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Road vehicles — Pedestrian protection — Head impact test method

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

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 22, *Road vehicles*, Subcommittee SC 36, *Safety and impact testing*.

This second edition cancels and replaces the first edition (ISO 14513:2006), of which it constitutes a minor revision.

It also incorporates the Technical Corrigendum ISO 14513:2006/Cor 1:2007.

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 adults, but it is anticipated that biomechanical data for children will later be studied in order to determine the potential for child pedestrian protection.

Road vehicles — Pedestrian protection — Head impact test method

1 Scope

This International Standard specifies a test method to simulate the head impact of an adult pedestrian to the bonnet top of passenger vehicles or light truck vehicles of up to 3,5 t (GVM), as defined in ISO 3833. The impact device to be used in this test method will be robust for a vehicle impact velocity of up to 11 m/s. The test method specified addresses the reduction of an adult 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 to be 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 utilizes 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 an adult pedestrian head in a simulated impact with a motorized road vehicle. Research suggests vehicle safety improvements in vehicle derived from such pedestrian impact tests may be beneficial also to bicyclists in vehicle front impact.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. 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 6487, *Road vehicles — Measurement techniques in impact tests — Instrumentation*

3 Terms and definitions

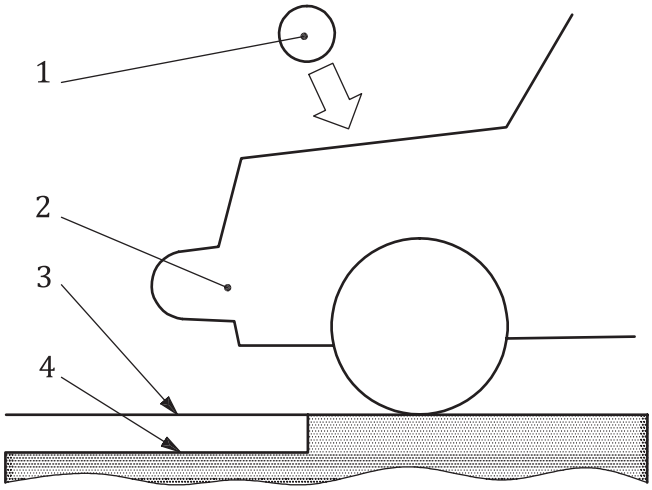
For the purposes of this document, the following terms and definitions apply.

3.1
normal ride attitude
vehicle attitude in driving order positioned on the ground, with the 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 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 tire contact points of a vehicle while the vehicle is in its *normal ride attitude* (3.1)

Note 1 to entry: See Figure 1.

Note 2 to entry: 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 impactor
2 vehicle
3 ground reference plane
4 ground

Figure 1 — Configuration of ISO head impact test method

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

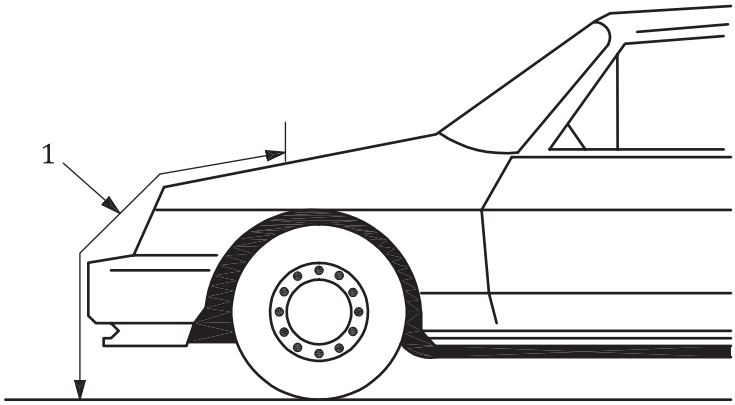
3.4
wrap around distance
geometric trace described on the top of the bonnet by one end of a long flexible tape, the other end held in contact with the *ground reference plane* (3.2) when it is held in a vertical fore and aft plane of the vehicle and traversed across the front of the bonnet and bumper of the vehicle, when it is in the normal ride attitude

Note 1 to entry: See Figure 2.

Note 2 to entry: 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
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 at 45° is traversed down the side of the bonnet, while maintaining contact with the surface of the body shell

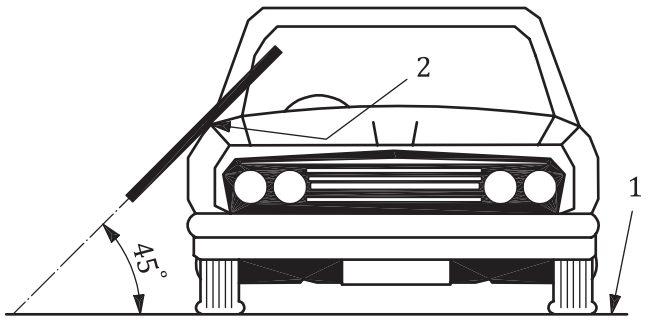
Note 1 to entry: See Figure 3.



Key

1 wrap around distance

Figure 2 — Determination of wrap around distance



Key

1 straight line reference

2 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

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

Head form impactor described in Clause 5 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 is 165 mm as shown in Figure 4. The mass shall be (4,5 ± 0,1) 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.

5.1.2 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.

If three uniaxial accelerometers are used, one of the accelerometers shall have its sensitive axis perpendicular to the mounting face and its seismic mass shall be positioned within a cylindrical tolerance field of 1 mm radius and 20 mm length. The centre line of the tolerance field shall run perpendicular to the mounting face and its mid-point shall coincide with the centre of the sphere of the headform impactor.

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

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

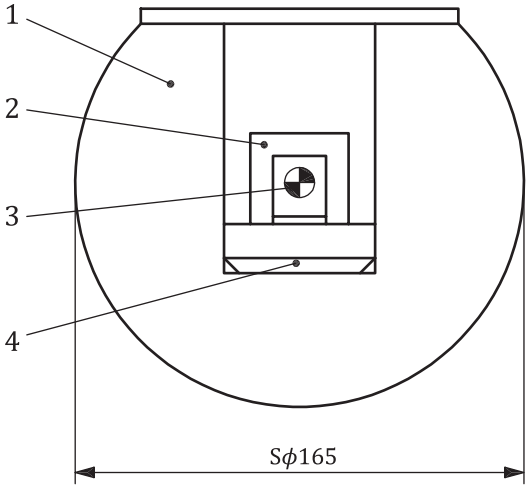
5.2 Impact area

Bonnet top shall be bounded by the geometric trace of the 1 500 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 forward most of either the 2 100 mm wrap around distance or the rear most line created when the head form makes contact with the bonnet without first contacting the windscreen.

5.3 Impact angle

The 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 7.1.

Dimensions in millimetres



Key

1 spherical
2 accelerometer
3 impactor centre of gravity
4 accelerometer mount

Figure 4 — Head form impactor

5.4 Head form impactor calibration

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

5.5 Propulsion of head form impactor

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

5.6 Rear face of head impactor

This is 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.

6 Preparation of test vehicle

6.1 Components

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.

6.2 Parking brake

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

6.3 Time

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

7 Test conditions

7.1 Impact angle and impact velocity

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

7.1.2 Angle of velocity vector

The angle of the velocity vector of the head form impactor at impact with respect to Ground Reference Level shall be (65 ± 2)°, as explained in Annex B. The velocity of the head impactor at the time of impact shall be selected based on the objectives of the test and the relationship between head impact velocity and vehicle impact velocity as presented in Annex B.

7.2 Impact points

7.2.1 Bonnet top

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).

7.2.2 Testing points

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

8 Recording of test results

8.1 Data acquisition

Data shall be acquired in accordance with ISO 6487.

8.2 Head form impactor data

8.2.1 The velocity of the 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.

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

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

$$t_2 - t_1 \leq 15 \ ms$$

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.

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

Annex A
(normative)

Calibration method for head form impactor

A.1 Performance criteria

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

A.2 Requirements

A.2.1 Range for acceleration

When the head form impactor is dropped from a height of 376 mm in accordance with A.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.

A.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.

A.2.3 Temperature conditions

The head form impactor shall have a temperature of (20 ± 5) °C at the time of impact.

A.3 Test method

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

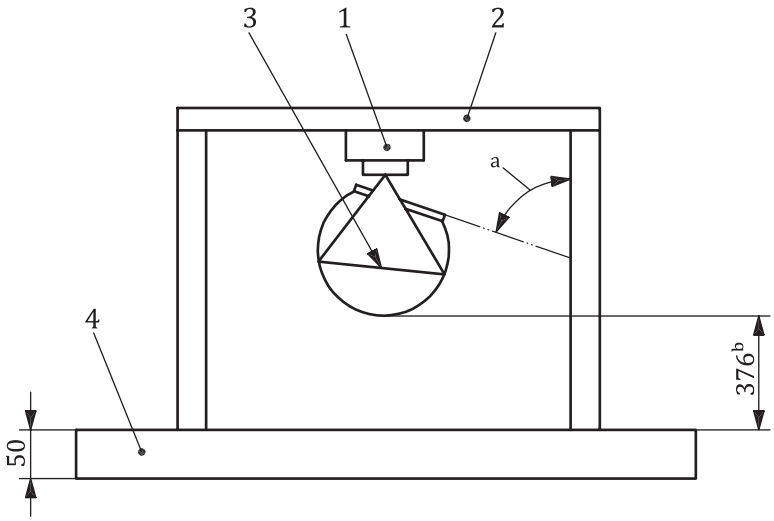
A.3.2 The head form impactor shall be dropped from the specified height by means that ensure instant release onto a rigidly supported flat horizontal steel plate, 50 mm thick and 600 mm^2, which has a clean dry surface and a surface finish of between 0,2 µm and 2,0 µm.

A.3.3 The head form impactor shall be dropped with the rear face of the impactor at the test angle chosen in 7.1.2 with respect to the vertical, as specified in Figure A.1.

The suspension of the head form impactor shall be such that the head form impactor does not rotate during the fall.

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

Dimensions in millimetres



Key

1 release mechanism
2 drop rig
3 support system
4 rigid steel plate
[a] Drop angle.
[b] Drop height.

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

Annex B
(normative)

Velocity and angle

B.1 Relationship between the vehicle impact velocity and the adult head impact velocity

Studies have shown a relationship to exist between the vehicle impact velocity and the head impact velocity relative to the bonnet at the time of contact in a pedestrian impact. Data representing this relationship is given in Figure B.1. Various studies have shown that the head impact velocity to be related to vehicle impact velocity as follows:

$$v_{HF} = kv \tag{B.1}$$

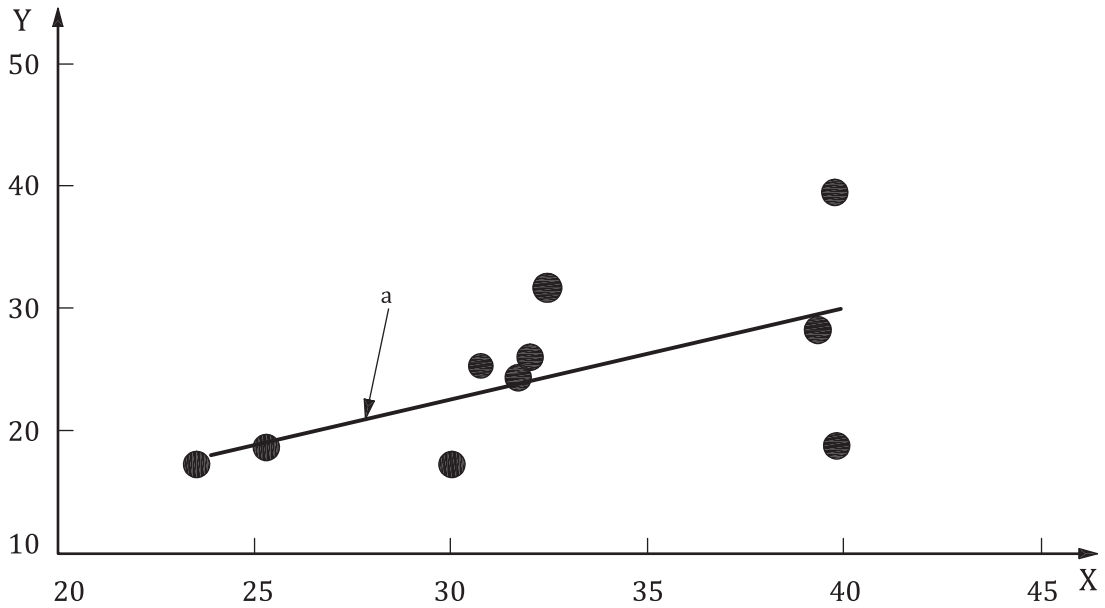
where

v_{HF} is the head impact velocity on the bonnet;

k is a constant;

v is the vehicle impact velocity.

The value of k has been determined to be in the range from 0,4 to 1,1. To facilitate uniformity, it is recommended that a value of 0,75 be used for k.



Key

X vehicle impact velocity, v (km/h)

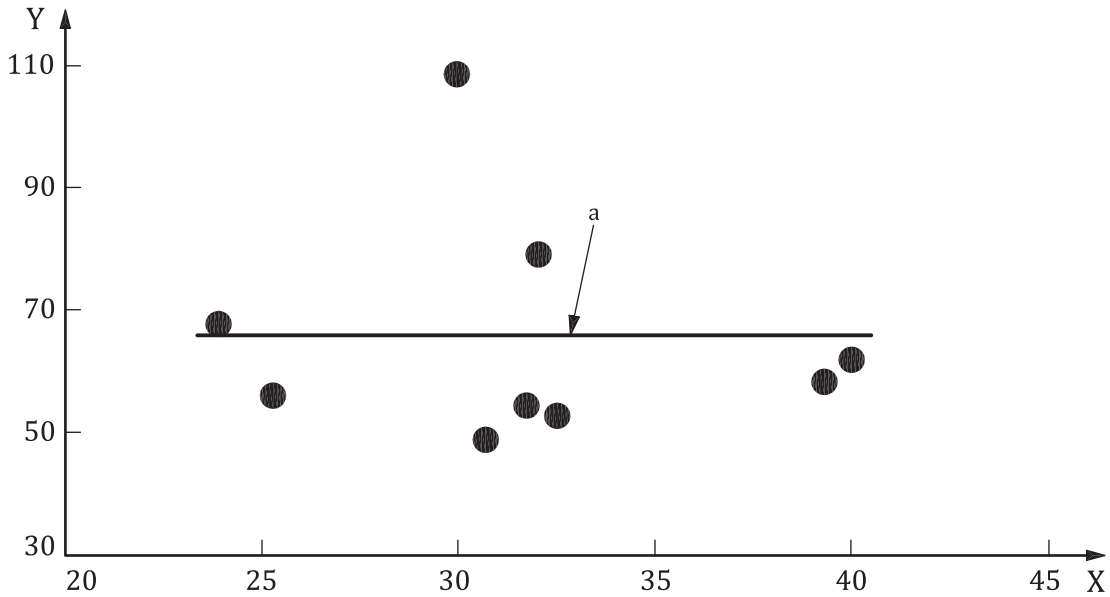
Y head impact velocity, v_{HF} (km/h)

a Bonnet contact, $v_{HF} = 0{,}75\ v$.

Figure B.1 — Characteristics between the vehicle impact velocity and the head impact velocity

B.2 Relationship between vehicle impact velocity and head impact angle

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 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 cadavers on a wide variety of vehicle types show there is virtually no relationship between vehicle impact velocity and head impact angle at the time of impact (Figure B.2). Due to the absence of a relationship between head impact angle and vehicle impact velocity, the average of 65,4° is chosen for this test method.



Key

X vehicle impact velocity, *v* (km/h)

Y head impact angle (°)

a The average angle for bonnet contact is 65,4°.

Figure B.2 — Characteristics between the vehicle impact velocity and the head impact angle

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