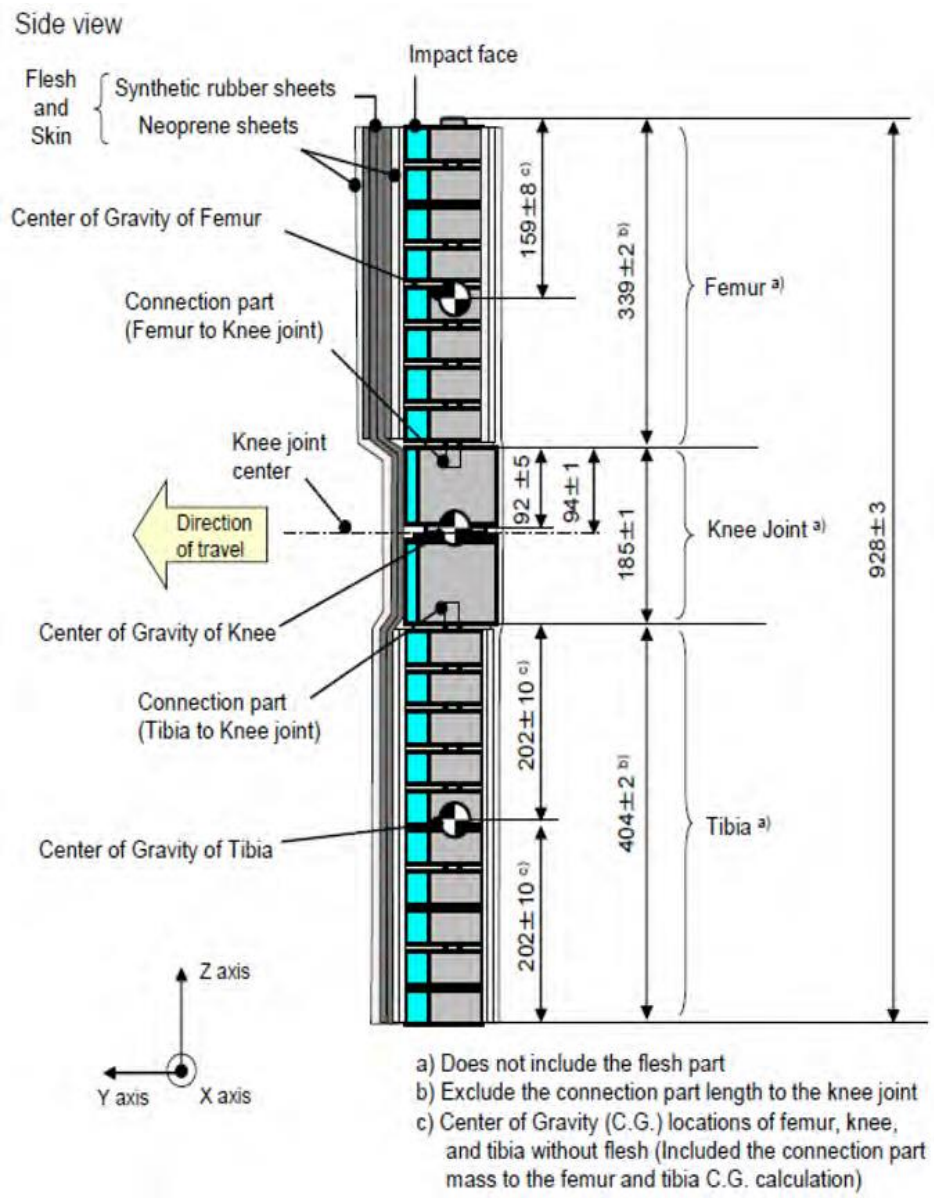


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Figure 13: Flexible lower legform impactor schematic plan views of femur, tibia, and knee dimensions (top view)

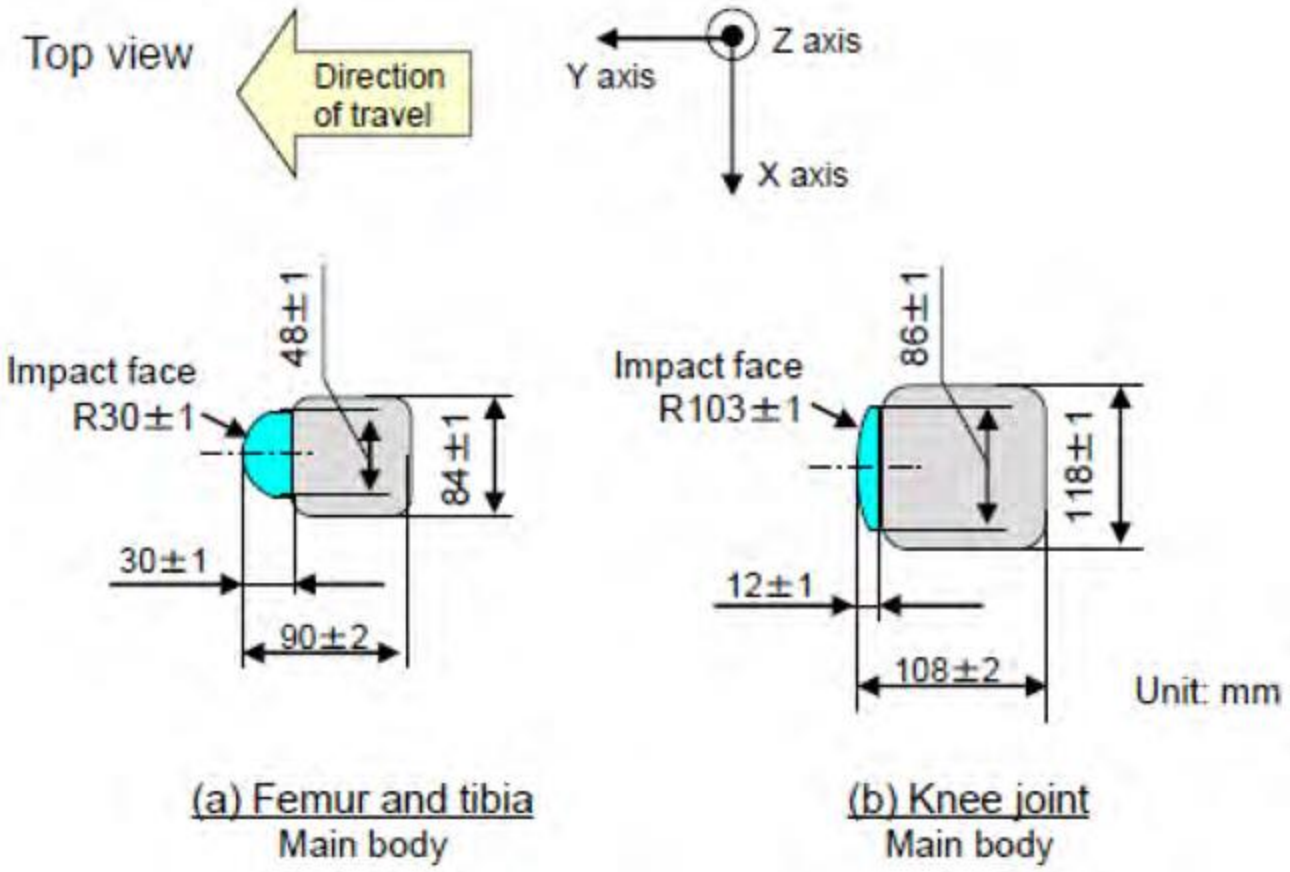
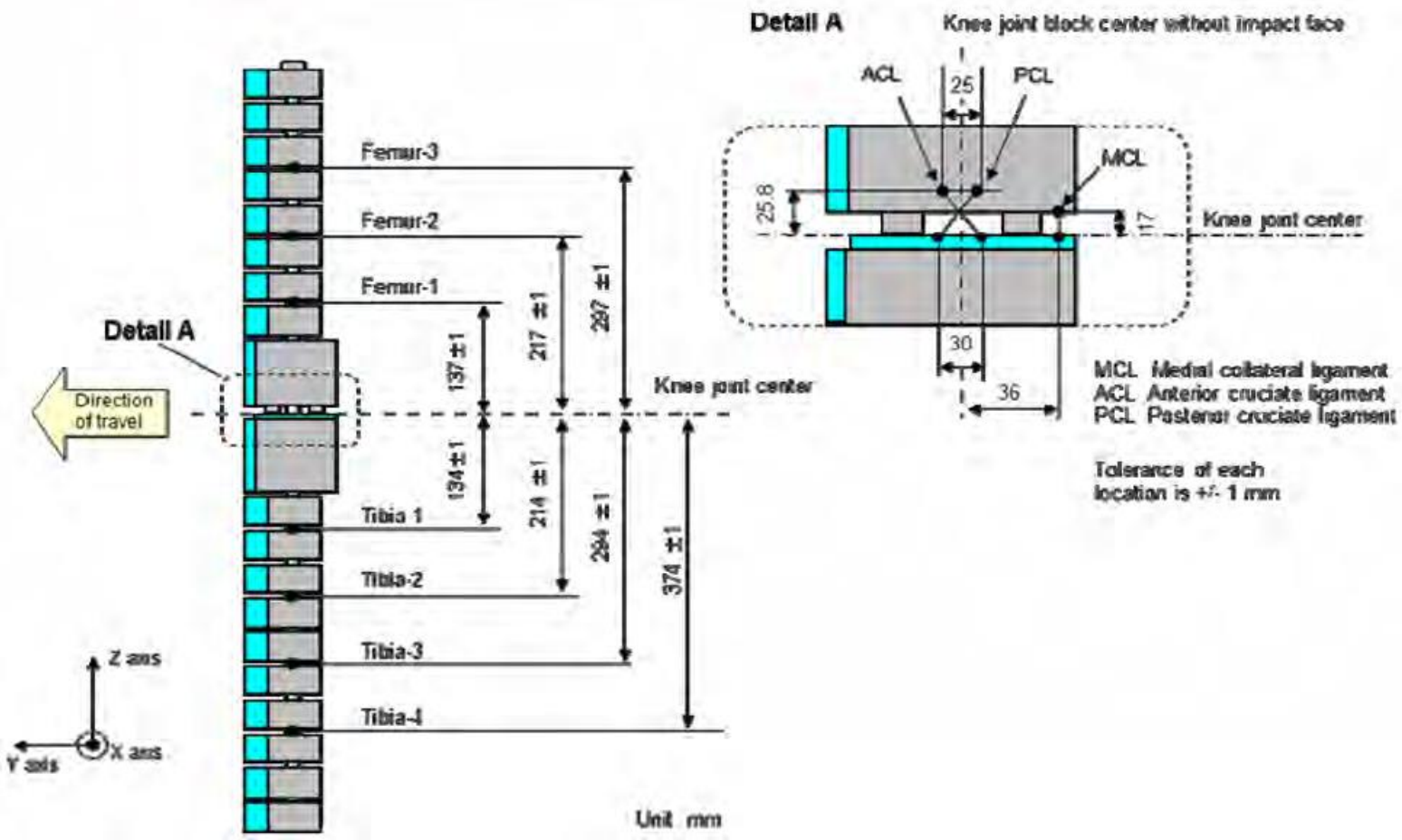


Figure 14: Flexible lower legform impactor instrument locations



95.6.3 Upper legform impactor

95.6.3.1 The upper legform impactor shall be rigid, foam covered at the impact side, and 350 +/ - 5 mm long (see Figure 15).

95.6.3.2 The total mass of the upper legform impactor including those propulsion and guidance components which are effectively part of the impactor during the impact shall be 9.5 +/ - 0.1 kg.

95.6.3.3 The total mass of the front member and other components in front of the load transducer assemblies, together with those parts of the load transducer assemblies in front of the active elements, but excluding the foam and skin, shall be 1.95 +/- 0.05 kg.

95.6.3.4 The upper legform impactor for the bumper test shall be mounted to the propulsion system by a torque limiting joint and be insensitive to off-axis loading. The impactor shall move only in the specified direction of impact when in contact with the vehicle and shall be prevented from motion in other directions including rotation about any axis.

95.6.3.5 The torque limiting joint shall be set so that the longitudinal axis of the front member is vertical at the time of impact with a tolerance of +/-2 deg., with the joint friction torque set to 675 +/- 25 Nm.

95.6.3.6 The centre of gravity of those parts of the impactor which are effectively forward of the torque limiting joint, including any weights fitted, shall lie on the longitudinal centre line of the impactor, with a tolerance of +/- 10 mm.

95.6.3.7 The length between the load transducer centre lines shall be 310 +/- 1 mm and the front member diameter shall be 50 +/- 1 mm.

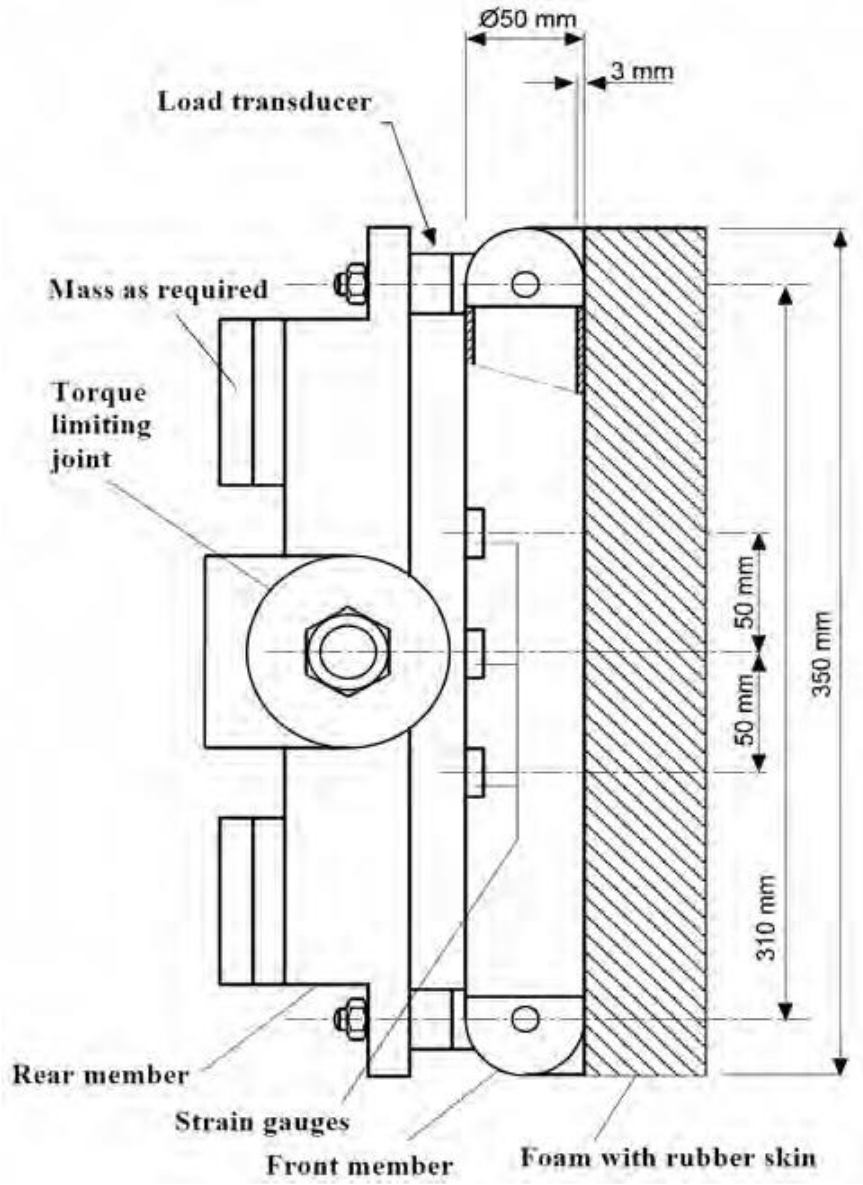
95.6.4 Upper legform instrumentation

95.6.4.1 The front member shall be strain gauged to measure bending moments in three positions, as shown in Figure 15, each using a separate channel. The strain gauges are located on the impactor on the back of the front member. The two outer strain gauges are located 50 +/ - 1 mm from the impactor's symmetrical axis. The middle strain gauge is located on the symmetrical axis with a +/-1 mm tolerance.

95.6.4.2 Two load transducers shall be fitted to measure individually the forces applied at either end of the upper legform impactor, plus strain gauges measuring bending moments at the centre of the upper legform impactor and at positions 50 mm either side of the centre line (see Figure 15).

95.6.4.3 The instrumentation response value CFC, as defined in ISO 6487:2002, shall be 180 for all transducers. The CAC response values, as defined in ISO 6487:2002, shall be 10 kN for the force transducers and 1,000 Nm for the bending moment measurements.

Figure 15: Upper legform impactor



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95.6.5 Child and adult headform impactors

95.6.5.1 Child headform impactor (see Figure 16)

95.6.5.1.1 The child headform impactor shall be made of aluminium, be of homogenous construction and be of spherical shape. The overall diameter shall be 165 +/- 1 mm. The mass shall be 3.5 +/- 0.07 kg. The moment of inertia about an axis through the centre of gravity and perpendicular to the direction of impact shall be within the range of 0.008 to 0.012 kgm2. The centre of gravity of the headform impactor including instrumentation shall be located in the geometric centre of the sphere with a tolerance of +/-2 mm.

The sphere shall be covered with a 14 +/- 0.5 mm thick synthetic skin, which shall cover at least half of the sphere.

95.6.5.1.2 The first natural frequency of the child headform impactor shall be over 5,000 Hz.

95.6.5.2 Child headform instrumentation

95.6.5.2.1 A recess in the sphere shall allow for mounting one triaxial or three uniaxial accelerometers within +/-10 mm seismic mass location tolerance from the centre of the sphere for the measurement axis, and +/-1 mm seismic mass location tolerance from the centre of the sphere for the perpendicular direction to the measurement axis.

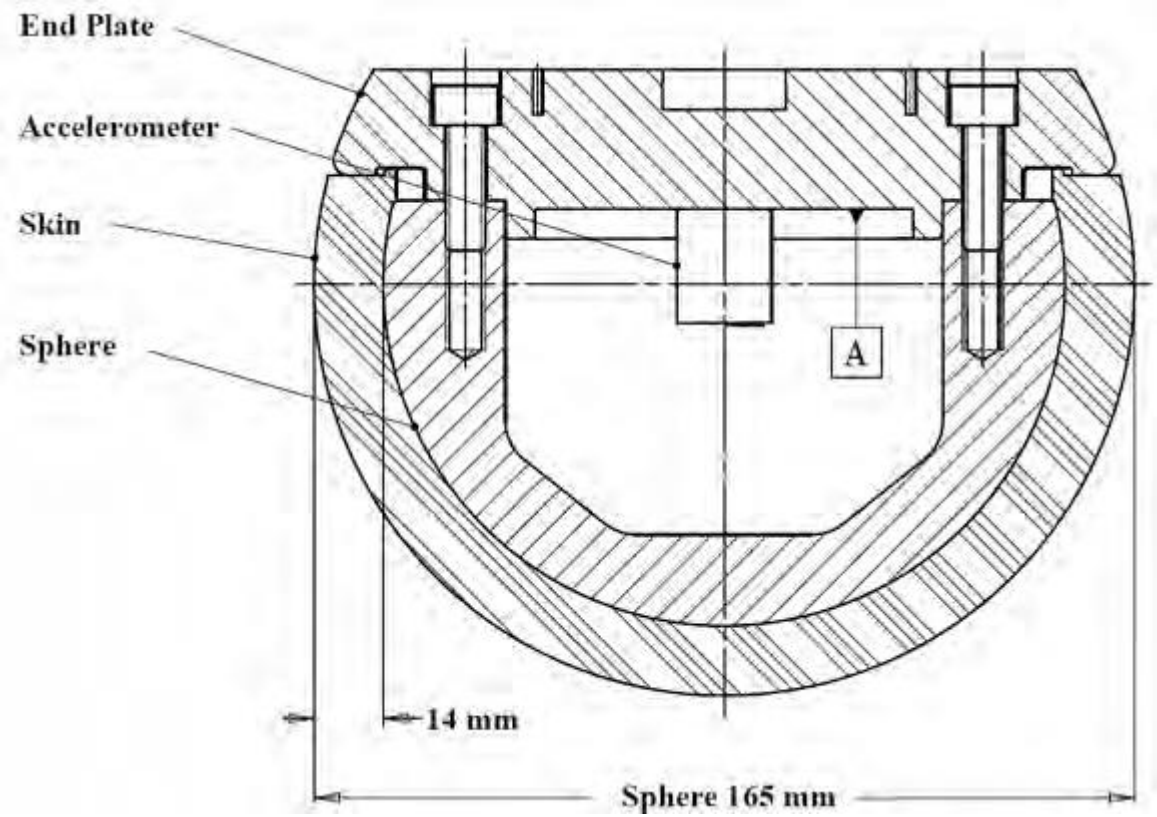
95.6.5.2.2 If three uniaxial accelerometers are used, one of the accelerometers shall have its sensitive axis perpendicular to the mounting face A (see Figure 16) and its seismic mass shall be positioned within a cylindrical tolerance field of 1 mm radius and 20 mm length.

The centre line of the tolerance field shall run perpendicular to the mounting face and its mid-point shall coincide with the centre of the sphere of the headform impactor.

95.6.5.2.3 The remaining accelerometers shall have their sensitive axes perpendicular to each other and parallel to the mounting face A and their seismic mass shall be positioned within a spherical tolerance field of 10 mm radius. The centre of the tolerance field shall coincide with the centre of the sphere of the headform impactor.

95.6.5.2.4 The instrumentation response value CFC, as defined in ISO 6487:2002, shall be 1,000. The CAC response value, as defined in ISO 6487:2002, shall be 500 g for the acceleration.

Figure 16: Child headform impactor

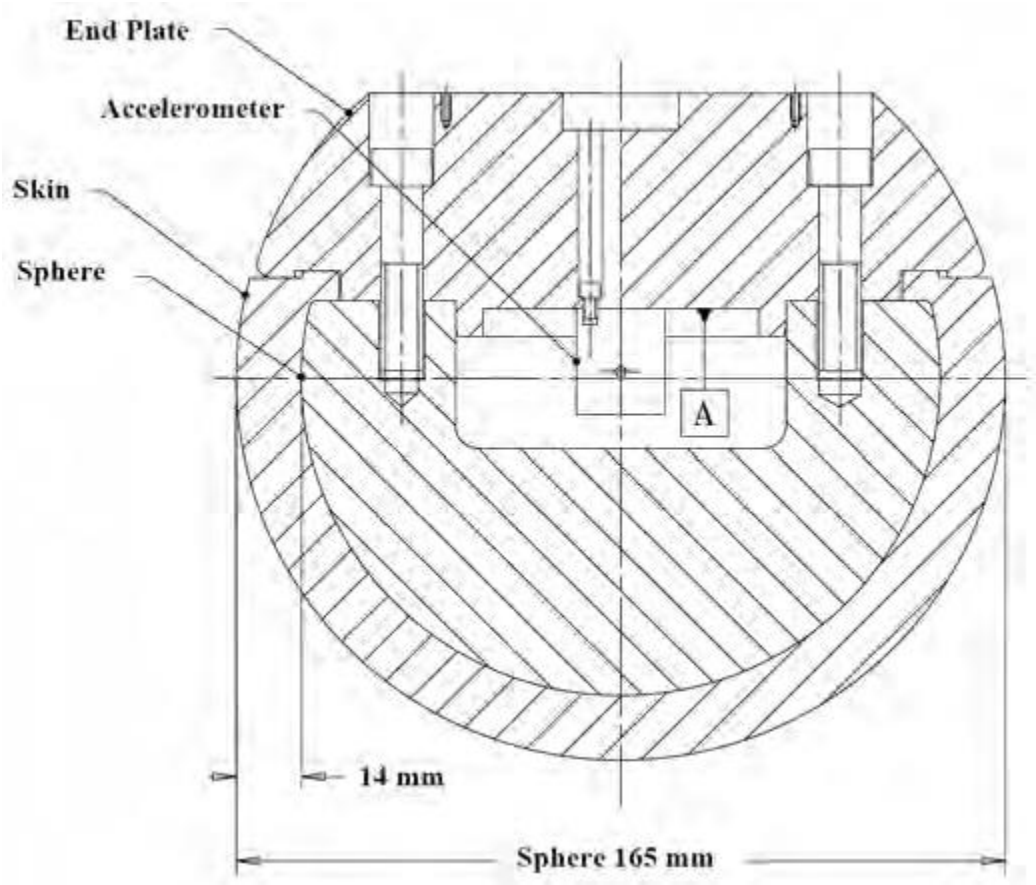


95.6.5.3 Adult headform impactor (see Figure 17)

95.6.5.3.1 The adult headform impactor shall be made of aluminium, be of homogenous construction and be of spherical shape. The overall diameter is 165 +/- 1 mm as shown in Figure 17. The mass shall be 4.5 +/- 0.1 kg. The moment of inertia about an axis through the centre of gravity and perpendicular to the direction of impact shall be within the range of 0.010 to 0.013 kgm^2. The centre of gravity of the headform impactor including instrumentation shall be located in the geometric centre of the sphere with a tolerance of +/-5 mm.

The sphere shall be covered with a 14 +/- 0.5 mm thick synthetic skin, which shall cover at least half of the sphere.

Figure 17: Adult headform impactor



95.6.5.3.2 The first natural frequency of the headform impactor shall be over 5,000 Hz.

95.6.5.4 Adult headform instrumentation

95.6.5.4.1 A recess in the sphere shall allow for mounting one triaxial or three uniaxial accelerometers within +/-10 mm seismic mass location tolerance from the centre of the sphere for the measurement axis, and +/-1 mm seismic mass location tolerance from the centre of the sphere for the perpendicular direction to the measurement axis.

95.6.5.4.2 If three uniaxial accelerometers are used, one of the accelerometers shall have its sensitive axis perpendicular to the mounting face A (see Figure 17) and its seismic mass shall be positioned within a cylindrical tolerance field of 1 mm radius and 20 mm length.

The centre line of the tolerance field shall run perpendicular to the mounting face and its mid-point shall coincide with the centre of the sphere of the headform impactor.

95.6.5.4.3 The remaining accelerometers shall have their sensitive axes perpendicular to each other and parallel to the mounting face A and their seismic mass shall be positioned within a spherical tolerance field of 10 mm radius. The centre of the tolerance field shall coincide with the centre of the sphere of the headform impactor.

95.6.5.4.4 The instrumentation response value CFC, as defined in ISO 6487:2002, shall be 1,000. The CAC response value, as defined in ISO 6487:2002, shall be 500 g for the acceleration.

95.6.5.5 Rear face of the child and adult headform impactors

A rear flat face shall be provided on the outer surface of the headform impactors which is perpendicular to the direction of travel, and typically perpendicular to the axis of one of the accelerometers as well as being a flat plate capable of providing for access to the accelerometers and an attachment point for the propulsion system.

95.7 Test procedures

95.7.1 Lower legform to bumper

95.7.1.1 For each test the impactor (femur, knee joint and tibia) shall be covered by flesh and skin composed of synthetic rubber sheets (R1, R2) and neoprene sheets (N1F, N2F, N1T, N2T, N3) as shown in Figure 18. The size of the sheets shall be within the requirements described in Figure 18. The sheets are required to have compression characteristics as shown in Figure 19. The compression characteristics shall be checked using material from the same batch as the sheets used for the impactor flesh and skin.

95.7.1.2 All impactor components shall be stored for a sufficient period of time in a controlled storage area with a stabilized temperature

of 20 +/- 4 deg. C prior to impactor removal for testing. After removal from the storage the impactor shall not be subjected to conditions other than those pertaining in the test area as defined in paragraph 95.5.1.1.

95.7.1.3 Each test shall be completed within two hours of when the impactor to be used is removed from the controlled storage area.

95.7.1.4 The selected measuring points shall be in the bumper test area as defined in paragraph 95.2.13.

95.7.1.5 A minimum of three lower legform to bumper tests shall be carried out, one each to the middle and the outer thirds of the bumper test area at positions judged to be the most likely to cause injury. Tests shall be to different types of structure, where they vary throughout the area to be assessed. The selected test points shall be a minimum of 84 mm apart as measured horizontally and perpendicular to the longitudinal median plane of the vehicle. The positions tested by the laboratories shall be indicated in the test report.

95.7.1.6 The direction of the impact velocity vector shall be in the horizontal plane and parallel to the longitudinal vertical plane of the vehicle. The tolerance for the direction of the velocity vector in the horizontal plane and in the longitudinal plane shall be +/-2 deg. at the time of first contact. The axis of the impactor shall be perpendicular to the horizontal plane with a tolerance of +/-2 deg. in the lateral and longitudinal plane. The horizontal, longitudinal and lateral planes are orthogonal to each other (see Figure 20).

95.7.1.7 The bottom of the impactor (without parts needed for the purposes of launching and/or protection) shall be at 75 mm above ground reference plane at the time of first contact with the bumper (see Figure 21), with a +/-10 mm tolerance. When setting the height of the propulsion system, an allowance must be made for the influence of gravity during the period of free flight of the impactor.

95.7.1.8 The lower legform impactor for the bumper tests shall be in "free flight" at the moment of impact. The impactor shall be released to free flight at such a distance from the vehicle that the test results are not influenced by contact of the impactor with the propulsion system during rebound of the impactor.

The impactor may be propelled by any means that can be shown to meet the requirements of the test.

95.7.1.9 At the time of first contact the impactor shall have the intended orientation about its vertical axis, for the correct operation of its knee joint, with a yaw angle tolerance of +/ -5 deg. (see Figure 20).

95.7.1.10 For the lower legform testing, a horizontal and vertical impact tolerance of +/- 10 mm shall apply. The test laboratory may verify

at a sufficient number of measuring points that this condition can be met and the tests are thus being conducted with the necessary accuracy.

95.7.1.11 During contact between the impactor and the vehicle, the impactor shall not contact the ground or any object which is not part of the vehicle.

95.7.1.12 The impact velocity of the impactor when striking the bumper shall be 11.1 +/- 0.2 m/s.
The effect of gravity shall be taken into account when the impact velocity is obtained from measurements taken before the time of first contact.

95.7.1.13 The tibia bending moments shall not exceed +/- 15 Nm within an evaluation interval of 30 ms immediately prior to impact.

95.7.1.14 The offset compensation shall be done with the flexible lower legform impactor in resting position prior to the test/acceleration phase.

Figure 18: Flexible lower legform impactor: Flesh and skin dimensions

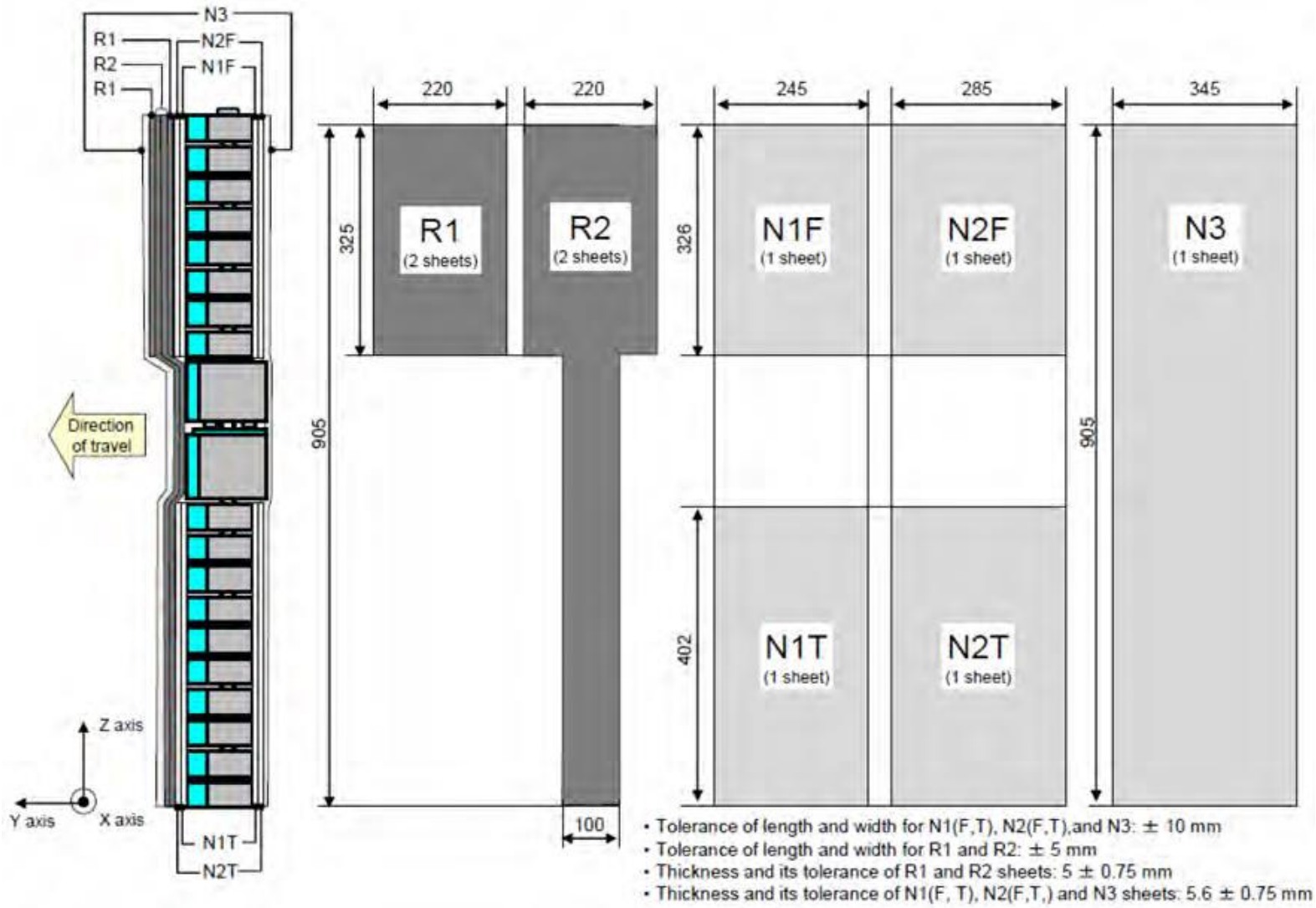
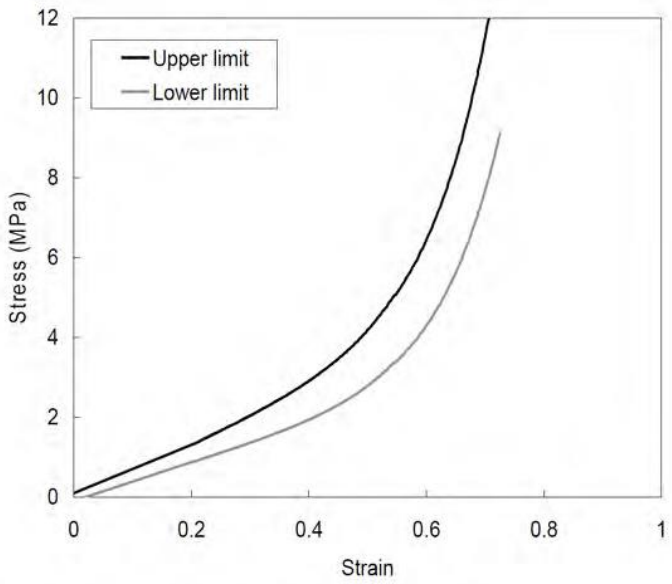


Figure 19: Flexible lower legform impactor: Flesh and skin compression characteristics

(a) Synthetic rubber sheets



(b) Neoprene sheets

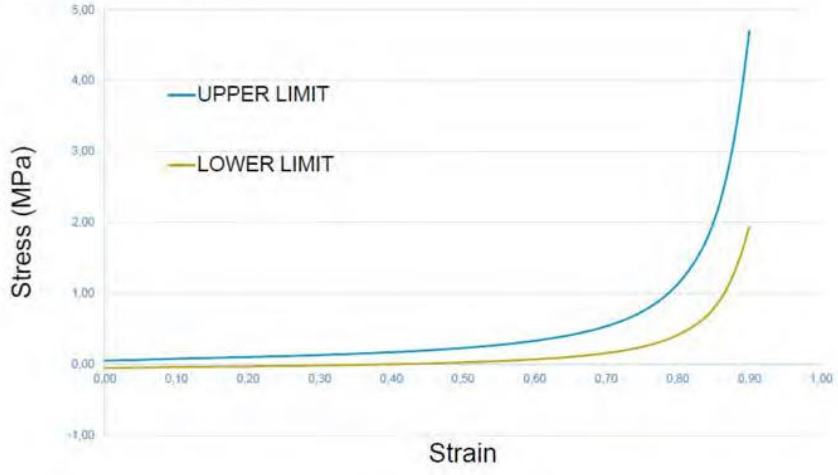


Figure 20: Tolerances of angles for the flexible lower legform impactor at the time of the first impact

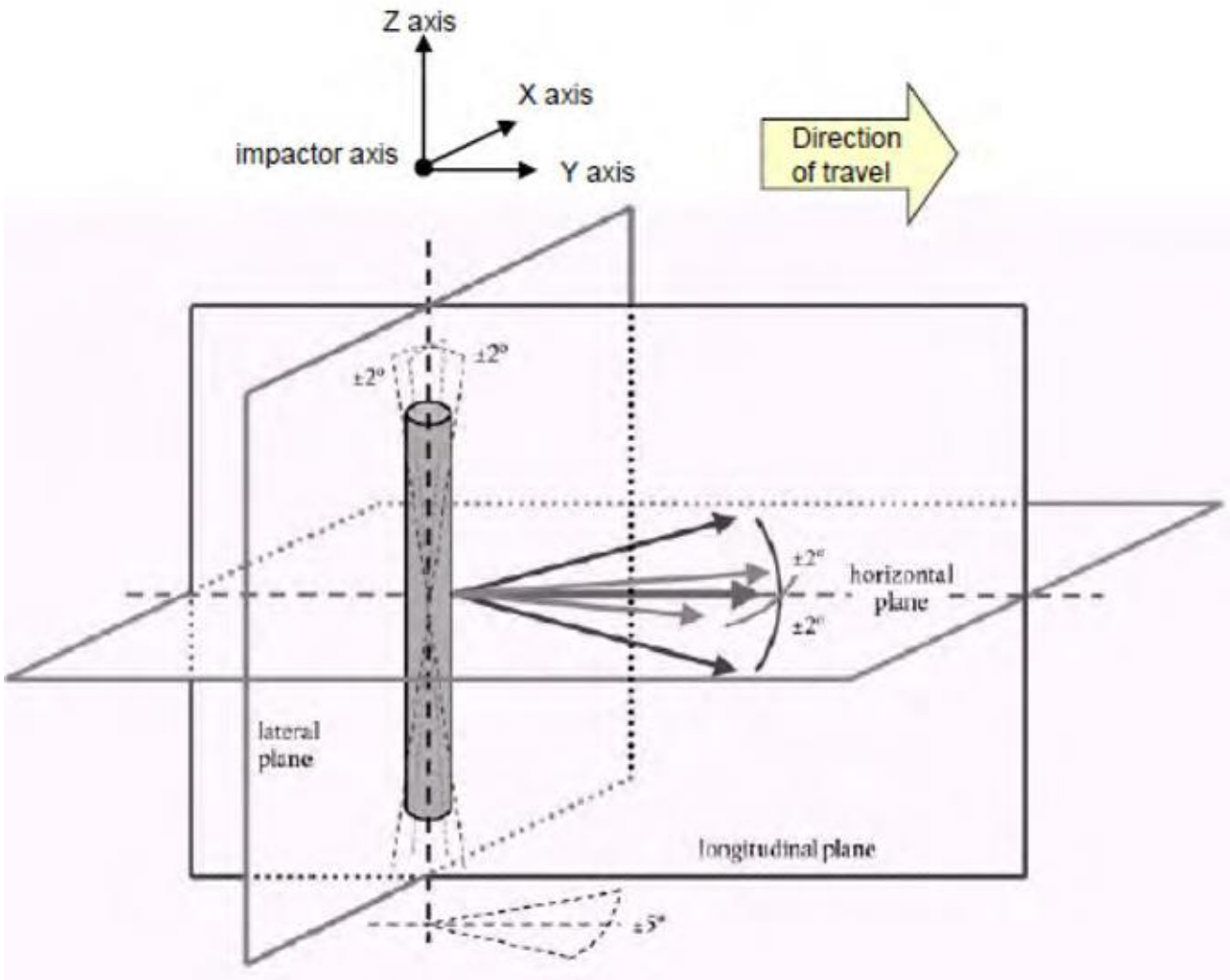
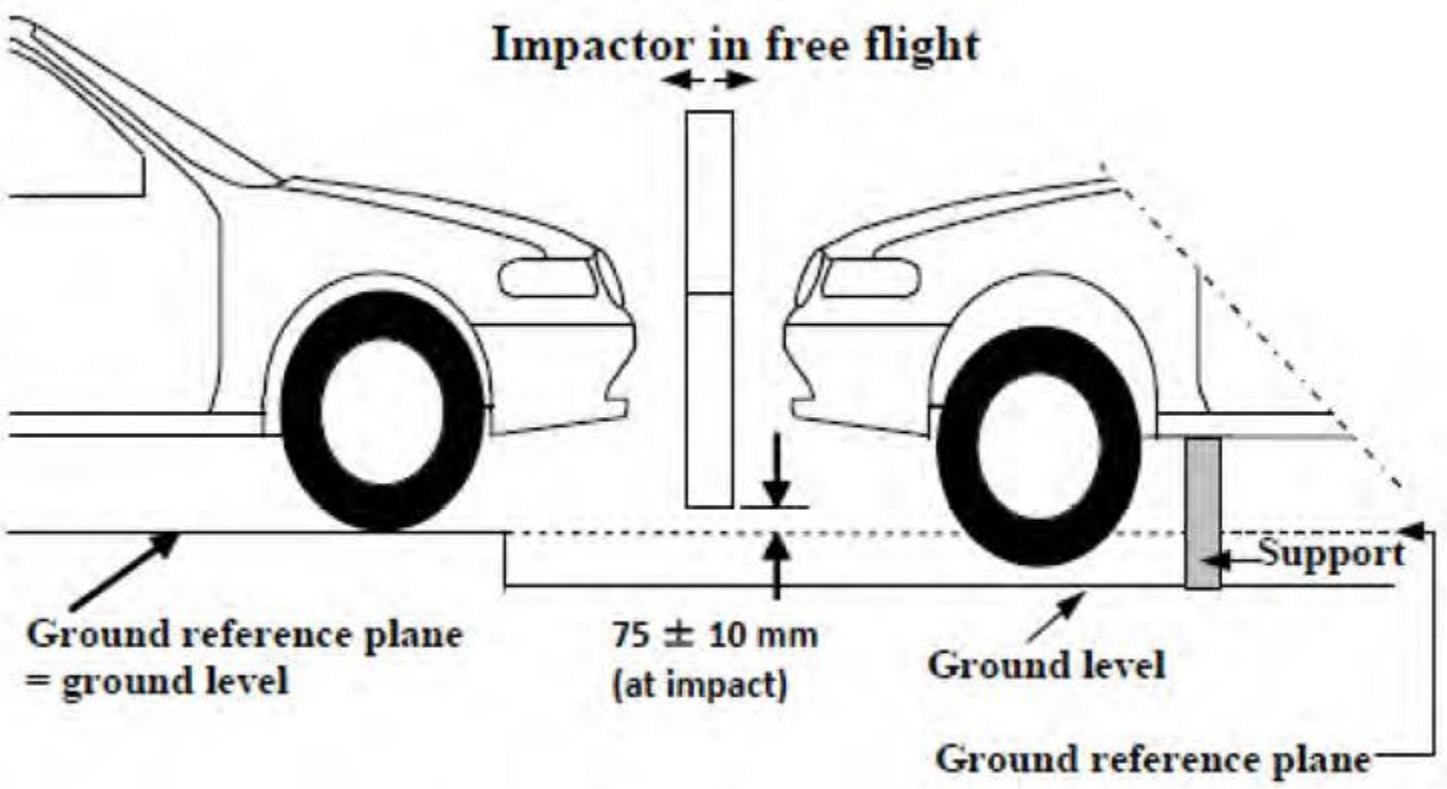


Figure 21: Flexible Lower legform impactor to bumper tests for complete vehicle in normal ride attitude (left) and for cut-body mounted on supports (right)



95.7.2 Upper legform to bumper

95.7.2.1 For each test the foam flesh shall be two new sheets of 25 mm thick foam type CF-45 or equivalent, which shall be cut from the sheet of material used for the dynamic certification test. The skin shall be a 1.5 mm thick fibre reinforced rubber sheet. The mass of the foam and the rubber skin together shall be 0.6 +/- 0.1 kg (this excludes any reinforcement, mountings, etc. which are used to attach the rear edges of the rubber skin to the rear member). The foam and rubber skin shall be folded back

towards the rear, with the rubber skin attached via spacers to the rear member so that the sides of the rubber skin are held parallel. The foam shall be of such a size and shape that an adequate gap is maintained between the foam and components behind the front member, to avoid significant load paths between the foam and these components.

95.7.2.2 The test impactor or at least the foam flesh shall be stored during a period of at least four hours in a controlled storage area with a stabilized humidity of 35 +/- 15 per cent and a stabilized temperature of 20 +/- 4 deg. C prior to impactor removal for test. After removal from the storage the impactor shall not be subjected to conditions other than those pertaining in the test area.

95.7.2.3 Each test shall be completed within two hours of when the impactor to be used is removed from the controlled storage area.

95.7.2.4 The selected measuring points shall be in the bumper test area as defined in paragraph 95.2.13.

95.7.2.5 A minimum of three upper legform to bumper tests shall be carried out, one each to the middle and the outer thirds of the bumper test area at positions judged to be the most likely to cause injury. Tests shall be to different types of structure, where they vary throughout the area to be assessed. The selected measuring points shall be a minimum of 84 mm apart as measured horizontally and perpendicular to the longitudinal median plane of the vehicle. The positions tested by the laboratories shall be indicated in the test report.

95.7.2.6 The direction of impact shall be parallel to the longitudinal axis of the vehicle, with the axis of the upper legform vertical at the time of first contact. The tolerance to this direction is +/-2 deg.

At the time of first contact the impactor centre line shall be vertically midway between the upper bumper reference line and the lower bumper reference line with a +/- 10 mm tolerance and the impactor vertical centre line shall be positioned laterally with the selected impact location with a tolerance of +/- 10 mm. The test laboratory may verify at a sufficient number of measuring points that this condition can be met and the tests are thus being conducted with the necessary accuracy.

95.7.2.7 The impact velocity of the upper legform impactor when striking the bumper shall be 11.1 +/- 0.2 m/s.

95.7.3 Child and adult headform test procedures - Common test specifications

95.7.3.1 Propulsion of the headform impactors

95.7.3.1.1 The headform impactors shall be in "free flight" at the moment of impact, at the required impact velocity (as specified in paragraphs 95.7.4.6. and 95.7.5.6.) and the required direction of impact (as specified in paragraphs 95.7.4.7. and

95.7.5.7.).

95.7.3.1.2 The impactors shall be released to "free flight" at such a distance from the vehicle that the test results are not influenced by contact of the impactor with the propulsion system during rebound of the impactor.

95.7.3.2 Measurement of impact velocity

95.7.3.2.1 The velocity of the headform impactor shall be measured at some point during the free flight before impact, in accordance with the method specified in ISO 3784:1976. The accuracy of velocity measurement shall be +/-0.01 m/sec. The measured velocity shall be adjusted considering all factors which may affect the impactor between the point of measurement and the point of impact, in order to determine the velocity of the impactor at the time of impact. The angle of the velocity vector at the time of impact shall be calculated or measured.

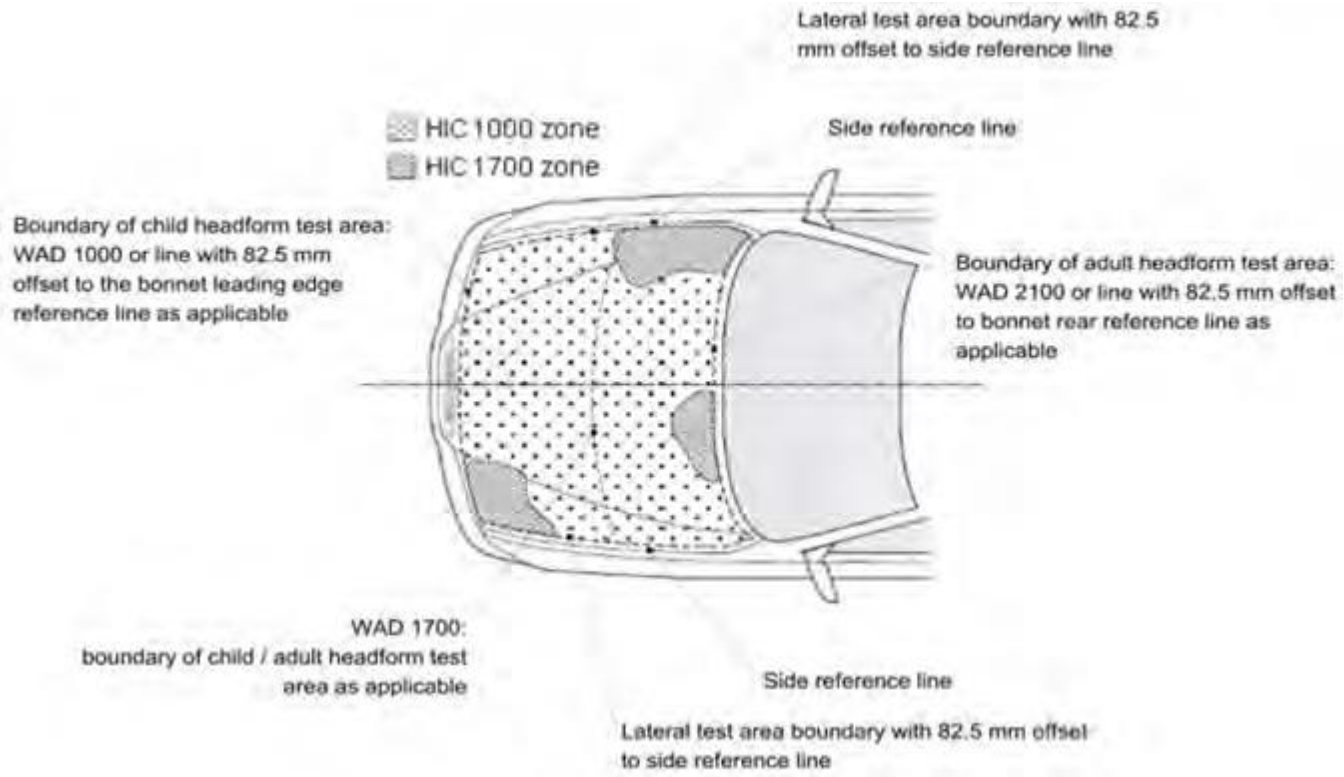
95.7.3.3 Recording

95.7.3.3.1 The acceleration time histories shall be recorded, and HIC shall be calculated. The measuring point on the front structure of the vehicle shall be recorded. Recording of test results shall be in accordance with ISO 6487:2002.

95.7.3.4 Splitting of headform test zones

95.7.3.4.1 The manufacturer shall identify the zones of the bonnet top test area where the HIC must not exceed 1,000 (HIC1000 zone) or 1,700 (HIC1700 zone) (see Figure 22).

Figure 22: Example of marking of HIC1000 zone and HIC1700 zone



95.7.3.4.2 Marking of the "bonnet top test area" as well as "HIC1000 zone" and "HIC1700 zone" will be based on a drawing supplied by the manufacturer, when viewed from a horizontal plane above the vehicle that is parallel to the vehicle horizontal zero plane. A sufficient number of x and y co-ordinates shall be supplied by the manufacturer to mark up the areas on the actual vehicle while considering the vehicle outer contour in the z direction.

95.7.3.4.3 The areas of "HIC1000 zone" and "HIC1700 zone" may consist of several parts, with the number of these parts not being limited. The determination of the impacted zone is done by the measuring point.

95.7.3.4.4 The calculation of the surface of the bonnet top test area as well as the surface areas of "HIC1000 zone" and "HIC1700

zone" shall be done on the basis of a projected bonnet when viewed from a horizontal plane parallel to the horizontal zero plane above the vehicle, on the basis of the drawing data supplied by the manufacturer.

95.7.3.4.5 Impact test points - Particular specifications

Notwithstanding the provisions of paragraphs 95.7.4.2. and 95.7.5.2. below, if a number of measuring points have been selected in order of potential to cause injury and the test area remaining is too small to select another measuring point while maintaining the minimum spacing between points, then less than nine tests for each impactor may be performed. The positions tested by the laboratories shall be indicated in the test report. However, the technical services conducting the tests shall perform as many tests as necessary to guarantee the compliance of the vehicle with the head injury criteria (HIC) limit values of 1000 for the HIC1000 zone and 1700 for the HIC1700 zone, especially in the points near to the borders between the two types of zones.

95.7.4 Child headform - Specific test procedure

95.7.4.1 Tests shall be made to the front structure within the boundaries as defined in paragraph 95.2.15. For tests on the rear area of the bonnet top, the headform impactor shall not contact the windscreen or A-pillar before impacting the bonnet top.

95.7.4.2 A minimum of nine tests shall be carried out with the child headform impactor, three tests each to the middle and the outer thirds of the child/small adult bonnet top test areas, at positions judged to be the most likely to cause injury.

Tests shall be to different types of structure, where these vary throughout the area to be assessed and at positions judged to be the most likely to cause injury.

95.7.4.3 The selected measuring points for the child/small adult headform impactor shall be a minimum of 165 mm apart and within the child headform test area as defined in paragraph 95.2.15.

These minimum distances are to be set with a flexible tape held tautly along the outer surface of the vehicle.

95.7.4.4 No measuring point shall be located so that the impactor will impact the test area with a glancing blow resulting in a more severe second impact outside the test area.

95.7.4.5 For the child headform testing, a longitudinal and transversal impact tolerance of +/- 10 mm shall apply. This tolerance is measured along the surface of the bonnet. The test laboratory may verify at a sufficient number of measuring points that this condition can be met and the tests are thus being conducted with the necessary accuracy.

95.7.4.6 The headform velocity at the time of impact shall be 9.7 +/- 0.2 m/s.

95.7.4.7 The direction of impact shall be in the longitudinal vertical plane of the vehicle to be tested at an angle of 50 +/- 2 deg. to the horizontal. The direction of impact of tests to the front structure shall be downward and rearward.

95.7.5 Adult headform specific test procedure

95.7.5.1 Tests shall be made to the front structure within the boundaries as defined in paragraph 95.2.1. For tests at the rear of the bonnet top, the headform impactor shall not contact the windscreen or A-pillar before impacting the bonnet top.

95.7.5.2 A minimum of nine tests shall be carried out with the adult headform impactor, three tests each to the middle and the outer thirds of the adult bonnet top test areas, at positions judged to be the most likely to cause injury.

Tests shall be to different types of structure, where these vary throughout the area to be assessed and at positions judged to be the most likely to cause injury.

95.7.5.3 The selected measuring points on the bonnet for the adult headform impactor shall be a minimum of 165 mm apart and within the adult headform test area as defined in paragraph 95.2.1.

These minimum distances are to be set with a flexible tape held tautly along the outer surface of the vehicle.

95.7.5.4 No measuring point shall be located so that the impactor will impact the test area with a glancing blow resulting in a more severe second impact outside the test area.

95.7.5.5 For the adult headform testing, a longitudinal and transversal impact tolerance of +/- 10 mm shall apply. This tolerance is measured along the surface of the bonnet. The test laboratory may verify at a sufficient number of measuring points that this condition can be met and the tests are thus being conducted with the necessary accuracy.

95.7.5.6 The headform velocity at the time of impact shall be 9.7 +/- 0.2 m/s.

95.7.5.7 The direction of impact shall be in the longitudinal vertical plane of the vehicle to be tested at an angle of 65 +/- 2 deg. to the horizontal. The direction of impact of tests to the front structure shall be downward and rearward.

95.8 Certification of the impactor

95.8.1 Flexible lower legform impactor certification

95.8.1.1 The impactor shall be certified using two certification tests as follows: First, the certification shall be conducted according to the inverse certification (IC) test procedure prescribed in paragraph 95.8.1.4. before starting a vehicle test series. Second, after a

maximum of 10 vehicle tests, certification should be conducted according to the pendulum certification (PC) test procedure prescribed in paragraph 95.8.1.3.. Ongoing certification testing then shall constitute the sequence IC - PC - PC - IC - PC - PC - etc. with a maximum of 10 tests between each certification.

In addition, the impactor shall be certified according to the procedures prescribed in paragraph 95.8.1.2. below at least once a year.

95.8.1.2 Static certification tests

95.8.1.2.1 The femur and the tibia of the flexible lower legform impactor shall meet the requirements specified in paragraph 95.8.1.2.2. when tested according to paragraph 95.8.1.2.4.. The knee joint of the lower legform impactor shall meet the requirements specified in paragraph 95.8.1.2.3. when tested according to paragraph 95.8.1.2.5.. The stabilized temperature of the impactor during the certification tests shall be 20 +/- 2 deg. C.

The CAC response values, as defined in ISO 6487:2002, shall be 30 mm for the knee ligament elongations and 4 kN for the applied external load. For these tests, low-pass filtering at an appropriate frequency is permitted to remove higher frequency noise without significantly affecting the measurement of the response of the impactor.

95.8.1.2.2 When the femur and the tibia of the impactor are loaded in bending in accordance with paragraph 95.8.1.2.4., the applied moment and the generated deflection at the centre of the femur and the tibia (Mc and Dc) shall be within the corridors shown in Figure 23.

95.8.1.2.3 When the knee joint of the impactor is loaded in bending in accordance with paragraph 95.8.1.2.5, the MCL, ACL, and PCL elongations and applied bending moment or the force at the centre of the knee joint (Mc or Fc) shall be within the corridors shown in Figure 24.

95.8.1.2.4 The edges of the femur and tibia, not bending parts, shall be mounted to the support rig firmly as shown in Figure 25 and Figure 26. The Y-axis of the impactor shall be parallel to the loading axis within 180 +/- 2 deg. tolerance. To obtain repeatable loading, low friction Polytetrafluoroethylene (PTFE) plastic pads are used under each support (see Figure 25 and Figure 26).

The centre of the loading force shall be applied at the centre of the femur and the tibia within +/-2 mm tolerance along the Z-axis. The force shall be increased so as to maintain a deflection rate between 10 and 100 mm/minute until the

bending moment at the centre part (Mc) of the femur or tibia reaches 380 Nm.

95.8.1.2.5 The ends of the knee joint shall be mounted to the support rig firmly as shown in Figure 27. The Y-axis of the impactor shall be parallel to the loading axis within +/- 2 deg. tolerance. To obtain repeatable loading, low friction Polytetrafluoroethylene (PTFE) plastic pads are used under each support (see Figure 27). To avoid impactor damage, a neoprene sheet shall be set underneath the loading ram and the impactor face of the knee joint which is described in the Figure 13 (b) shall be removed. The neoprene sheet used in this test shall have compression characteristics as shown in Figure 19 (b).

The centre of the loading force shall be applied at the knee joint center within +/- 2mm tolerance along the Z-axis (see Figure 27). The external load shall be increased so as to maintain a deflection rate between 10 and 100 mm/minute until the bending moment at the centre part of the knee joint (Mc) reaches 400 Nm.

95.8.1.3 Dynamic certification tests (pendulum test)

95.8.1.3.1 Certification

95.8.1.3.1.1 The test facility used for the certification test shall have a stabilized temperature of 20 +/- 2 deg. C during the test.

95.8.1.3.1.2 The temperature of the certification area shall be measured at the time of certification and recorded in a certification report.

95.8.1.3.2 Requirements

95.8.1.3.2.1 When the flexible lower legform impactor is used for a test according to paragraph 95.8.1.3.3, the absolute value of the maximum bending moment of the tibia at:

(a) Tibia-1 shall be 235 Nm≦272 Nm;

(b) Tibia-2 shall be 187 Nm≦219 Nm;

(c) Tibia-3 shall be 139 Nm≦166 Nm;

(d) Tibia-4 shall be 90 Nm≦111 Nm.

The absolute value of the maximum elongation of:

(a) MCL shall be 20.5≦24.0 mm;

(b) ACL shall be 8.0 mm≦10.5 mm;

(c) PCL shall be 3.5 mm≦5.0 mm.

For all these values for the maximum bending moment and the maximum elongation, the readings used shall be from the initial impact timing to 200 ms after the impact timing.

95.8.1.3.2.2 The instrumentation response value CFC, as defined in ISO 6487:2002, shall be 180 for all transducers. The CAC response values, as defined in ISO 6487:2002, shall be 30 mm for the knee ligament elongations and 400 Nm for the tibia bending moments.

95.8.1.3.3 Test procedure

95.8.1.3.3.1 The flexible lower legform impactor, including the flesh and skin, shall be suspended from the dynamic certification test rig 15 +/- 1 deg. upward from the horizontal as shown in Figure 28. The impactor shall be released from the suspended position and fall freely against the pin joint of the test rig as shown in Figure 28.

95.8.1.3.3.2 The knee joint centre of the impactor shall be 30 +/- 1 mm below the bottom line of the stopper bar, and the tibia impact face without the flesh and skin shall be located 13 +/- 2 mm from the front upper edge of the stopper bar when the impactor is hanging freely as shown in Figure 28.

95.8.1.4 Dynamic certification tests (inverse test)

95.8.1.4.1 Certification

95.8.1.4.1.1 The test facility used for the certification test shall have a stabilized temperature of 20 +/- 2 deg. C during the test.

95.8.1.4.1.2 The temperature of the certification area shall be measured at the time of certification and recorded in a certification report.

95.8.1.4.2 Requirements

95.8.1.4.2.1 When the flexible lower legform impactor is used for the test according to paragraph 95.8.1.4.3 of this annex, the absolute value of the maximum bending moment of the tibia:

(a) Tibia-1 shall be 230 Nm ≦ 272 Nm;

(b) Tibia-2 shall be 210 Nm ≦ 252 Nm;

(c) Tibia-3 shall be 166 Nm $\leqq$ 192 Nm;

(d) Tibia-4 shall be 93 Nm $\leqq$ 108 Nm.

The absolute value of the maximum elongation of:

(a) MCL shall be 17.0 $\leqq$ 21.0 mm;

(b) ACL shall be 8.0 mm $\leqq$ 10.0 mm;

(c) PCL shall be 4.0 mm $\leqq$ 6.0 mm.

For all these values for the maximum bending moment and the maximum elongation, the readings used shall be from the initial impact timing to 50 ms after the impact timing.

95.8.1.4.2.2 The instrumentation response value CFC, as defined in ISO 6487:2002, shall be 180 for all transducers. The CAC response values, as defined in ISO 6487:2002, shall be 30 mm for the knee ligament elongations and 400 Nm for the tibia bending moments.

95.8.1.4.3 Test procedure

95.8.1.4.3.1 The assembled flexible lower legform impactor (with the flesh and skin) shall be hung vertically and freely suspended from a test rig as shown in Figure 29. It is then impacted by the upper edge of a linearly guided aluminium honeycomb impactor, covered by a thin paper cloth with a maximum thickness of 1 mm, at an impact speed of 11.1 +/- 0.2 m/s. The legform shall achieve a free flight condition within 10 ms after the time of first contact of the honeycomb impactor.

95.8.1.4.3.2 The honeycomb of 5052 alloy, which is attached in front of the moving ram, shall be 200 +/- 5 mm wide, 160 +/- 5 mm high and 60 +/- 2 mm deep and shall have a crush strength of 75 pound per square inch (psi) +/-10 per cent. The honeycomb should have cell sizes of either 3/16 inch or 1/4 inch and a density of 2.0 pound per cubic foot (pcf) for the 3/16 inch cell size or a density of 2.3 pcf for the 1/4 inch cell size.

95.8.1.4.3.3 The upper edge of the honeycomb face shall be in line with the rigid plate of the linearly guided impactor. At the time of first contact, the upper edge of the honeycomb shall be in line with the knee joint centre line within a vertical tolerance of +/-2 mm.

The honeycomb shall not be deformed before the impact test.

95.8.1.4.3.4 At the time of the first contact, the flexible lower legform impactor pitch angle (rotation around the Y-axis) and therefore the pitch angle of the velocity vector of the honeycomb impactor shall be within a tolerance of +/-2 deg. in relation to the lateral vertical plane. The flexible lower legform impactor roll angle (rotation around the X-axis) and therefore the roll angle of the honeycomb impactor shall be within a tolerance of +/-2 deg. in relation to the longitudinal vertical plane. The flexible lower legform impactor yaw angle (rotation around the Z-axis) and therefore the yaw angle of the velocity vector of the honeycomb impactor shall be within a tolerance of +/-2 deg.

95.8.2 Upper legform impactor certification

95.8.2.1 The certified impactor may be used for a maximum of 20 impacts before re-certification (this limit does not apply to propulsion or guidance components). The impactor shall also be re-certified if more than one year has elapsed since the previous certification or if any impactor transducer output, in any impact, has exceeded the specified CAC.

95.8.2.2 Certification

95.8.2.2.1 The foam flesh for the test impactor shall be stored for a period of at least four hours in a controlled storage area with a stabilized humidity of 35 +/- 10 per cent and a stabilized temperature of 20 +/- 2 deg. C prior to impactor removal for certification. The test impactor itself shall have a temperature of 20 +/- 2 deg. C at the time of impact. The temperature tolerances for the test impactor shall apply at a relative humidity of 40 +/- 30 per cent after a soak period of at least four hours prior to their application in a test.

95.8.2.2.2 The test facility used for the certification test shall have a stabilized humidity of 40 +/- 30 per cent and a stabilized temperature of 20 +/- 4 deg. C during certification.

95.8.2.2.3 Each certification shall be completed within two hours of when the impactor to be calibrated is removed from the controlled storage area.

95.8.2.2.4 The relative humidity and temperature of the certification area shall be measured at the time of certification, and recorded in the certification report.

95.8.2.3 Requirements

95.8.2.3.1 When the impactor is propelled into a stationary cylindrical pendulum the peak force measured in each load transducer shall be not less than 1.20 kN and not more than 1.55 kN and the difference between the peak forces measured in the

top and bottom load transducers shall not be more than 0.10 kN. Also, the peak bending moment measured by the strain gauges shall not be less than 190 Nm and not more than 250 Nm on the centre position and not less than 160 Nm and not more than 220 Nm for the outer positions. The difference between the upper and lower peak bending moments shall not be more than 20 Nm.

For all these values, the readings used shall be from the initial impact with the pendulum and not from the arresting phase. Any system used to arrest the impactor or pendulum shall be so arranged that the arresting phase does not overlap in time with the initial impact. The arresting system shall not cause the transducer outputs to exceed the specified CAC.

95.8.2.3.2 The instrumentation response value CFC, as defined in ISO 6487:2002, shall be 180 for all transducers. The CAC response values, as defined in ISO 6487:2002, shall be 10 kN for the force transducers and 1,000 Nm for the bending moment measurements.

95.8.2.4 Test procedure

95.8.2.4.1 The impactor shall be mounted to the propulsion and guidance system, by a torque limiting joint. The torque limiting joint shall be set so that the longitudinal axis of the front member is perpendicular to the axis of the guidance system, with a tolerance of +/ -2 deg., with the joint friction torque set to 675 +/- 25 Nm. The guidance system shall be fitted with low friction guides that allow the impactor to move only in the specified direction of impact, when in contact with the pendulum.

95.8.2.4.2 The impactor mass shall be adjusted to give a mass of 12 +/- 0.1 kg, this mass includes those propulsion and guidance components which are effectively part of the impactor during impact.

95.8.2.4.3 The centre of gravity of those parts of the impactor which are effectively forward of the torque limiting joint, including the extra masses fitted, shall lie on the longitudinal centreline of the impactor, with a tolerance of +/-10 mm.

95.8.2.4.4 The impactor shall be certified with previously unused foam.

95.8.2.4.5 The impactor foam shall not be excessively handled or deformed before, during or after fitting.

95.8.2.4.6 The impactor with the front member vertical shall be propelled horizontally at a velocity of 7.1 +/- 0.1 m/s into the stationary pendulum as shown in Figure 30.

95.8.2.4.7 The pendulum tube shall have a mass of 3 +/- 0.03 kg, a wall thickness of 3 +/- 0.15 mm and an outside diameter of 150

mm +1 mm/-4 mm. Total pendulum tube length shall be 275 +/- 25 mm. The pendulum tube shall be made from cold finished seamless steel (metal surface plating is permissible for protection from corrosion), with an outer surface finish of better than 2.0 micrometer. It shall be suspended on two wire ropes of 1.5 +/- 0.2 mm diameter and of 2.0 m minimum length. The surface of the pendulum shall be clean and dry. The pendulum tube shall be positioned so that the longitudinal axis of the cylinder is perpendicular to the front member (i.e. level), with a tolerance of +/-2 deg., and to the direction of impactor motion, with a tolerance of +/-2 deg., and with the centre of the pendulum tube aligned with the centre of the impactor front member, with tolerances of +/-5 mm laterally and +/-5 mm vertically.

95.8.3 Child and adult headform

95.8.3.1 The certified impactors may be used for a maximum of 20 impacts before recertification. The impactors shall be re-certified if more than one year has elapsed since the previous certification or if the transducer output, in any impact, has exceeded the specified CAC.

95.8.3.2 Drop test

95.8.3.2.1 When the headform impactors are dropped from a height of 376 +/- 1 mm in accordance with paragraph 95.8.3.3. below, the peak resultant acceleration measured by one triaxial (or three uniaxial) accelerometer (accelerometers) in the headform impactor shall be:

(a) For the child headform impactor not less than 245 g and not more than 300 g;

(b) For the adult headform impactor not less than 225 g and not more than 275 g.

The acceleration time curve shall be uni-modal.

95.8.3.2.2 The instrumentation response values CFC and CAC for each accelerometer shall be 1,000 Hz and 500 g respectively as defined in ISO 6487:2002.

95.8.3.2.3 The headform impactors shall have a temperature of 20 +/- 2 deg. C at the time of impact. The temperature tolerances shall apply at a relative humidity of 40 +/- 30 per cent after a soak period of at least four hours prior to their application in a test.

95.8.3.3 Test procedure

95.8.3.3.1 The headform impactor shall be suspended from a drop rig as shown in Figure 31.

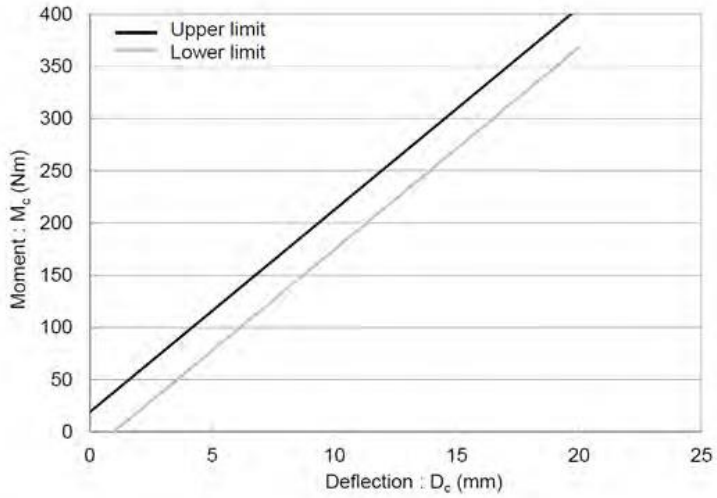
95.8.3.3.2 The headform impactor shall be dropped from the specified height by means that ensure instant release onto a rigidly supported flat horizontal steel plate, over 50 mm thick and over 300 x 300 mm square which has a clean dry surface and a surface finish of between 0.2 and 2.0 micrometers.

95.8.3.3.3 The headform impactor shall be dropped with the rear face of the impactor at the test angle specified in paragraph 95.7.4.7. for the child headform impactor and in paragraph 95.7.5.7. for the adult headform impactor with respect to the vertical as shown in Figure 31. The suspension of the headform impactor shall be such that it does not rotate during the fall.

95.8.3.3.4 The drop test shall be performed three times, with the headform impactor rotated 120 deg. around its symmetrical axis after each test.

Figure 23: Flexible lower legform impactor: Requirement corridors of the femur and the tibia in the static certification test (see paragraph 95.8.1.2.2.)

(a) Femur bending corridor



(b) Tibia bending corridor

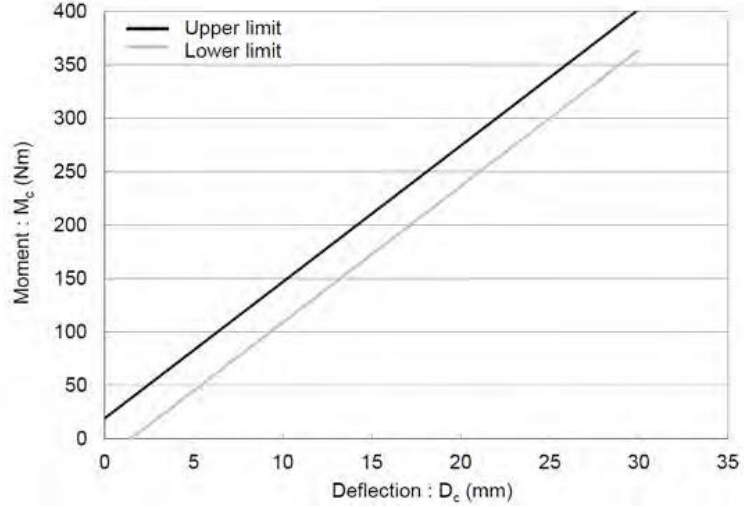
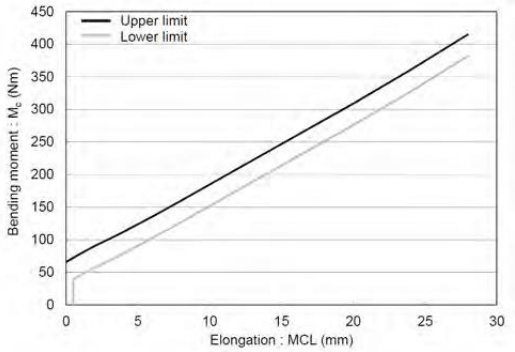
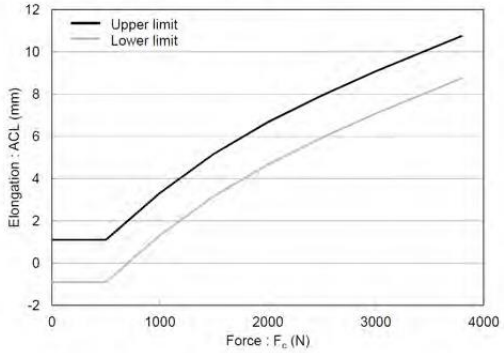


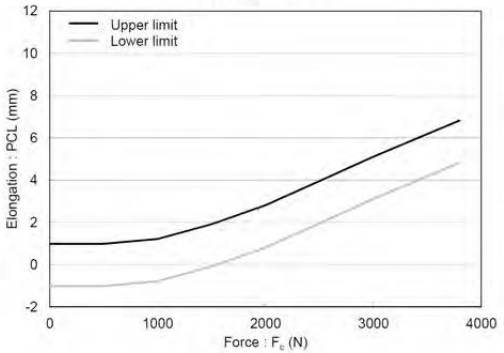
Figure 24: Flexible lower legform impactor: Requirement corridors for the knee joint in the static certification test (see paragraph 95.8.1.2.3.)



(a) for MCL



(b) for ACL



(c) for PCL

Figure 25: Flexible lower legform: Impactor test set-up for the femur in the static certification test (see paragraph 95.8.1.2.4.)

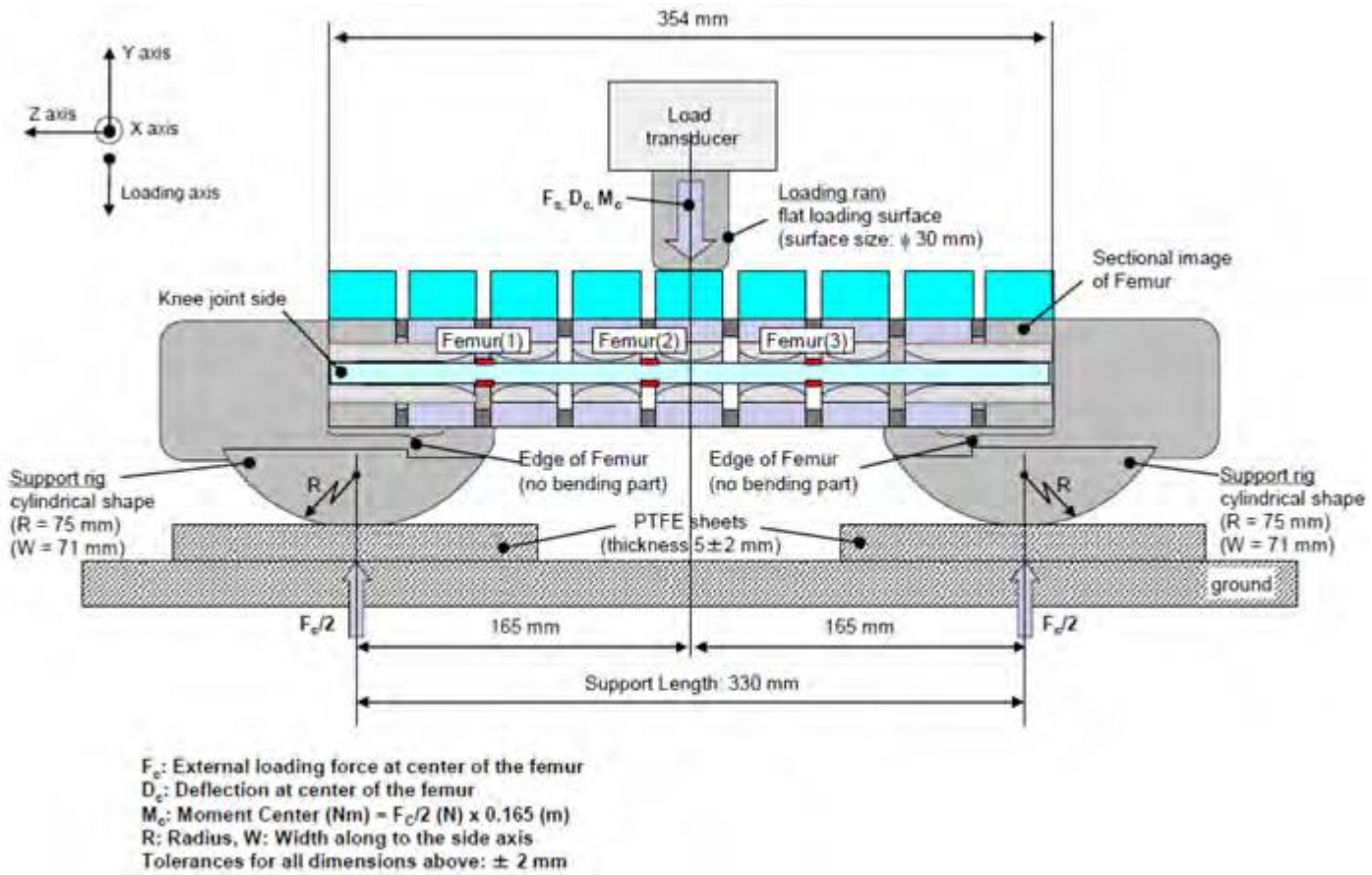


Figure 26: Flexible lower legform impactor: Test set-up for the tibia in the static certification test (see paragraph 95.8.1.2.4.)

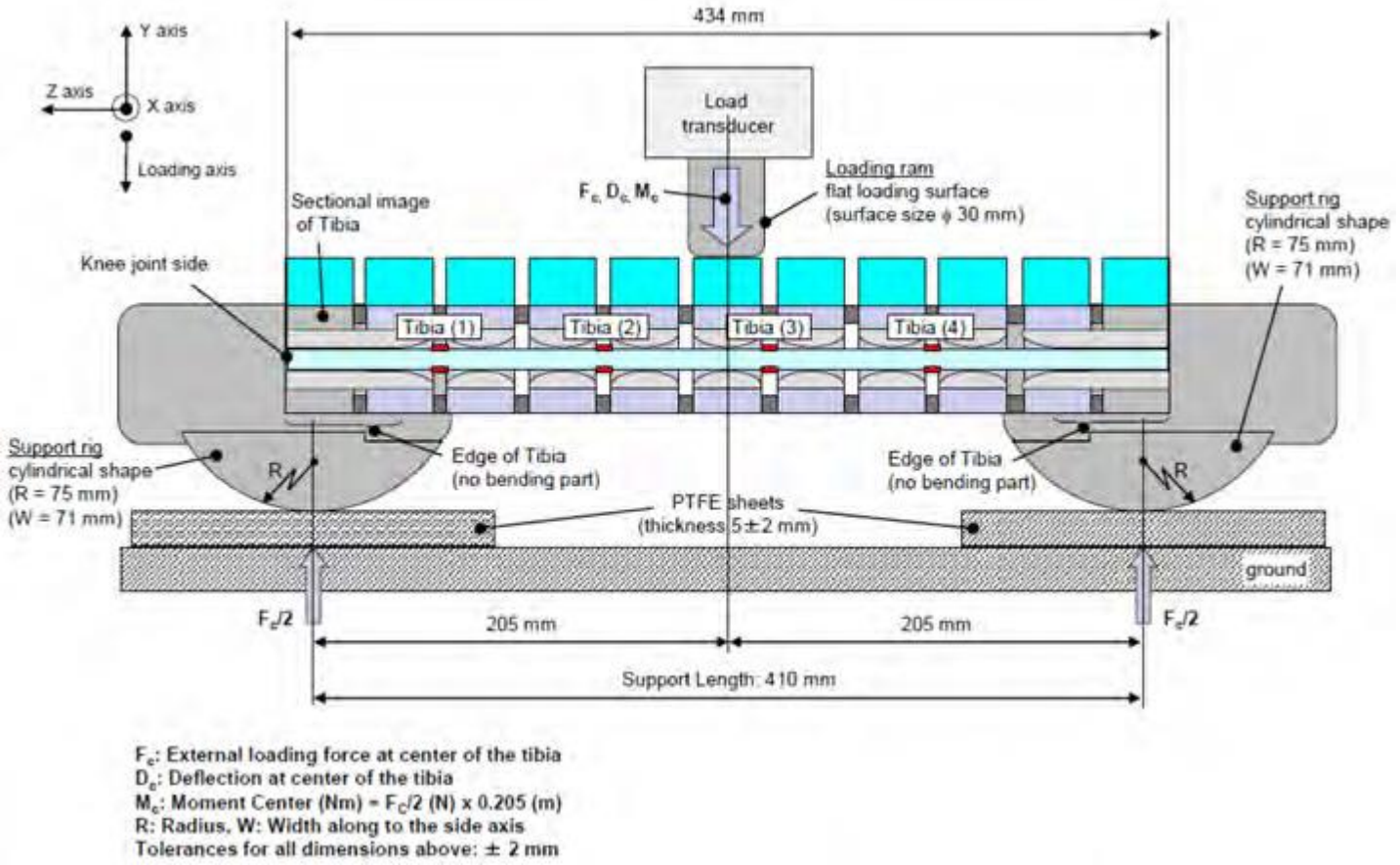


Figure 27: Flexible lower legform impactor: Test set-up for the knee joint in the static certification test (see paragraph 95.8.1.2.5.)

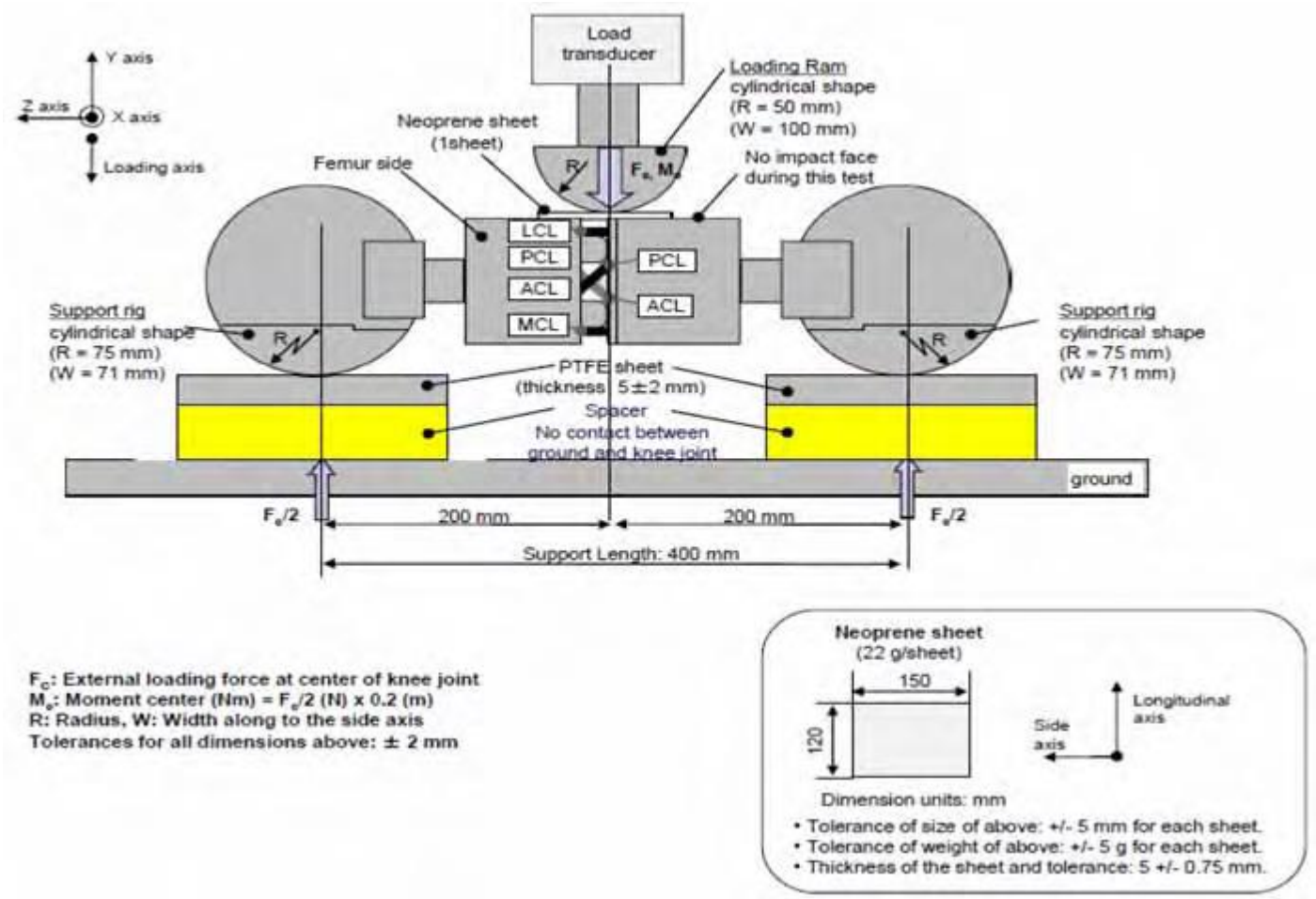


Figure 28: Flexible lower legform impactor: Test set-up for the dynamic lower legform impactor certification test (pendulum test, see paragraph 95.8.1.3.3.1.)

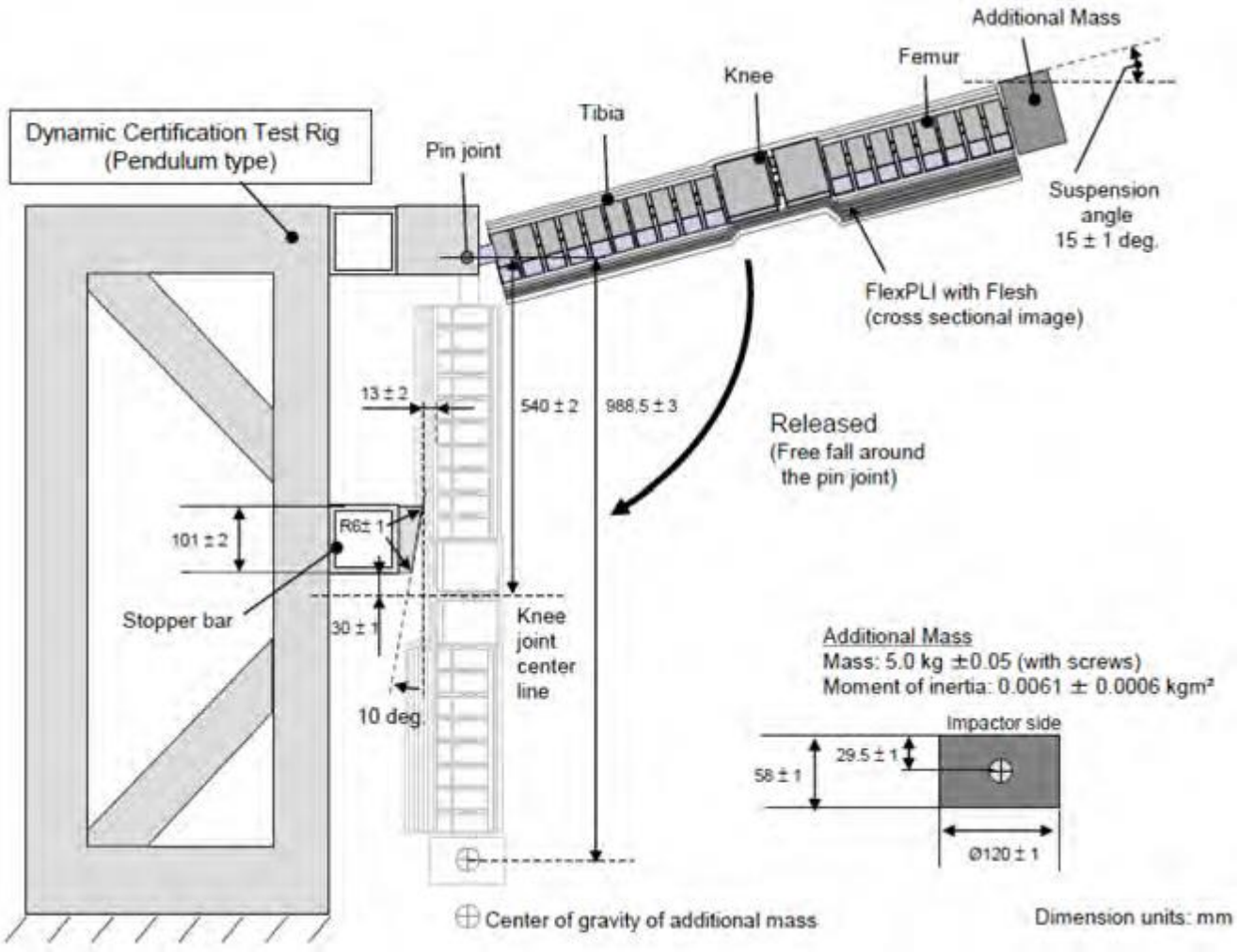


Figure 29: Flexible lower legform impactor: Test set-up for the dynamic lower legform impactor certification test (inverse test, see paragraph 95.8.1.4.3.1)

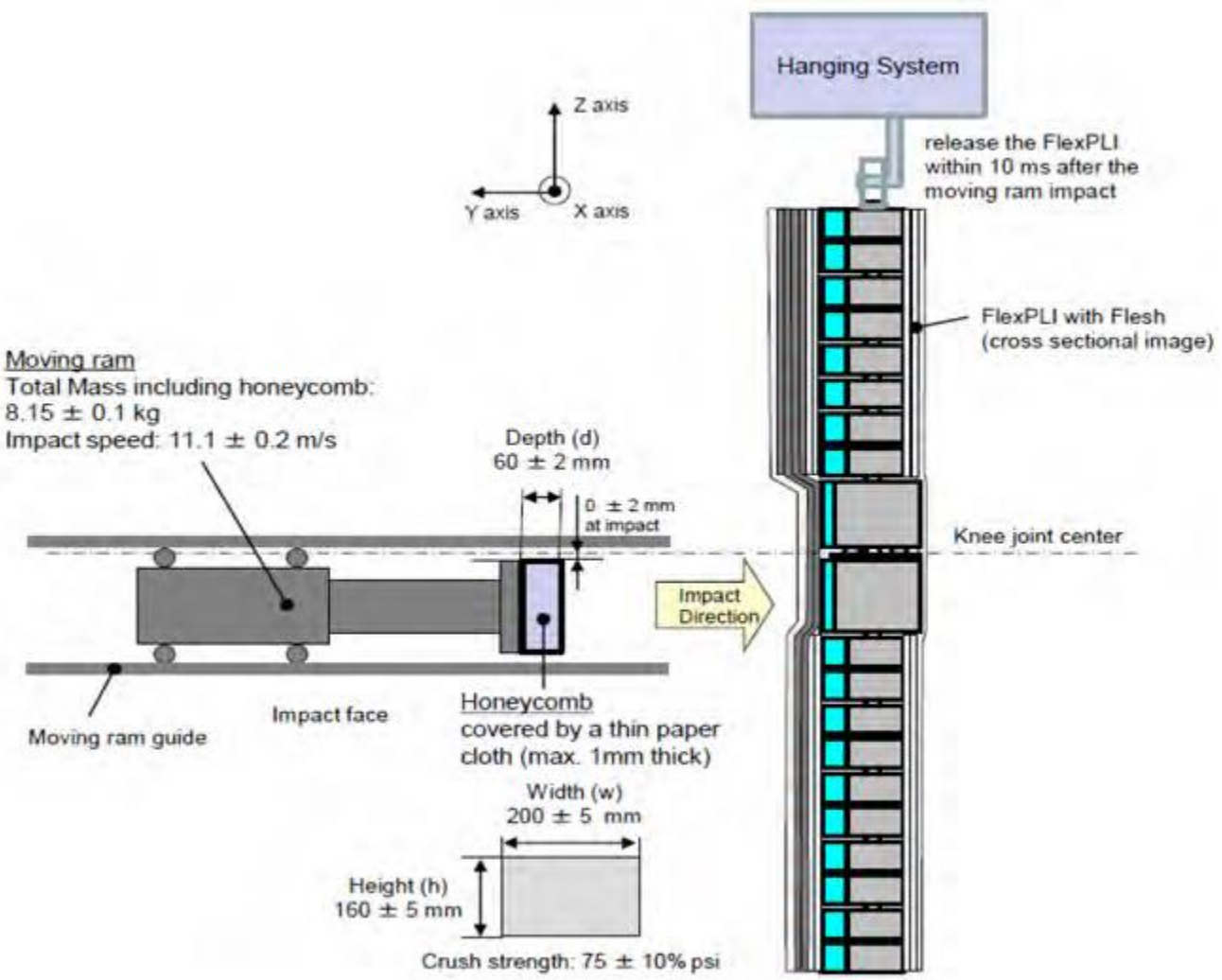


Figure 30: Test set-up for dynamic upper legform impactor certification test

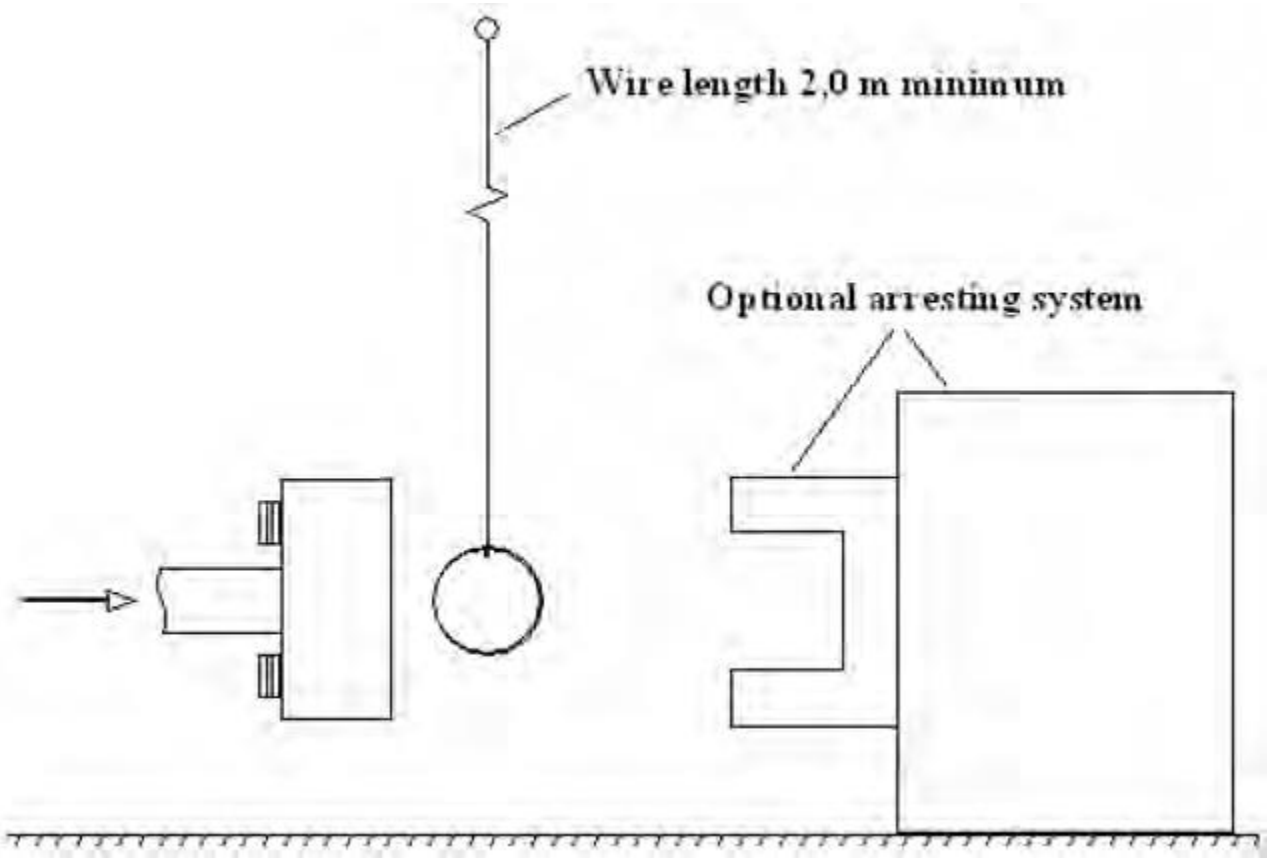
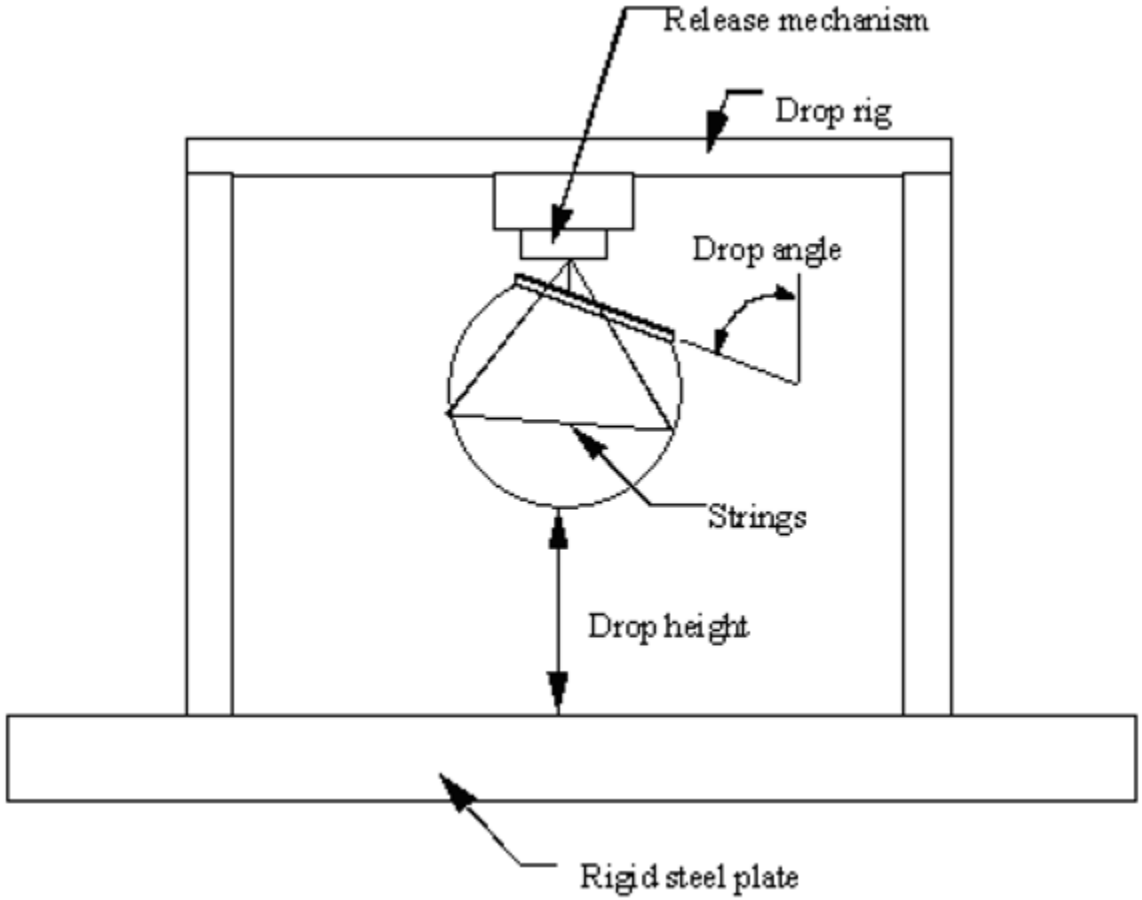


Figure 31: Test set-up for dynamic headform impactor biofidelity test


Release mechanism
Drop rig
Drop angle
Strings
Drop height
Rigid steel plate