TECHNICAL REPORT

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Road vehicles — Test procedures for evaluating occupant interactions with deploying side impact airbags

Véhicules routiers — Méthodes d'essai pour évaluer les interactions de l'occupant avec les sacs gonflables latéraux en cours de déploiement

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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 3.

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is entirely informative in nature and does not have to be reviewed until the data it provides are considered to be no longer valid or useful.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 Technical Report 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*.

Introduction

Side air bags (SAB) are inflatable devices intended to help reduce the risk of injury to the head, chest or pelvis, or all these, of vehicle occupants adjacent to the impacted side of the vehicle. Side impact accident data indicate that the vehicle side is most likely to be contacted by a passenger car, a truck or a fixed object such as a pole or tree (the vehicle side also may contact the ground during rollovers, but such contact is generally expected to be less severe than when contacted by the three main objects mentioned above). 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 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 or ride in exactly the vehicle design position, but leans or rests 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.

Road vehicles — Test procedures for evaluating occupant interactions with deploying side impact airbags

1 Scope

This Technical Report outlines test procedures for evaluating the effects of the interactions between deploying side air bags (SAB) and occupants. Out-of-position occupant test procedures are described in this Technical Report, while in-position test procedures are covered in other ISO Technical Reports, for example, full vehicle pole crash tests [9] and instrumented arm evaluations [8].

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 to 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.

Engineering judgment should be used in selecting the tests to be conducted with each individual system. Such tests should be selected to produce the most comprehensive assessment of the system. Additional tests may need to be conducted with slight modifications of the dummy positioning to help ensure the robustness of the occupant interaction measurements.

References [13] to [17] in the Bibliography provide some background on human impact tolerance and criteria, while references [18] and [19] describe scaling techniques for different size occupants and references [20] to [22] offer interpretations of dummy responses relative to human injury potential that may be helpful in the evaluation.

2 Terms and definitions

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

2.1
side air bag
SAB
air bag designed primarily to help reduce occupant injury potential where the significant collision force vector is lateral

2.1.1
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

2.1.2
chest (thoracic) air bag
air bag that deploys between the occupants upper torso and the vehicle side structure

2.1.3
pelvic air bag
air bag that deploys between the occupant's pelvis/thigh area and the vehicle side structure

2.1.4
combination air bag
air bag that deploys to help protect two or more occupants' body areas (e.g. a head-and-chest-combination air bag)

2.2
out-of-position occupant
⟨side impact collisions⟩ occupant who is seated within the deployment area of a side air bag

2.3
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

2.4
moving deformable barrier
MDB
energy-absorbing movable barrier used to impact either side of a test vehicle

[ISO 10997:1996]

2.5
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 The pole is preferably (350 ± 10) mm in diameter and set off from any vertical mounting surface (e.g. if attached to a fixed rigid barrier face) by at least 1 500 mm (see ISO 3560 and [9]).

2.6
seat bight
seat back/seat cushion junction

2.7
high-hooded vehicle
vehicle such as a large van or truck that has the top of its hood or radiator higher than 1 000 mm above ground

3 Test device

3.1 General

Refer to Tables 2 and 3 for the dummies that are appropriate for use in the test described in this Technical Report.

NOTE These dummies are referenced in ISO/TR 12349-1 and ISO/TR 12349-2.

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

3.2 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. The SID-IIs has been fully evaluated and has been adopted for use in ISO/TR 12349-1. It was specifically designed to help evaluate the injury potential of side air bags.

NOTE 1 See Bibliography (Daniel et al. [23], Kinkish et al. [24] and Sherer et al. [25] for instrumentation details and side air bag injury potential.

4 Instrumentation

4.1 General

Measurements, possibly applicable to air bag testing, which can be made using the approved anthropomorphic test device for each age group are given in ISO/TR 12349-1 and ISO/TR 12349-2. All measurements should be recorded and filtered according to ISO 6487 and SAE J211 (most recent edition) for body regions. These measurements should be continuous functions of time, so that other quantities referred to in the Bibliographical 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 1 000 frames per second (3 000 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.

4.2 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 four hours prior to its application in a test, or that specified for the dummy by the manufacturer.

4.3 Electrical grounding

The test dummy, vehicle and all related instrumentation shall be grounded. 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. Both grounding and spraying are very important due to the high likelihood for electrostatic discharges resulting from the inflation of the air bag.

5 Air bag location/impacting object/other test matrix

The vehicle-to-fixed pole crash test procedure has been selected instead of a dynamic side impact crash test or high-hooded vehicle simulation crash test (see Table 1). 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. Engineering judgment should be used to determine the appropriate seat track positions when conducting the pole test. The child/adult out-of-position (OOP) and instrumented arm interaction tests are shown in Tables 2 and 3 for front-and rear-seating positions.

Table 1 — Pole test matrix

Air bag types	Seat position		
	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 type	Test device	Test position	Body regions
Seat mount	SID-IIs, with 1/2 arm (If same air bag as passenger, tests may be conducted in either position.)	Inboard facing, leaning against door (see 6.2.8.2)	Head, neck, thoracic, abdominal
	SID-IIs, with instrumented arm	Arm on armrest (see 6.1.2.2)	Arm
Door mount	SID-IIs, with 1/2 arm (If same air bag as passenger, tests may be conducted in either position.)	Forward facing against door trim (see 6.2.7.2)	Neck, thoracic, abdominal
	SID-IIs, with instrumented arm	Arm on armrest (see 6.1.2.2)	Arm
Roof-rail mount	SID-IIs, with 1/2 arm or Hybrid III small female (If same air bag as passenger, tests may be conducted in either position.)	Forward facing, against door trim, seat highest position (see 6.2.7.3)	Head, neck

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

Air bag type	Test device	Test position	Body regions
Seat mount	3-year-old child Hybrid III	Child on booster seat facing forward leaning against door trim (see 6.2.2.2)	Head, neck, thoracic, abdominal
		Facing rearward leaning against door (see 6.2.3)	Head, neck, thoracic,
		Lying across seat, head on door trim, wedge support (see 6.2.6.3)	Head, neck
	6-year-old child Hybrid III	Child on booster seat facing forward leaning against door trim (see 6.2.2.3)	Head, neck, thoracic, abdominal
	SID-IIs, with 1/2 arm	Inboard facing against door (see 6.2.8.2)	Head, neck, thoracic, abdominal
	SID-IIs, with instrumented arm	Arm on armrest (see 6.1.2.2)	Arm
Door/Quarter panel mount	3-year-old child Hybrid III	Outboard facing, leaning against door trim (see 6.2.4)	Head, neck, thoracic
		Inboard facing, leaning back against door trim (see 6.2.5.2)	Head, neck
		Lying across seat, head against door trim (see 6.2.6.2)	Head, neck
		Lying across seat, head on door trim, wedge support (see 6.2.6.3)	Head, neck
	SID-IIs, with 1/2 arm	Forward facing against door trim (see 6.2.7.2)	Neck, thoracic, abdominal
	SID-IIs, with instrumented arm	Arm on armrest (see 6.1.2.2)	Arm
Roof-rail mount	6-year-old child Hybrid III	Inboard facing, leaning back against door, seated on booster (see 6.2.5.3)	Head, neck
	SID-IIs, with 1/2 arm or Hybrid III small female	Forward facing against door trim, seat highest position (see 6.2.7.3)	Head, neck
		Facing inboard against door, seat highest position (see 6.2.8.3)	Head, neck

6 Test details

6.1 Test procedures referenced in other ISO documents

6.1.1 Dynamic vehicle-to-pole crash test

Refer to Table 1 and the test procedure given in [9].

6.1.2 Instrumented arm static test procedure

6.1.2.1 General

Refer to Tables 2 and 3 for test matrices.

6.1.2.2 Elbow on armrest

Refer to the test procedures given in [8].

6.2 Child and small adult out-of-position static tests

6.2.1 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 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.

The tests shall be conducted with the seat in its rearmost seat track and its full-down position, unless otherwise specified. Position the seat back to the manufacturer's design angle or 25°. Adjust the headrest to its full-down position. Set the upper safety belt anchor adjustment 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 centerline 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.

6.2.2 Child on booster seat facing forward, leaning against door trim panel

6.2.2.1 General

These positions are for seat-mounted air bag systems (see 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 the procedure to achieve this goal. The test is conducted using both the 3-year-old and 6-year-old child Hybrid-III dummies.

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 centerline of the seat and 20 mm to 50 mm from the leading edge of seat cushion.

Centre the foam block on the 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 (one channel), 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 (one channel) and bag pressure (one channel). The primary measurements of concern are the head acceleration and neck forces and moments.

6.2.2.2 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 the foam block, aligning the spine with the leading edge of the seat back bolster (forward-most contour line).

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

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

d) With feet held in position, slide the 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 the heels over 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 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.

a) Front view **b) Side view**

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

6.2.2.3 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 the foam block, aligning the spine with the leading edge of the seat back bolster (forward-most contour line).

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

c) Align the legs so that they cross the heel placement points (previously marked on the seat cushion).

NOTE The heels will probably be off the seat cushion.

d) With feet held in position, slide the pelvis forward and parallel to the centerline 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 that 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.

a) Front view

b) Side view

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

6.2.3 Child facing rearward in vehicle, leaning against door

This position is for seat-mounted air bag systems (see 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 the procedure to achieve this goal. The test is conducted using the three-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 its feet overhanging the front edge of the seat cushion.

b) Align the sternum as closely 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 as possible to the outboard edge of the seat cushion bolster, 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 so 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 comes into contact with the seat back.

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

a) Front view **b) Side view**

Figure 3 — Child facing rearward in vehicle leaning against door

a) Front view **b) Side view**

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 (one canal), 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 (one channel) and bag pressure (one channel). The primary measurements of concern are the sternum compression, rate of sternum compression, chest acceleration and neck forces and moments.

6.2.4 Child facing outboard-leaning against seat and door trim panel

This position is for door/quarter-mounted air bag systems (see 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 the procedure to achieve this goal. The test is conducted with the vehicle window open using the three year-old child Hybrid III dummy.

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

a) Place the test dummy 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) Adjust the dummy in the rearward direction, until the dummy comes into contact with the seat back surface.

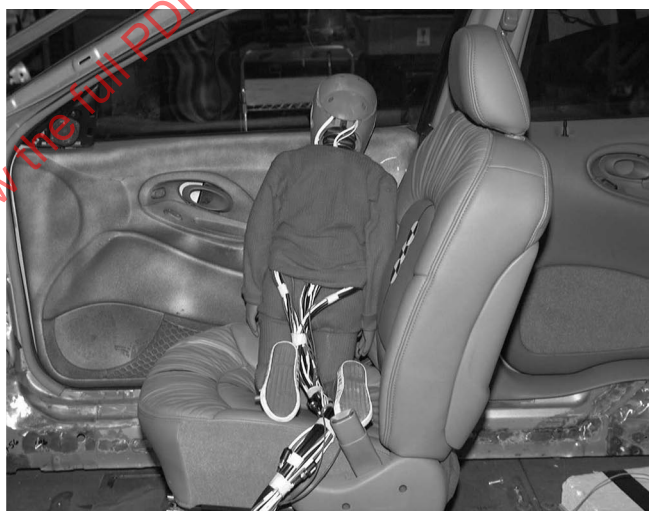
c) Adjust the seat track position to align the dummy's thorax midsagittal plane, as closely as possible with the vertical centreline of the air bag module.

d) Keeping the head in its neutral orientation (i.e. the head should not be forced into flexion or extension), adjust the dummy in the cross-vehicle direction by leaning the torso outboard until the dummy's head or chest comes into contact with 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 so that they are parallel with its torso.

a) Front view



b) Side view

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, 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 (one channel) and bag pressure (one channel). The primary measurements of concern are the sternum compression, rate of sternum compression, chest acceleration and neck forces and moments.

6.2.5 Child facing inboard leaning against door or window glazing

6.2.5.1 General

This position is for door/quarter-mounted or roof rail-mounted air bag systems (see 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 the procedure to achieve this goal. The test is conducted using the three-year-old or six-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 one channel, 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 (one channel) and bag pressure (one channel). The primary measurements of concern are the head acceleration and neck compression and moments.

6.2.5.2 Door/quarter-mounted air bag module system

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

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

a) Adjust the seat track position to align the dummy's head midsagittal plane, as closely as possible with the vertical centreline of the air bag module.

b) Place the test dummy on the seat facing inboard.

c) Keeping the head in its neutral orientation (i.e., head should not be forced into flexion or extension), adjust the dummy 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 a means of adjustment is available.

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

a) Front view **b) Side view**

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

6.2.5.3 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 centerline of the seat and 20 mm to 50 mm from the leading edge of the seat cushion.

Centre the foam block on the seat cushion so that it extends over the cushion bolsters and is in contact with the seat back bolsters. Do not tape or otherwise attach the booster to the seat.

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

a) Place the test dummy on the foam booster in the seat, facing inboard.

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

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

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

a) Front view **b) Side view**

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

6.2.6 Child lying across seat with head against door trim panel

6.2.6.1 General

These positions are for seat-mounted and/or door-mounted air bag systems (see Table 3). Both the possible dummy positions defined in 6.2.6.2 and 6.2.6.3 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 (one channel), 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 (one channel) and bag pressure (one channel). The primary measurements of concern are the head acceleration and neck forces and moments.

6.2.6.2 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 the procedure to achieve this goal. The test is conducted using the three-year-old child Hybrid-III dummy.

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

a) Adjust the seat track position to align the dummy's head midsagittal plane as closely as possible with the vertical centreline of the air bag module.

b) Place the test dummy on its back in a reclining position on the seat, aligned across the vehicle and facing upward, in contact with the seat back.

c) Place the arms at the dummy's side and just touching the seat cushion.

d) Adjust the dummy 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.

a) Front view **b) Side view**

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

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

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

The back support foam block dimensions are 300 mm deep by X_1 mm wide by X_2 mm thick. The X_1 and X_2 dimensions are determined in order 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 specified below. The dummy's position in the vehicle is shown in Figure 9.

a) For a door-mounted air bag module, adjust the seat track position to align the dummy's head midsagittal plane as closely as possible with the vertical centreline of the air bag module. For a seat-mounted air bag module, place the seat track is in its rearmost and full down position.

b) Place the test dummy on its back in a reclining position on the seat, aligned across the vehicle and facing upward in the vehicle, and in contact with the seat back.

c) Bending the dummy at the waist and keeping the head in its neutral orientation (i.e. the head should not be forced into flexion or extension), adjust the dummy 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 closely as possible with the horizontal centreline of the module. Use an appropriately sized wedge-shaped foam block to support the dummy's back. The wedge size should not interfere with the dummy's kinematics or air bag deployment.

d) Adjust the arm closest to the front edge of the seat so that it is parallel to the torso resting on the foam block, and with the finger tips just touching the seat cushion.

e) Adjust the upper arm on the seat back side 45° forward of the torso centreline with the forearm at 90° to the upper arm.

a) Front view **b) Side view**

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

6.2.7 Small adult facing forward against door

6.2.7.1 General

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 (one channel), 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 (one channel) and bag pressure (one channel). The primary measurements of concern are the head acceleration, upper and lower neck forces and moments, rib compression and rate of rib compression.

6.2.7.2 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 the 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. elevated 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 it comes into contact with 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.

a) Front view **b) Side view**

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

6.2.7.3 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 the procedure to achieve this goal. The test is conducted using the SID-IIs dummy with its half-arm or using 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.

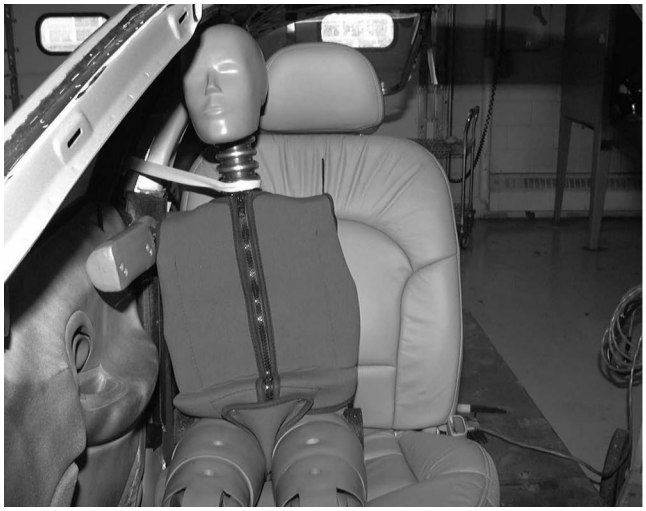
b) The outboard arm should be rotated such that the arm is horizontal (i.e. elevated to clear any armrest present in the door trim.

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.



a) Front view

b) Side view

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

6.2.8 Small adult facing inboard against door

6.2.8.1 General

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

The dummy channels recommended to be measured are: head acceleration (ax, ay, az), head angular acceleration (one channel), 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 (one channel) and bag pressure (one channel). The primary measurements of concern are the head acceleration, upper and lower neck forces and moments, rib compression and rate of rib compression.

6.2.8.2 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 the 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) Place the test dummy in a seated position on the seat facing towards the centre of the vehicle, against the seat back.

b) Adjust the dummy 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.