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Road vehicles — Test devices for target vehicles, vulnerable road users and other objects, for assessment of active safety functions —

Part 2: Requirements for pedestrian targets

Véhicules routiers — Dispositifs d'essai pour véhicules cibles, usagers de la route vulnérables et autres objets, pour l'évaluation de fonctions de sécurité active —

Partie 2: Exigences pour cibles de piétons

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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

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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).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 33, *Vehicle dynamics and chassis components*.

A list of all parts in the ISO 19206 series can be found on the ISO website.

Introduction

ADAS (Advanced Driver Assistance Systems) and Active Safety systems are designed to support decision-making for the driver, extend the driver's awareness of the traffic situation with advanced warnings, improve the behaviour of the vehicle, and even take over vehicle control in an emergency situation. The goal is to completely avoid an accident or at least reduce the severity of an accident.

Testing of active safety systems requires documentation of test materials, test environment, testing procedures, and performance criteria. This document series addresses the specification of test target objects for traffic scenarios representing vehicles, vulnerable road users and other objects in the forward path of the subject vehicle.

This document addresses the specification of pedestrian test targets.

A pedestrian test target needs to resemble the characteristics of a human, yet provide safety for the subject vehicle and test operators in the event that contact is made between the subject vehicle and the pedestrian target. Crashworthiness and durability requirements for the pedestrian target require that the material and construction of the pedestrian target are adapted to fit the purposes.

Pedestrian test targets may need to represent a range of pedestrian sizes to evaluate the performance of an active safety system. Test cases may address both stationary and moving targets and, as such, the physical construction of the target may accommodate a target carrier system capable of mimicking the motions of a human. This document includes requirements on the target carrier system as applicable.

Targets described in this document series may be used for system development or applied in conjunction with existing standards, or standards under development, for assessment of ADAS and active safety functions of vehicles.

Road vehicles — Test devices for target vehicles, vulnerable road users and other objects, for assessment of active safety functions —

Part 2: Requirements for pedestrian targets

1 Scope

This document specifies performance requirements for surrogate targets used to assess the system detection and activation performance of active safety systems.

This document specifies the properties of pedestrian targets that represent an adult or a child in terms of size, shape, reflection properties, etc. for testing purposes. The document addresses the detection requirements for a pedestrian target in terms of sensing technologies commonly in use at the time of publication of this document, and where possible, anticipated future sensing technologies. It also addresses methodologies to verify the target response properties to these sensors, as well as some performance requirements for the target carrier.

This document does not address the test procedures in terms of speeds, positions, or timing of events. Performance criteria for the active safety system being evaluated are also not addressed.

A related test procedure using pedestrian targets according to this document can be found in ISO 19237.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 8855:2011, *Road vehicles — Vehicle dynamics and road-holding ability — Vocabulary*

ISO 8608, *Mechanical vibration — Road surface profiles — Reporting of measured data*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 8855:2011 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at https://www.iso.org/obp

3.1
subject vehicle
SV
vehicle with active safety system to be tested

3.2
pedestrian target
PT
test device representing a pedestrian used to test active safety systems

3.3
target body
physical structure that resembles a human used to activate sensor systems

3.4
target carrier
mechanical system used to move the target body according to a test protocol

Note 1 to entry: It may be a self-propelled platform or external devices connected with cables, beams, or similar structures.

Note 2 to entry: Target body fixation is included in the target carrier.

3.5
measurement equipment
equipment used to record the position of the pedestrian target relative to the subject vehicle to ensure that the test protocol is followed within prescribed tolerances and record data documenting the function of the active safety system and allowing its performance to be assessed

4 Symbols and abbreviated terms

CCD	Charge-Coupled Device
FIR	Far Infrared
LIDAR	Light Detection and Ranging
NIR	Near Infrared
PMD	Photonic Mixer Device
RCS	Radar Cross Section

5 Pedestrian target specifications

5.1 Pedestrian size

The pedestrian targets specified in this document reflect both adults and children. Male and female attributes are not explicitly defined as the systems being tested should not rely on the sex of the pedestrian. References for subsequent requirements are based on sample measurements of different demographics and compiled into categories. The following pedestrian sizes are relevant for this document:

— Adult: 50 %-ile male (walking mode);

— Child: 6-7 year old (running mode).

5.2 Dimensions of the targets

Annex A and Table A.1 provides the dimensional requirements for walking postures of a 50 %-ile male adult and running postures of a 6-7 year old child.

5.3 Safety considerations

Drivers of the subject vehicle shall not be exposed to any substantial risk of personal injury resulting from impact of the PT by the SV. The pedestrian target and its components should not cause more than cosmetic damage to the subject vehicle when struck at a relative velocity of 60 km/h. The conditions specified by the test procedure application shall be taken into consideration.

NOTE Test procedures for specific applications typically indicate what measures are taken to reduce the risk of injury and vehicle damage. These measures can include instructions to disable subject vehicle systems such as supplementary occupant restraints, seatbelt pre-tensioners, vulnerable user protection systems, etc.

EXAMPLE The Euro NCAP AEB VRU test procedure specifies that if a vehicle is equipped with a deployable pedestrian/VRU protection system, this system must be deactivated before the testing commences.

5.4 Repairability

The pedestrian target should be easily reassembled or repaired after contacts up to a relative speed of 60 km/h. Field repairs should be possible with hand tools. After repair, the target body and/or target carrier system shall be checked according to 6.5.

NOTE This requirement does not apply to disposable targets.

5.5 Environmental conditions

The pedestrian target shall fulfil all requirements in a temperature range of −5 °C to +40 °C. The pedestrian target shall not deteriorate under storage temperatures in the range of −20 °C to +80 °C when properly stored.

NOTE The specified temperature range recognises that there could be substantial technical challenges achieving a cost-effective target fulfilling the requirements at lower temperatures than −5 °C.

5.6 Postures and articulation

5.6.1 General

Pedestrian target postures can be of static (non-articulated) or articulated type. Articulated targets equipped with moving legs, and optionally with moving arms, shall demonstrate that the motions are consistent with standard gait phases (see Figure 1).

The posture of the adult PT shall show an inclination of about 5° from upright (85° from horizontal), see Annex A, Table A.1 and Figure A.1 a).

The posture of a running child PT is approximately 12° from upright (78° from horizontal), see Annex A, Table A.1 and Figure A.2 a).

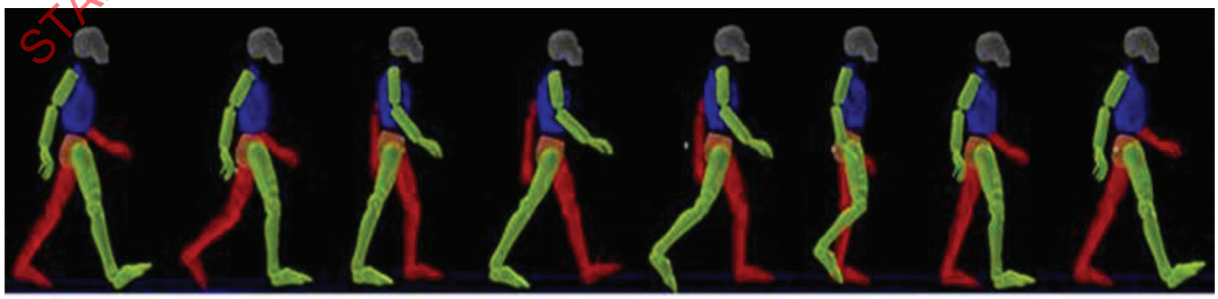


Figure 1 — Gait phases

5.6.2 Static posture

A static adult PT shall represent the walking phase MS. The lateral centre of mass of the target structure shall lie in-between the feet. The static child PT shall represent an appropriate running phase corresponding to LR.

5.6.3 Articulation posture

For articulated PTs, leg movement shall be realized in a manner that realistically represents that of a real pedestrian. Articulation properties as described in Annex D shall be followed.

Since real pedestrians may or may not exhibit arm motion, such arm motion is optional for articulated PTs. If implemented, they shall also be realized in a manner that realistically represents that of a real pedestrian.

6 Pedestrian target response to sensing technologies

6.1 General

Requirements related to sensing technologies commonly in use at the time of publication of this document are given in 6.2, 6.3 and 6.4.

A PT intended for use with a specific set of sensing technologies needs only to meet the requirements of those technologies.

6.2 Optical requirements

6.2.1 General

Sensors operating on optical principles include CCD and CMOS camera sensors, stereo camera sensors, Photonic Mixer Devices (PMD) and Light Detection and Ranging (LIDAR). These systems cover visible and near infrared (NIR) light frequency spectra. PMD and LIDAR are more reliant on infrared reflectivity of the target surface.

6.2.2 Reference measurements

When technology specific measurements are required, information of the type of sensor used, environmental conditions during measurements, and date of measurement shall be provided with the description of the pedestrian target. The version of the pedestrian target and the target carrier shall be traceable to manufacturing drawings or supplier specifications. For more information, see Annex C.

6.2.3 Colours and clothing

Skin surface parts shall be non-reflective and skin-coloured. Hair may be represented by a hairpiece or integrated in the head design by other means.

For camera-based systems it is recommended to use a long-sleeved t-shirt and trousers in different, non-reflective, colours. A black t-shirt and blue jeans are recommended. Clothing shall be loose fitting, but fluttering shall be avoided. Features necessary for the optical recognition as specified in Annex B shall be followed.

6.3 Radar requirements

6.3.1 General

At the time of publication of this document, automotive applications of radar are using 24 GHz and 76 GHz – 81 GHz.

6.3.2 Reference measurements

Annex C provides the required reference measurement setups for human subjects to be used for verification.

When technology specific measurements are required, information of the type of sensor used, environmental conditions during measurements, and date of measurement shall be provided with the description of the reference subject(s). The version of the pedestrian target and the target carrier shall be traceable to manufacturing drawings or supplier specifications.

6.3.3 Radar cross section measurement of PT

The radar reflective characteristics of the pedestrian targets, including the target carrier, should be comparable to a real pedestrian of the same size. Recommendations on radar properties are given in Annex B and Annex C.

For every radar frequency relevant for the pedestrian target, a set of RCS (radar cross section) measurements shall be made. The main steps are as follows:

1) Measurement of pedestrian reference subjects or RCS standard targets;

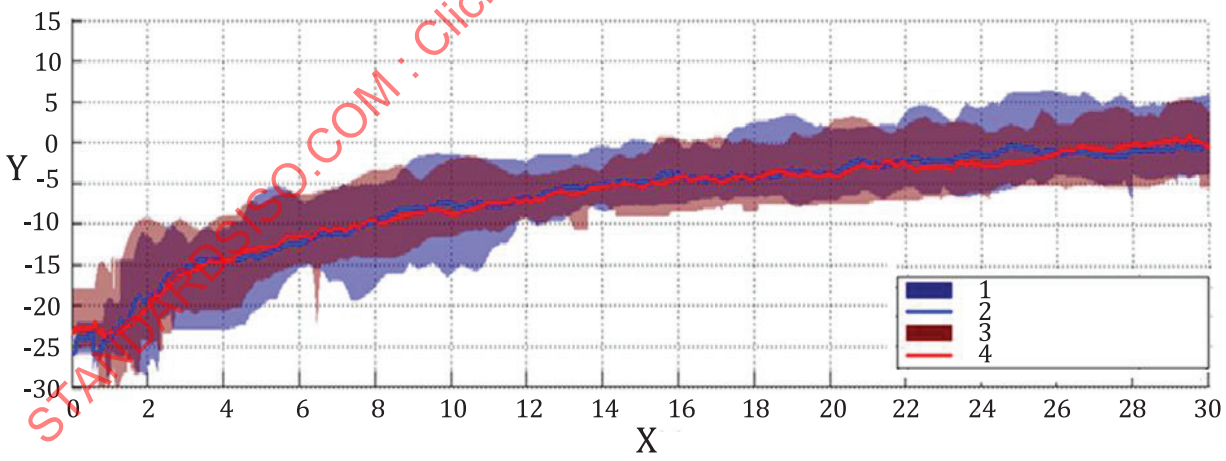
2) Establishment of boundaries;

3) Verification that the pedestrian target RCS measurements are within the boundaries.

An example of the results of this process is illustrated in Figure 2.

The following scenario is described in C.3.3:

— Static PT approached by moving vehicle or moving fixture, to check for inconsistencies at different distances and different PT orientation angles.



Key

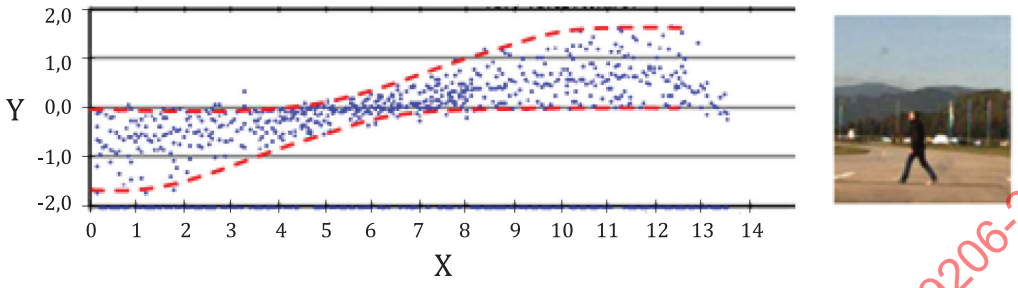
1 min-max with clothes
2 mean value with clothes
3 min-max nearly without clothes
4 mean value nearly without clothes
X distance (m)
Y RCS (dBsm)

Figure 2 — Radar cross-section measurement, example for adult pedestrians at 76 GHz

6.3.4 Micro-Doppler effect for articulated PT

Articulation of the PT legs will result in a micro-Doppler effect on the radar reflective characteristics. The micro-Doppler spread shall be comparable to that of a real pedestrian. In order to ensure a micro-Doppler effect comparable to human beings the articulation of the legs shall provide the characteristics of D.2

Example of micro-Doppler effect is shown in Figure 3.



Key

X time (s)

Y relative velocity (m/s)

Figure 3 — Example of micro-Doppler effect with boundaries for a crossing pedestrian target

6.4 Thermal requirements for Far IR vision systems

6.4.1 General

Inclusion of passive thermal sensor requirements is optional.

Far Infrared (FIR) vision systems can provide information to active safety systems in conditions of low light or otherwise limited visibility. A thermal camera detects FIR electromagnetic radiation with a wavelength in the range of 8 to 14 µm. Imaging is provided by means of an appropriate camera.

6.4.2 Reference measurements

When technology specific measurements are required, information of the type of sensor used, environmental conditions during measurements, and date of measurement shall be provided with the description of the reference subject(s). The version of the pedestrian target and the target carrier system shall be traceable to manufacturing drawings or supplier specifications.

6.4.3 Thermal characteristics

Pedestrian targets commonly in use at the time of publication of this document do not feature human-specific FIR characteristics. Developers of pedestrian targets that incorporate such characteristics should ensure that the characteristics of the pedestrian targets are comparable to a real pedestrian of the same size.

Characterization of these properties should follow the same main steps as described in clause 6.3.3:

1) Measurement of pedestrian reference subjects;

2) Establishment of boundaries;

3) Verification that the pedestrian target FIR measurements are within the boundaries.

6.5 Calibration and verification

The pedestrian target manufacturer shall provide a certificate detailing which test information has been used to verify the product performance and which sensor technologies it conforms to.

Calibration shall be based on representative characteristics of the applied detection technology as described in 6.2, 6.3 and 6.4, and the related Annexes.

For field verification of PT functionality, see Annex E.

7 Functional requirements for PT including target carrier system

7.1 General requirements

The target carrier system shall be capable of positioning the target within tolerances required by the different test procedures. Repeatable test performance requires that subject vehicle and pedestrian target relative speed and position shall be consistent between test repetitions. Unless more stringent requirements are needed by a specific test procedure, the positioning requirements outlined in this clause are the minimum requirements for the pedestrian target. Recommendations for measurement equipment are given in Annex C.

The following requirements and recommendations apply to the target carrier system:

— All visible parts of the target carrier system should be transparent or coloured to minimize the contrast with background, e.g. grey, to approximate the test area road surface. In case of a uniform background the colour shade of the background can be used;

— Visible parts of the target carrier system should be non-reflective to light sources, e.g. headlamps during low natural light conditions;

— The target carrier system and resulting motion of the pedestrian target shall minimally affect target characteristics (radar, optical signature, etc). Design measures, e.g., radar absorbing material, shall be used at the PT mounting to ensure that the PT carrier provides minimal radar reflections;

— No deformations of target structure shall occur that influence the sensor response;

— The shoes of the dummy should not be more than 25 mm above the road surface;

— The articulated PT shall not appear to levitate or move its legs without moving forward or otherwise move or lean unnaturally with respect to its speed of travel. See Annex D for more specific information;

— The mounting of the pedestrian target body on the target carrier system (see Annex F for an example interface specification) shall be secure and not permit the target body and target carrier system to separate during any positioning sequence, within the limits specified in 7.2 through 7.4;

— An unlocking system may be needed to release the PT immediately before or upon impact to prevent/reduce severe damage by the collision;

— The target carrier shall accelerate and decelerate in a smooth manner, except for actions intended to avoid impact or damage. The PT shall not show unnatural changes of posture or movement during acceleration or deceleration.

The positioning requirements in 7.2 through 7.4 are with reference to a coordinate system oriented with the dummy. The longitudinal axis is parallel with the direction of travel. The face of the dummy is oriented in the direction of travel.

7.2 Longitudinal positioning

7.2.1 Speed range for operation

Maximum speed shall be at least 10 km/h (2,8 m/s). The speed control accuracy shall be ±0,18 km/h (±0,05 m/s).

7.2.2 Accelerations

Accelerations between –2,5 m/s^2 (stopping) and +2,0 m/s^2 (start walking) shall be possible.

7.3 Lateral positioning

7.3.1 General

The pedestrian target shall be able to meet the lateral positioning requirements in 7.3.2 and 7.3.3 while operating in the speed range defined in 7.2.1 over a smooth road surface no rougher than road class A as defined in ISO 8608.

7.3.2 Yaw angle

The pedestrian target shall be capable of maintaining a straight-line path within ±2° of the direction of travel.

7.3.3 Lateral position

During straight line manoeuvres, the pedestrian target should not drift laterally more than ±0,05 m from the planned longitudinal path, for distances up to 15 m. For longer distances, a lateral drift of ±0,3 % could be acceptable.

7.4 Vertical positioning

7.4.1 General

The pedestrian target shall be able to meet the vertical positioning requirements in 7.4.2 and 7.4.3 while operating in the speed range defined in 7.2.1 over a smooth road surface no rougher than road class A as defined in ISO 8608.

7.4.2 Pitch angle

For straight line motions at constant speed, the pitch angle of the PT shall not exceed ±2°.

7.4.3 Vertical motions

The pedestrian target should not vibrate or bounce more than 15 mm when operating in the speed range defined in 7.2.1.

Annex A
(normative)

Adult and child pedestrian target dimensions and postures

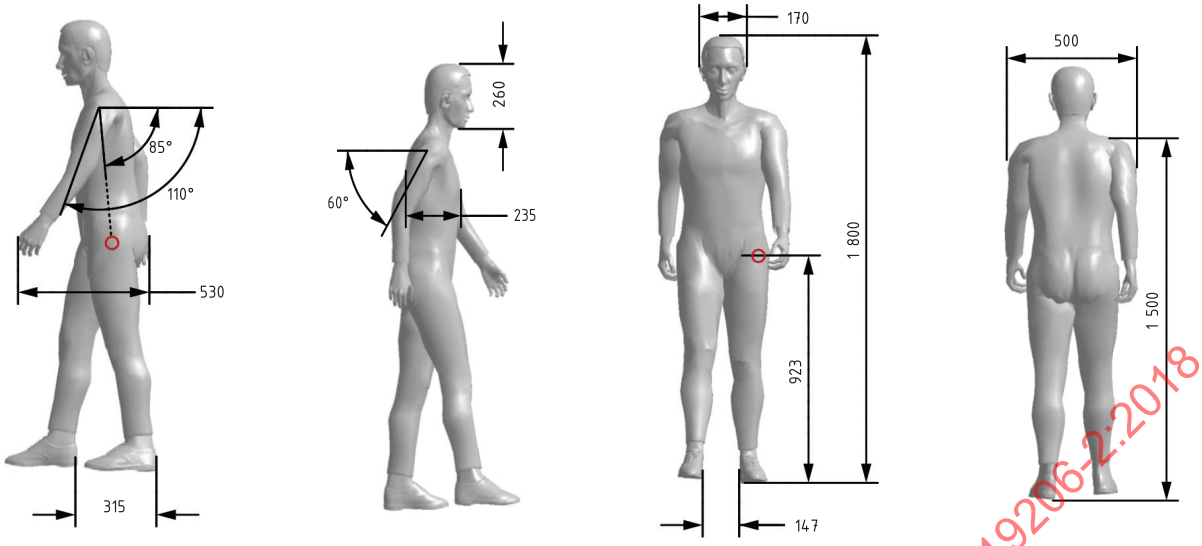
Table A.1 provides the information for adult walking and child running postures.

Table A.1 — Adult and child PT dimensions and postures

Dummy	Segment	Aspect / direction	Unit	Dimension	Tolerance	Illustration
Adult	Body height (inclusive shoes)	Walking posture	mm	1 800	±20	Figure A.1 c)
	H-Point height		mm	923	±20	Figure A.1 c)
	Heel to heel distance[a]	longitudinal	mm	315	±10	Figure A.1 a)
		lateral	mm	147	±10	Figure A.1 c)
	Shoulder height		mm	1 500	±20	Figure A.1 d)
	Shoulder width		mm	500	±20	Figure A.1 d)
	Head height		mm	260	±10	Figure A.1 b)
	Head width		mm	170	±10	Figure A.1 c)
	Torso depth	longitudinal	mm	235	±10	Figure A.1 b)
	Distance front hand – back side	longitudinal	mm	530	±10	Figure A.1 a)
	Torso angle	longitudinal	deg (°)	85	±2	Figure A.1 a)
	Upper arm angle	right side	deg (°)	60	±2	Figure A.1 b)
		left side	deg (°)	110	±2	Figure A.1 a)
Child	Body height (inclusive shoes)	Running posture	mm	1 154	±20	Figure A.2 c)
	H-Point height		mm	607	±20	Figure A.2 c)
	Heel to heel distance[b]	longitudinal	mm	494	±10	Figure A.2 a)
		lateral	mm	129	±10	Figure A.2 c)
	Shoulder height		mm	920	±20	Figure A.2 d)
	Shoulder width		mm	298	±20	Figure A.2 d)
	Head height		mm	250	±10	Figure A.2 b)
	Head width		mm	150	±10	Figure A.2 c)
	Torso depth	longitudinal	mm	139	±10	Figure A.2 b)
	Distance front hand – back side	longitudinal	mm	362	±10	Figure A.2 a)
	Torso angle	longitudinal	deg (°)	78	±2	Figure A.2 a)
	Upper arm angle	right side	deg (°)	50	±2	Figure A.2 b)
		left side	deg (°)	112	±2	Figure A.2 a)

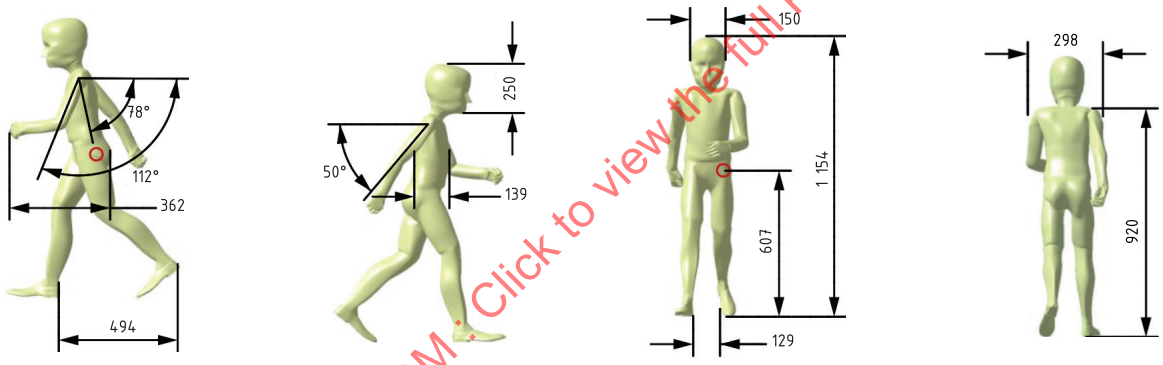
[a] Only valid for the static posture.

[b] Only valid for the static posture.



a) b) c) d)

Figure A.1 — Adult PT reference dimensions



a) b) c) d)

Figure A.2 — Child PT reference dimensions

Annex B
(normative)

Sensor-specific recognition properties

B.1 General

The pedestrian target (PT) shall be able to represent the human attributes in relation to the sensors used in the vehicle. For system testing with a certain detection technology in the vehicle, the PT shall be equipped with the relevant corresponding features given below.

B.2 Visual and near infrared (NIR) properties

B.2.1 Visual properties

The following requirements shall be fulfilled to enable a proper recognition with regard to visual detection:

— There shall be no visible reflective components on the PT;

— Skin surface parts shall be finished with a low-reflective skin;

— The head hair shall be imitated by using black coloured texture, alternatively a hairpiece can be used;

— The PT shall be, or appear to be, clothed with a long-sleeved t-shirt and trousers in different colours, t-shirt in black and jeans in blue;

— Clothing shall be loosely fitted and not form any large, unnatural or dominating planar wrinkles.

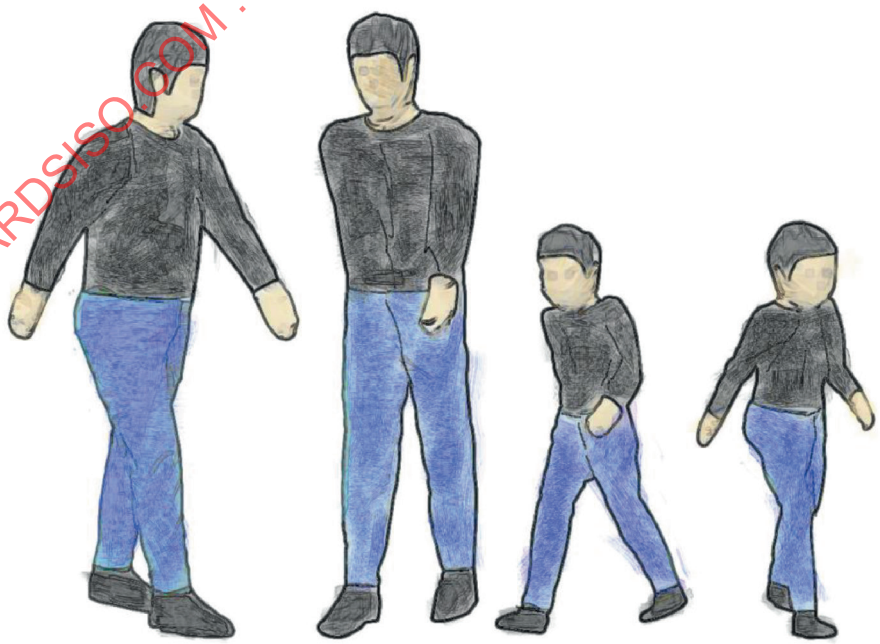


Figure B.1 — Visual properties of adult and child target

The clothing should be made from tear-proofed and water-resistant material. See Table B.1 for recommendations.

Table B.1 — Clothing material recommendations

Property	Reference standard	Value / unit
Area weight		<300 g/m^2
Water resistance	ISO 811 or AATCC 127	>600 mm
Strength	ISO 9073-18 or ASTM D5034	>159 kg >350 lbs
Light fastness	ISO 105-B10 or AATCC 169	>6 000 h
Wear resistance	ISO 12947-1 or ASTM D3884	>500 cycles

B.2.2 Near infrared properties

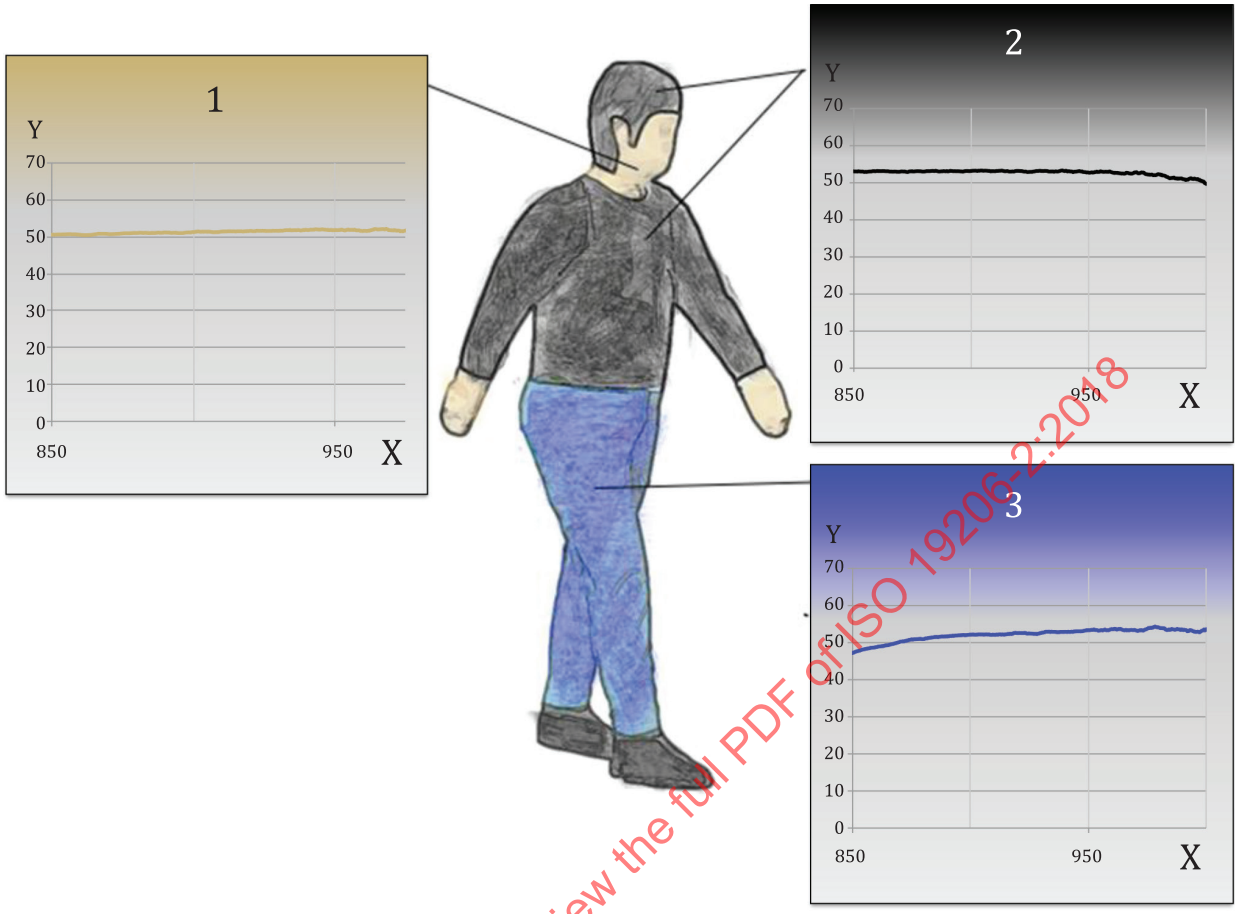
With regard to NIR detection (for a wavelength of around 850 nm to 910 nm), the following specifications should be fulfilled in addition to the ones in B.2.1:

— The IR reflectivity of the clothes should be within the range of 40 % to 60 %;

— The IR reflectivity of the visible skin surface parts should conform to original human skin within the range of 40 % to 60 %;

— The IR reflectivity of the hairpiece should conform to original human hairs within the range of 20 % to 60 %;

At the selection of the clothing it shall be ensured that the IR reflectivity measured with a 45° sensor attachment shall not differ more than 20 % from the reflectivity measured with a 90° sensor attachment.



Key

1 skin, face, hands
2 hair, shoes, black top
3 trousers
X wave length (nm)
Y IR reflectivity (%)

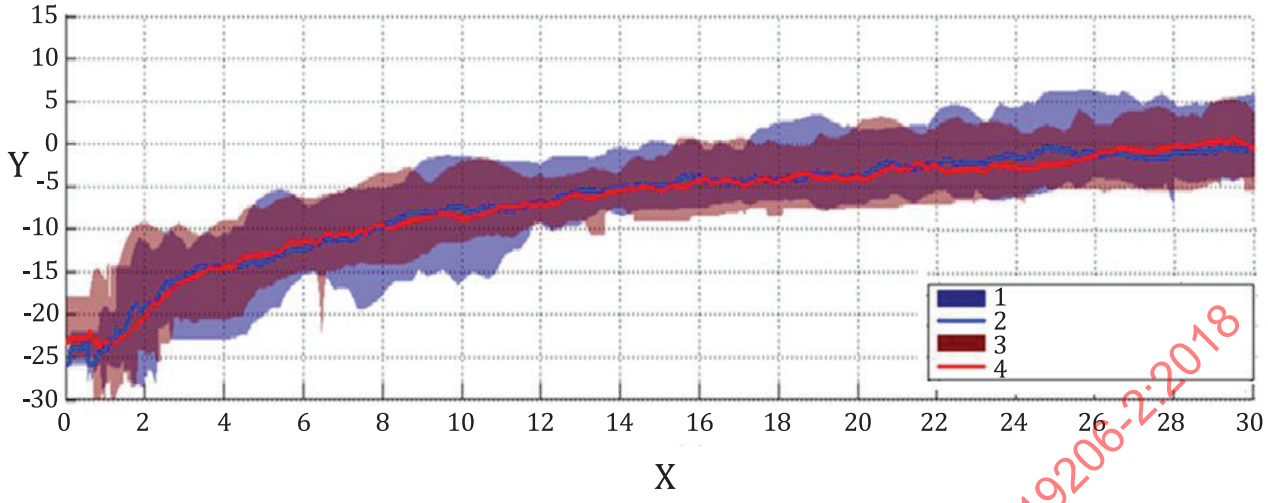
Figure B.2 — IR reflectivity of skin, hair and clothing

B.3 Radar properties

The radar reflectivity characteristics of the pedestrian target shall be equivalent to a pedestrian of the same size. This should be proven according to a test setup described in Annex C.

The measured Radar Cross-Section (RCS) of a pedestrian or PT may be reduced with decreasing distance. This may result from a small vertical field of view of the radar (making some portions of the pedestrian no longer visible to the sensor), phase-incoherent backscattering phenomenon under near-field conditions, etc.

The RCS shall be determined as a function of distance between the PT and sensor (see example in Figure B.3, and C.3.3).

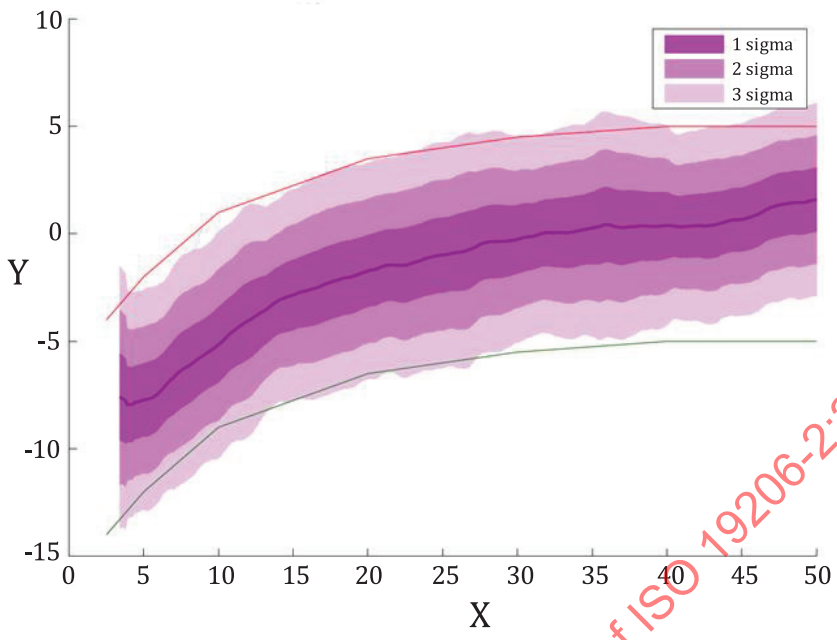


Key

1 min-max with clothes
2 mean value with clothes
3 min-max nearly without clothes
4 mean value nearly without clothes
X distance (m)
Y RCS (dBsm)

Figure B.3 — RCS, example of adult pedestrians at 76 GHz

Figure B.4 shows an example of a statistical evaluation of RCS measurements of human pedestrians. The standard deviations (sigma) of RCS measurements are depicted.



Key

X distance (m)

Y estimated RCS (dBsm)

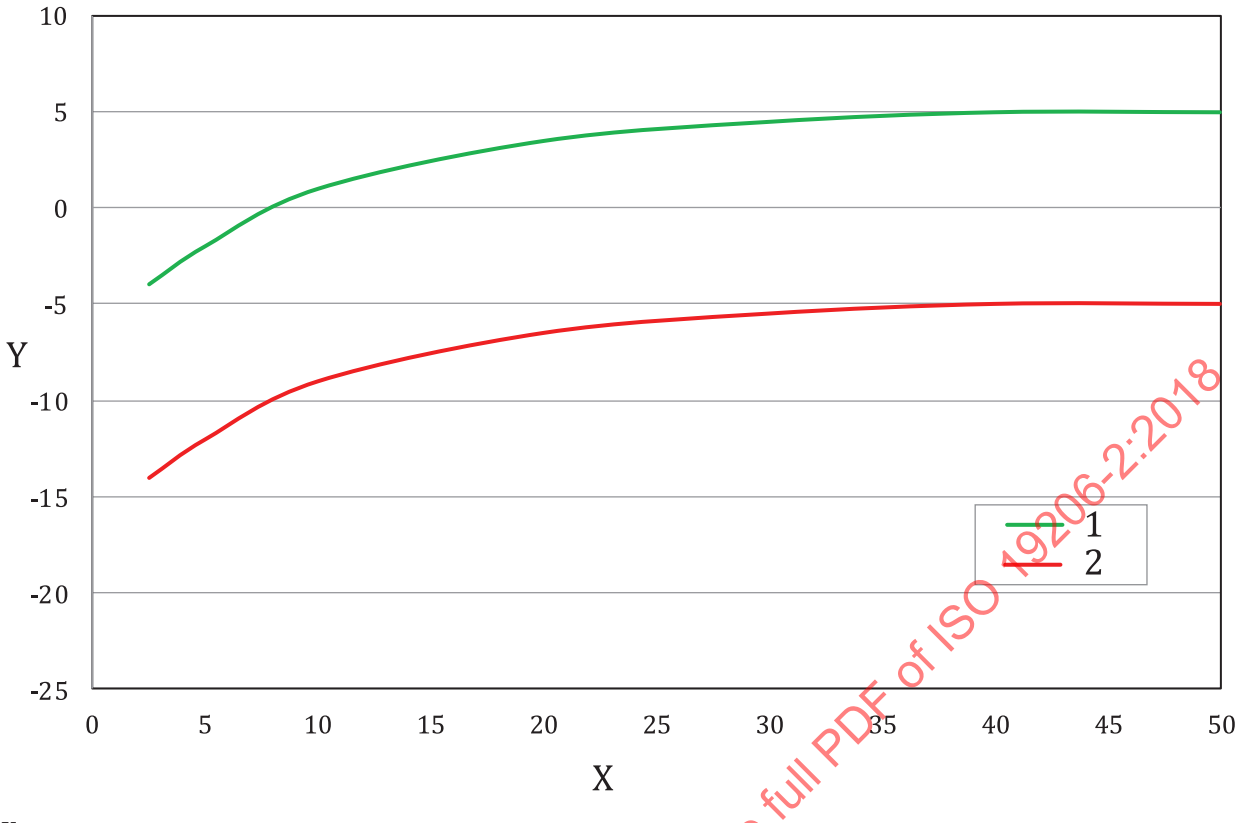
Figure B.4 — Statistical evaluation of RCS measurements of real pedestrians

Additional RCS measurements, evaluation methodologies and RCS-measurements of real pedestrians are presented in report JRC78619 of the European Commission Joint Research Centre, *Radar Cross Section Measurements of Pedestrian Dummies and Humans in the 24/77 GHz Frequency Bands*, see http://publications.jrc.ec.europa.eu/repository/handle/JRC78619.

If the PT does not provide a sufficient RCS and therefore has to be equipped with additional reflectors, they should be distributed throughout the body. On the other hand, in case the RCS of the PT is too high, absorption material should be distributed homogeneously over the body. It shall be ensured that the surface reflectivity is homogeneously distributed over the whole body of the PT to achieve the effect of decreasing RCS at a shorter distance by only partial coverage.

The RCS of pedestrian targets (adult and child) should be within a defined range, e.g. the ±3 sigma region depicted in Figure B.4. This recommendation is subject to future refinement based on sensor evolution and field experience.

Depicted in Figure B.5 is an example of RCS boundaries for measurements (performed as described in C.3.3 with the given scenario) with a specific commercially available 77 GHz sensor.

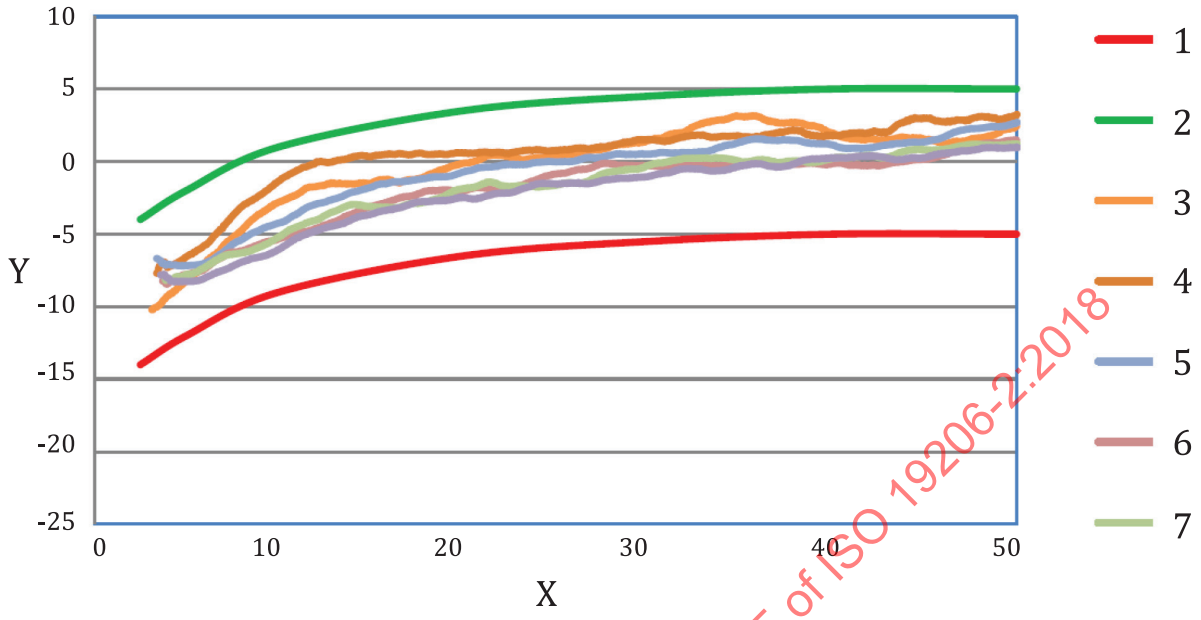


Key

1 upper boundary RCS
2 lower boundary RCS
X distance (m)
Y RCS (dBsm)

Figure B.5 — Pedestrian target example RCS boundaries for measurements at 77GHz

RCS values obtained using other sensors or mounting positions may vary from those shown in Figure B.5. A verification/adaption of the boundaries (Figure B.6) will be necessary for validation of the PT, i.e., the boundaries of the average RCS curves should be determined individually for each frequency and sensor variant.



Key

1 lower boundary RCS
2 upper boundary RCS
3 PT sensor 1
4 PT sensor 2
5 human 1, left side
6 human 1, right side
7 human 2, left side
X distance (m)
Y RCS (dBsm)

Figure B.6 — RCS measurements of real pedestrians vs. adult articulated PT

Annex C
(normative)

Pedestrian target measurements and measurement equipment

C.1 Measurement of position, speed, and acceleration of the pedestrian target

Relevant parameters like position, speed, and acceleration of the pedestrian target shall be possible to measure continuously.

The measurement equipment shall be supplied with energy independent of the vehicle.

All requested values shall be measured with the required accuracy and shall be documented.

Table C.1 lists the recommended specifications for measurement equipment needed to conduct field verification tests and confirm positioning performance of the PT. Any formal testing of active safety system will follow protocols with prescribed measurement equipment.

Table C.1 — Recommended measurement equipment specifications

Recorded data	Range	Resolution	Accuracy
PT Longitudinal speed	0,1-25 km/h	0,01 km/h	±0,25 % of full scale
Longitudinal and lateral position of SV and PT[a]	±50 m from a reference position on track	0,03 m	±0,05 m absolute

[a] When relative position of vehicles are to be determined, the synchronisation of separate data record should be within ±5 ms. Communication of signals between PT and SV can also be used for this purpose.

Sensors placed in the pedestrian target are susceptible to damage in the event of a collision. Sensors can be placed within the target carrier if their relative position to the target is stable with ±10 mm variations during operation.

C.2 Measurement of IR reflectivity

C.2.1 Equipment and calibration

Measurement of the IR reflectivity is carried out using a spectrometer for wavelength range 800 nm to 900 nm.

Before the start of the measurement the device shall be calibrated with a reflection standard, reflectance 99 %. The calibration should be verified by reflectance standards with reflectivity of e.g. 50 % or 20 %.

C.2.2 Measurement setup

The measurement of the target should be conducted with a special attachment to the measurement sensor, which ensures a defined distance and angles (90° and 45°) between sensor and target depicted in Figure C.1.

The measurement shall be performed at three different points of the measuring object and shall be recorded.

The resulting IR reflectivity value corresponds to the average of the three reflectivity measurements.

Figure C.1 — Measurement sensor attachments, 90° and 45°

C.3 Measurement of radar reflectivity

C.3.1 General

Measurement of the radar reflectivity is carried out using a measurement setup according to the specification below:

— Measurements of the human subject and of the PT should be made in the same manner;

— The PT shall be mounted on its target carrier system;

— The sensor can be mounted on a host vehicle or a special fixture;

— In the absence of other vehicle-specific requirements, the measurements should be performed with sensor height position given in C.3.2;

— A reference measurement with a corner reflector (calibrated at 10 dBsm) before and after measurements is recommended.

See Figures C.2 and C.3 for illustrations of the measurement setup and test environment.

C.3.2 Measurement setup

C.3.2.1 Radar sensor positioning

— Vertical distance to ground: 500 mm ± 150 mm (position on vehicle may require a different height positioning);

— Mounted at the centre line ±100 mm;

— Horizontal alignment ±1° to centre line;

— Vertical alignment ±1° to centre line.

C.3.2.2 Vehicle or moving fixture

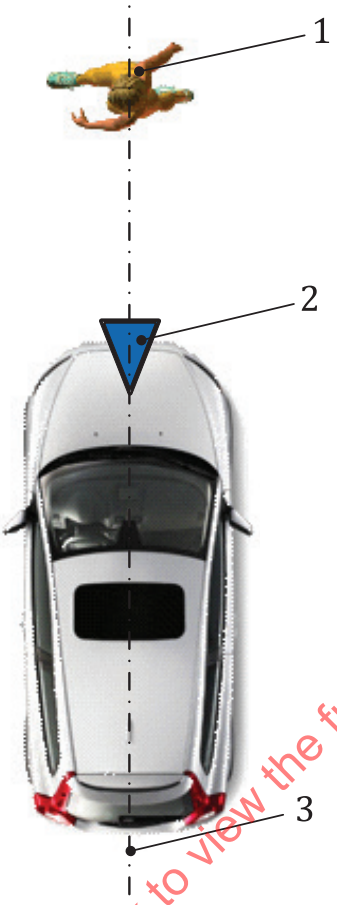
— Angular driving deviation <2°;

— Positioning accuracy longitudinal/lateral <50 mm.

C.3.2.3 Pedestrian Target

— Positioning accuracy longitudinal/lateral <10 mm;

— Angular orientation deviation <3° in the moving direction.



Key

1 PT
2 radar sensor
3 centreline

Figure C.2 — Measurement setup

C.3.2.4 Test environment

— No additional objects/buildings in the observation area;

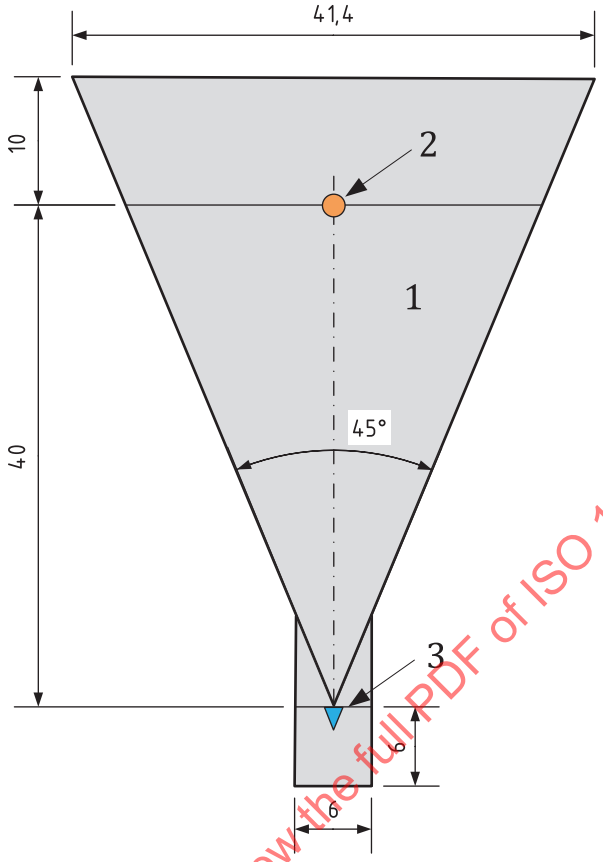
— Test area surface to be completely covered with tarmac or concrete;

— No metallic or other strong radar reflecting parts in ground or other surrounding area;

— Reference measurement with corner reflector at 40 m distance: 10 dBsm;

— Corner reflector mounting height 1 m.

Dimensions in m



Key

1 free space
2 PT
3 radar sensor

Figure C.3 — Test environment

C.3.3 Measurement scenario

The measurement scenario has the following parameters:

— Static PT with moving vehicle or moving fixture;

— Measurement range: 4 m ≤ x ≤ 40 m;

— Measurement can be made in either direction;

— Continuous measurement along the distance;

— Speed approximately 10 km/h, no abrupt acceleration;

— PT orientation angles 90°, 270° for crossing scenarios;

— PT orientation angles 0°, 180° for longitudinal scenarios;

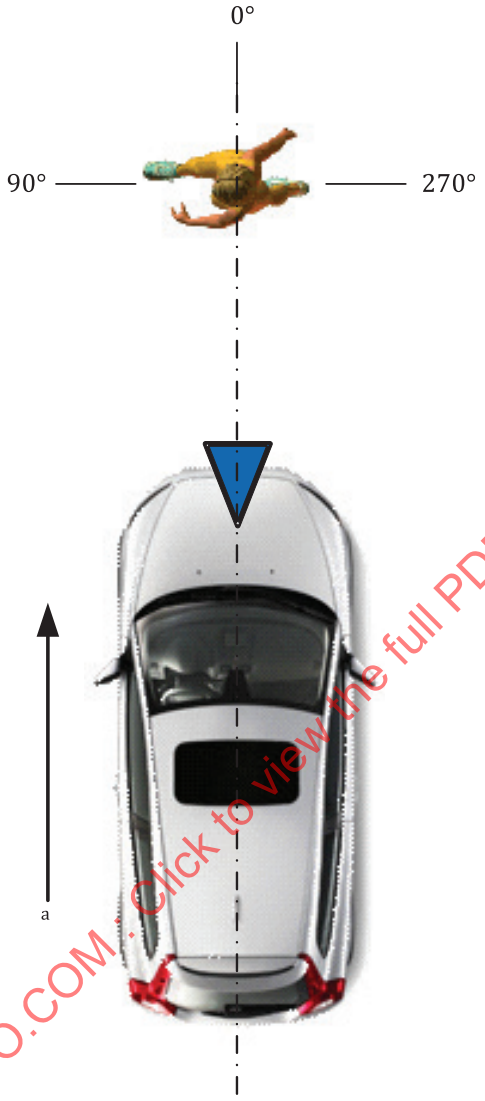
— Measurements to be repeated 5 times per orientation;

— Low pass filtering using a sliding average window (±2,5 m);

— Averaging the low pass filtered curves from the 5 measurements;

— Reference measurement with at least two different real adult pedestrians that are known to fit in the RCS boundaries for verification of measurement setup;

— RCS of tested PT should stay within a defined range for both sides of the pedestrian target.



Key

a moving direction

Figure C.4 — Test scenario

Annex D
(normative)

Pedestrian target articulation properties

D.1 Articulation properties

The articulated PT consists of two articulated legs, two static or optionally articulated arms, torso, and an interface (centre-tube) either from lower side (platform) or from upper side (test rig).

Leg articulation is needed for the PT; arm movement is optional since it is not necessarily a characteristic of humans while walking/running.

In order to provide robustness and cost efficiency of the PT, an articulation of hips only is preferred in order to simulate human like leg movement.

D.2 Repeatability and reproducibility requirements

The articulation of the PT shall be repeatable with respect to its position in its path.

The articulation is defined by the position (posture) and velocities of the knees and ankles.

The velocities of PTs of the size described in Annex A shall stay within the ±3 sigma corridor depicted in Figure D.1 (a - h) for an adult and child PT.

Articulation of the feet shall be in a plane parallel to the plane defined by the PT movement and the vertical (z) axis. Tolerance requirement: ±1°.

When visible from the subject vehicle, articulation shall be synchronized with the forward movement of the PT.

In order to support repeatable articulation pattern at each test run, the same articulation posture shall be ensured at the reference point (RP). At the RP, the position of the applicable body parts shall conform to the specified posture evaluated using video or other suitable means. The posture of the legs at the reference point shall be recorded and checked after testing.

EXAMPLE 1 The RP can be defined for near-side and far-side crossing scenarios at a lateral offset of 2 m (H-point of PT) to the middle of the driving lane (see Figure D.2). At the reference point the legs have a posture TSw as shown in Figures D.2 and D.3. The torso is within ±10 % of the target velocity when the reference point is passed.

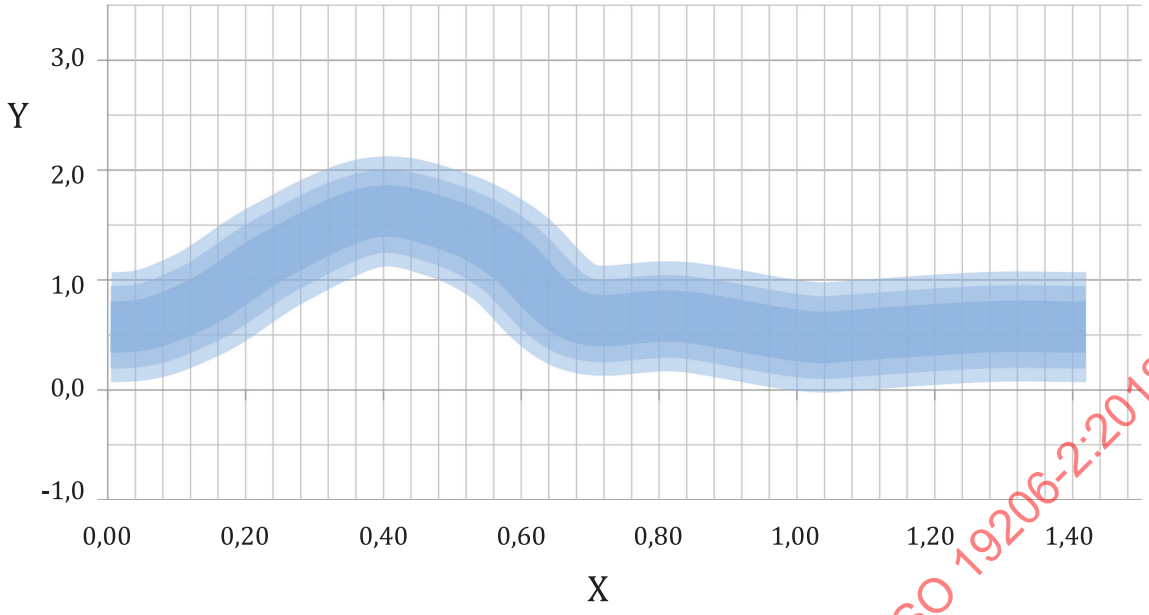
The torso and H-Point shall have a constant speed motion with minimal swinging. The articulation of the PT shall reach a steady state without initial, unintended swinging 1 s after start of movement.

EXAMPLE 2 The PT starts articulation at least 1s before reaching the RP, e.g.

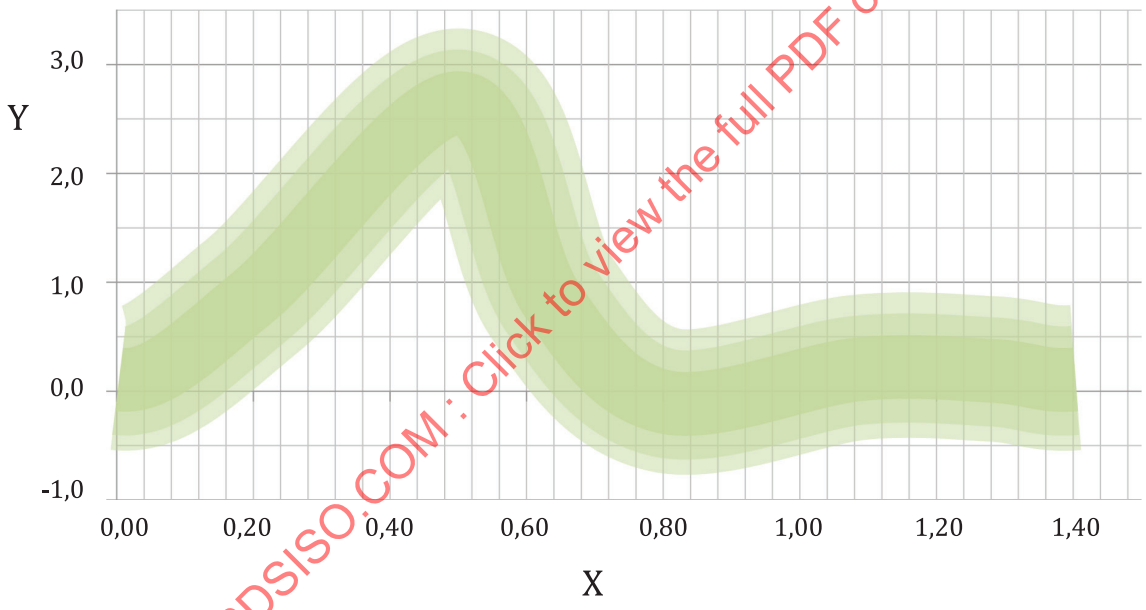
— 3,0 m (near-side scenario, 5 km/h);

— 4,5 m (far-side scenario, 8 km/h);

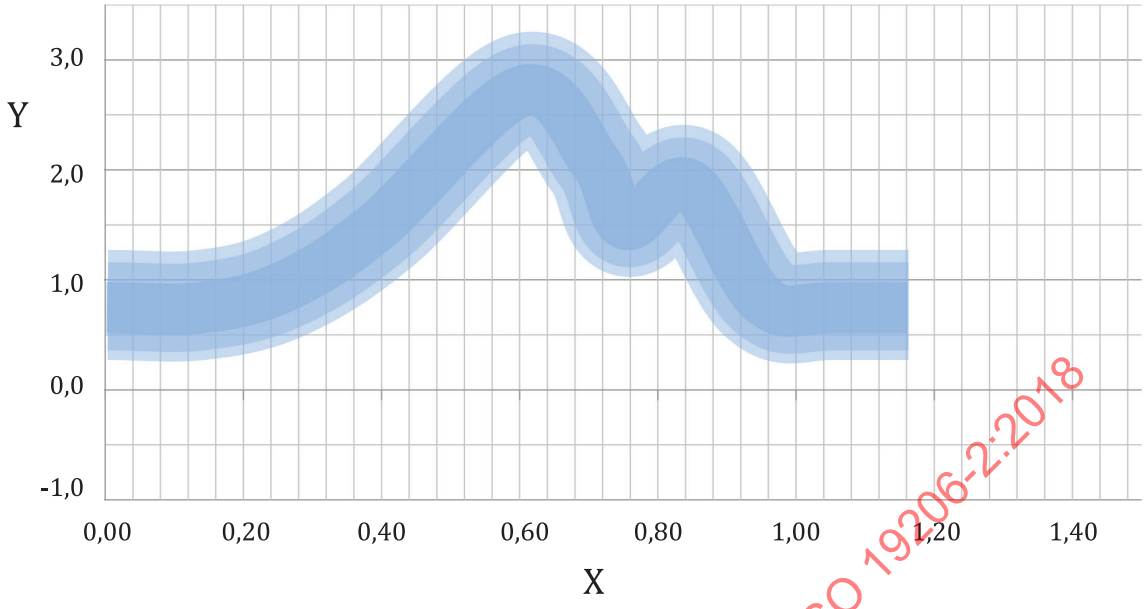
between PT and the middle of the lane.



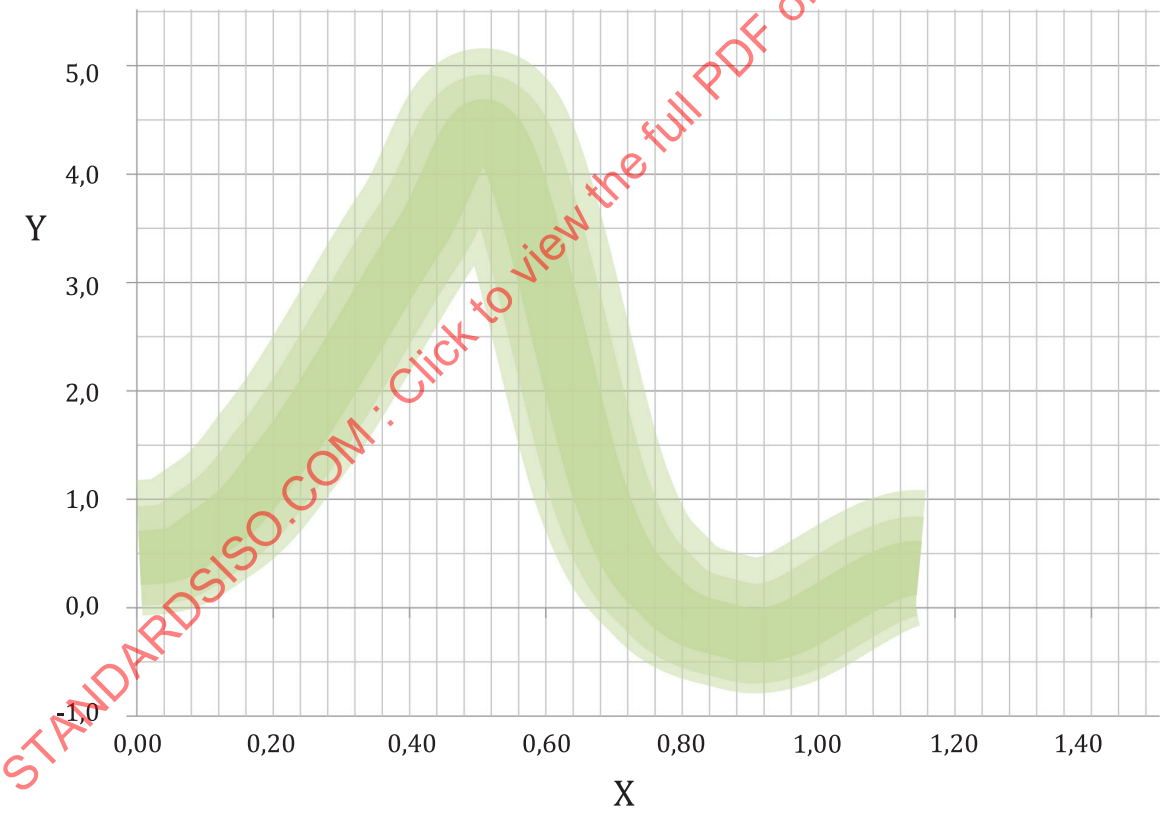
a) Knee adult — 3 km/h



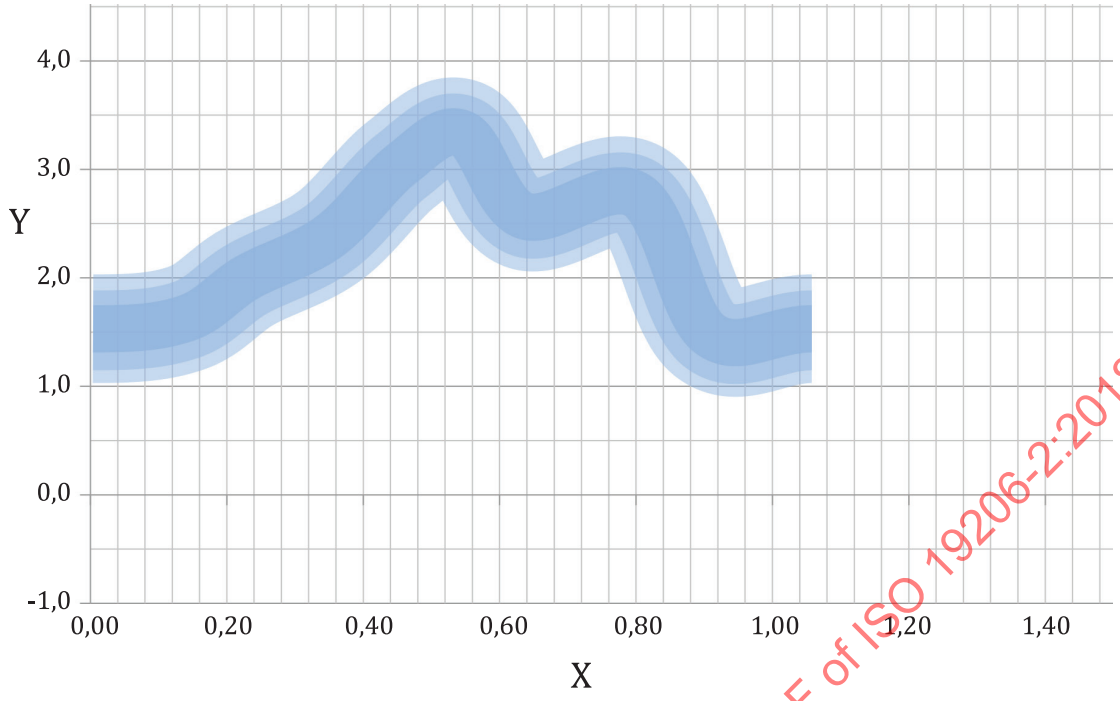
b) Ankle adult — 3 km/h



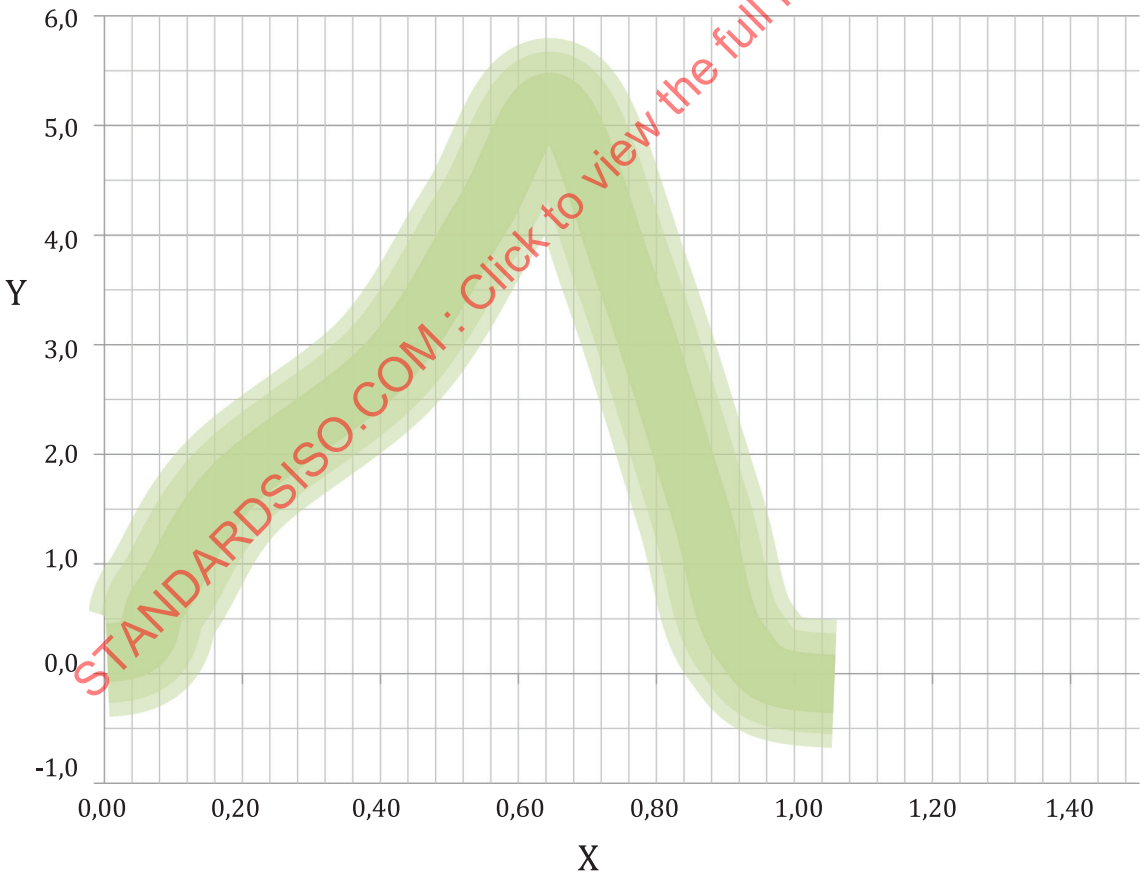
c) Knee adult — 5 km/h



d) Ankle adult — 5 km/h



e) Knee adult — 8 km/h



f) Ankle adult — 8 km/h