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Road vehicles — Pedestrian protection — Child head impact test method

Véhicules routiers — Protection des piétons — Méthode d'essai de choc de la tête d'un enfant

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 16850 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 10, *Impact test procedures*.

Introduction

The intent of this International Standard is to help reduce pedestrian head injuries by providing a standardized test method which will allow different test organizations to use the results from pedestrian impact tests conducted by other organizations.

The test method specified applies to children.

Road vehicles — Pedestrian protection — Child head impact test method

1 Scope

This International Standard specifies a test method to simulate the child impact of a child pedestrian to the bonnet of passenger vehicles or some light truck vehicles, as defined in ISO 3833.

The purpose of this test method is to simulate frontal impact of a vehicle, laterally to a pedestrian.

The impact device to be used in this test method will be robust for a vehicle impact velocity of up to 11 m/s.

While the test method specified addresses the reduction of a child pedestrian head injury risk, it does not test for injuries to other regions of the pedestrian. The evaluation of injury risk to other pedestrian body regions is determined using other test methods.

This test method does not consider downward pitching of the vehicle due to pre impact braking.

This test method and the corresponding HIC measurement utilize a free flight head form impactor, and does not consider the kinematics of the pedestrian body as a whole, nor does it consider the subsequent post-impact kinematics and potential injury risk.

NOTE The test method covers a child pedestrian's head in a simulated impact with a motorized road vehicle. Research suggests that safety improvements in vehicles derived from such pedestrian impact tests may be beneficial also to bicyclists in vehicle front impact.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 3784, *Road vehicles — Measurement of impact velocity in collision tests*

ISO 3833, *Road vehicles — Types — Terms and definitions*

ISO 6487, *Road vehicles — Measurement techniques in impact tests — Instrumentation*

3 Terms and definitions

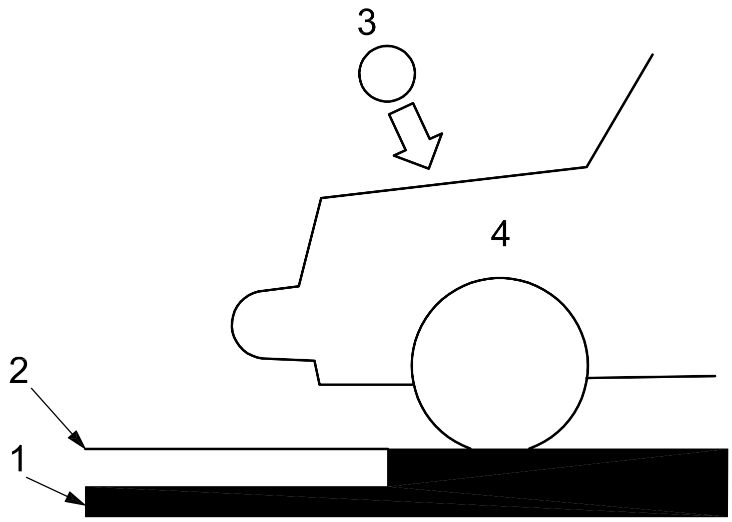
For the purposes of this document, the following terms and definitions apply.

3.1
normal ride attitude
vehicle attitude in driving order positioned on the ground, with the tyres 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 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
ground reference plane
horizontal plane, either real or imaginary, that passes through all tyre contact points of a vehicle while the vehicle is in its normal ride attitude (see Figure 1)

NOTE 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.



Key

1 ground
2 ground reference plane
3 impactor
4 vehicle

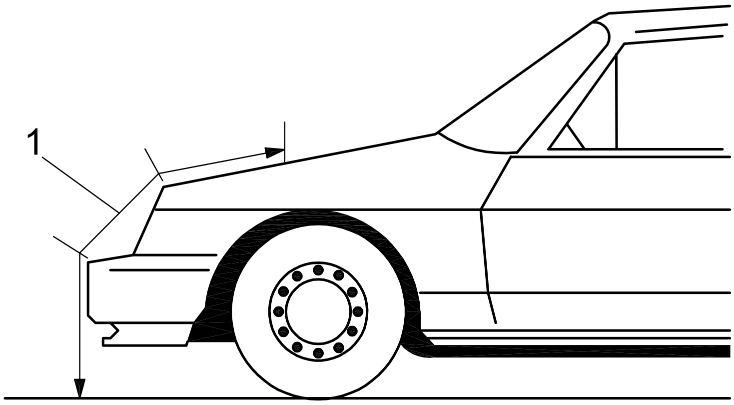
Figure 1 — Configuration of ISO head impact test method

3.3
bonnet top
outer structure that includes the upper surfaces of the bonnet and of the wings (outer fenders), the scuttle (cowl top) and the lower edge of the windscreen

3.4
wrap around distance
WAD
geometric trace described on the top of the bonnet by one end of a long flexible tape, the other end held in contact with the ground reference plane when it is held in a vertical fore and aft plane of the vehicle and traversed across the front of the bonnet and bumper of the vehicle when it is in the normal ride attitude (see Figure 2)

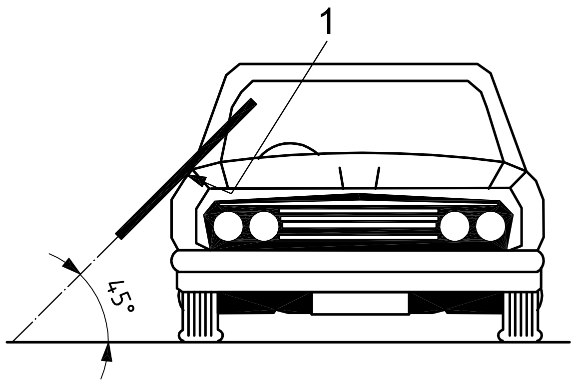
NOTE The tape is held taught throughout the operation with one end held in contact with the ground reference plane, vertically below the front face of the bumper and the other end held in contact with the bonnet top. The length of the tape is the same as values of wrap around distance required in 5.2.

3.5
bonnet side reference line
BSRL
geometric trace of the highest points of contact between a straight edge and the side of a bonnet, when the straight edge, held parallel to the lateral vertical plane of the vehicle and inclined inwards 45° is traversed down the side of the bonnet, while maintaining contact with the surface of the body shell (see Figure 3)



Key
1 wrap around distance

Figure 2 — Determination of wrap around distance



Key
1 bonnet side reference line

Figure 3 — Determination of bonnet side reference line

3.6
head injury criterion
HIC
calculated value describing the injury risk to pedestrian head colliding with a vehicle, and calculated from the head resultant acceleration time history

3.7
bonnet rear reference line
BRRL
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

4 Test equipment

4.1 Impact test site

The test shall be conducted on a flat, smooth and hard surface with a slope not exceeding 1 %.

4.2 Head form impactor

The head form impactor described in 5.1 shall be used in this test method.

5 Requirements

5.1 Head form impactor

5.1.1 Size and mass

The contact surface of the head form impactor shall be spherical. The diameter shall be 165 mm with a tolerance of ± 1 mm as shown in Figure 4. This diameter includes the thickness of any flesh if needed in the design. The mass shall be (3,5 ± 0,07) kg. The centre of gravity of the head form impactor shall be located in the geometric centre of the sphere with a tolerance of ± 5 mm. The moment of inertia shall be in the range of 0,007 5 kgm^2 to 0,020 0 kgm^2.

NOTE The mass of the headform is that of the 6-year-old child which is defined in the paper referenced in the Bibliography [3].

5.1.2 Instrumentation

One triaxial (or three uniaxial) accelerometers for head form impactor shall be attached in the recess at the centre of the head form impactor. Tolerances of the accelerometers from the geometric centre of the spherical surface shall be ± 10 mm in the direction of impact, and ± 1 mm in the direction perpendicular to the impact.

The instrumentation response values CFC and CAC for the accelerometers shall be 1 000 Hz and 500 g respectively as defined in ISO 6487.

5.2 Impact area

The bonnet top shall be bounded by the geometric trace of the 1 000 mm wrap around distance in the front, as defined in 3.4, and the bonnet side reference lines, as defined in 3.5, in which the angle of the straight edge inclined inwards shall be 45° and rear boundary shall be the wrap around distance of 1 700 mm or the BRRL as defined in 3.7.

5.3 Impact angle for child head form impactor

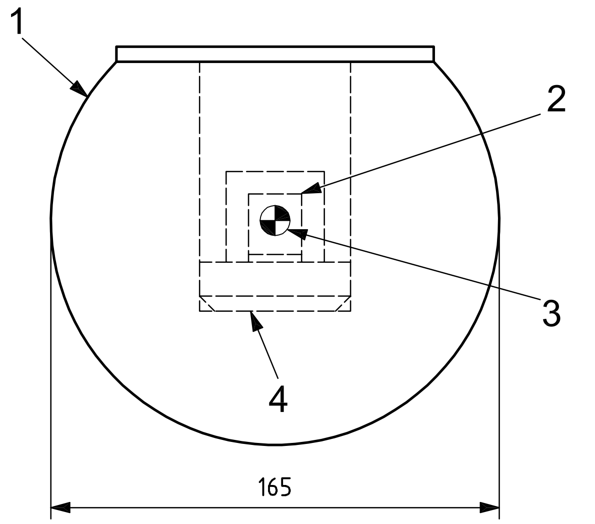
The child head form impactor shall be propelled at a given angle into the bonnet top so as to ensure that the impact angle at the impact moment is as specified in 7.2.

5.4 Child head form impactor calibration

The child head form impactor shall meet the calibration requirements specified in Annex B.

NOTE The head form is a spherical representation of a 6-year-old child. The diameter of the head form is the circumference of the 6-year-old head divided by pi. The calibration requirements of the headform are those of the 6-year-old child which are defined in the paper referenced in the Bibliography [3].

Dimensions in millimetres



Key

1 spherical

2 accelerometer

3 impactor centre of gravity

4 accelerometer mount

Figure 4 — Child head form impactor

5.5 Propulsion of child head form impactor

The child head form impactor shall be propelled into a stationary vehicle. The method of child head form impactor propulsion is at the discretion of the test office. However, the child head form impactor should be launched to free flight at a required velocity.

5.6 Temperature conditions

The child head form impactor shall have a temperature of (20 ± 2) °C at the time of impact.

5.7 Rear face of child head impactor

The rear face of the child head impactor is a plane at the outer surface 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.

6 Preparation of test vehicle

6.1 Either a complete vehicle or a cut-body shall be used for the test. The cut-body should include all the parts of the vehicle structure and components that may be involved in a pedestrian child head impact.

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

6.3 Sufficient time shall be allowed before testing for the temperature of all vehicle components to stabilize (see 7.1).

7 Test conditions

7.1 Atmospheric conditions

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

7.2 Impact angle and impact velocity

7.2.1 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 bonnet top shall be downward and rearward, as if the vehicle were on the ground.

7.2.2 The angle of the velocity vector of the child head form impactor at impact with respect to horizontal shall be (53 ± 2)° as explained in Annex C. The velocity of the child head impactor at the time of impact shall be selected based on the objectives of the test and the relationship between child head impact velocity and vehicle impact velocity as presented in Annex C.

7.3 Impact points

7.3.1 Tests shall be made to the bonnet top within the boundaries as defined in 5.2. During all tests, the centre of the head form impactor shall, at the time of first contact, be a minimum of 82,5 mm inside the defined bonnet side reference line (see 3.5) and 82,5 mm forward the BRRL as defined in 3.7.

7.3.2 The points selected for testing shall be indicated in the test report.

8 Recording of test results

Data shall be acquired in accordance with ISO 6487.

8.1 Child head form impactor data

8.1.1 The velocity of the child head form impactor shall be measured during the free flight immediately before impact, in accordance with the method specified in ISO 3784. The accuracy of velocity measurement shall be ± 0,1 m/s.

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 measured.

8.1.2 The acceleration time histories shall be recorded, and HIC shall be calculated as follows:

$$\mathrm{HIC} = \left(\frac{1}{t_2 - t_1} \int_{t_1}^{t_2} a \, \mathrm{d}t \right)^{2,5} (t_2 - t_1)$$

$$t_2 - t_1 \leqslant 15 \text{ ms}$$

where

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

t_1 and t_2 are the two time instants during the impact, defining the beginning and the end of the recording for which the value of HIC is a maximum.

8.1.3 The first point of contact on the bonnet top of the vehicle shall be recorded.

Annex A
(informative)

Resolution 65 of ISO/TC22/SC10/WG2

ISO TC22/SC10/WG2 believes that information is not currently available to specify a narrow boundary separating the acceptable impact zones for the child or adult head impactor. The upper and lower limits for these zones are defined by wrap around distance (WAD). WG2 concludes that the child head impactor only should be used at WADs of 1 500 mm or less and that the adult head impactor only should be used at WADs of 2 100 mm or more. WG2 believes that a transition zone exists within the WAD range of 1 500 mm to 2 100 mm; that this transition zone is narrower than 600 mm; that either a child or adult impactor (but not both) should be used in tests within this transition zone; and that there is insufficient information currently available to specify the location of the transition zone within the 1 500 mm to 2 100 mm WAD range. WG2 recommends that, until further data are obtained or additional analysis are performed, each organization specifying head impactor tests should use current data to determine the size and location of a transition zone within the WAD range of 1 500 mm to 2 100 mm.

Resolution 65 taken at the 28th meeting of ISO/TC22/SC10/WG2 October 31-November 1, 2000 in Williamsburg, VA USA

Annex B
(normative)

Calibration method for child head form impactor

B.1 Performance criteria

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

B.2 Requirements

B.2.1 Range for acceleration

When the child head form impactor is dropped from a height of 376 mm in accordance with B.3, the peak resultant acceleration measured by one triaxial (or three uniaxial) accelerometer (accelerometers) in the child head form impactor shall be not less than 245 g and not more than 300 g. The acceleration time curve shall be unimodal.

B.2.2 CFC and CAC

The instrumentation response values CFC and CAC for the accelerometer shall be 1 000 Hz and 500 g respectively as defined in ISO 6487.

B.2.3 Temperature conditions

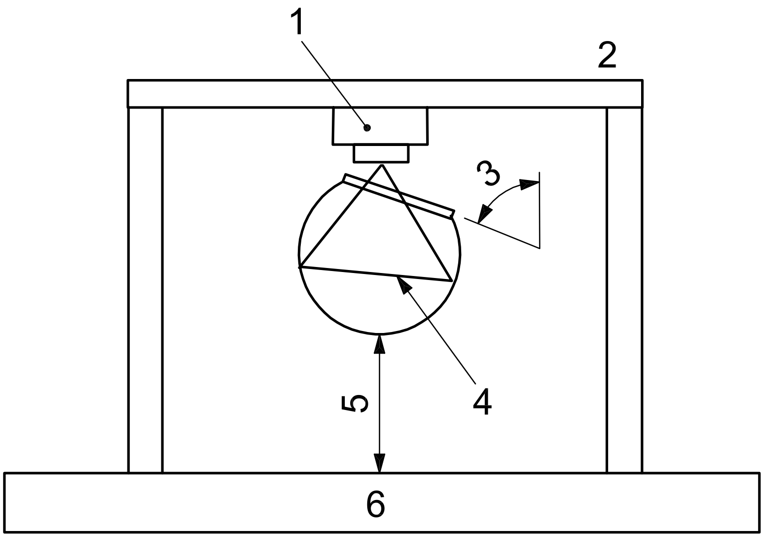
The child head form impactor shall have a temperature of (20 ± 2) °C at the time of impact.

B.3 Test method

B.3.1 The child head form impactor shall be suspended from a drop rig as shown in Figure B.1.

B.3.2 The child head form impactor shall be dropped from the specified height by means that ensure instant release onto a rigidly supported flat horizontal steel plate, 50 mm thick and 600 mm^2 which has a clean dry surface and a surface finish of between 0,2 μm and 2,0 μm.

B.3.3 The drop test shall be performed three times, with the child head form impactor rotated 120° around its symmetrical axis after each test.



Key

1 release mechanism
2 drop rig
3 drop angle
4 strings
5 drop height
6 rigid steel plate

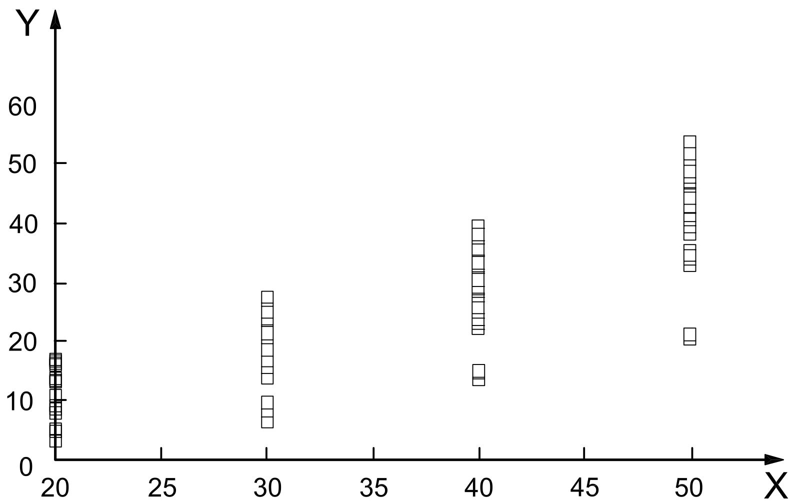
Figure B.1 — Test set-up for dynamic child head form impactor calibration test

Annex C
(informative)

Impact velocity and impact angle

C.1 Relationship between the vehicle impact velocity and the child head impact velocity using MADYMO and cadaver data

Studies have shown a relationship between the vehicle velocity and the child head impact velocity relative to the bonnet at the time of contact in a pedestrian impact using MADYMO simulation and INRETS cadaver data. This relationship is shown in Figures C.1 and C.2.



Key

X vehicle impact velocity (km/h)

Y head impact velocity (km/h)

$K = v_h / v$

where:

K is the ratio of the head impact velocity to vehicle velocity;

v_h is the head impact velocity at the moment of contact on the bonnet; and

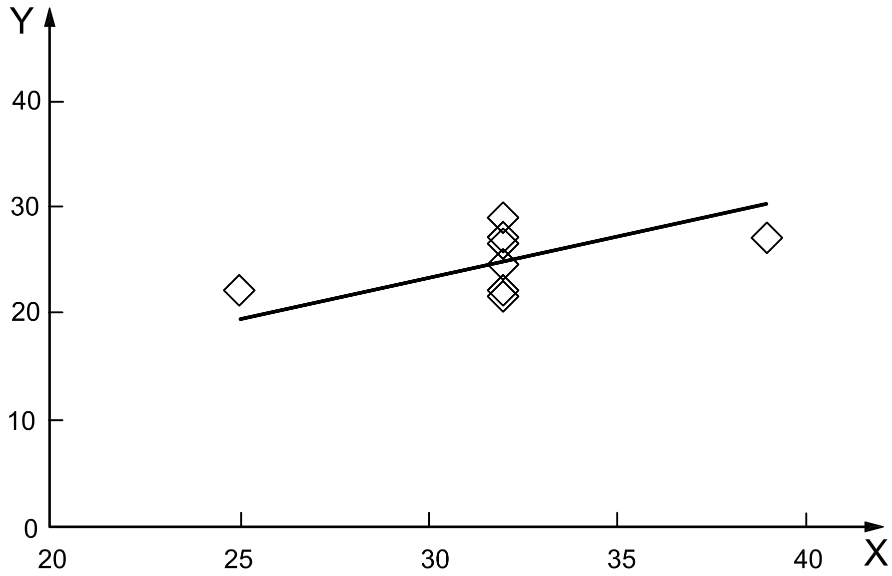
v is the vehicle velocity.

From JARI data (K = 0,78)

From VDA data (K = 0,72)

From Chalmers Univ. data (K = 0,74)

Figure C.1 — Characteristics between the vehicle impact velocity and the child head impact velocity from MADYMO



Key

X vehicle impact velocity (km/h)

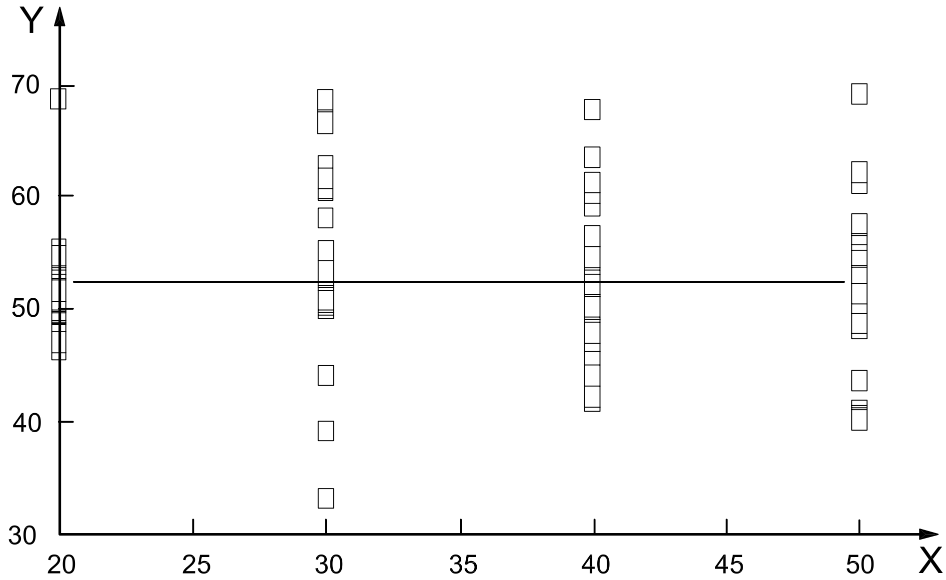
Y head impact velocity (km/h)

n = 8 case from INRETS (K = 0,77)

Figure C.2 — Characteristics between the vehicle impact velocity and the child head impact velocity from INRETS cadaver data

C.2 Relationship between vehicle impact velocity and child head impact angle using MADYMO

In a pedestrian impact to the front of a vehicle where the bonnet leading edge is below the height of the pedestrian's neck, the child head rotates down toward the bonnet at the same time that it translates rearward with respect to the vehicle. This gives rise to a velocity vector at the time of first contact with the bonnet that is parallel to the fore-aft vertical plane of the vehicle but is neither horizontal nor vertical. Tests using MADYMO simulation model on a wide variety of vehicle types show there is virtually no relationship between vehicle impact velocity and child head impact angle at the time of impact (Figures C.1, C.2 and C.3). Due to the absence of a relationship between child head impact angle and vehicle impact velocity, the average of 53° is chosen for this test procedure.



Key

X vehicle impact velocity (km/h)

Y head impact angle (°)

Average of impact angle is 52,8°.

Figure C.3 — Characteristics between the vehicle impact velocity and the child head impact angle

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[1] ISHIKAWA, H., KAJZER, J. and SCHROEDER, G., *Computer Simulation of Impact Response of the Human Body in Vehicle-Pedestrian Accident* , 37th Stapp Vehicle Crash Conference, November 1993, SAE Paper No . 933129

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