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World Forum for Harmonization of Vehicle Regulations (WP.29)

Working Party on Passive Safety (GRSP)
(XXX session, XXX 200X,agenda item XXX)

PROPOSAL FOR A NEW DRAFT GLOBAL TECHNICAL REGULATION
ON PEDESRIAN SAFETY

Transmitted by the expert from JAPAN

Draft global technical regulation for Pedestrian Safety

A. Statement of Technical Rationale and Justification

1 OBJECTIVE OF GTR

1.1. Proposal to develop a GLOBAL TECHNICAL REGULATION

2. EXISTING OR FUTURE NATIONAL / REGIONAL LEGISLATION AND RESEARCH ACTIVITY

2.1. SITUATION IN JAPAN

Pedestrian fatalities account for about 30% of all traffic fatalities in Japan. The new regulation is addressed to the protection of the head and the outline is shown in Annex 1.

2.2. SITUATION IN EU

About 8,000 pedestrians and cyclists are killed and a further 300,000 injured in the European Community each year in road accidents. On the 19th of February, 2003 the European Commission voted to adopt a draft proposal for a Directive on Pedestrian Protection which would be presented to the Council and European Parliament. The contents of the proposal are based on the industry commitment, on the scientific work performed by Working Group 17 of the European Enhanced Vehicle-safety Committee (EEVC) and the Joint Research Centre (JRC) of the European Commission.

This proposal lays down technical requirements for the type approval of motor vehicles with regard to pedestrian protection. See Annex 2

2.3. SITUATION IN OTHER COUNTRIES

Canada is currently reviewing their bumper regulation. The Canadian bumper regulation is one if not the most stringent in the world (all the safety features of the vehicle have to be functional after an 8 km/h impact). Canada needs to investigate the effect of the Canadian bumper designs on pedestrian safety.

The US terminated development of a pedestrian head impact requirement in the early 1990's. Since that time, the US efforts have been focused on research in support of the IHRA pedestrian safety working group.

If other countries start working on pedestrian safety and are able to share their work with the Pedestrian Safety gtr Informal Group, it will be taken into account in future discussions.

2.4. RESEARCH ACTIVITIES OF IHRA PEDESTRIAN SAFETY WORKING GROUP

There are test methods for Adult/Child head and Adult leg that has been developed by IHRA PEDESTRIAN SAFETY WORKING GROUP which consists of JAPAN, AUSTRALIA, THE UNITES STATES OF AMERICA. EEVC. See INF GR/PS/49, 50 and IHRA PS 119 R2

2.5. RESEARCH ACTIVITIES OF EEVC WG17

There are test methods for Adult/Child head and Adult leg that has been developed by IHRA WG17. See EEVC WORKING GROUP 17 REPORT IMPROVED TEST METHODS TO EVALUATE PEDESTRIAN PROTECTION AFFORDED BY PASSENGER CARS.

3. ACCIDENT ANALYSIS

Overall pedestrian fatalities / injuries and their evolution over time

The Pedestrian Safety gtr Informal Group tried to accumulate all available pedestrian traffic accident data.

As result, the group received pedestrian accident databases from the IHRA/Pedestrian Safety WG (comprehensive in-depth accidents study - INF GR/PS/3-31), German accident data (INF GR/PS/12-13-25), Italian data (INF GR/PS/14), UN accident data (INF GR/PS/15), Spanish data (INF GR/PS/16), European Industry's data (INF GR/PS/17), Canadian data (INF GR/PS/20), Netherlands data (INF GR/PS/21) and Swedish data (INF GR/PS/41).

The most in depth accident data came from the IHRA/PS-WG, but all the above mentioned data supports the same trends seen in the IHRA/PS study.

The UN statistics for pedestrian traffic accidents show a decrease in the fatality and injury numbers of 30 to 40% over the last 20 years, but absolute numbers are still important enough to make some actions.

4. TARGET OF GTR

The accident data show us that in addition to the EU and Japan, other countries (e.g. Australia and South Korea) also suffer high pedestrian fatalities. Establishing a gtr (with harmonized tools, methods and level of protection) offers the opportunity not only to align existing requirements (in the EU and Japan) but also to potentially lower pedestrian injuries worldwide.

It is the intention of Japan to use the content of the gtr for their next step in their national legislation. Also the second phase of the EU provisions offer the possibility for alignment with the gtr.

The Pedestrian Safety gtr Informal Group collected all available traffic accident data for pedestrians from all available sources. Based on these accident data, the Informal Pedestrian gtr Safety Group concludes and recognises that the majority of fatalities (numbers) and serious injuries occurred on:

- Child head vs. top surface of bonnet/wing.
- Adult head vs. top surface of bonnet/wing + windscreen area and A-pillars,
- Adult leg vs. front bumper of vehicles,

A crash speed (between a car and a pedestrian) of 40 km/h can cover more than 75% of total injuries including fatalities. Injuries caused by higher speed crashes will also be influenced positively by a reduction in injury severity

4.1. DISTRIBUTION OF INJURIES

Comparing the ages, statistics show the highest frequency of accidents is for children of 5 to 9 years old, and for adults over 60 years old.

According to the in-depth study of the IHRA/PS-WG, the frequency of fatal and serious injuries (AIS 2-6) is highest for following body regions: head injuries for adult and child, and leg injuries for adult.

Each of these body regions covers more than 30% of total accidents and the group believes it should focus on protecting these body regions.

The highest next to head and leg injuries are chest injuries with about 10 %. Other injured body regions are much lower with only a few percents.

For the vehicle parts, the major sources of adult head injuries are the top surface of bonnet/wing and windscreen area and A-pillars. For the child head injury, this is the top surface of the bonnet/wing. For the adult leg injury, the major source is the front bumper of vehicles. (INF GR/PS/3-31) Results from a Japanese ITARDA study on leg injuries (INF GR/PS/26) showed that it is necessary to protect both the tibia and the knee joint. As a consequence it was deemed necessary to look into a new flexible legform. It would make it possible to assess the injury risk of both the tibia and the knee joint.

Spanish accident data (INF GR/PS/16) based on severe accidents showed that head, legs and thorax are the first priority when combining severity and frequency of injuries.

4.2. CRASH SPEEDS

Pedestrian accident data for crash speed between vehicles and pedestrians are collected and the cumulative frequency of the crash speeds shows that a crash speed of up to 40 km/h can cover more than 75% of total pedestrian accidents. 30km/h covers [%] and 50km/h covers [%] of total pedestrian accidents.
(INF GR/PS/3-31).

4.3. SCOPE (CATEGORIES / SHAPES)

Vehicle shape is important and is studied by the IHRA PS WG for passenger cars. The group agreed to use this work as basis. It influences the speed and angle of the head test conditions. It needs to be checked how light trucks / vans / exotic shapes can be included (if not included yet). If additional shapes are identified to which the sub system tests have not been validated, this should be taken into account. The importance of shape can be further addressed in the test procedure specifications.

The group also gave consideration to the existing work underway in relation to the drafting pedestrian legislation. The different approaches used in achieving a definition of the scope present a challenge. Legitimate concerns on the fleet differences of the Contracting Parties were raised such as the limitation of passenger cars by weight or by the number of seating positions, or the market importance of a vehicle category in one country whilst the same vehicle category is virtually non existent in others.

In an attempt to cover for all these concerns a matrix was proposed. The headings would cover all categories considered necessary by the group. It was recognised that these fleet differences may require sub-classifications of the proposed GRSG definitions in this gtr proposal. The group wants to stress that the intention clearly would be to comply with the GRSG Common Tasks categories when approved by WP29.

A possible approach for the application of the matrix could list all the tests the group would agree upon. It was recognised that technical feasibility will be critical in establishing the application of these tests. Hence a staged approach with a possible distinction in the application date could be included in the proposed gtr tests.

Each Contracting Party signing up to the gtr would then be listed in this matrix indicating which test for which category they require. This could be seen as different levels of application.

Rather than having a national option to extend the scope outside the scope of the gtr, this solution would provide for all options within the gtr.

Example of the matrix:

	Cat X	Cat Y	Cat Z	...
gtr test A	CP α, CP β, CP ω	CP δ		
gtr test B	CP α, CP β	CP δ		
gtr test C		CP δ	CP ω	
...				

Example: Cat X = Category 1-1 < 2,5 tonnes GVM of TRANS/WP.29/GRSG/2003/10
Cat Y = Category 1-1 of TRANS/WP.29/GRSG/2003/10
Cat Z = Definition to cover for the US pick-up trucks

The group also agreed that the scope should presently be limited to new types of vehicle only since the necessary technical changes to the vehicle needed for achieving the high level of protection can only reasonably be incorporated into a vehicle during the development of a new type.

The group requests consideration and guidance from GRSP on this proposed approach.

5. TEST PROCEDURES

5.1. RELEVANCE (FULL SCALE / SUBSYSTEM)

The group agreed that a simple, reliable, repeatable test is better for legislation. The general conclusion thus was that sub system tests are the best way forward. There is currently no effective full-scale test for regulation.

For research simulation, PMHS and a pedestrian dummy can be very helpful to assess injury tolerances and kinematics. Computer simulation could be also of assistance in the selection of the most severe impact point.

The group agreed the headform impactor tests(adult headform, child headform) and legform impactor test(leg form) as subsystem test.

5.2. Headform test

Based on IHRA studies, the following test procedures are decided.

Impactor velocity is [32]km/h simulating the crash speed of 40km/h between vehicles and pedestrians. The impactor mass is [3.5]kg for child and [4.5]kg for adult. [3.5]kg impactor mass also represents small adults. Comparing the ages, statistics(SUMMARY OF IHRA PEDESTRIAN SAFETY WG ACTIVITIES (2003) – PROPOSED TEST METHODS TO EVALUATE PEDESTRIAN PROTECTION AFFORDED BY PASSENGER CARS)show the highest frequency of accidents is for children of 6 to 10 years old, and for adults over 60 years old.

5.3. Legform test

[Based on IHRA studies, the following test procedure is decided.

This test method applies to adult. Flexible impactor makes it possible to assess the injury risk of both the tibia and the knee joint. It is thus used for the legform test.]

6. REQUIREMENT

6.1. BENEFITS (MONETORY, SOCIAL)

It was considered that a cost study can only be done in a pragmatic way. It was tried within EEVC and even within the EU it was not possible because amongst others the differences in the hospital care system. It can only be done as examples for separate countries. The other option would be to use an idealised standard. Members of the group also referred to three papers that were produced based on the EEVC reports. These cost effectiveness studies are from BASt, the Netherlands and MIRA and could be provided to this group.

However the group requested guidance from WP29/AC.3 on what monetary value has to be used since different regions use different values, and also guidance on cost benefit procedures methods. WP29/AC.3 asked each contracting parties to provide information needed for evaluating cost and benefit at the global level to the group.

6.2. TECHNICAL AND ECONOMIC FEASIBILITY

The group already took note of the feasibility study performed in IHRA (INF GR/PS/5) on the IHRA proposed head tests. The main conclusions are:

No vehicle fulfils EEVC/WG17 requirements completely

No traditional solution currently exist to pass EEVC/WG17 requirements (not possible with padding only)

No sensor techniques are available yet to offer other solutions

The group also checked with Euro and Australian NCAP programs. The group reaches conclusions on that more feasibility studies / assessments have to be performed by the group members, taking into account the latest technological developments.

6.3. COST EFFECTIVENESS

Continue to be discussed.

7. OTHER MEASURES THAT CAN POTENTIALLY REDUCE PEDESTRIAN INJURIES

The group, taking note of the terms of reference, also reviewed the issue of other safety measures besides passive safety measures on the vehicle itself.

The group recognized that active safety measures are not within its field of competence but at the same time agreed that such issues should be brought to the attention of WP29 and AC.3.

As pointed out by several experts, including OICA, pedestrian protection could be considered as a whole, including active and passive measures. Some experts noted that consideration of other safety measures might help in ensuring that the vehicle passive safety requirements are kept at a realistic and feasible level.

OICA in particular mentioned brake assisting systems which can, in emergency situations, substantially improve the braking performance and consequently reduce the impact speed when the impact is unavoidable.

OICA also pointed to the importance of the infrastructure and presented the results of a 1998 study conducted on behalf of ACEA by the consultants ORIENTATIONS (F) and TMS Consultancy (UK) – INF GR/PS/29. This study, which evaluated the effect of infrastructural measures based on real data evaluations, concluded that such measures could dramatically reduce the number of pedestrian victims (fatalities/injuries) at low cost.

While it was agreed that such infrastructure measures are not within the remit of the group, it was also agreed that it could be useful and efficient to inform WP29 as well as other authorities of the need to take these issues into account for real world safety improvements. The group also noted the importance of educational measures as well as the need to enforce existing road traffic legislation.

B. Text of Regulation

1. Scope and Purpose

This global technical regulation specifies requirement for the pedestrian safety. The purpose of this global technical regulation is to reduce injuries to pedestrians and other vulnerable road users who are hit by the frontal surfaces of the vehicles. This global technical regulation applies to power-driven vehicles of categories 1-1 and 2 defined in UNIFORM PROVISIONS SETTING FORTH COMMON DEFINITIONS AND PROCEDURES TO BE USED IN GLOBAL TECHNICAL REGULATIONS (gtr 0). The scope of this GTR includes category 1-1 of less than 2.5ton GVM, category 1-1 of more than 2.5 ton GVM, category 2 derived from category 1-1 of not more than 2.5 ton GVM and caterory 2 of less than 3.5 ton.It is dependent on contracting parties to extend the application on the basis of technical and economic feasibility. The extension of the application is referred to in the Application.

For reference of gtr0;

1. POWER DRIVEN VEHICLES WITH FOUR OR MORE WHEELS.

1.1. "Category 1 vehicle" means a power driven vehicle with four or more wheels designed and constructed primarily for the carriage of (a) person(s).

1.1.1. "Category 1-1 vehicle" means a category 1 vehicle comprising not more than eight seating positions in addition to the driver's seating position. A category 1-1 vehicle cannot have standing passengers.

1.1.2. "Category 1-2 vehicle" means a category 1 vehicle designed for the carriage of more than eight passengers, whether seated or standing, in addition to the driver.

1.2. "Category 2 vehicle" means a power driven vehicle with four or more wheels designed and constructed primarily for the carriage of goods. This category shall also include:

i tractive units

ii chassis designed specifically to be equipped with special equipment.

1.3. To determine whether a vehicle is to be regarded as a category 1 vehicle or a category 2 vehicle for the application of gtrs, the following shall apply [in cases where it is not immediately apparent whether a vehicle is a category 1 or 2 vehicle]:

1.3.1. If a vehicle meets all of the following conditions:

$P-(M+N \times 68) > N \times 68$,

$N \leq 6$ and

Pay mass as defined in paragraph 6. of annex 3 exceeds [150/200] kg,

the vehicle shall be deemed to be a category 2 vehicle.

In all other cases, the vehicle shall be deemed to be a category 1 vehicle.

Where,

P= Gross vehicle mass as defined in paragraph 4 of annex 3.

M= Mass in running order as defined in paragraph 3 of annex 3.

N= Maximum number of simultaneous seating and standing positions excluding the driver seating position

1.3.2. If there is a seat anchor for a removable seat, the removable seat is to be counted in the determination of the number of seating positions and of the pay mass.

Seating position means any individual seat or any part of a bench seat intended to seat one person.

1.3.3. Until the entry into force of a gtr on seats, contracting parties can use their own criteria to decide the number of seating positions.

1.4. "Special Purpose vehicle" means a vehicle sharing features with a vehicle of category 1 or 2 for performing a special function for which special body arrangement and/or equipment are necessary. Features shared with a category 1 or 2 vehicle shall be covered by the respective gtr.

Definition and requirements of the Special Purpose part of the vehicle will be decided by each Contracting Party where the vehicle is to be registered.

2. Application

This global technical regulation applies to all wheeled vehicles falling within the scope of the agreement concerning the establishment of global technical regulations for wheeled vehicles.

	Category 1-1 with a gross vehicle mass < 2500 kg	Category 1-1	Category 2 derived from category 1-1 with a gross vehicle mass < 2500 kg	Category 2 derived from category 1-1 with a mass in running order < 2500 kg	Category 2 with a mass in running order < [2500] kg	…
gtr test 1	Region x Region y Region z	Region y	Region y	…	…	…
gtr test 2	Region x Region y	Region z	…	…	…	…
gtr test 3	…	Region x	…	…	Region z	…
…	…	…	…	…	…	…

Examples of Region:

Region x covers all European Member states,

Region y covers Japan,

Region Z covers the US,

Etc. for other contracting parties.

Examples of Tests:

gtr test 1 is the Child Head to Bonnet,

gtr test 2 is the Adult Leg to Bumper,

Etc. for each of the different agreed tests.

3. Definition

For the purpose of this regulaiton following definition will apply:

3.1. Definition on adult head form test

3.1.1. <u>"Normal ride attitude"</u>means the vehicle attitude in driving order positioned on the ground , with the tires inflated to recommended pressures , the front wheels in the straight-ahead position , with maximum capacity of all fluids necessary for operation of the vehicle , (with all standard as provided by the vehicle manufacturer), with one adult male 50th percentile dummy or an equivalent mass placed on the driver's seat , and with one adult male 50th percentile dummy or an equivalent mass placed on the front passenger's seat , and the suspension set in normal running conditions specified by the manufacturer (especially for vehicles with an active suspension or a device for automatic levelling) .

3.1.2. "Ground reference plane" means a horizontal plane, either real or imaginary, that passes through all tire contact points of a vehicle while the vehicle is in its normal ride attitude. If the vehicle is resting on the ground, then the ground plane 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 the ground plane.

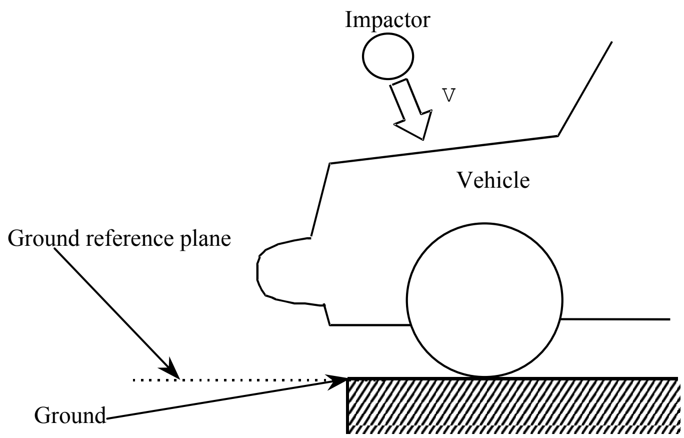


Figure 1: Configuration of IHRA Head Impact Test Procedure

3.1.3. "Front structure (Adult Headform Test Area)" means the outer structure that includes the upper surfaces of the bonnet and of the wings (outer fenders), the scuttle (cowl top), the windscreen, the A pillars and the roof. It is bounded by the front reference line in the front and the rear reference line in the rear, as defined in sections 3.1.4.1. and 3.1.4.2., and by the side reference lines as defined in sections 3.1.5. and 3.1.7.

NOTES: The adult headform test area and the child headform test area as defined in section 3.2.3. is overlapping. It is lead by to reflect the actual accident data simply, however, there is no significant difference for the pedestrian relief ratio between the overlapping test method (keep the overlapping area) and the boundary line test method (separate the overlapping area to adult and child test area using a boundary line). (see IHRA/PS/209)

3.1.4. Wrap around reference lines

3.1.4.1. "Front reference line (FL) " means the 1700 mm wrap around reference line is the geometric trace described on the vehicle front structure by one end of a 1700 mm long flexible tape, when it is held in a vertical fore and aft plane of the vehicle and traversed across the front of the vehicle front structure and bumper of the vehicle when it is in the normal ride attitude. The tape is held taught throughout the operation with one end held in contact with the ground reference plane, vertically below the front face of the bumper and the other end held in contact with the vehicle front structure.

3.1.4.2. "Rear reference line (RL)" means the 2100 mm wrap around reference line is found using a similar procedure of the FL using an alternative tape of 2100 mm length (see Figure 2A). For small cars where the wrap around distance to the rear windscreen reference line as defined in section 3.1.8.1. is less than 2100 mm at any point, then the rear windscreen reference line will be used as the rear reference line at that point (see Figure 2B). For tall cars where the wrap around distance to the rear reference line is over the vertical limit reference line, as defined in section 3.1.8.2., at any point, then the vertical limit reference line will be used as the rear reference line (see Figure 2C).

3.1.5. "Bonnet rear reference line (BRL)" means the geometric trace of the most rearward points of contact between a 165 mm sphere and a bonnet when the sphere is traversed across a bonnet while maintaining contact with the windscreen (see Figure 3A).

3.1.6. "Side reference line(SL) of front structure up to the BRL " means the geometric trace of the highest points of contact between a straight edge and the side of a front structure, when the straight edge, held parallel to the lateral vertical plane of the vehicle and inclined inwards by 45° is traversed down the side of front structure, while maintaining contact with the surface of the body shell. (see Figure 3B).

3.1.7. "Side reference lines beyond the BRL" means the geometric trace of the highest points of contact between a straight edge and the side of a front structure, when the straight edge, held parallel to the lateral vertical plane of the vehicle and inclined inwards by 45° is traversed down the side of front structure, while maintaining contact with the surface of the body shell. (see Figure 3C).

3.1.8. Other Reference Lines

3.1.8.1. "Rear windscreen reference line (RWL)" means the windscreen reference line is defined as the geometric trace of contact between a straight edge and the upper windscreen frame, when the straight edge, held parallel to the vertical longitudinal plain of the car and inclined rearwards by 75 degrees, is traversed across and in contact with the upper windscreen frame, see Figure 2A.

3.1.8.2. "Vertical limit reference line (VLL)" means the vertical limit reference line is defined as 1900 height line (see Figure 2C).

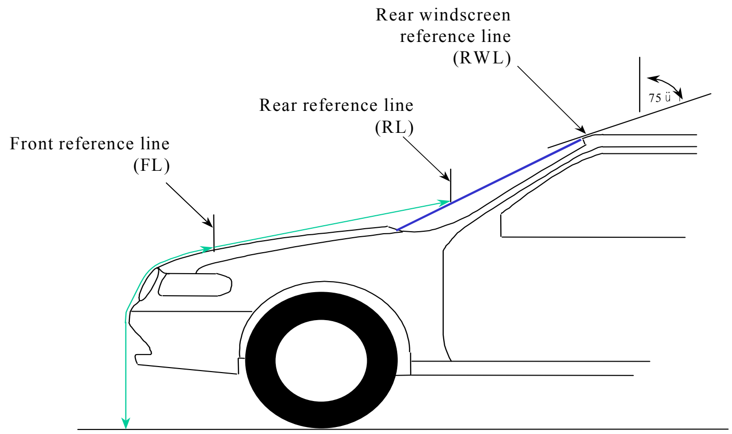


Figure 2A. Determination of FL, RL and RWL

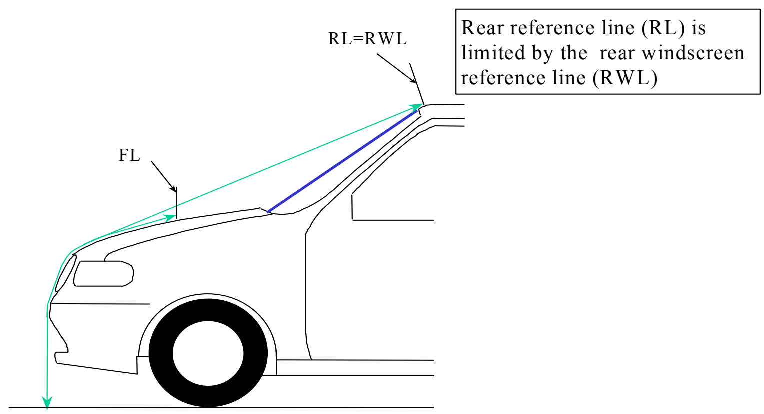


Figure 2B. Determination of FL, RL and RWL for small cars

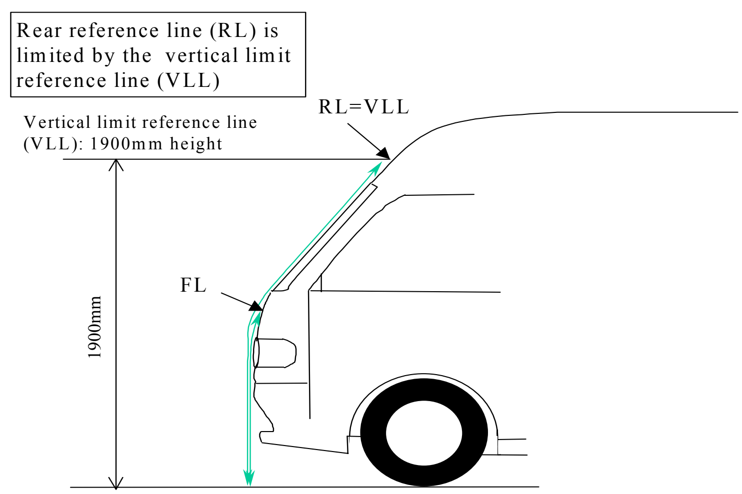


Figure 2C. Determination of FL, RL and VLL for tall cars

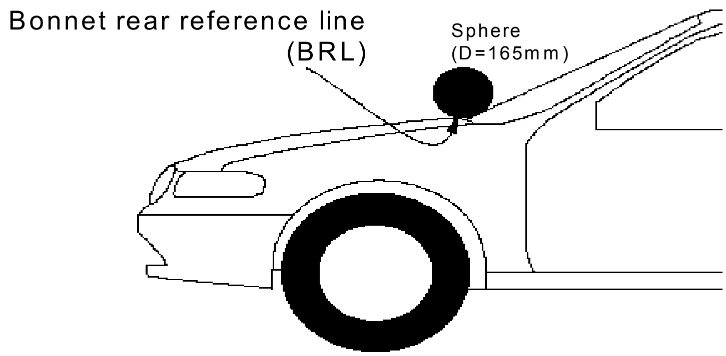


Figure 3A: Determination of bonnet rear reference line (BRL)

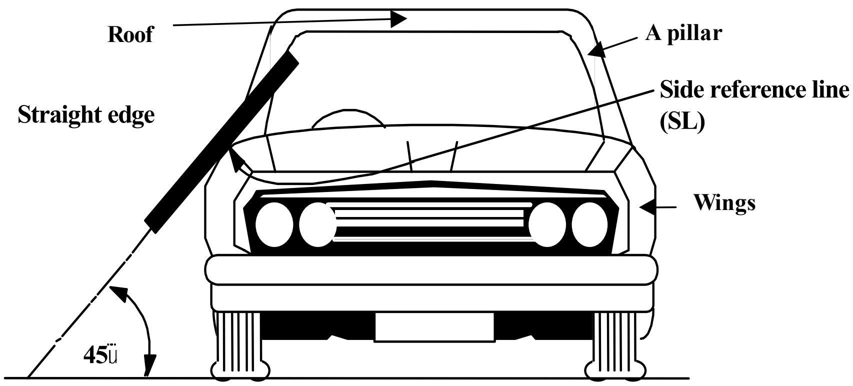


Figure 3B: Determination of side reference lines of front structure up to the BRL

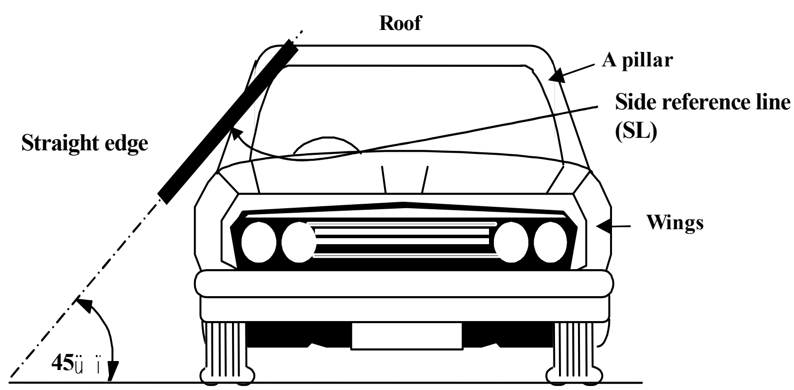


Figure 3C: Determination of side reference lines of front structure beyond the BRL

3.1.9. "Target Point" means this location is defined as the intersection of the headform longitudinal axis projection onto the vehicle (point A on Figure 4).

3.1.10. "Impact Point" means this location is the actual first contact point of the headform with the vehicle (point B on Figure 4). The proximity of this point with the target point is dependent upon both the angle of travel by the headform and contour of the vehicle surface.

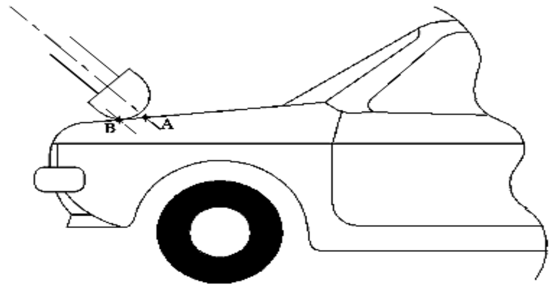


Figure 4: Target point and impact point

3.1.11. <u>"Head Injury Criterion"</u> means HIC shall be calculated from the resultant of accelerometer time histories using the formula ($t_2 - t_1 \le 15$ msec)

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

Where

a is the resultant acceleration as a multiple of " g " ;

t_1 and t_2 are the two time instants (expressed in seconds) during the impact, defining the beginning and the end of the recording for which the value of HIC is a maximum

3.2. Definition on child head form test

3.2.1. <u>"Normal ride attitude"</u> means the vehicle attitude in driving order positioned on the ground , with the tires inflated to recommended pressures , the front wheels in the straight-ahead position , with maximum capacity of all fluids necessary for operation of the vehicle , (with all standard as provided by the vehicle manufacturer), with one adult male 50th percentile dummy or an equivalent mass placed on the driver's seat , and with one adult male 50th percentile dummy or an equivalent mass placed on the front passenger's seat , and the suspension set in normal running conditions specified by the manufacturer (especially for vehicles with an active suspension or a device for automatic levelling) .

3.2.2. <u>"Ground reference plane"</u> means a horizontal plane, either real or imaginary, that passes through all tire contact points of a vehicle while the vehicle is in its normal ride attitude. If the vehicle is resting on the ground, then the ground plane 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 the ground plane.

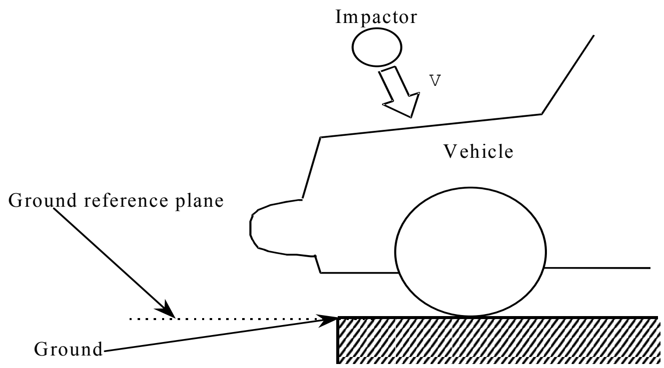


Figure 5: Configuration of IHRA Head Impact Test Procedure

3.2.3. "Front structure (Child Headform Test Area)" means the outer structure that includes the upper surfaces of the bonnet and of the wings (outer fenders), the scuttle (cowl top), the windscreen, the A pillars and the roof. It is bounded by the front reference line in the front and the rear reference line in the rear, as defined in section 3.2.4.1 and 3.2.4.2, and by the side reference lines as defined in sections 3.2.5 and 3.2.7.

NOTES:

The child headform test area and the adult headform test area as defined in section 3.1.3 is overlapping. It is lead by to reflect the actual accident data simply, however, there is no significant difference for the pedestrian relief ratio between the overlapping test method (keep the overlapping area) and the boundary line test method (separate the overlapping area to adult and child test area using a boundary line). (see IHRA/PS/209)

3.2.4. Wrap around reference lines

3.2.4.1. "Front reference line (FL)" means the 1000mm wrap around reference line is the geometric trace described on the vehicle front structure by one end of a 1000mm long flexible tape, when it is held in a vertical fore and aft plane of the vehicle and traversed across the front of the vehicle front structure and bumper of the vehicle when it is in the normal ride attitude. The tape is held taught throughout the operation with one end held in contact with the ground reference plane, vertically below the front face of the bumper and the other end held in contact with the vehicle front structure.

3.2.4.2. "Rear reference line (RL)" means the 1700 mm wrap around reference line is found using a similar procedure of the FL using an alternative tape of 1700 mm length (see Figure 6A). For small cars where the wrap around distance to the windscreen reference line as defined in section 3.2.8 is less than 1700 mm at any point, then the rear windscreen reference line will be used as the rear reference line at that point (see Figure 6B).

3.2.5. <u>“Bonnet rear reference line (BRL)”</u> means the geometric trace of the most rearward points of contact between a 165 mm sphere and a bonnet when the sphere is traversed across a bonnet while maintaining contact with the windshield (see Figure 7A).

3.2.6. <u>“Side reference line (SL) of front structure up to the BRL”</u> means the geometric trace of the highest points of contact between a straight edge and the side of a front structure, when the straight edge, held parallel to the lateral vertical plane of the vehicle and inclined inwards by 45° is traversed down the side of front structure, while maintaining contact with the surface of the body shell. (see Figure 7B).

3.2.7. <u>“Side reference lines beyond the BRL”</u> means the geometric trace of the highest points of contact between a straight edge and the side of a front structure, when the straight edge, held parallel to the lateral vertical plane of the vehicle and inclined inwards by 45° is traversed down the side of front structure, while maintaining contact with the surface of the body shell. (see Figure 7C).

3.2.8. <u>“Rear of windscreen reference line (RWL)”</u> means the windscreen reference line is defined as the geometric trace of contact between a straight edge and the upper windscreen frame, when the straight edge, held parallel to the vertical longitudinal plain of the car and inclined rearwards by 75 degrees, is traversed across and in contact with the upper windscreen frame, see Figure 6A.

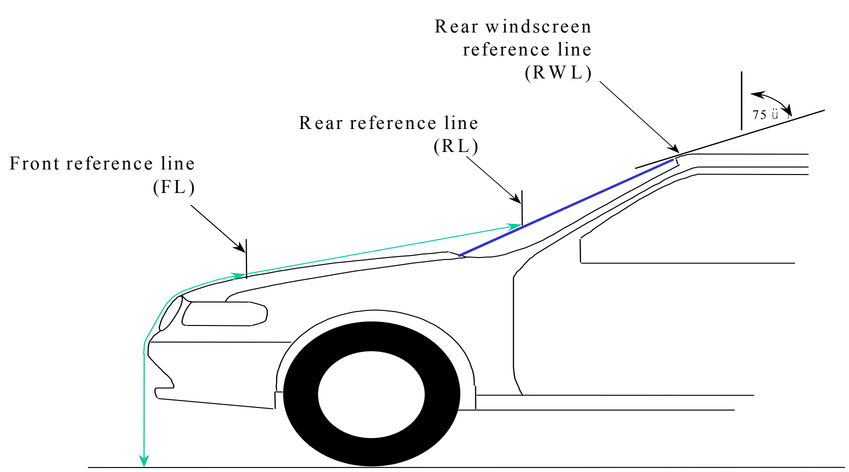


Figure 6A. Determination of FL, RL and RWL

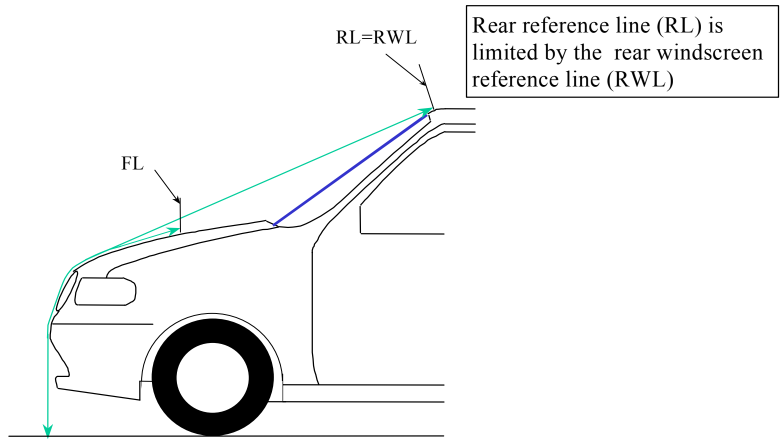


Figure 6B. Determination of FL, RL and RWL for small cars

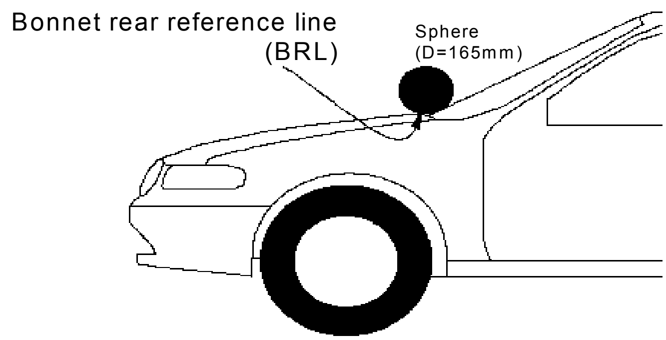


Figure 7A: Determination of bonnet rear reference line (BRL)

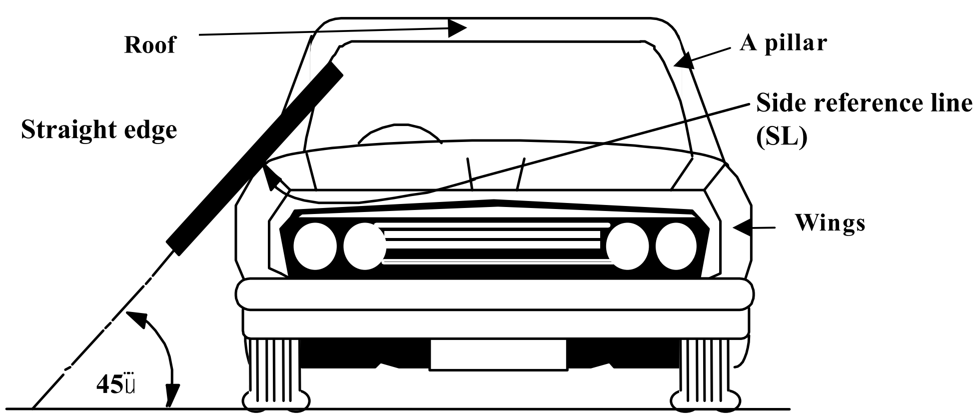


Figure 7B: Determination of side reference lines of front structure up to the BRL

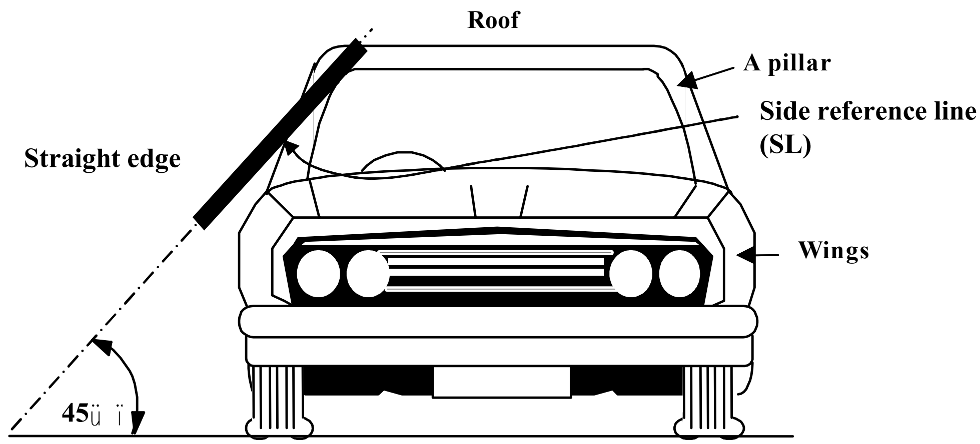


Figure 7C: Determination of side reference lines of front structure beyond the BRL

3.2.9. "Target Point" means this location is defined as the intersection of the headform longitudinal axis projection onto the vehicle (point A on Figure 8).

3.2.10. "Impact Point" means this location is the actual first contact point of the headform with the vehicle (point B on Figure 8). The proximity of this point with the target point is dependent upon both the angle of travel by the headform and contour of the vehicle surface.

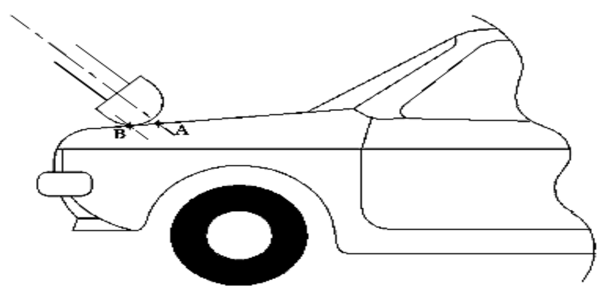


Figure 8: Target point and impact point

3.2.11. "Head Injury Criterion" means HIC shall be calculated from the resultant of accelerometer time histories using the formula ($t_2 - t_1 \leq 15$ msec)

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

where

a is the resultant acceleration as a multiple of " g " ;

t_1 and t_2 are the two time instants (expressed in seconds) during the impact, defining the beginning and the end of the recording for which the value of HIC is a maximum

3.3. Definition on adult leg form test

3.3.1. "Leg form impactor knee joint" means mechanical joint of a leg form impactor with deformable elements simulate a human knee in lateral impact only.

3.3.2. "Thigh" means mechanical components above the leg form impactor knee joint.

3.3.3. "Leg" means mechanical components below the leg form impactor knee joint.

3.3.4. "Front face" means front part of a vehicle likely to strike the pedestrian's leg.

3.3.5. "Corners of front face" means Vertical lines that pass through the points at which vertical planes, set at 60° to the vertical longitudinal plane of a vehicle, contact and are tangential to the outer surface of the front face. (see Figure 9)

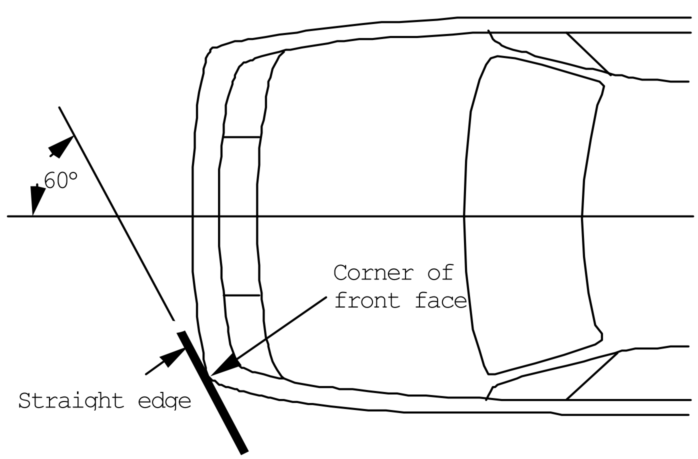


Figure 9
Corner of Front Face

3.3.6. "Knee joint center" means center of the bending part of the deformable element before deformation.

3.3.7. "Valgus angle" means the angle of the knee joint in abduction.

3.3.8. "Impact point" means the point on the vehicle front face where initial contact occurs.

4. General requirements
Vehicles defined in Scope and Application shall comply with Adult headform test, Child

headform test and leg form test.

5. Performance Requirements and Associated Test Conditions and Procedures

5.1. Requirement on adult head test method

5.1.1. Performance Requirement

Recording of test results shall be acquired in accordance with ISO 6487.

5.1.1.1. Head form impactor data

The velocity of the head form impactor shall be measured at some point during the free flight before impact, in accordance with the method specified in ISO 3784. 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 to give 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.

The acceleration time histories shall be recorded, and HIC shall be calculated.

The first point of contact on the front structure of the vehicle shall be recorded.

5.1.1.2. Threshold

In adult headform to front structure tests, the head injury criterion HIC, calculated from the resultant of the headform accelerometer time histories, in accordance with section 3.1.11, shall not exceed [1000].

5.1.2. Test Conditions

5.1.2.1. Atmospheric conditions

Relative humidity and temperature shall be measured at the time of the test, and recorded in the test report.

5.1.2.2. Impact velocity

The headform velocity at the time of impact shall be 32km/h which stimulates the vehicle impact speed of [40 km/h], the shape category of the vehicle under test and the location of each selected test point. (see Figure 11 and Table 1)

5.1.2.3. Direction of impact

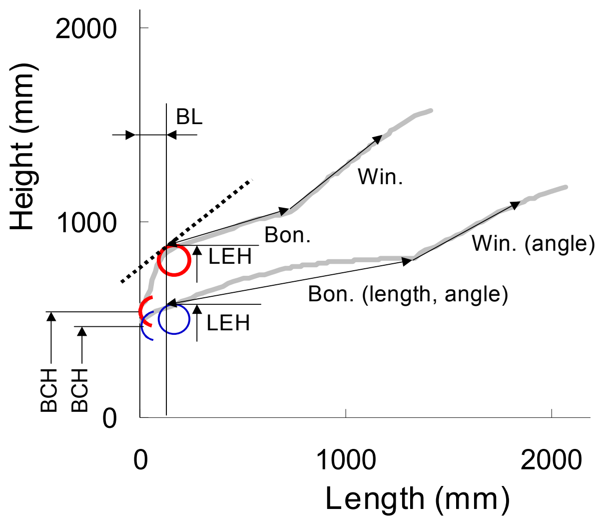
The direction of impact shall be in the fore and aft vertical plane of the section of the vehicle to be tested. The tolerance is ± 2°. The direction of impact of tests to the front structure shall be downward and/or rearward.

5.1.2.4. Angle of impact

The angle of the velocity vector of the head form impactor at impact with respect to horizontal shall be dependent on the vehicle shape and dimensions and the average angles are shown.(see Table 1)

5.1.2.5. Impact points

Tests shall be made to the front structure within the boundaries as defined in section B 3.1.3. During all tests of the front structure, up to the bonnet rear reference line, the centre of the head form impactor shall, at the time of first contact, be a minimum of 82,5 mm inside the defined side reference lines (see section B 3.1.5.) of the sections under test. For tests beyond the bonnet rear reference line, the centre of the head form impactor shall, at the time of first contact, be a minimum of [0,0] mm inside the impact recommend line (see Figure12). The points selected for testing shall be indicated in the test report.



Sedan + Light vehicle + Sports type

		Lower	Middle	Upper
BL	(mm)	127	127	127
BCH	(mm)	435	475.5	516
LEH	(mm)	565	702	839
Bon. length	(mm)	1200	917.5	635
Bon. angle	(deg.)	11	14.5	18
Win. angle	(deg.)	29	34.5	40
Bottom depth	(mm)	42	98	154
Bootm hight	(mm)	182	225.5	269

SUV

		Lower	Middle	Upper
BL	(mm)	195	195	195
BCH	(mm)	544	640	736
LEH	(mm)	832	1000	1168
Bon. length	(mm)	1023	933.5	844
Bon. angle	(deg.)	11	9.75	8.5
Win. angle	(deg.)	36	39.5	43
Bottom depth	(mm)	48	123	198
Bootm hight	(mm)	248	348	448

1Box

		Lower	Middle	Upper
BL	(mm)	188	188	188
BCH	(mm)	448	576	704
LEH	(mm)	864	1004	1144
Bon. length	(mm)	361	259	157
Bon. angle	(deg.)	40	40	40
Win. angle	(deg.)	30	38	46
Bottom depth	(mm)	63	95	127
Bootm hight	(mm)	214	292.5	371

Figure 10. Vehicle shape classification by corridors

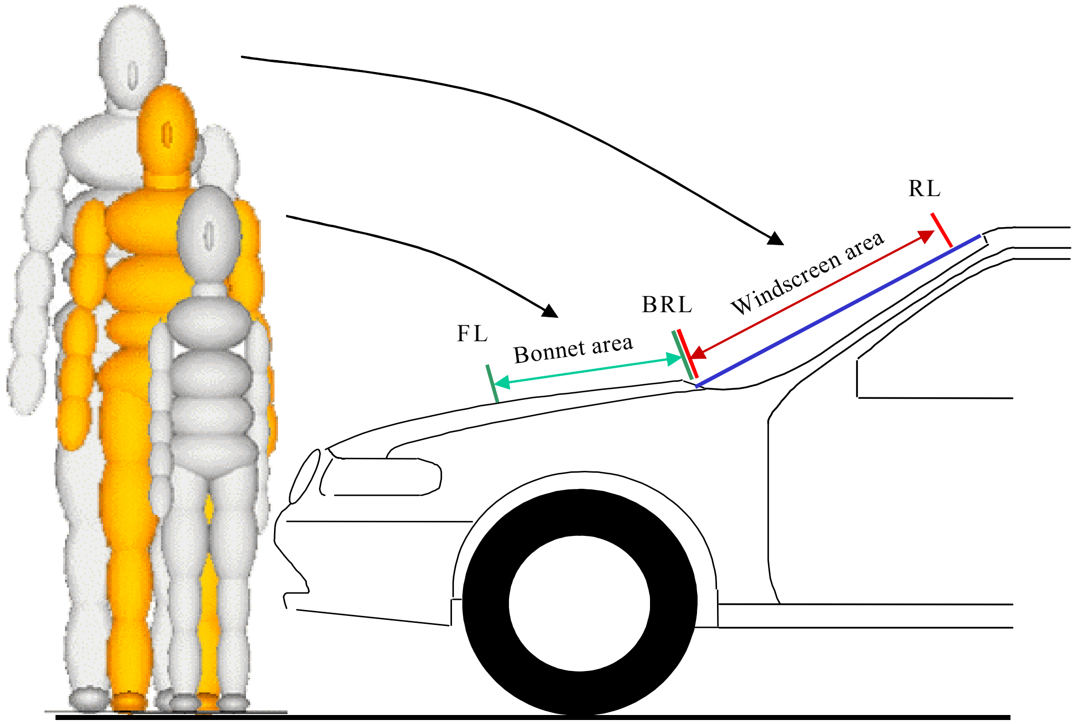


Figure 11. Principles of headform impact test

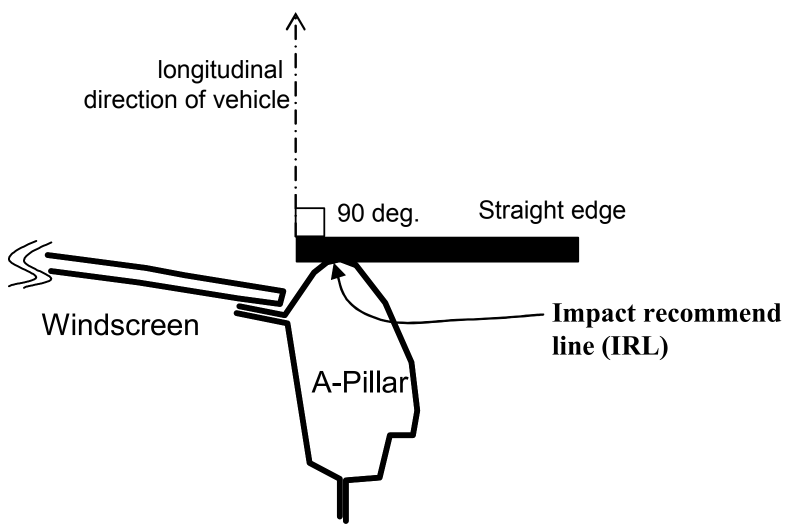


Figure 12 Impact recommend line (IRL) for the A-Pillar

Table 1. Headform test conditions (impact velocity and impact angle)

Shape Corridor	Car impact speed 40km/h					
	Impact Velocity (km/h)			Impact Angle (deg.)		
	Bonnet	Windscreen	BLE/Grille	Bonnet	Windscreen	BLE/Grille
Sedan +	30.4 +/- 7.2	35.2 +/- 6.8	nc	66.0 +/- 14.0	38.4 +/- 10.9	nc
SUV	30.8 +/- 8.8	nc	nc	76.7 +/- 22.2	nc	nc
One box	nc	29.6 +/- 3.2	nc	nc	47.3 +/- 9.6	nc

*nc: No Contact, ** Adult Headform Impact Test Conditions,
*** Linear interpretation to be used to determine impact conditions for in-between speeds if required.

5.1.3. Test Procedures

5.1.3.1. Impact test site
A flat, smooth and hard surface with a slope not exceeding 1 %.

5.1.3.2. Head form impactor
As described in section 5.1.3.4. and shown in Figure 13.

5.1.3.3. Applicable vehicles
Passenger vehicle.

5.1.3.4. Requirements of Head form impactor

5.1.3.4.1. Size and mass
The contact surface of the head form impactor shall be spherical. The diameter is 165 mm as shown in Figure 13. 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 with in the rage of 0,0075 to 0,0200 kgm^2. The centre of gravity of the head form impactor including instrumentation shall be located in the geometric centre of the sphere with a tolerance of ± 2 mm.

5.1.3.4.2. Instrumentation
A recess in the sphere shall allow for mounting one triaxial or three uniaxial accelerometers within ± 10 mm seismic mass location tolerancefrom the centre of the sphere for the measurement axis, and ± 1 mm seismic mass location tolerancefrom the centre of the sphere for the perpendicular direction to the measurement axis. The instrumentation response value CFC, as defined in ISO 6487: 1987, shall be 1000. The CAC response value, as defined in ISO 6487: 1987, shall be 500 g for the acceleration.

5.1.3.4.3. First natural frequency
First natural frequency of the headform impactor shall be over 5000 Hz.

5.1.3.5. Propulsion of the headform impactor
The headform impactor shall be in 'free flight' at the moment of impact, at the required impact velocity (see 5.1.2.2.) and the required impact angle (see 5.1.2.3. and 5.1.2.4.). 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 method of headform propulsion is at the discretion of the test authorities.

5.1.3.6. Certification of the headform impactor
The headform impactor shall meet the performance requirements specified in Annex A. The certified impactor may be used for a maximum of 20 impacts before re-certification. The impactor 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.

5.1.3.7. Temperature and humidity conditions
The stabilised temperature of the headform impactor at the time of impact shall be 20° ± 4° C. A relative humidity should be 10 to 70 percent after a soak period of at least four

hour prior to its application in a test.

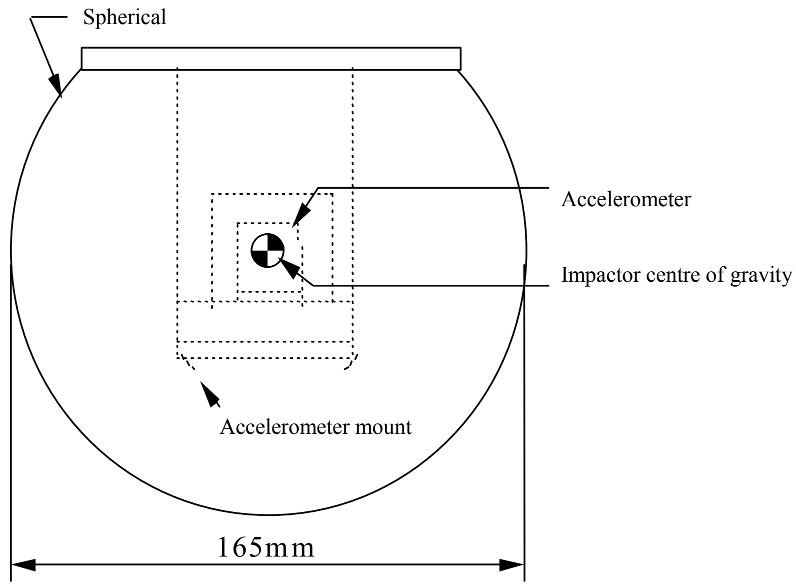


Figure 13: Head form impactor

5.1.3.8. Rear face of head impactor
A plane at the outer surface of the head form impactor 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 used for access to the accelerometers and an attachment point for the propulsion system.

5.1.3.9. Preparation of test vehicle
Either a complete vehicle or a cut - body, adjusted to the following conditions, shall be used for the test. All the parts of the vehicle structure and components that may be involved in a pedestrian head impact shall be in place in the test vehicle.
The parking brake shall be applied, or the cut - body shall be securely mounted.
Sufficient time must be allowed before testing for the temperature of all vehicle components to stabilize (see 5.1.2.1.).

5.2. Requirement on child head test method

5.2.1. Performance Requirement
Recording of test results shall be acquired in accordance with ISO 6487.

5.2.1.1. Head form impactor data
The velocity of the head form impactor shall be measured at some point during the free flight before impact, in accordance with the method specified in ISO 3784. The accuracy of velocity measurement shall be ± 0,01m/sec.
The measured velocity shall be adjusted considering all factors that may affect the impactor between the point of measurement and the point of impact to give 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.
The acceleration time histories shall be recorded, and HIC shall be calculated.
The first point of contact on the front structure of the vehicle shall be recorded.

5.2.1.2. Threshold
In child headform to front structure tests, the head injury criterion HIC, calculated from the resultant of the headform accelerometer time histories, in accordance with 3.2.11, shall not exceed [1000].

5.2.2. Test Condition

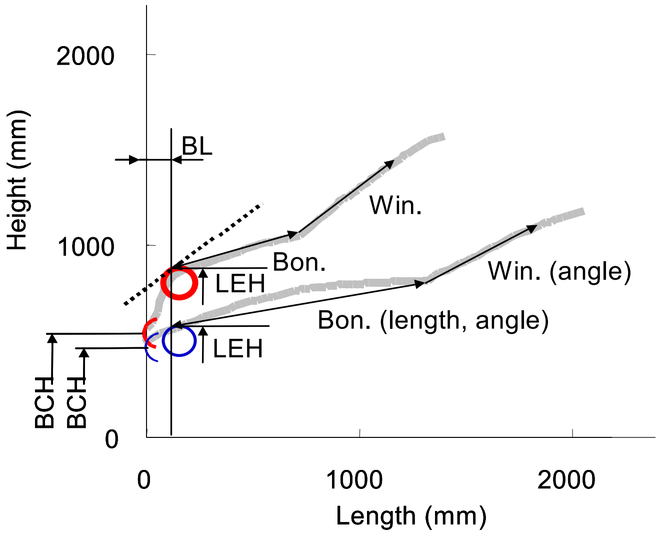
5.2.2.1. Atmospheric conditions
Relative humidity and temperature shall be measured at the time of the test, and recorded in the test report.

5.2.2.2. Impact velocity
The headform velocity at the time of impact shall be 32km/h which stimulates the vehicle impact speed of [40 km/h], the shape category of the vehicle under test and the location of each selected test point. (see Figure 15 and Table 2)

5.2.2.3. Direction of impact
The direction of impact shall be in the fore and aft vertical plane of the section of the vehicle to be tested. The tolerance is ± 2°. The direction of impact of tests to the front structure shall be downward and/or rearward.

5.2.2.4. Angle of impact
The angle of the velocity vector of the head form impactor at impact with respect to horizontal shall be dependent on the vehicle shape and dimensions and the average angles are shown. (see Table 2)

5.2.2.5. Impact points
Tests shall be made to the front structure within the boundaries as defined in section 3.2.3. During all tests of the front structure, up to the bonnet rear reference line, the centre of the head form impactor shall, at the time of first contact, be a minimum of 82.5 mm inside the defined side reference lines (see 3.2.5.) of the sections under test. For tests beyond the bonnet rear reference line, the centre of the head form impactor shall, at the time of first contact, be a minimum of [0,0] mm inside the impact recommend line (see Figure 16).
The points selected for testing shall be indicated in the test report.



Sedan + Light vehicle + Sports type

		Lower	Middle	Upper
BL	(mm)	127	127	127
BCH	(mm)	435	475.5	516
LEH	(mm)	565	702	839
Bon. length	(mm)	1200	917.5	635
Bon. angle	(deg.)	11	14.5	18
Win. angle	(deg.)	29	34.5	40
Bottom depth	(mm)	42	98	154
Bootm hight	(mm)	182	225.5	269

SUV

		Lower	Middle	Upper
BL	(mm)	195	195	195
BCH	(mm)	544	640	736
LEH	(mm)	832	1000	1168
Bon. length	(mm)	1023	933.5	844
Bon. angle	(deg.)	11	9.75	8.5
Win. angle	(deg.)	36	39.5	43
Bottom depth	(mm)	48	123	198
Bootm hight	(mm)	248	348	448

1Box

		Lower	Middle	Upper
BL	(mm)	188	188	188
BCH	(mm)	448	576	704
LEH	(mm)	864	1004	1144
Bon. length	(mm)	361	259	157
Bon. angle	(deg.)	40	40	40
Win. angle	(deg.)	30	38	46
Bottom depth	(mm)	63	95	127
Bootm hight	(mm)	214	292.5	371

Figure 14 : Vehicle shape classification by corridors

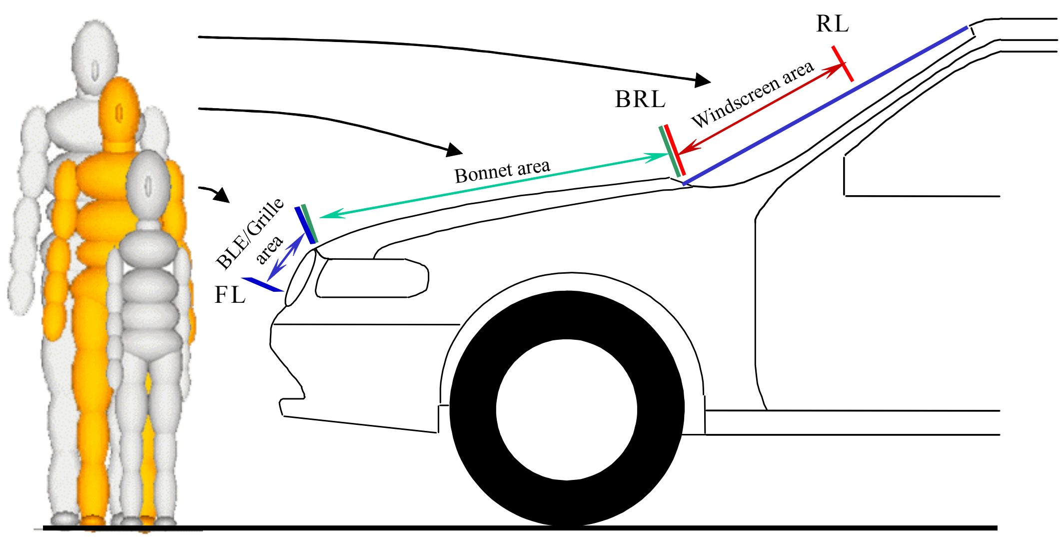


Figure 15: Principles of headform impact test

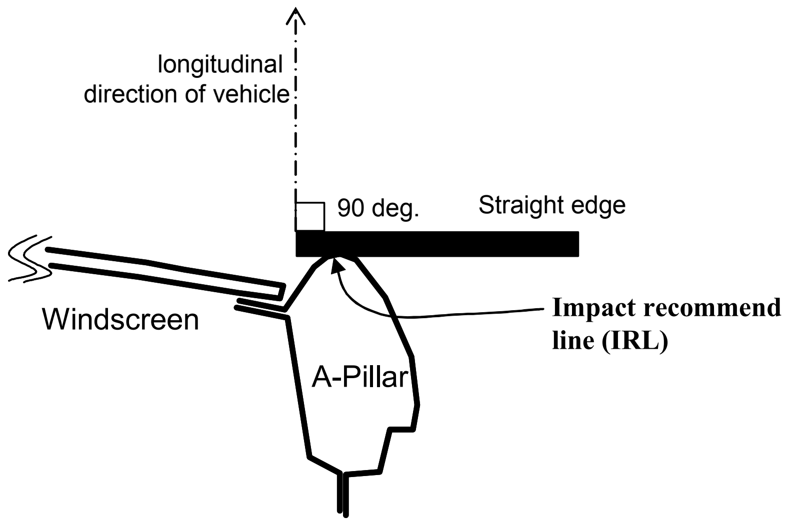


Figure 16: Impact recommend line (IRL) for the A-Pillar

Table 2. Headform test conditions (impact velocity and impact angle)

Shape Corridor	Car impact speed 40km/h					
	Impact Velocity (km/h)			Impact Angle (deg.)		
	Bonnet	Windscreen	BLE/Grille	Bonnet	Windscreen	BLE/Grille
Sedan +	30.0 +/- 4.0	nc	nc	66.0 +/- 6.3	nc	nc
SUV	27.2 +/- 1.6	nc	32.0 +/- 3.6	59.2 +/- 2.6	nc	22.5 +/- 4.2
One box	27.6 +/- 0.8	nc	33.2 +/- 3.2	49.8 +/- 1.8	nc	17.4 +/- 6.1

*nc: No Contact, ** Child Headform Impact Test Conditions
*** Linear interpretation to be used to determine impact conditions for in-between speeds if required.

5.2.3. Test Procedures

5.2.3.1 Impact test site
A flat, smooth and hard surface with a slope not exceeding 1 %.

5.2.3.2. Head form impactor
As described in section 5.2.3.4. and shown in Figure 17.

5.2.3.3. Applicable vehicles
Passenger vehicle and comercial vehicle.

5.2.3.4. Requirements of Head form impactor

5.2.3.4.1. Size and mass

The contact surface of the head form impactor shall be spherical. The diameter is 165±1 mm as shown in Figure 17. 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 with in the rage of 0,0075 to 0,0200 kgm^2 . The centre of gravity of the head form impactor including instrumentation shall be located in the geometric centre of the sphere with a tolerance of ± 2 mm.

5.2.3.4.2. Instrumentation

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.
The instrumentation response value CFC, as defined in ISO 6487: 1987, shall be 1000. The CAC response value, as defined in ISO 6487: 1987, shall be 500 g for the acceleration.

5.2.3.4.3. First natural frequency

First natural frequency of the headform impactor shall be over 5000 Hz.

5.2.3.5. Propulsion of the headform impactor

The headform impactor shall be in 'free flight' at the moment of impact, at the required impact velocity (see section 5.2.2.2.) and the required impact angle (see section 5.2.2.3. and 5.2.2.4.). 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 method of headform propulsion is at the discretion of the test authorities.

5.2.3.6. Certification of the headform impactor

The headform impactor shall meet the performance requirements specified in Annex A. The certified impactor may be used for a maximum of 20 impacts before re-certification. The impactor 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.

5.2.3.7. Temperature and humidity conditions

The stabilised temperature of the headform impactor at the time of impact shall be 20° ± 4° C. A relative humidity should be 10 to 70 percent after a soak period of at least four hour prior to its application in a test.

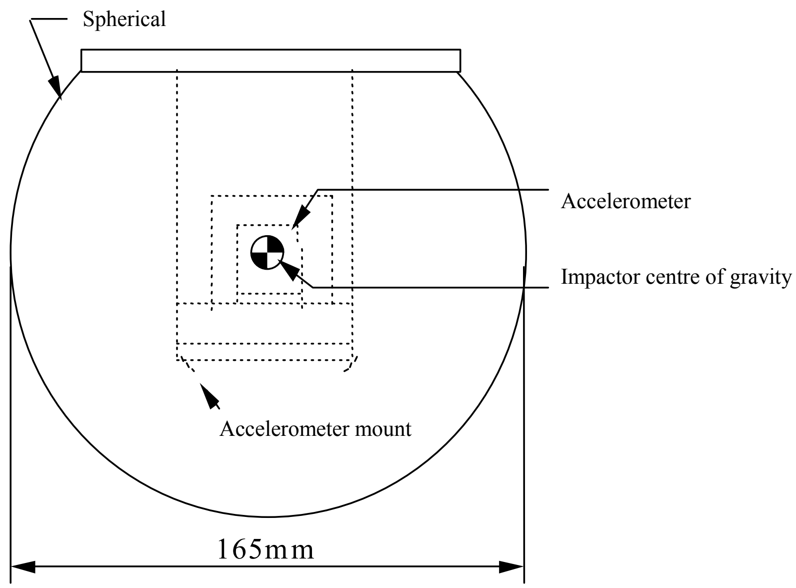


Figure 17: Head form impactor

5.2.3.8. Rear face of head impactor

A plane at the outer surface of the head form impactor 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 used for access to the accelerometers and an attachment point for the propulsion system.

5.2.3.9. Preparation of test vehicle

Either a complete vehicle or a cut - body, adjusted to the following conditions, shall be used for the test. All the parts of the vehicle structure and components that may be involved in a pedestrian head impact shall be in place in the test vehicle.

The parking brake shall be applied, or the cut - body shall be securely mounted.

Sufficient time must be allowed before testing for the temperature of all vehicle components to stabilize (see section 5.2.2.1.).

5.3. Requirement on adult leg test method

5.3.1. Performance Requirement

5.3.1.1. Measurement requirements for leg form impactor

Data shall be acquired in accordance with ISO 6487.

5.3.1.2. Leg form impactor data

Leg form impactor data shall be recorded in accordance with table 3

Table 3

Measurements Items #1	Location	Direction	CAC #2	CFC (Hz) #3
(1) Valgus angle	Knee joint center	y	40 degree	180
(2) Bending angle	Knee joint center	y	1000 Nm	180
(3) Shearing displacement	Knee joint center	y	20 mm	180
(4) Shearing force	Knee joint center	y	10kN	180
(5) Ligament Elongation	ACL, PCL, MCL (and LCL)	x-z	25 mm	180
(6) Contact force	Area of first contact	x	10 kN	180
(7) Contact acceleration	Area of first contact	x	40 kN	180
(8) Strain	Several points on the long bone	x-z	1.5 % strain	180
(9) Contact force	Knee joint surface (Lateral and Medial)	z	5 kN	180

Foot notes:
#1 Either (1) or (2) or (5) can be measured.
Either (3) or (4) or (5) can be measured.
Either (6) or (7) or (8) can be measured.
#2 Electrical instrumentation measurement, channel Amplitude Class
#3 Channel Filter Class

5.3.1.3. Threshold

In legform to bumper tests at impact speed of [ ] Km/h, the maximum dynamic knee bending angle shall not exceed [ ] degree or the maximum bending moment shall not exceed [ ] Nm, the maximum dynamic knee shearing displacement shall not exceed [ ] mm or the maximum shearing force shall not exceed [ ] kN, or ligament elongation shall not exceed, ACL [ ] mm, PCL [ ] mm, MCL [ ]mm, LCL [ ] mm, and the maximum contact force measured at the upper end of the tibia (leg) shall not exceed [ ] kN or the maximum contact acceleration measured at the upper end of the tibia (leg) shall not exceed [ ] m/s^2, or strains on the long bone shall not exceed [ ] % strain, and contact force on the knee joint surface shall not exceed [ ] kN for lateral and medial side.

5.3.1.4. Test specimen

The points tested shall be indicated in the test report.
(Annexes: 5 Biofidelic performance characteristics
6 Biofidelic performance characteristics for Thigh, Leg, and Knee joint)

5.3.2. Test Conditions

5.3.2.1. Atmospheric conditions

Relative humidity, atmospheric pressure, and temperature shall be measured at the time of the test, and recorded in the test report.

5.3.2.2. Angle of impact

The direction of impact shall be parallel to the longitudinal vertical plane of the vehicle, with the axis of the leg form vertical at the time of first contact (5.3.3.7.). The tolerance of the velocity vector of the impactor is ± 2°.

5.3.2.1. Impact point

Tests shall be made to the front face of the vehicle between the corners, as defined in 3.3.5.. The center of each impact shall be a minimum of 60 mm inside the defined corners of the front face. Sufficient test points shall be selected to evaluate the vehicle structure. Test points on a single vehicle front face shall be separated by sufficient distance to preclude influence of preexisting damage on subsequent impacts.

5.3.2.2. Impact velocity

The velocity at the time of impact shall be cover up to [50] Km/h

5.3.2.3. Velocity measurement

The velocity of the leg form impactor shall be measured at some point during the free flight before impact. The accuracy of velocity measurement shall be ± 0,1m/s.

5.3.3 Test Procedures

5.3.3.1. Impact test site

A flat, smooth and hard surface with a slope not exceeding 1% under the test vehicle as illustrated in Figure 19.

5.3.3.2. Leg form impactor

A device sensitive to the front face characteristics of the vehicle, with a knee joint in accordance with the model described in section 5.3.3.5.1. shown Figure 18.

5.3.3.3. Propulsion system

The leg form impactor shall be propelled by a propulsion system as defined in section 5.3.3.6..

5.3.3.4. Applicable vehicles

All Passenger vehicles specified in the definition of the category under 1998 Agreement.

5.3.3.5. Requirements of Leg form impactor

5.3.3.5.1.Physical properties

Dimensions (Figure 18) and mass distribution of the leg form impactor are based on a 50^{th} percentile male[1)].

a) leg length between the bottom and the knee joint center :493 ± 5 mm;
(In this leg form impactor, leg means tibia.)
b) thigh length between the knee joint center and the top : 428 ± 5 mm;
c) center of gravity of leg from the knee joint center : 233 ± 10 mm;
d) center of gravity of thigh from the knee joint center : 218 ± 10 mm;
e) total leg form impactor mass : 13,4 ± 0,1 kg;
f) thigh mass including skin and foam : 8,6 ± 0,1 kg;
g) leg mass including skin and foam : 4,8 ± 0,1 kg;
h) moment of inertia around y axis of leg : 0,120 ± 0,001 kg m^2;
i) moment of inertia around y axis of thigh : 0,127 ± 0,001 kg m^2;
j) an adapter can be fitted to the top of the thigh to permit the attachment of the leg form impactor to the propulsion system. If an adapter is used the thigh with adapter must still comply with the thigh requirement of mass, center of gravity, and moment of inertia.
k) there shall be a flesh and/or skin on the outer surface of the leg form impactor . This material shall be human like.

[1)] Robbins, D.H. ' Anthropometry of Motor Vehicle Occupants, Volume 2' NHTSA Contract DTNH22-80-C-07502 Pub. 1985

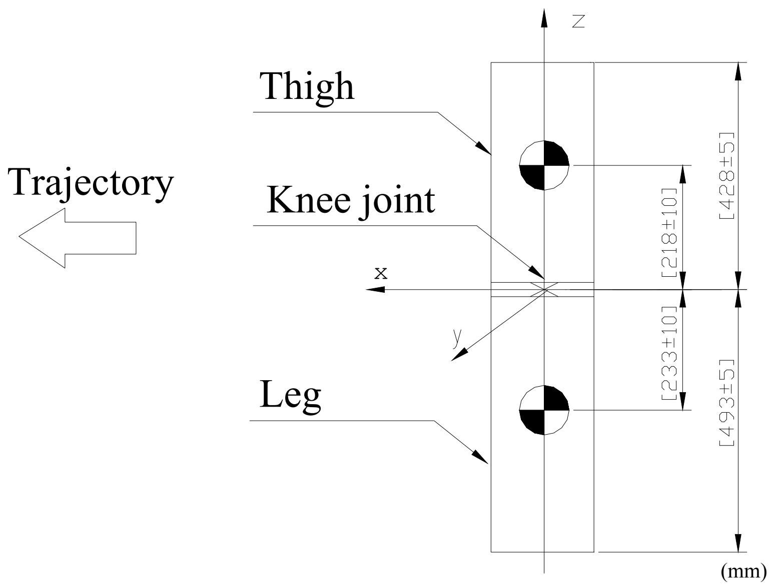


Figure 18
Leg Form Impactor

5.3.3.5.2.Shape of leg form impactor

The shape of the leg form impactor shall be cylindrical. The outer diameter of the thigh and leg shall be the same. Outer diameter is 120 ± 10 mm including flesh thickness of 30 ± 5 mm.

5.3.3.5.3.Biofidelic performance characteristics

The leg form impactor shall meet the biofidelity performance targets specified in Annex 5.

5.3.3.5.4.Certification of leg form impactor

The leg form impactor shall meet the certification requirements as outlined in Annex 6.

5.3.3.5.5.Calibration of leg form impactor deformable elements

Once the structural design of the deformable knee element, which meets the requirements, specified in sections 5.3.3.5.3. and 5.3.3.5.4. is completed, the designer of the leg form impactor shall provide a calibration test procedure in which each batch of deformable knee elements shall be checked to see if their performance is acceptable. Such calibration test procedure can be applied statically if this test proves that the characteristics of the batch are similar with those of the original design. The response adopted as a requirement for a calibration test should allow for reasonable variation in production.

5.3.3.6. Propulsion of leg form impactor

The leg form impactor shall be propelled in free flight into the stationary test vehicle. The method of leg form impactor propulsion is at the discretion of the test office; however, the knee joint should be supported during leg form impactor acceleration. The trajectory of the leg form impactor shall be parallel to the ground within ±6° at impact with the vehicle, and its angular velocity at this time shall be less than 50° /sec. Because of the effect of gravity and depending on the length of free flight, this may require that the trajectory of the leg form impactor at the time of its release from the propulsion system be at an angle above horizontal. There shall be no contact between the leg form impactor and the propulsion system during impact with the vehicle.

5.3.3.7. Leg form impactor setting

The leg form impactor (5.3.3.2.) shall be straight, and vertical in pitch and roll at the time of impact (see Figure 19). The tolerances for pitch, roll, and yaw are ± 5°.

The lower end of the leg form impactor shall be at or within 10 mm of the level of the ground reference plane at impact with the vehicle. The leg form impactor shall not contact the ground during the impact as illustrated in Figure 19.

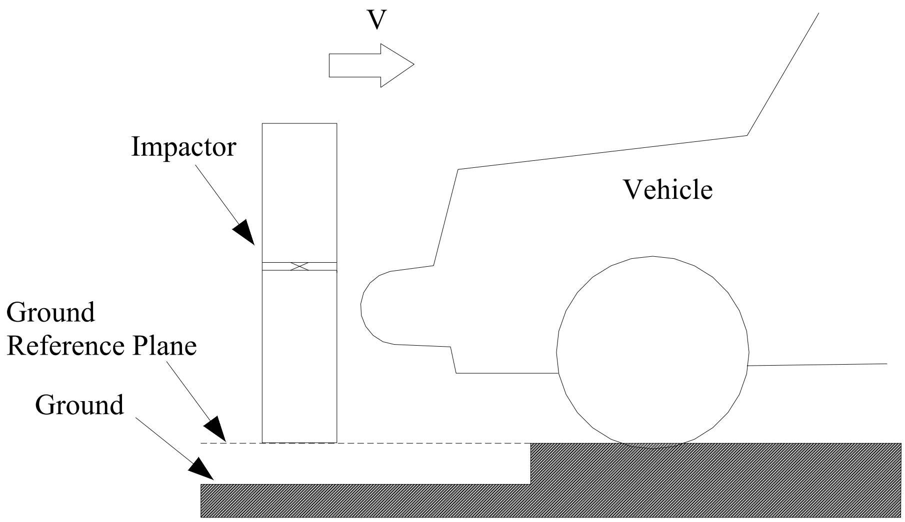


Figure 19
Configuration of the ISO Pedestrian Leg Form
Impact Test Procedure

5.3.3.8. Test temperature

The leg form impactor shall have a temperature of 20 ± 5 °C at the time of impact. However, a narrower range may be required to keep the performance of the leg form impactor within the specified limits.

5.3.3.9. Preparation of test vehicle

Either a complete vehicle or cut - body, shall be used for the test. All parts of the vehicle structure and components that may be involved in a pedestrian leg impact shall be in place.

The ground clearance of the test vehicle or cut-body shall be set to simulate that of an actual vehicle with tyres inflated to the nominal tyre pressure specified by the manufacturer. Spacers may be placed under the tyres in order to bring the vehicle to a height that will allow the free flight of the leg form impactor.

Note: Testing with or without a license plate is at the discretion of the test laboratory or the government body. Material and size of the license plate may be standardized during

a given test program when the vehicle is tested with a license plate.
For tests of a complete vehicle, the suspension shall be set to the normal ride height attained at the test impact velocity (specified in the relevant laws and regulations or by the concerned government agencies) and shall include the complete vehicle curb mass, ISO MO6, as defined in ISO 1176:1990, definition 4.6, with one adult male 50th percentile dummy or an equivalent mass placed on the driver's seat , and with one adult male 50th percentile dummy or an equivalent mass placed on the passenger's seat ,
For test of a cut-body, the height of the body above the ground reference plane shall be the same as the complete vehicle loaded as specified in section 5.3.3.9.
The parking brake shall be applied, or the cut - body shall be securely mounted.
Sufficient time must be allowed before testing for the temperature of all vehicle components to stabilize (see 5.3.2.1.).

5.4. Labeling
To be developed

6. Annex (applicable to the 1958 Agreement)

6.1. Conformity of production
To be developed

Annex 1

Japanese draft regulation of Pedestrian Safety

1. Scope of vehicles
   - Passenger cars having no more than 10 seats
   - Trucks having a GVW not exceeding 2,500kg and a similar front shape as the passenger cars above mentioned

2. Effective Date
   - Vehicles except for vehicles defined in the next indent
   □New-type vehicles: September 2005
   □Continuously-manufactured vehicles: September 2010
   - Low height vehicles, Vehicles requiring high endurance, such as SUVs and trucks, Full cab over vehicles, Hybrid-engine vehicles
   □New-type vehicles: September 2007
   □Continuously-manufactured vehicles: September 2012

3. Test Procedure

3-1. Test area
The child and adult head impactor test will be considered for the regulation.
Test area for child head impactor: 1,000mm ≤ WAD ≤ 1,700mm
Test area for adult head impactor: 1,700mm ≤ WAD ≤ 2,100mm
Note: WAD (Wrap-Around Distance) means the distance from the ground to the point on the bonnet along the vehicle front structure.

3-2. Impactor (See Appendix 3)
Child head impactor: Diameter 165mm, weight 3.5kg
Adult head impactor: Diameter 165mm, weight 4.5kg

3-3. Impact speed and angle

	Child head impactor		Adult head impactor	
	Speed (km/h)	Angle (deg)	Speed (km/h)	Angle (deg)
Category 1	32	65	32	65
Category 2	32	60	32	90
Category 3	32	25	32	50

(Above head impact conditions were estimated from the IHRA car-pedestrian 40 km/h impact computer simulation results)

	Definition	Note
Category 1	Vehicle having a BLE height of less than 835mm	Sedan type
Category 2	Vehicle having a BLE height of not less than 835mm	SUV type
Category 3	Vehicle having a bonnet angle of not less than 30 deg.	1 Box type

Note: BLE height: Bonnet Leading Edge height

3-4. Criteria

HIC (Head Injury Criteria), defined by the following formula, should not exceed 1,000 on two-thirds or more of the test area. On the remaining area, HIC should not exceed 2,000.

In appendix 1 of the regulation the Draft test procedure is illustrated, in Appendix 2 the test area is specified as well as the bonnet leading edge reference line, in Appendix 3 the specifications and certification test of head form impactors are outlined.
Japan has already indicated that a next step will include requirements for the lower leg. In order to achieve this, Japan will use the content of the gtr as its next step in legislation.
For more details see INF GR/PS/33.

Annex 2

European Union NA Phaze I

The proposed measures apply to passenger cars and car-derived vans (category M1, of a total permissible mass not exceeding 2.5 tonnes, and N1 derived from M1, of a total permissible mass not exceeding 2.5 tonnes).

As the construction of passenger cars is covered by Community legislation under the EC whole vehicle type approval system set up by Directive 70/156/EEC, as amended, the proposed requirements will also be incorporated into this system.

The technical provisions are described in Appendix 1 of the proposal. The proposed basic requirements will be tested according to detailed prescriptions which will be set out in a Commission decision.

In a first phase, starting in 2005, new types of vehicles must comply with two tests concerning protection against head injuries and leg injuries:

 Legform to Bumper: One of the two following legform tests are required to be performed:

- Lower legform to bumper: The test is performed at an impact speed of 40km/h. The maximum dynamic knee bending angle shall not exceed 21.0°, the maximum dynamic knee shearing displacement shall not exceed 6.0mm, and the acceleration measured at the upper end of the tibia shall not exceed 200g
- Upper legform to bumper: The test is performed at an impact speed of 40km/h. The instantaneous sum of the impact forces with respect to time shall not exceed 7.5kN and the bending moment on the upper legform impactor shall not exceed 510Nm.

Child/Small Adult headform to bonnet top: The test is performed at an impact speed of 35 km/h using a 3.5 kg headform impactor with a diameter of 165 mm. The Head Performance Criterion (HPC) shall not exceed 1000 over 2/3 of the bonnet test area and 2000 for the remaining 1/3 of the bonnet test area.

In Phase 1 the following tests are required for monitoring purposes only:

Upper legform to bonnet leading edge: The test is performed at an impact speed up to 40 km/h. The instantaneous sum of the impact forces with respect to time should not exceed a possible target of 5.0 kN and the bending moment on the upper legform impactor shall be recorded and compared with the possible target of 300 Nm.

Adult headform to windscreen: The test is performed at an impact speed of 35 km/h using a 4.8 kg headform impactor. The Head Performance Criterion (HPC) shall be recorded and compared with the possible target of 1000.

In a second phase, starting in 2010, four tests of increased severity according to the recommendations by EEVC will be required for new types of vehicles, two tests concerning head injuries and two concerning leg injuries. Within five years all new vehicles will have to comply with these test requirements.

Legform to Bumper:

One of the two following legform tests are required to be performed:

- Lower legform to bumper: The test is performed at an impact speed of 40km/h. The maximum dynamic knee bending angle shall not exceed 15.0°, the maximum dynamic knee shearing displacement shall not exceed 6.0mm, and the acceleration measured at the upper end of the tibia shall not exceed 150g.

- Upper legform to bumper: The test is performed at an impact speed of 40 km/h. The instantaneous sum of the impact forces with respect to time shall not exceed 5.0kN and the bending moment on the upper legform impactor shall not exceed 300Nm.

Child headform to bonnet top: The test is performed at an impact speed of 40km/h using a 2.5kg headform impactor with a diameter of 130 mm. The Head Performance Criterion (HPC) shall not exceed 1000 for the whole of the bonnet test area.

Adult headform to bonnet top: The test performed at an impact speed of 40km/h using a 4.8kg headform impactor with a diameter of 165 mm. The Head Performance Criterion (HPC) shall not exceed 1000 for the whole bonnet test area.

Upper legform to bonnet leading edge: The test is performed at an impact speed up to 40km/h. The instantaneous sum of the impact forces with respect to time shall not exceed 5.0kN and the bending moment on the upper legform impactor shall not exceed 300Nm.

Pedestrian protection objectives can be achieved by active or passive safety measures. Considering the speed of technological development in this area, this proposal foresees that alternative measures to the requirements laid down in the proposal might be developed. A feasibility assessment will therefore be carried out by 1 July 2004 concerning the proposed technical test provisions and in particular other measures which potentially may have at least equal protective effects to those proposed. Should the feasibility assessment show that these alternative measures have at least equal protective effects the Commission shall consider relevant proposals to amend this Directive.

Concerning the withdrawal of rigid bull bars, following the views expressed by the Council and the European Parliament, suggesting that a legislative approach would cover not only the original equipment manufacturers but also the independent after-market, the Commission intends to propose a Directive containing a test procedure for all bull-bars and similar devices placed on the market.

For more details see INF GR/PS/34.

Annex: 3

Certification procedure for adult head form impactor

A1 Drop test

A1.1 Performance Criteria

The head form impactor shall meet the requirements specified in section 2 when tested as specified in section 3.

A1.2. Requirements

A1.2.1 When the head form impactor is dropped from a height of 376 ± 1 mm in accordance with section 3 the peak resultant acceleration measured by one triaxial (or three uniaxial) accelerometer (accelerometers) in the head form impactor shall be not less than 225 g and not more than 275 g. The acceleration time curve shall be unimodal.

A1.2.2 The instrumentation response values CFC and CAC for the accelerometer shall be 1000 Hz and 500 g respectively as defined in ISO 6487: 1987.

A1.2.3 Temperature conditions

The head form impactor shall have a temperature of 20 ± 2°C at the time of impact. The temperature tolerances at a relative humidity of 10 to 70 percent after a soak period of at least four hour prior to its application in a test.

A1.3. Test Procedure

A1.3.1 The head form impactor shall be suspended from a drop rig as shown in Figure A1 .

A1.3.2 The head form 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 mm square which has a clean dry surface and a surface finish of between 0,2 and 2,0 micrometers.

A1.3.3 The head form impactor shall be dropped with the rear face of the impactor at the test angle chosen in 7.4 with respect to the vertical as specified in Figure A1. The suspension of the head form impactor shall be such that the head form impactor does not rotate during the fall .

A1.3.4 The drop test shall be performed three times, with the head form impactor rotated 120° around its symmetrical axis after each test.

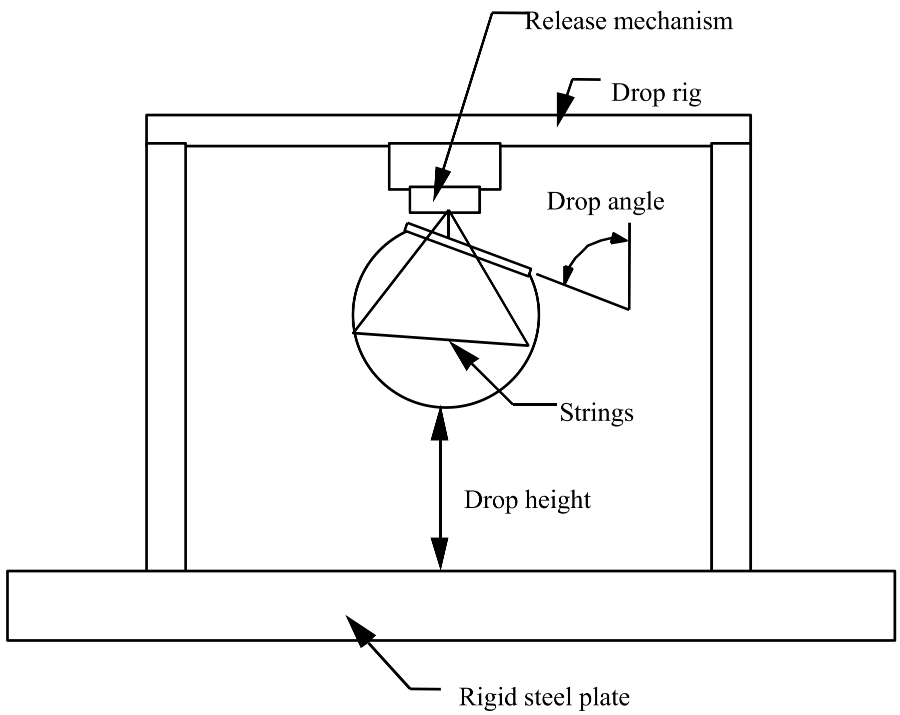


Figure A1: Test set-up for dynamic head form impactor biofidelity test

NOTES:

Does not require a lateral headform certification test in the IHRA headform certification test procedure because of following reasons,

1) Skin deformation speed in the lateral headform certification test is quite high comparing to the skin deformation speed in the vehicle headform test.

2) First natural frequency of the headform impactor is regulated as over 5000 Hz therefore resonance problem is already solved.

Annex: 4

Certification procedure for child head form impactor

A1 Drop test

A1.1 Performance Criteria

The head form impactor shall meet the requirements specified in section 2 when tested as specified in section 3.

A1.2. Requirements

A1.2.1 When the head form impactor is dropped from a height of 376 ± 1 mm in accordance with section 3 the peak resultant acceleration measured by one triaxial (or three uniaxial) accelerometer (accelerometers) in the head form impactor shall be not less than 245 g and not more than 300 g. The acceleration time curve shall be uni-modal.

A1.2.2 The instrumentation response values CFC and CAC for the accelerometer shall be 1000 Hz and 500 g respectively as defined in ISO 6487: 1987.

A1.2.3 Temperature conditions

The head form impactor shall have a temperature of 20 ± 2°C at the time of impact. The temperature tolerances at a relative humidity of 10 to 70 percent after a soak period of at least four hour prior to its application in a test.

A1.3. Test Procedure

A1.3.1 The head form impactor shall be suspended from a drop rig as shown in Figure A1.

A1.3.2 The head form 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 mm square which has a clean dry surface and a surface finish of between 0,2 and 2,0 micrometers.

A1.3.3 The head form impactor shall be dropped with the rear face of the impactor at the test angle chosen in 7.4 with respect to the vertical as specified in Figure A1. The suspension of the head form impactor shall be such that the head form impactor does not rotate during the fall.

A1.3.4 The drop test shall be performed three times, with the head form impactor rotated 120° around its symmetrical axis after each test.

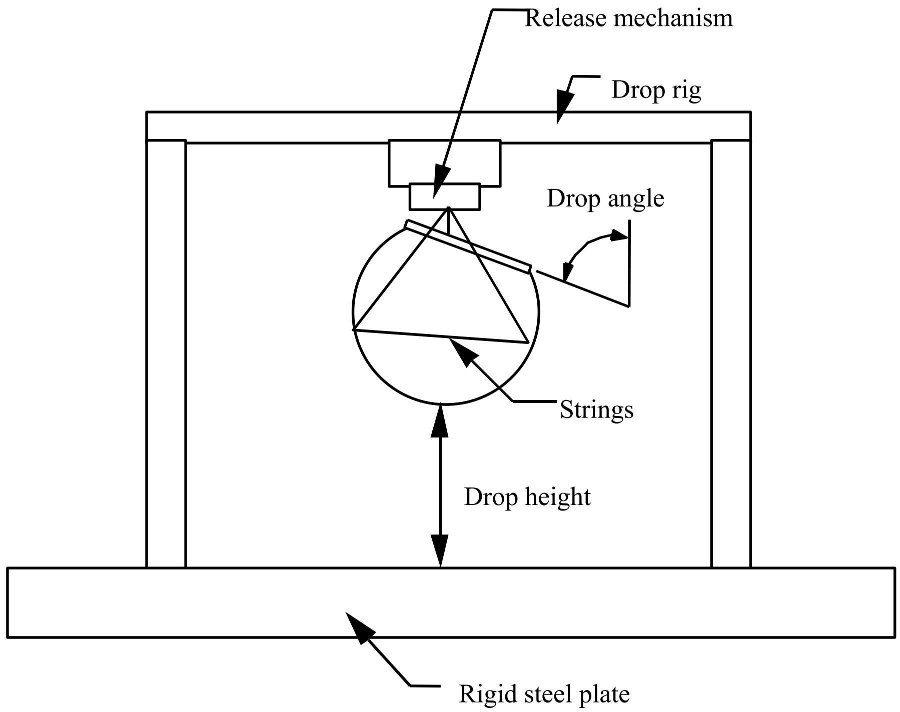


Figure A1: Test set-up for dynamic head form impactor biofidelity test

NOTE:

Does not require a lateral headform certification test in the IHRA headform certification test procedure because of following reasons,

1) Skin deformation speed in the lateral headform certification test is quite high comparing to the skin deformation speed in the vehicle headform test.

2) First natural frequency of the headform impactor is regulated as over 5000 Hz therefore resonance problem is already solved.

Annex: 5

Biofidelic performance characteristics the leg form impactor

1. Introduction

In this annex, biofidelic performance characteristics of the leg form impactor are shown including test set-ups.

2. Test set-up

Individual test set-up is designed to obtain both bending moment and shearing force.

2.1. Specification for bending test (see Figure A-1)

Pre-loading mass, F	: 40kg
Loading device and support face	: 50mm x 150mm
Padding block	: 50mm x 50mm x 150mm (for impactor)
	: 25mm x 50mm x 150mm (for support)
Dimensions	: D = 904mm , d1 = 74mm , d2 = 400mm
Measurements	: Loading device acceleration (CFC 180)
	: Loading device force (CFC 180)
	: Loading device velocity at time of impact
	: Medial support load (CFC 180)

2.2. Specification for shearing test (see Figure A-2)

Pre-loading mass, F	: 40kg
Loading device and support face	: 50mm x 150mm
Padding block	: 50mm x 50mm x 150mm (for impactor)
	: 25mm x 50mm x 150mm (for support)
Dimensions	: D = 874mm , d1 = 45mm , d2 = 45mm, d3 = 103mm
Measurements	: Loading device acceleration (CFC 180)
	: Loading device force (CFC 180)
	: Loading device velocity at time of impact
	: Medial support load (CFC 180)

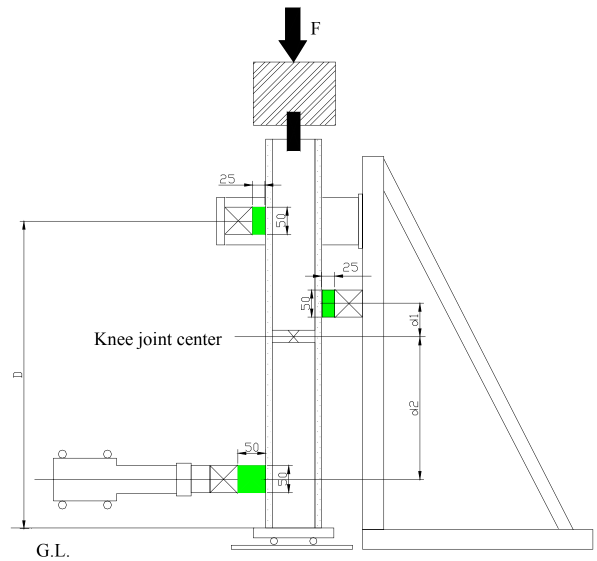


Figure A-1

Test set-up: Dynamic bending moment

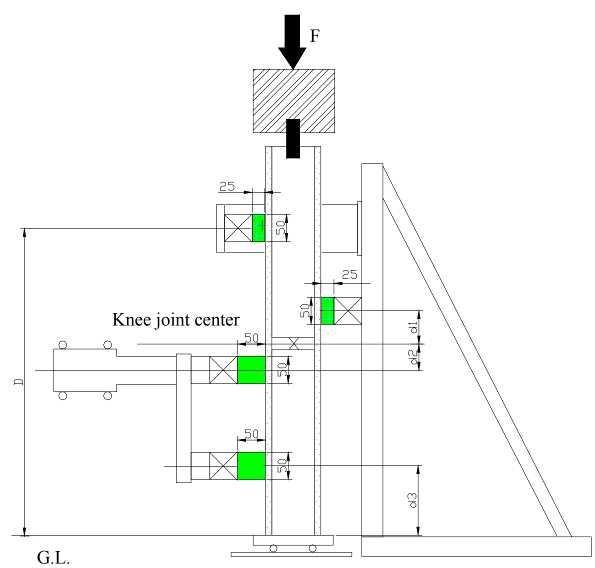
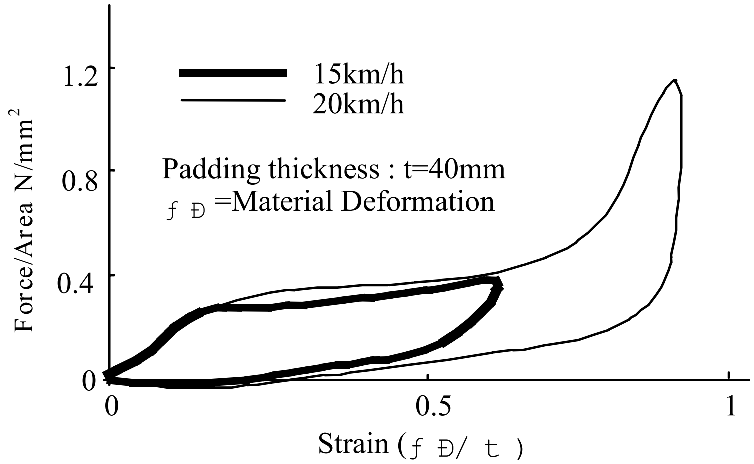


Figure A-2

Test set-up: Dynamic shearing force

2.3. Padding dynamic characteristics

The dynamic characteristics of the Styrodur padding used in this test is shown in Figure A-3. This is based on compression between two flat plates.



Annex: 6

Biofidelic performance characteristics for Thigh, Leg, and Knee joint

1. Introduction

In this annex, biofidelic performance characteristics of the leg form impactor are shown including test set-ups.

2. Test set-up

Individual test set-up is designed to validate the thigh, leg, and knee joint individually.

2.1. Specification for dynamic thigh 3 point bending test (see Figure B-1)

Ram mass, M : [67.8] kg

Initial Impact Speed, V_0 : [1.0]m/s

Round Support : Radius [75]mm

Support Length : [360]mm

Measurements : Ram acceleration (CFC 180)

: Deflection of Thigh (CFC 180)

: Support load (CFC 180)

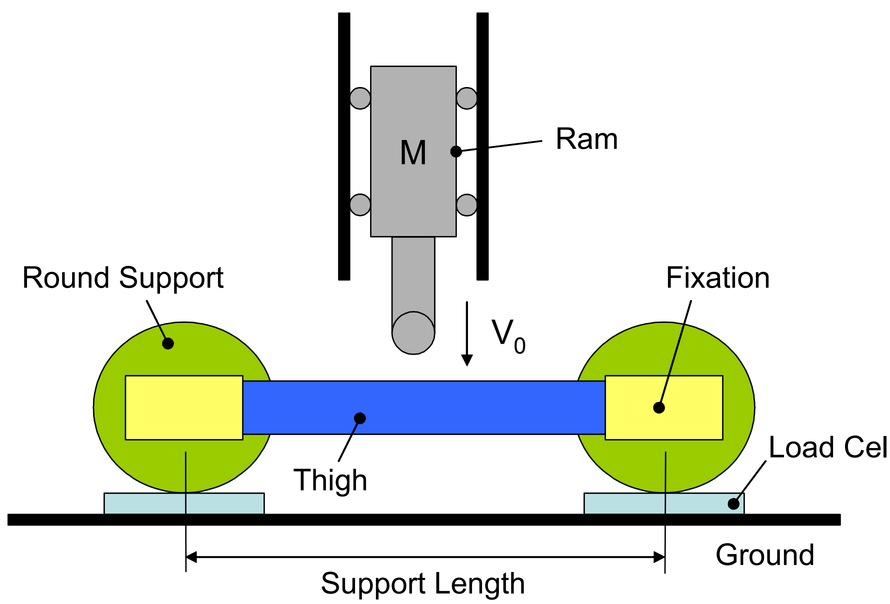


Figure B-1 Dynamic thigh 3-point bending test set up

2.2. Specification for dynamic leg 3 point bending test (see Figure B-2)

Ram mass, M	: [67.8] kg
Initial Impact Speed, V_0	: [1.0]m/s
Round Support	: Radius [75]mm
Support Length	: [320]mm
Measurements	: Ram acceleration (CFC 180)
	: Deflection of Thigh (CFC 180)
	: Support load (CFC 180)

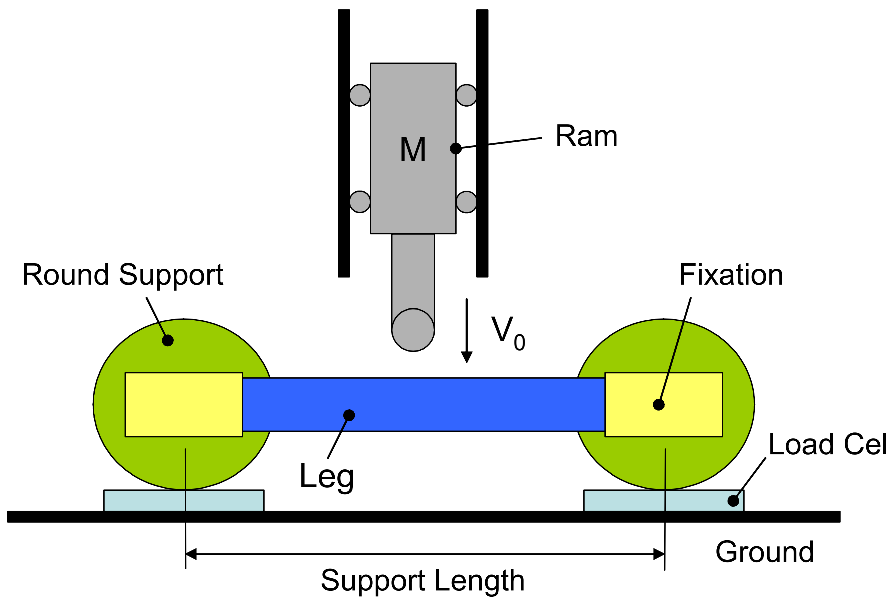


Figure B-2 Dynamic leg 3-point bending test set up

2.3 Specification for dynamic knee joint 4 point bending test (see Figure B-3)

Ram mass, M	: [74.5] kg
Initial Impact Speed, V_0	: [1.4]m/s
Round Support	: Radius [75]mm
Fork Length	: [360]mm
Support Length	: [550]mm
Measurements	: Ram acceleration (CFC 180)
	: Knee joint angle (CFC 180)
	: Moment on the knee joint(CFC 180)

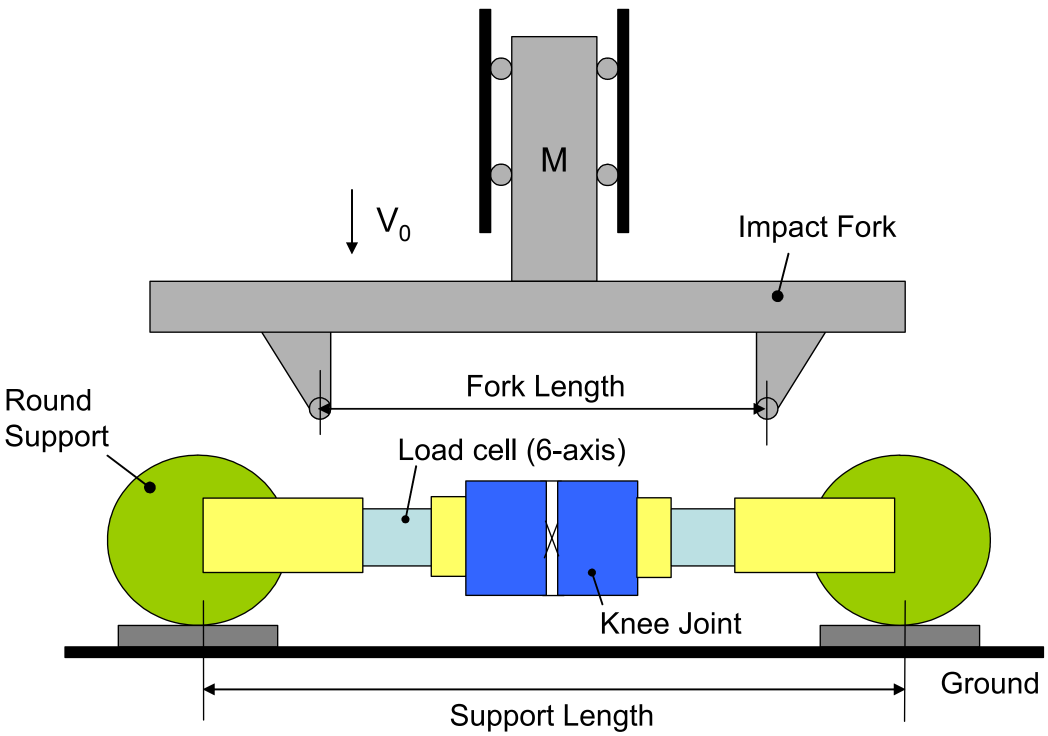


Figure B-3 Dynamic knee joint 4-point bending test set up

3. Requirement

Individual requirement is designed to validate the thigh, leg, and knee joint individually.

3.1. Requirement for dynamic thigh 3 point bending test (see Figure B-4)

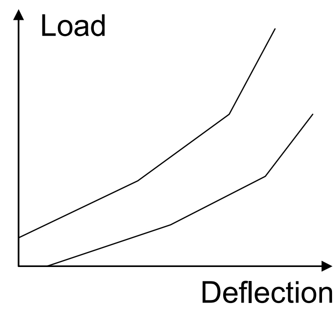


Figure B-4 Dynamic thigh 3 point bending test corridor

3.2 Requirement for dynamic leg 3 point bending test (see Figure B-5)

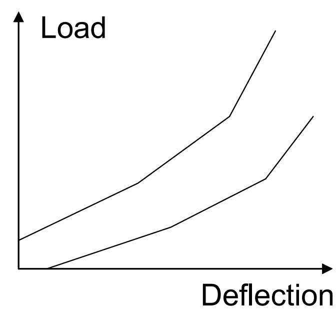


Figure B-5 Dynamic leg 3 point bending test corridor

3.3. Requirement for dynamic knee joint 4 point bending test (see Figure B-6)

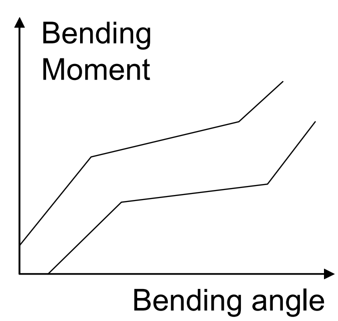


Figure B-6 Dynamic knee joint 4 point bending test corridor