TECHNICAL REPORT

ISO/TR 14933

Second edition
2012-12-15

Road vehicles — Test procedures for evaluating out-of-position vehicle occupant interactions with deploying side air bags

Véhicules routiers — Méthodes d'essai pour l'évaluation des interactions d'un occupant en position anormale dans un véhicule avec les sacs gonflables latéraux en cours de déploiement

Reference number
ISO/TR 14933:2012(E)

COPYRIGHT PROTECTED DOCUMENT

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

Contents

Page

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.

In exceptional circumstances, when a technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example), it may decide by a simple majority vote of its participating members to publish a Technical Report. A Technical Report is entirely informative in nature and does not have to be reviewed until the data it provides are considered to be no longer valid or useful.

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/TR 14933 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 10, *Impact test procedures*.

This second edition cancels and replaces the first edition (ISO/TR 14933:2001), which has been technically revised.

Introduction

Side air bags (SAB) are inflatable devices intended to help reduce the risk of injury to the head and/or the chest and/or the pelvis of vehicle occupants adjacent to the impacted side of the vehicle. Side impact accident data indicate that the vehicle side is most likely to come into contact with a passenger car, a truck or a fixed object, such as a pole or tree[1)]. Accident data also indicate that serious-to-fatal injuries in side impact are most likely to occur to the head, neck, chest, abdomen, pelvis and extremities.

During its inflation process in an accident, an air bag generates a considerable amount of kinetic energy and, as a result, substantial forces can be developed between the deploying air bag and the nearby occupant. A considerable but unknown portion of the occupant population does not drive/ride in exactly the vehicle design position, but lean/rest in various ways against the armrest, door, glazing or other side panel of the vehicle, where air bag reaction forces may be even greater. These test procedures were developed to help improve the understanding of such interactions and to help aid in the assessment of future air bag designs.

This Technical Report describes the more common interactions, recognizing that the range of possible interactions is essentially limitless.

References[1] to[5] provide some background on human impact tolerance and criteria, while references[6] and[7] describe scaling techniques for different size occupants and references[8] to[10] offer interpretations of dummy responses relative to human injury potential that may be helpful in the evaluation.

1) The vehicle side may also come into contact with the ground during rollovers, but such contact is generally expected to be less severe than when coming into contact with the three main objects mentioned above.

Road vehicles — Test procedures for evaluating out-of-position vehicle occupant interactions with deploying side air bags

1 Scope

This Technical Report outlines test procedures for evaluating the effects of the interactions between deploying side air bags (SAB) and vehicle occupants. The in-position test procedures are referred to in other ISO international standards, such as, full-vehicle pole crash tests (ISO 15829) and instrumented arm evaluations (ISO 15827). Out-of-position vehicle occupant test procedures are described in this Technical Report.

This Technical Report describes dummies, procedures, instrumentation and test configurations that can be used for investigating the interactions that occur between a deploying side air bag and a vehicle occupant in front and rear seats. Air bags may deploy from the door or side trim panel, the armrest, the seat back or cushion, the roof support pillars, and the roof rail area. Occupants can range in size from young children through very large adults. These test procedures are sufficiently broad to cover these areas. Static tests are used for these evaluations, since external forces do not accelerate the vehicle buck.

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 6487:2012, *Road vehicles — Measurement techniques in impact tests — Instrumentation*

ISO/TR 12349 (all parts):1999, *Road vehicles — Dummies for restraint system testing*

ISO/TR 15827:2007, *Road vehicles — Test procedures — Evaluating small female dummy arm and forearm interactions with driver frontal airbags and side airbags*

ISO/TR 15829:2004, *Road vehicles — Side impact test procedures for the evaluation of occupant interactions with side airbags by pole impact simulation*

SAE J211-1:2007, *Instrumentation for impact test — Part 1: Electronic instrumentation*

SAE J211-2:2008, *Instrumentation for impact test — Part 2: Photographic instrumentation*

3 Definitions

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

3.1
side air bag
SAB
air bag designed primarily to help reduce occupant injury potential where the significant collision force vector is lateral

3.2
head air bag
air bag that deploys between the occupant's head and the vehicle side structure or an external object that could contact the head

3.3
chest (thoracic) air bag
air bag that deploys between the occupants upper torso and the vehicle side structure

3.4
pelvic air bag
air bag that deploys between the occupant's pelvis/thigh area and the vehicle side structure

3.5
combination air bag
air bag that deploys to help protect two or more occupants' body areas

EXAMPLE A head and chest combination air bag.

3.6
out-of-position occupant
occupant who is seated within the deployment area of a side air bag (for side impact collisions)

3.7
instrumented arm
upper and/or lower arm that fits on a production dummy, with accelerometers and/or load cells to help measure the interactive forces, accelerations and moments on the upper extremities during air bag deployment

3.8
rigid pole
vertically-oriented circular, rigid pole-like structure, beginning no more than 100 mm above the ground, and extending above the roof of the impacting vehicle

Note 1 to entry: See ISO 3560 and ISO 15829.

3.9
seat bight
seat back/seat cushion junction

4 Tests

4.1 General

Tests described in this Technical Report should be selected to produce the most comprehensive assessment of the occupant protection system in out-of-position conditions. Additional tests may need to be conducted with slight modifications of the dummy positioning to help ensure the robustness of the occupant interaction measurements.

4.2 Test device

4.2.1 General

Refer to Tables 2 and 3 for the dummies that are appropriate for use in this Technical Report. These dummies are referenced in ISO/TR 12349 (all parts).

The dummy's head skin should be cleaned with alcohol and dusted with baby powder to achieve acceptable frictional characteristics.

4.2.2 SID-IIs

The SID-IIs represents a 50th percentile 12 to 13 year old adolescent or small adult generic dummy designed to indicate injury potential to the head, neck, shoulder, arm, chest, abdomen, lumbar spine, pelvis, thighs and legs as described in Part 572. The SID-IIs has been fully evaluated and has been adopted

into ISO/TR 12349 for use. See references[11] to[13] for instrumentation details. It was specifically designed to help evaluate the injury potential of side air bags[11] to.[13]

5 Instrumentation

5.1 General

Measurements, possibly applicable to air bag testing, that can be made using the approved anthropomorphic test device for each age group are contained in ISO/TR 12349. All measurements should be recorded and filtered according to the latest version of ISO 6487 and SAE J211 for body regions. These measurements should be continuous functions of time, so that other quantities referred to in the references may be derived. Caution must be exercised with dummy compression measurements. In some of these tests, the rate of loading may be high enough to cause discontinuities in the compression data of the SID-IIs.

Monitor the air bag deployment and dummy interactions by high-speed cameras (or equivalent video equipment) operating at a minimum speed of 1000 frames per second (3000 fps is recommended). The cameras should be positioned so that the field-of-view encompasses the test setup and includes the anticipated movement of the dummy during the test.

5.2 Dummy test temperature

The test dummy temperature should be within a temperature range of 20,6 °C to 22,2 °C at a relative humidity to 10 % to 70 % after a soak period of at least 4 h prior to its application in a test, or that specified for the dummy by the manufacturer.

5.3 Electrical grounding

The test dummy, vehicle and all related instrumentation must be grounded to the data collection system. The test dummy shall be grounded with cables attached to the dummy's head, thorax and pelvis, which shall be connected to earth ground during all testing. Between tests, spray the dummy with an anti-static spray. These are both very important due to the high likelihood for electrostatic discharges as a result of the inflating air bag.

6 Air bag location/impacting object/other test matrix

The vehicle-to-fixed pole crash test procedure was selected in Table 1 instead of a dynamic side impact crash test or high-hooded vehicle simulation crash test. The rationale is that a pole crash test is the most severe and produces the highest dummy interaction responses. Additionally, a pole test presents the greatest challenge for designing the side air bag sensor system. The child/adult out-of-position and instrumented arm interaction tests are shown in Tables 2 and 3 for front and rear seating positions.

Table 1 — Pole test matrix

	Seat position		
Air bag types	Foremost	Mid	Rearmost
Seat	X	X	X
Door	X	X	X
Roof-rail	X	X	X

Table 2 — Side air bag OOP summary test matrix for driver seat (small – large adults)

Air Bag Types	Test Devices	Test Positions	Body Regions
Seat Mount	**SID-IIs, with ½ Arm** (If same air bag as passenger, tests may be conducted in either position.)	**7.2.8.1 – Inboard facing, leaning against door**	Head, Neck, Thoracic, Abdominal
	SID-IIs, with Instrumented Arm	**7.1.2.1 – Arm on armrest**	Arm
Door Mount	**SID-IIs, with ½ Arm** (If same air bag as passenger, tests may be conducted in either position.)	**7.2.7.1 – Forward facing against door trim**	Neck, Thoracic, Abdominal
	SID-IIs with Instrumented Arm	**7.1.2.1 – Arm on armrest**	Arm
Roof-Rail Mount	**SID-IIs, with ½ Arm or Hybrid III Small Female** (If same air bag as passenger, tests may be conducted in either position.)	**7.2.7.2 – Forward facing, against door trim, seat highest position**	Head, Neck

Table 3 — Side air bag summary test matrix for front passenger and rear seats (children – adults)

Air Bag Types	Test Devices	Test Positions	Body Regions
Seat Mount	**3-year-old Child Hybrid III**	**7.2.2.1 – Child on booster seat facing forward leaning against door trim**	Head, Neck, Thoracic, Abdominal
		7.2.3 – Facing rearward leaning against door	Head, Neck, Thoracic
		7.2.6.2 – Lying across seat, head on door trim, wedge support	Head, Neck
	6-year-old Child Hybrid III	**7.2.2.2 – Child on booster seat facing forward leaning against door trim**	Head, Neck, Thoracic, Abdominal
	SID-IIs, with ½ Arm	**7.2.8.1 – Inboard facing against door**	Head, Neck, Thoracic, Abdominal
	SID-IIs, with Instrumented Arm	**7.1.2.1 – Arm on armrest**	Arm
Door/Quarter Panel Mount	**3-year-old Child Hybrid III**	**7.2.4 – Outboard facing, leaning against door trim**	Head, Neck, Thoracic
		7.2.5.1 – Inboard facing, leaning back against door trim	Head, Neck
		7.2.6.1 – Lying across seat, head against door trim	Head, Neck
		7.2.6.2 – Lying across seat, head on door trim, wedge support	Head, Neck
	SID-IIs, with ½ Arm	**7.2.7.1 – Forward facing against door trim**	Neck, Thoracic, Abdominal
	SID-IIs, with Instrumented Arm	**7.1.2.1 – Arm on armrest**	Arm

Table 3 *(continued)*

Air Bag Types	Test Devices	Test Positions	Body Regions
Roof-Rail Mount	**6-year-old Child Hybrid III**	**7.2.5.2 – Inboard facing, leaning back against door, seated on booster**	Head, Neck
	SID-IIs, with ½ Arm or Hybrid III Small Female	**7.2.7.2 – Forward facing against door trim, seat highest position**	Head, Neck
		7.2.8.2 – Facing inboard against door, seat highest position	Head, Neck

7 Test details

7.1 Test procedures referenced in other ISO international standards

7.1.1 Dynamic vehicle-to-pole crash test

Refer to Table 1 and the ISO 15829 test procedure.

7.1.2 Instrumented arm static test procedure

Refer to Tables 2 and 3 and ISO/TR 15827for test matrices.

7.1.2.1 Elbow on armrest

Refer to the ISO/TR 15827 test procedure.

7.2 Child and small adult out-of-position static tests.

7.2.1 General

These tests have been developed to help evaluate the inflation induced injury potential of side air bags. The test dummy positions were developed to both block the deployment path of the side air bags and also to position the measurement systems of the dummy in the path of the deployment of the air bags. The tests are conducted in a static mode. Evaluations should be conducted with representative seats and door trim panels located in the vehicle design position.

Tests are conducted with the seat in its rearmost seat track and its full-down position, unless otherwise specified. Position the seat back to manufacturer's design angle or 25 degrees. The headrest is adjusted to its full-down position. The upper safety belt anchor adjustment is set to its highest position. All windows on the inflation side should be in the closed position, unless otherwise specified.

To aid in the dummy positioning, identify and mark the centreline of the seat back and seat cushion. Additionally, draw a horizontal line locating the top edge of the side air bag module, *line A*.

In vehicles with more than one type of side air bag system per seating position, the evaluations should be conducted individually and as a system.

7.2.2 Child on booster seat facing forward leaning against the door trim panel

These positions are for seat-mounted air bag systems (Table 3). The intention of this test is to maximize the head/neck interaction by aligning the neck with the top of the side air bag module. Modifications may have to be made to this procedure to achieve this goal. The test is conducted using both the 3-year-old and 6-year-old child Hybrid-III dummies as described in Part 572.

The booster seat foam block dimensions are 300 mm deep by 450 mm wide by 75 mm thick. The foam has a density of 40 g/l-80 g/l. A typical foam material is expanded polypropylene (EPP).

Locate and mark on the seat cushion two points for heel placement at 75 mm from the centreline of the seat and 20 mm to 50 mm from the leading edge of seat cushion.

Center the foam block on seat cushion extending it over the cushion bolsters and in contact with seat back bolsters. Do not tape or otherwise attach the booster to the seat.

The dummy channels recommended to be measured are: head acceleration (Ax, Ay, Az), head angular acceleration (1), upper neck forces and moments (Fx, Fy, Fz, Mx, My, Mz), lower neck forces and moments (Fx, Fy, Fz, Mx, My, Mz), chest acceleration (Ax, Ay, Az) and pelvic acceleration (Ax, Ay, Az). The air bag data channels (optional) are: module force (1) and bag pressure (1). The primary measurements of concern are the head acceleration and neck forces and moments.

7.2.2.1 Three-year-old child Hybrid-III dummy positioning

Follow the dummy positioning sequence specified below. The dummy positioned in the vehicle is shown in Figure 1.

a) Seat the dummy on the outboard edge of foam block, aligning the spine with the leading edge of the seat bolster (forward most contour line).

b) Place head in between seat bolster and B-pillar.

c) Place heels at heel placement points (previously marked on seat cushion).

d) With feet held in position, slide pelvis forward and parallel to the centreline of the vehicle, until the head/neck junction (i.e. lower edge of the skin at the base of the head) is aligned vertically with the top edge of the air bag module, *line A*.

e) Reposition heels over placement points if necessary.

f) With the vehicle door closed and the dummy's right arm raised (to clear armrest), slide the pelvis and upper torso outboard until contact with the door is achieved, and the head rests between the B-pillar and the seat back. The head/neck junction may shift down (10 mm to 20 mm) during the process.

g) Place the right arm on the armrest.

h) Flex the left arm such that the upper arm is in contact with the seat back, and the fingertips are in contact with booster seat.

Figure 1 — Three-year-old-child on booster seat facing forward leaning against the door trim panel

7.2.2.2 Six-year-old child Hybrid-III dummy positioning

Follow the dummy positioning sequence specified below. The dummy positioned in the vehicle is shown in Figure 2.

a) Seat the dummy on the outboard edge of foam block, aligning spine with the leading edge of seat bolster (forward most contour line).

b) Place head in between seat bolster and B-pillar.

c) Align the legs such that they cross the heel placement points (previously marked on seat cushion). Note: The heels will probably be off the seat cushion.

d) With feet held in position, slide pelvis forward and parallel to the centreline of the vehicle, until the dummy's neck/torso junction is coincident with the top edge of the air bag module, *line A.*

e) Align the legs, so they cross the placement points, if necessary.

f) With the vehicle door closed and the dummy's right arm raised (to clear armrest), slide the pelvis and upper torso outboard until contact with the door is achieved, and the head rests between the B-pillar and the seat back. The neck/torso junction may shift down (10 mm to 20 mm) during the process.

g) Place the right arm on the armrest.

h) Flex the left arm such that the upper arm is in contact with the seat back, and the finger tips are in contact with the booster seat.

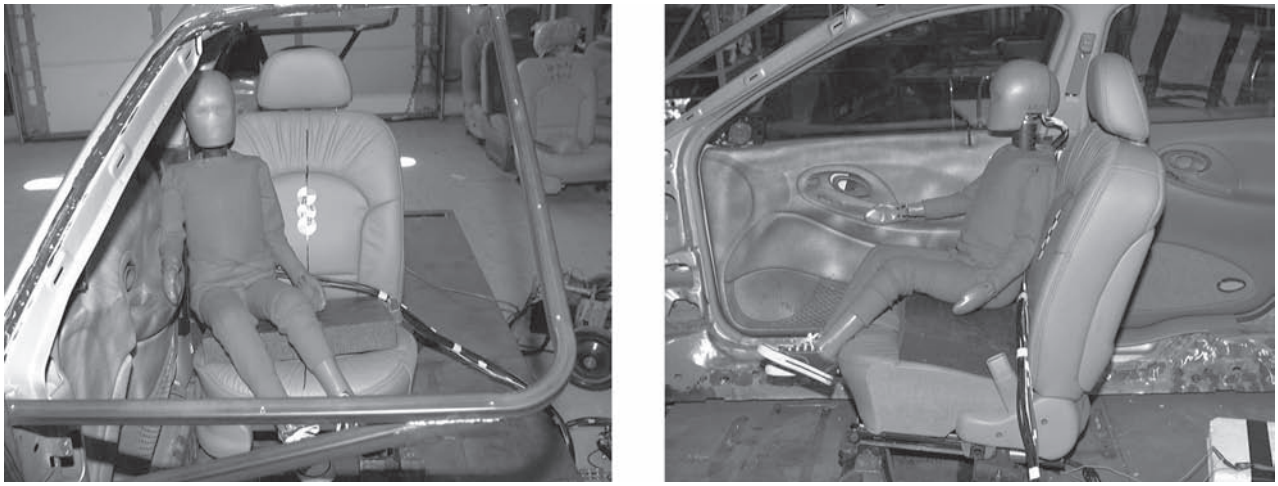

Figure 2 — Six-year-old-child on booster seat facing forward leaning against the door trim panel

7.2.3 Child facing rearward in vehicle leaning against door

This position is for seat-mounted air bag systems (Table 3). The intent of this test is to maximize chest interaction by aligning the sternum with the top of the side air bag module. Modifications may have to be made to this procedure to achieve this goal. The test is conducted using the 3-year-old child Hybrid-III dummy.

Follow the dummy positioning sequence specified below. The dummy positioned in the vehicle is shown in Figure 3. Figure 4 illustrates the dummy positioned on a high bolster-type seat.

a) Place the dummy along the outboard edge of the seat cushion kneeling and facing rearward, with feet overhanging the front edge of the seat cushion.

b) Align sternum as close as possible with the leading edge of the seat back bolster or forward most contour line. The sternum should be in contact with the seat.

c) Place the head between the seat and the B-pillar. The head should remain in its neutral orientation and should not be forced into flexion or extension. For the rear seat, the head should be placed as far outboard as possible.

d) Position the outboard leg at the outermost outboard edge of the seat cushion and parallel to the seat centreline. In the presence of seat cushion bolsters the outboard leg should be placed as close to the outboard edge of the seat cushion bolster as possible, while remaining on the cushion.

e) Slide the outboard knee and lower leg towards the seat bight until the top edge of the upper rib is aligned horizontally with the top edge of the air bag module, *line A.* The sternum should be in contact with the leading edge of the seat back bolster. In vehicles where the dummy fails to reach *line A*, place the outboard knee at the seat bight, at the outboard edge of the seat cushion.

f) Align the inboard leg such that it is parallel to the centreline of the seat cushion. Slide the right knee and lower leg towards the seat bight until a line drawn through both shoulder bolts is parallel to the transverse plane of the vehicle.

g) Rotate the inboard arm towards the seat back until the thumb contacts the seat back.

h) Rotate the outboard arm and hand so that they are vertically down or as close to vertical down as possible.

Figure 3 — Child facing rearward in vehicle leaning against door

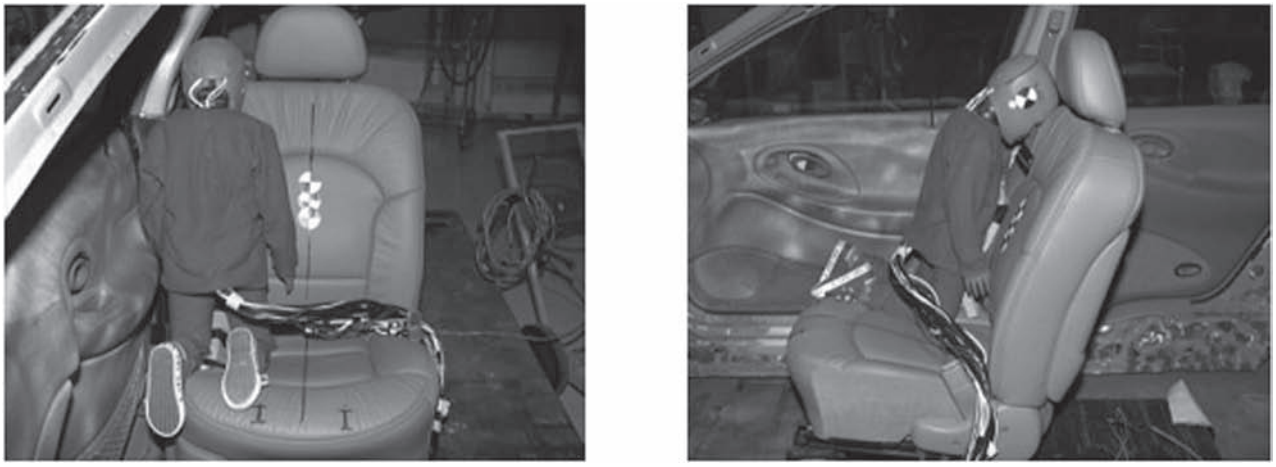

Figure 4 — Child facing rearward in vehicle leaning against door — High bolster-type seat (illustrated by foam taped to bolster)

The dummy channels recommended to be measured are: head acceleration (Ax, Ay, Az), head angular acceleration (1), upper neck forces and moments (Fx, Fy, Fz, Mx, My, Mz), lower neck forces and moments (Fx, Fy, Fz, Mx, My, Mz), chest acceleration (Ax, Ay, Az), mid-sternum compression (Dx), sternum acceleration (Ax, Az), lumbar spine forces and moments (Fx, Fy, Fz, Mx, My, Mz) and pelvic acceleration (Ax, Ay, Az). The air bag data channels (optional) are: module force (1) and bag pressure (1). The primary measurements of concern are the sternum compression, rate of sternum compression, chest acceleration and neck forces and moments.

7.2.4 Child facing outboard leaning against seat and door trim panel

This position is for door/quarter-mounted air bag systems (Table 3). The intent of this test is to maximize chest interaction by aligning the dummy's thorax midsagittal plane with the vertical centreline of the side air bag module. Modifications may have to be made to this procedure to achieve this goal. The test is conducted with the vehicle window open using the 3-year-old child Hybrid III dummy.

Follow the dummy positioning sequence below. The dummy positioned in the vehicle is shown in Figure 5.

a) The test dummy is placed in a kneeling position on the seat facing outboard in the vehicle. The dummy's midsagittal plane should be perpendicular to the seat cushion surface.

b) The dummy is then adjusted in the rearward direction, until the dummy contacts the seat back surface.

c) The seat track position is adjusted to locate the dummy's thorax midsagittal plane to be aligned, as close as possible, to the vertical centreline of the air bag module.

d) Keeping the head in its neutral orientation (i.e. head should not be forced into flexion or extension), the dummy is adjusted in the cross vehicle direction by leaning the torso outboard until the dummy's head or chest contacts the door trim panel.

e) Adjust the knee position to align the vertical height of the top of the upper rib with the top edge of the air bag module, *line A*.

f) Adjust the dummy's arms to be parallel with its torso.

Figure 5 — Child facing outboard leaning against seat and door trim panel

The dummy channels to be measured are: head acceleration (Ax, Ay, Az), head angular acceleration (1), upper neck forces and moments (Fx, Fy, Fz, Mx, My, Mz), lower neck forces and moments (Fx, Fy, Fz, Mx, My, Mz), chest acceleration (Ax, Ay, Az), mid-sternum compression (Dx), upper and lower sternal accelerations (Ax), upper and lower spine accelerations (Ax), lumbar spine forces and moments (Fx, Fy, Fz, Mx, My, Mz) and pelvic acceleration (Ax, Ay, Az). The air bag data channels (optional) are: module force (1) and bag pressure (1). The primary measurements of concern are the sternum compression, rate of sternum compression, chest acceleration and neck forces and moments.

7.2.5 Child facing inboard leaning against door or window glazing

This position is for door/quarter-mounted or roof rail-mounted air bag systems (Table 3). The intent of this test is to maximize head and neck interactions by aligning the dummy's thorax midsagittal plane with the vertical centreline of the side air bag module. Modifications may have to be made to this procedure to achieve this goal. The test is conducted using the 3-year-old or 6-year-old child Hybrid III dummy. The most appropriate dummy size depends on the in-vehicle height location of the air bag module.

The dummy channels recommended to be measured are: head acceleration (Ax, Ay, Az), head angular acceleration (1), upper neck forces and moments (Fx, Fy, Fz, Mx, My, Mz), lower neck forces and moments (Fx, Fy, Fz, Mx, My, Mz), chest acceleration (Ax, Ay, Az) and pelvic acceleration (Ax, Ay, Az). The air bag data channels (optional) are: module force (1) and bag pressure (1). The primary measurements of concern are the head acceleration and neck compression and moments.

7.2.5.1 Door/quarter-mounted air bag module system

The test is conducted using the 3-year-old child Hybrid III dummy.

Follow the dummy positioning sequence below. The dummy positioned in the vehicle is shown in Figure 6.

a) The seat track position is adjusted to locate the dummy's head midsagittal plane to be aligned, as close as possible, to the vertical centreline of the air bag module.

b) The test dummy is placed on the seat facing inboard.

c) Keeping the head in its neutral orientation (i.e. head should not be forced into flexion or extension), the dummy is adjusted in the cross vehicle direction, such that the back is in contact with the door trim panel.

d) Slide the pelvis inboard (i.e. parallel to the lateral centreline of the vehicle), until the head/neck junction (i.e. lower edge of the skin at the base of the head) is aligned vertically with the top edge of the air bag module, *line A.* If the vertical alignment cannot be achieved, then adjust the vertical seat height, if available.

e) The dummy's upper arms are parallel with its torso and forearms bent forward so the finger tips just touch the seat cushion.

Figure 6 — Child facing inboard leaning against door or window glazing (door/quarter-mounted air bag system)

7.2.5.2 Roof rail-mounted air bag module

The test is conducted using the 6-year-old child Hybrid III dummy.

The booster seat foam block dimensions are 300 mm deep by 450 mm wide by 75 mm thick. The foam has a density of 40 g/l to 80 g/l. A typical foam material is expanded polypropylene (EPP).

Locate and mark on the seat cushion two points for heel placement at 75 mm from the centreline of the seat and 20 mm to 50 mm from the leading edge of seat cushion.

Center the foam block on seat cushion extending it over the cushion bolsters and in contact with seat back bolsters. Do not tape or otherwise attach the booster to the seat.

Follow the dummy positioning sequence below. The dummy positioned in the vehicle is shown in Figure 7.

a) The test dummy is placed on the foam booster in the seat facing inboard.

b) If necessary, adjust the seat track position forward until the dummy's head does not contact the B-pillar.

c) Keeping the head in its neutral orientation (i.e. head should not be forced into flexion or extension), the dummy is displaced laterally outboard, until the dummy's back is in contact with the door trim panel.

d) The dummy's upper arms are parallel with its torso and forearms are bent forward so the fingers just touch the seat cushion.

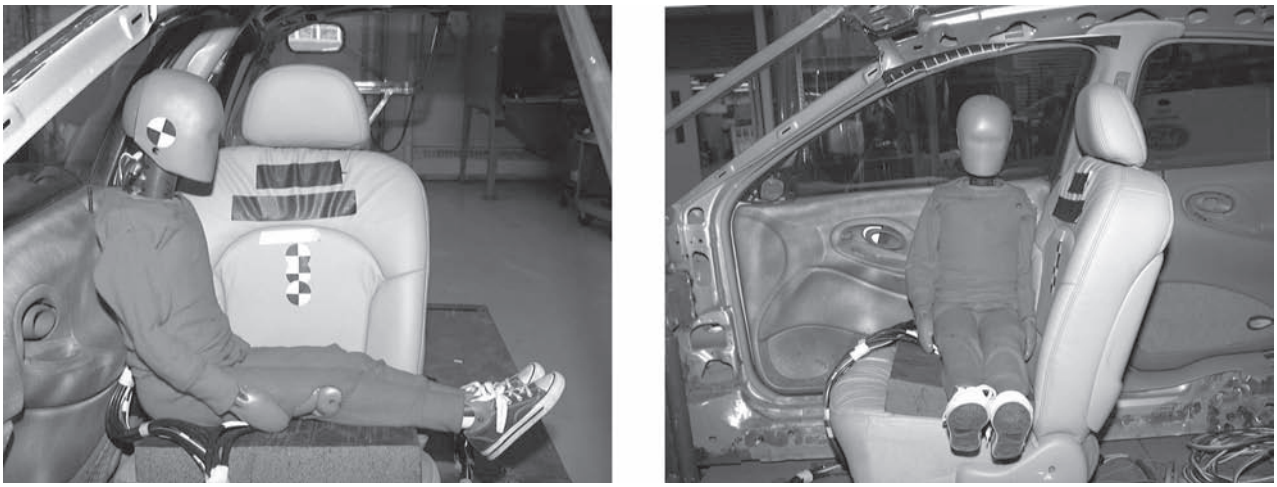

Figure 7 — Child on booster facing inboard leaning against door or window glazing (roof rail-mounted air bag system)

7.2.6 Child lying across seat with head against the door trim panel

These positions are for seat-mounted and/or door-mounted air bag systems (Table 3). Both of the possible dummy positions defined in sections 7.2.6.1 and 7.2.6.2 should be evaluated for a door-mounted air bag module.

The dummy channels recommended to be measured are: head acceleration (Ax, Ay, Az), head angular acceleration (1), upper neck forces and moments (Fx, Fy, Fz, Mx, My, Mz), lower neck forces and moments (Fx, Fy, Fz, Mx, My, Mz) and chest acceleration (Ax, Ay, Az). The air bag data channels (optional) are: module force (1) and bag pressure (1). The primary measurements of concern are the head acceleration and neck forces and moments.

7.2.6.1 Door/quarter-mounted side air bag system

The intention of this test is to maximize the head interaction by aligning the head with the vertical centreline of the air bag module. Modifications may have to be made to this procedure to achieve this goal. The test is conducted using the 3-year-old child Hybrid-III dummy.

Follow the dummy positioning sequence below. The dummy positioned in the vehicle is shown in Figure 8.

a) The seat track position is adjusted to locate the dummy's head midsagittal plane to be aligned, as close as possible, to the vertical centreline of the air bag module.

b) The test dummy is placed on its back in a reclining position on the seat aligned across the vehicle facing upward in the vehicle in contact with the seat back.

c) The arms are placed at the dummy's side and just touching the seat cushion.

d) The dummy is then adjusted in the cross vehicle direction by sliding it outboard against the door trim panel with the dummy's head against the door trim panel.

e) If necessary, for positioning stability, a piece of generic foam may be placed under the dummy's legs.

Figure 8 — Child lying across seat with head against the door trim panel (door/quarter-mounted air bag system)

7.2.6.2 Seat-mounted or door/quarter-mounted side air bag system

This test is conducted using the 3-year-old child Hybrid III dummy (only for the seat-mounted side air bag, lateral neck biofidelity needs to be determined or rotate the head and neck 90 degrees so that the face of the dummy faces the seat). The intention of this test is to maximize the head interaction by aligning the head with the vertical centreline of the air bag module. Modifications may have to be made to this procedure to achieve this goal.

The back support foam block dimensions are 300 mm deep by X1 mm wide by X2 mm tall. The X1 and X2 dimensions are determined to allow the dummy's head to rest on the door armrest. The foam has a density of 40 g/l to 80 g/l. A typical foam material is expanded polypropylene (EPP).

Follow the dummy positioning sequence below. The dummy's position in the vehicle is shown in Figure 9.

a) For a door-mounted air bag module, the seat track position is adjusted to locate the dummy's head midsagittal plane to be aligned, as close as possible, to the vertical centreline of the air bag module. For a seat-mounted air bag module, the seat track is in its rearmost and full down position.

b) The test dummy is placed on its back in a reclining position on the seat aligned across the vehicle facing upward in the vehicle in contact with the seat back.

c) Bending the dummy at the waist and keeping the head in its neutral orientation (i.e. head should not be forced into flexion or extension), the dummy is then adjusted in the cross vehicle direction by sliding it outboard against the door trim panel with the dummy's head resting on the door armrest or door trim panel, such that the head centre-of-gravity is aligned, as close as possible, with the horizontal centreline of the module. An appropriately sized wedge shaped foam block is used to

support the dummy's back. The wedge size should not interfere with the dummy's kinematics or air bag deployment.

d) The arm closest to the front edge of the seat is adjusted parallel to the torso resting on the foam block with the finger tips just touching the seat cushion.

e) The upper arm on the seat back side is adjusted 45 degrees forward of the torso centreline with the forearm at 90 degrees to the upper arm.

Figure 9 — Three-year-old child lying across seat with head on door trim panel

7.2.7 Small adult facing forward against door

These positions are for seat-mounted, door/quarter-mounted and roof rail-mounted air bag systems (Tables 2 and 3).

The dummy channels recommended to be measured are: head acceleration (Ax, Ay, Az), head angular acceleration (1), upper neck forces and moments (Fx, Fy, Fz, Mx, My, Mz), lower neck forces and moments (Fx, Fy, Fz, Mx, My, Mz), T-1 and T-12 spine accelerations (Ax, Ay, Az), lateral shoulder displacement (Dy), lateral thoracic rib compression (Dy), lateral abdominal rib compression (Dy), lateral shoulder acceleration (Dy), lateral thoracic rib accelerations (Ax, Ay, Az), lateral abdominal rib accelerations (Ax, Ay, Az), shoulder forces (Fx, Fy, Fz) and pelvic acceleration (Ax, Ay, Az). The air bag data channels (optional) are: module force (1) and bag pressure (1). The primary measurements of concern are the head acceleration, upper and lower neck forces and moments, rib compression and rate of rib compression.

7.2.7.1 Door/quarter-mounted air bag systems

The intention of this test is to maximize the head, neck and chest interactions by aligning the chest with the top edge of the air bag module. Modifications may have to be made to this procedure to achieve this goal. The test is conducted using the SID-IIs dummy with its half-arm.

Follow the dummy positioning sequence specified below. The dummy positioned in the vehicle is shown in Figure 10.

a) Place the dummy in the normal seated position in the centre of the seat with its midsagittal plane vertical.

b) The outboard arm should be rotated such that the arm is horizontal (i.e. up to clear any armrest present in the door trim).

c) Adjust the for/aft seat position to align the transverse plane of the dummy's thorax with the vertical centreline of the module.

d) Move the dummy outboard until the dummy contacts the trim panel without leaning the dummy to the side or twisting the torso. A vertical plane through the centreline of the dummy's shoulder stiffener and shoulder bolt should be parallel to the transverse plane of the vehicle.

e) Adjust the seat height, if applicable, such that the centre of the first thoracic rib is aligned with the top edge of the air bag module. Masking tape (25 mm) wrapped around the dummy's neck bracket may be used to hold the dummy in the vertical orientation.

f) Repeat step d), if necessary.

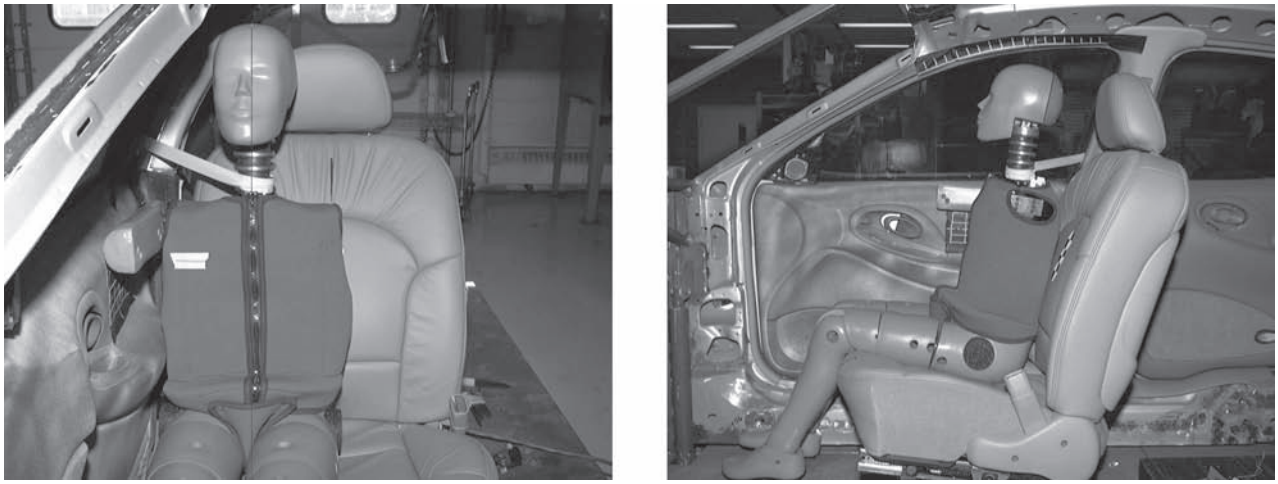

Figure 10 — Small adult facing forward against door — Door-mounted air bag system

7.2.7.2 Roof rail-mounted air bag systems

The intention of this test is to maximize the head and neck interactions by positioning the top of the head as close as possible to the air bag module. Modifications may have to be made to this procedure to achieve this goal. The test is conducted using the SID-IIs dummy with its half-arm or the Hybrid III Small Female dummy.

Follow the dummy positioning sequence specified below. The SID-IIs dummy positioned in the vehicle is shown in Figure 11.

a) Place the dummy in the normal seated position in the centre of the seat with its midsagittal plane vertical.

b) The outboard arm should be rotated such that the arm is horizontal (i.e. up to clear any armrest present in the door trim).

c) Adjust the for/aft seat position to maximize the head/air bag interaction.

d) Move the dummy outboard such that the dummy's head is in the deployment trajectory of the air bag. The dummy is allowed to lean to maximize the head/air bag interaction. A vertical plane through the centreline of the dummy's shoulder stiffener and shoulder bolt should be parallel to the transverse plane of the vehicle.

e) Adjust the seat height, if applicable, to the highest position.

f) Repeat step d), if necessary.

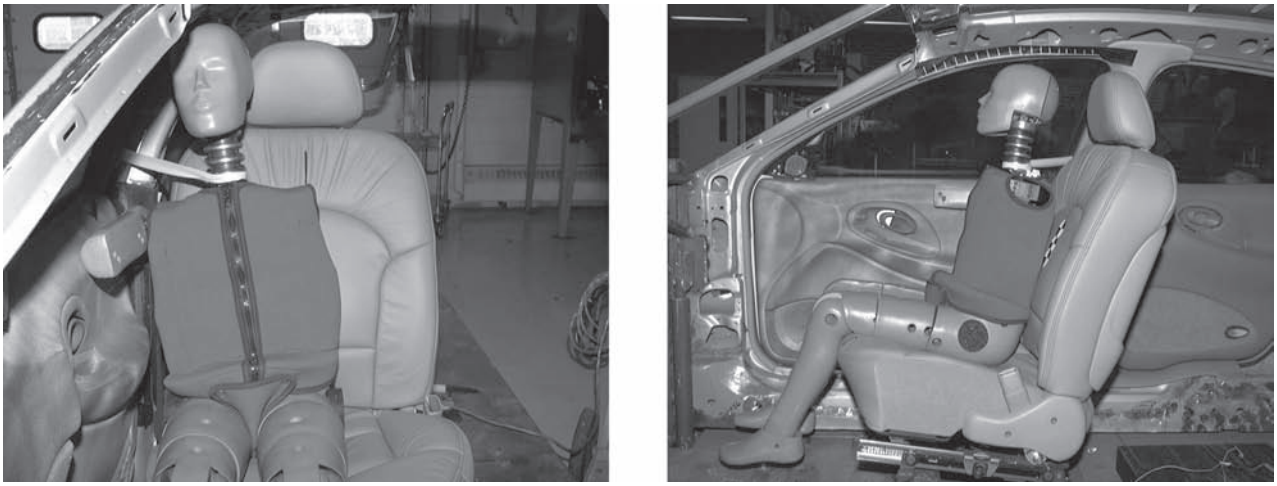

Figure 11 — Small adult facing forward against door — Roof rail-mounted air bag system

7.2.8 Small adult facing inboard against door

These positions are for seat-mounted and roof rail-mounted air bag systems (Tables 2 and 3).

The dummy channels recommended to be measured are: head acceleration (Ax, Ay, Az), head angular acceleration (1), upper neck forces and moments (Fx, Fy, Fz, Mx, My, Mz), lower neck forces and moments (Fx, Fy, Fz, Mx, My, Mz), T-1 and T-12 spine accelerations (Ax, Ay, Az), lateral shoulder displacement (Dy), lateral thoracic rib compression (Dy), lateral abdominal rib compression (Dy), lateral shoulder acceleration (Ay), lateral thoracic rib acceleration (Ax, Ay, Az), lateral abdominal rib acceleration (Ax, Ay, Az), shoulder forces (Fx, Fy, Fz) and pelvic acceleration (Ax, Ay, Az). The air bag data channels (optional) are: module force (1) and bag pressure (1). The primary measurements of concern are the head acceleration, upper and lower neck forces and moments, rib compression and rate of rib compression.

7.2.8.1 Seat-mounted side air bag system

The intention of this test is to maximize the head, neck and chest interactions by aligning the chest with the top edge of the air bag module. Modifications may have to be made to this procedure to achieve this goal. The test is conducted using the SID-IIs dummy with its half-arm.

Follow the dummy positioning sequence specified below. The dummy positioned in the vehicle is shown in Figure 12.

a) The test dummy is placed in a seated position on the seat facing towards the centre of the vehicle against the seat back.

b) The dummy is then adjusted in the cross vehicle direction by sliding the H-point outboard so that the dummy is against the door trim panel. A vertical plane through the centreline of the dummy's shoulder stiffener and shoulder bolt should be parallel to the longitudinal plane of the vehicle.

c) It is also adjusted in the front/rear direction by sliding the dummy's H-point forward until the centre of the first thoracic rib is aligned with the top edge of the air bag module. The dummy's spine should be vertical. Masking tape (25 mm) wrapped around the dummy's neck bracket may be used to hold the dummy in place.

d) The outboard arm should be rotated such that the arm is horizontal (i.e. up to side air bag module).

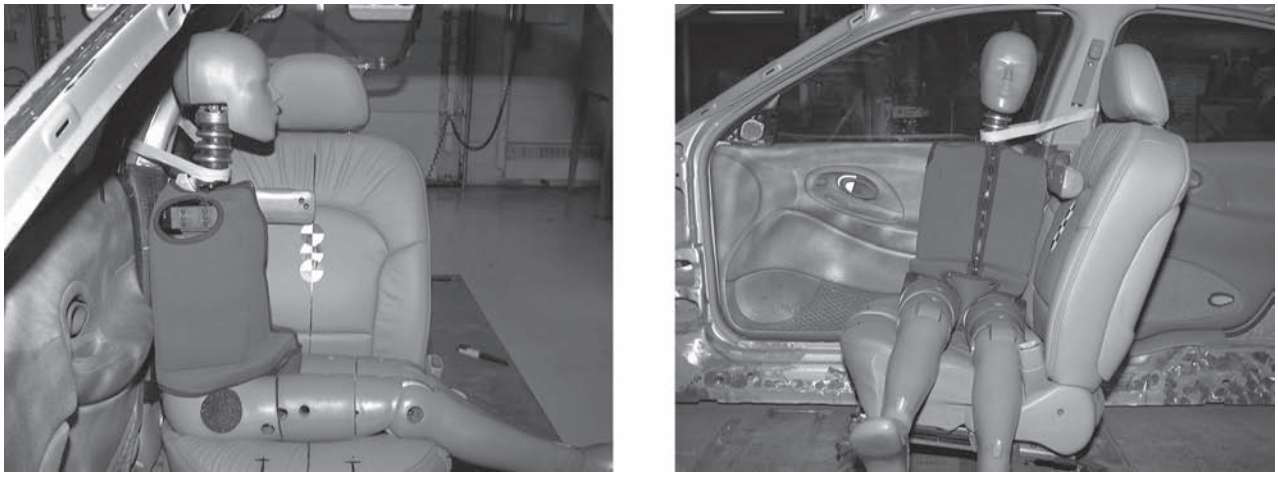

Figure 12 — Small adult facing inboard against door — Seat-mounted side air bag system

7.2.8.2 Small roof rail-mounted side air bag system

The intention of this test is to maximize the head and neck interactions by positioning the top of the head as close as possible to the air bag module. Modifications may have to be made to this procedure to achieve this goal. The test is conducted using the SID-IIs dummy with its half-arm or the Hybrid III Small Female dummy.

Follow the dummy positioning sequence specified below. The SID-IIs dummy positioned in the vehicle is shown in Figure 13.

a) The test dummy is placed in a seated position on the seat facing towards the centre of the vehicle against the seat back.

b) The dummy is then adjusted in the cross vehicle direction such that the dummy's head is in the deployment trajectory of the air bag. The dummy is allowed to lean to maximize the head/air bag interaction.

c) A vertical plane through the centreline of the dummy's shoulder stiffener and shoulder bolt should be parallel to the longitudinal plane of the vehicle. Masking tape (25 mm) wrapped around the dummy's neck bracket may be used to hold the dummy in place.

d) Adjust the seat height, if applicable, to the highest position.

e) Repeat step c), if necessary.

f) The outboard arm should be rotated such that the arm is horizontal.

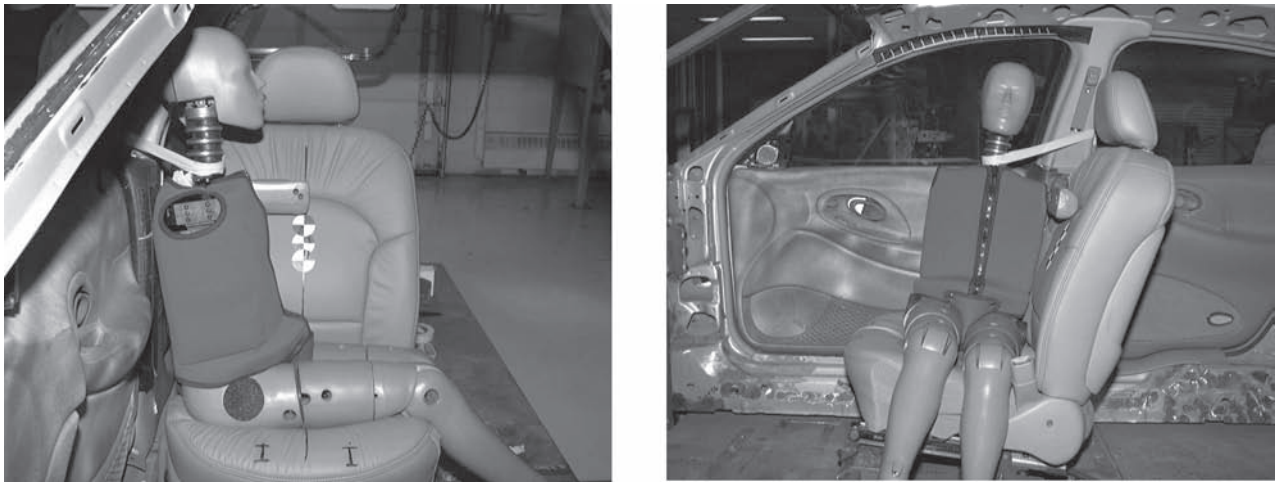

Figure 13 — Small adult facing forward against door — Roof rail-mounted air bag system

Bibliography

[1] AAMA submission to NHTSA on Advanced Technology Air Bags, Docket No. 98-4405; Notice 1, AAMA S98-13, NHTSA-1998-4405-79, December 17, 1998

[2] Mertz H.J.Anthropomorphic Test Devices. In: *Accidental Injury: Biomechanics and Prevention*, (Nahum A.M., & Melvin J.W.eds.). Springer-Verlag, New York, 1993, pp. 66–84.

[3] *Human Tolerance to Impact Conditions as Related to Motor Vehicle Design*. SAE Information Report J 885. July, 1986

[4] Prasad P., Daniel R.P. A Biomechanical Analysis of Head, Neck, and Torso Injuries to Child Surrogates Due to Sudden Torso Acceleration. *28th Stapp Car Crash Conference Proceedings*. November 6-7, 1984. (SAE 841656)

[5] Mertz H.J., Prasad P., Irwin A.L. Injury Risk Curves for Children and Adults in Frontal and Rear Collisions. *Proceeding of the 41st Stapp Car Crash Conference.* November 13-14, 1997 (SAE 973318)

[6] Mertz, H.J. *A Procedure for Normalizing Impact Response Data*. 1984 (SAE 840884)

[7] Irwin A.L., Mertz H.J. Biomechanical Bases for the CRABI and Hybrid III Child Dummies. *Proceeding of the 41st Stapp Car Crash Conference*. November 13-14,1997 (SAE 973317)

[8] Mertz H.J., Weber D.A. Interpretations of the Impact Responses of a Three Year Old Child Dummy Relative to Child Injury Potential. *Ninth International Technical Conference on Experimental Safety Vehicles*. November 1-4, 1982 (Also as SAE 826048)

[9] *Guidelines for Evaluating Out-of-Position Vehicle Occupant Interactions with Deploying Air Bags*. SAE Information Report J 1980. November 26, 1990

[10] ISO/TR 10982:1998, *Road vehicles — Test procedures for evaluating out-of-position vehicle occupant interactions with deploying air bags*

[11] Daniel R.P., Irwin A., Athey J., Balser J., Eichbrecht P., Hultman R.W. et al. The Small Size Advanced Side Impact Dummy Task Group of the Occupant Safety Research Partnership and Salloum, M. and Smrcka, J., First Technology Safety Systems, Technical Specifications of the SID-IIs Dummy. *Proceedings of the 39th Stapp Car Crash Conference.* 1995 (SAE 952735)

[12] Kirkish S.L., Hultman R.W., Scherer R.D., Daniel R.P., Rouhana S., Nusholtz G. et al. The Small Size Advanced Side Impact Dummy Task Group of the Occupant Safety Research Partnership and Salloum, M., First Technology Safety Systems, Status of Prove-Out Testing of the SID-IIs Alpha Prototype. *Fifteenth International Technical Conference on Enhanced Safety of Vehicles*. May, 1996 (Paper 96-S10-O-15)

[13] Scherer R.D., Kirkish S.L., McCleary J.P., Rouhana S.W., Athey J.B., Balser J.S. et al. Small Sized Advanced Side Impact Dummy Task Group of the Occupant Safety Research Partnership, Salloum, M. and Wang, Z., First Technology Safety Systems and Morgan, C. R., Robert A. Denton, Inc., SID-IIs Beta-Prototype Dummy Biomechanical Responses. *Proceedings of the 42nd Stapp Car Crash Conference.* 1998 (SAE 983151)

[14] ISO 3560:[2)], *Road vehicles — Frontal fixed barrier or pole impact test procedure*

[15] ISO 3784:1976, *Road vehicles — Measurement of impact velocity in collision tests*

[16] ISO 3833:1977, *Road vehicles — Types — Terms and definitions*

[17] ISO 10997:1996, *Passenger vehicles — Side impact with deformable moving barrier — Full scale test*

2) To be published (revision of ISO 3560:2001).

[18] SAE J1727:2010, *Injury calculation guidelines*

[19] SAE J1733:2007, *Sign convention for vehicle crash testing*

[20] 49 C.F.R. Part 572, DOT/NHTSA, *Anthropomorphic Test Devices*

ICS 43.020

Price based on 19 pages