TECHNICAL REPORT

ISO/TR 10982

Second edition
2013-11-15

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

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

Reference number
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Foreword

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

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

The committee responsible for this document is ISO/TC 22, *Road vehicles*, Subcommittee SC 10, *Impact test procedures*.

This second edition cancels and replaces the first edition (ISO/TR 10982:1998), which has been technically revised.

Annex A of this Technical Report is for information only.

Introduction

Although laws concerning the mandatory use of seat belts and child restraints have been enacted in most ISO member countries, surveys and accident statistics indicate that between 10 % and 50 % of front seat occupants involved in accidents had not used these restraint systems. Most, if not all, new vehicles marketed with air bags in ISO member countries specify that the air bag is supplemental to the existing belt/child seat restraint systems. However, front seat occupants may not comply with manufacturer's recommendations and laws. Hence, they may be near or against deploying driver and/or passenger air bag modules during collisions. Some data indicate that small, unrestrained children may get into such positions due to voluntary precrash riding positions[1] and/or due to preimpact braking and/or collision forces.[2] These factors may also cause some adults to be near the air bag modules, but preimpact braking is likely to have less effect on adults.

During the inflation process, 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 out-of-position occupant. Accident data and laboratory test results[4][9] have indicated that these forces could cause injuries to the head, neck, thorax, abdomen and legs.

Both mild and moderate severity crash pulses are described in this Technical Report. These pulses represent general deceleration-time histories. The mild severity crash pulse is near the threshold of many air bag deployments and represents a frequent accident event. This pulse can be used for child testing, since they are more likely than adults to be near the air bag modules in threshold deployment collisions. Since preimpact braking has much less of an effect on adults, the moderate severity crash pulse can be used for adult testing. These described pulses or other vehicle-specific pulses may be used.

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

This document is published as a Technical Report, rather than as an International Standard, because of the general inexperience in air bag testing and lack of real-world accident data correlation. When sufficient real-world data are available and/or there is sufficient testing experience, it may be appropriate to develop an International Standard.

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

1 Scope

This Technical Report outlines a number of test procedures that can be used for investigating the interactions that could occur between the deploying air bag and the occupant who is near the module at the time of deployment. Static and dynamic tests to investigate both driver and passenger systems are described. Comparative evaluation of the designs can be conducted using static tests. Favourable systems may be evaluated, if deemed necessary, by appropriate dynamic tests.

Children and infants restrained in child or infants seats are the subject of another Technical Report.[20]

2 Normative references

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

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

SAE J211, *Part-1 Instrumentation for impact test*

3 Terms and definitions

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

3.1
passenger air bag module location
<low mounted> rearward deploying module location in the area of the instrument panel, normally used for knee bolsters

3.2
passenger air bag module location
<mid mounted> rearward deploying module location above the knee bolster area in the instrument panel

3.3
passenger air bag module location
<top mounted> air bag system that deploys through the top surface of the instrument panel

3.4
out-of-position occupant
vehicle occupant who is near the air bag module at the time of deployment

4 Test drive

4.1 General

Two sizes of adult dummies and one child size dummy are available for out-of-position occupant investigations. It is suggested that the adult dummies be equipped with an optional neck cover to give a more humanlike shape to the neck and neck-head junction.

4.2 50th percentile male Hybrid III dummy

This dummy is specified in FMVSS part 572, subpart E.

4.3 "Small female" Hybrid III dummy

The small female dummy is a scaled-down version of the Hybrid III 50th percentile male dummy. The size, shape, response and measurement capability were defined by a task force of the SAE Human Biomechanics and Simulation Standards Committee.[11] This dummy is specified in FMVSS part 572, subpart O.

4.4 Three-year-old child Hybrid III dummy

This dummy was developed for passenger air bag testing[12] by a task force of the SAE Human Biomechanics and Simulation Standards Committee and is commercially available. This dummy is specified in FMVSS part 572, subpart P.

5 Instrumentation

5.1 Adult size dummy

Measurements that can be made or calculated using these test devices are listed below:

- facial forces;[19]
- head triaxial acceleration (three channels);
- head angular acceleration in sagittal place (at least one channel for an extra linear accelerometer);
- upper neck (C-1: occipital condyles) forces and moments (six channels);
- lower neck (C-7, T-1) forces and moments (six channels);
- chest triaxial acceleration (three channels);
- mid-sternum to thoracic spine deflection (one channel);
- mid-sternum acceleration (one channel);
- upper and lower ribcage deflection1) (five channels);
- lower thoracic spine (T-12) forces and moments2) (five to six channels);
- pelvis triaxial acceleration (three channels);
- for systems using inflatable knee restraints, the full spectrum of Hybrid III multi-channel femur and tibia load cells and knee displacement transducers can be used to measure leg loading.

5.2 Three-year-old child dummy

Measurements that can be made or calculated using the child dummy are listed below:

- head triaxial acceleration (three channels);
- head angular acceleration in sagittal plane (at least one channel for an extra linear accelerometer);
- upper neck (C-1) forces and moments (six channels);

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1) Instrumentation for measurements is being developed and is expected to be available for both dummies at a later date.

2) Only available for the small female.

— lower neck (C-1/T-1) forces and moments (six channels);

— shoulder forces (F_x, F_z; four channels);

— sternal acceleration (a_x; two channels);

— sternal deflection (one channel);

— spine triaxial accelerations (T-1, T-4, T-12; nine channels);

— lumbar forces and moments (six channels);

— pubic forces (F_x, F_z; two channels);

— pelvis triaxial acceleration (three channels).

5.3 Data requirements

All measurements should be recorded and filtered according to ISO 6487 and SAE J211 for body regions. These measurements should be continuous functions of time so other quantities, such as those found in references[8],[9],[13]-[17] may be derived.

5.4 Dummy test temperature

The test dummy temperature should be within the range of 20,6 °C to 22,2 °C (69 °F to 72 °F) at a relative humidity of 10 % to 70 % after a soak period of at least four hours prior to its application in a test.

6 Sled pulses

6.1 General

Mild severity and moderate severity crash pulses are defined in 6.2 and 6.3. The out-of-position child may be exposed to a pulse similar to the mild severity crash pulse since collisions of similar severity occur most often, and preimpact braking will cause the child to be out-of-position more often than the collision dynamics.

6.2 Mild severity crash pulse

This pulse is a half sine type with a peak acceleration occurring near the centre of the time duration of (8 ± 1)g[3)] between 40 ms to 100 ms, a velocity change of (27 ± 2) km/h, and a (150 ± 5) ms pulse duration. Typical acceleration-time and velocity-time curves, and nominal acceleration are shown in Figures 1 and 2.

6.3 Moderate severity crash pulse

This pulse is a half sine type with a peak acceleration occurring near the centre of the time duration of (13 ± 1)g between 40 ms to 80 ms, a velocity change of (29 ± 2) km/h, and a (110 ± 5) ms pulse duration. Typical acceleration-time and velocity-time curves, and nominal acceleration are shown in Figures 3 and 4.

3) $g = 9{,}806\ 65\ \text{m/s}^2$

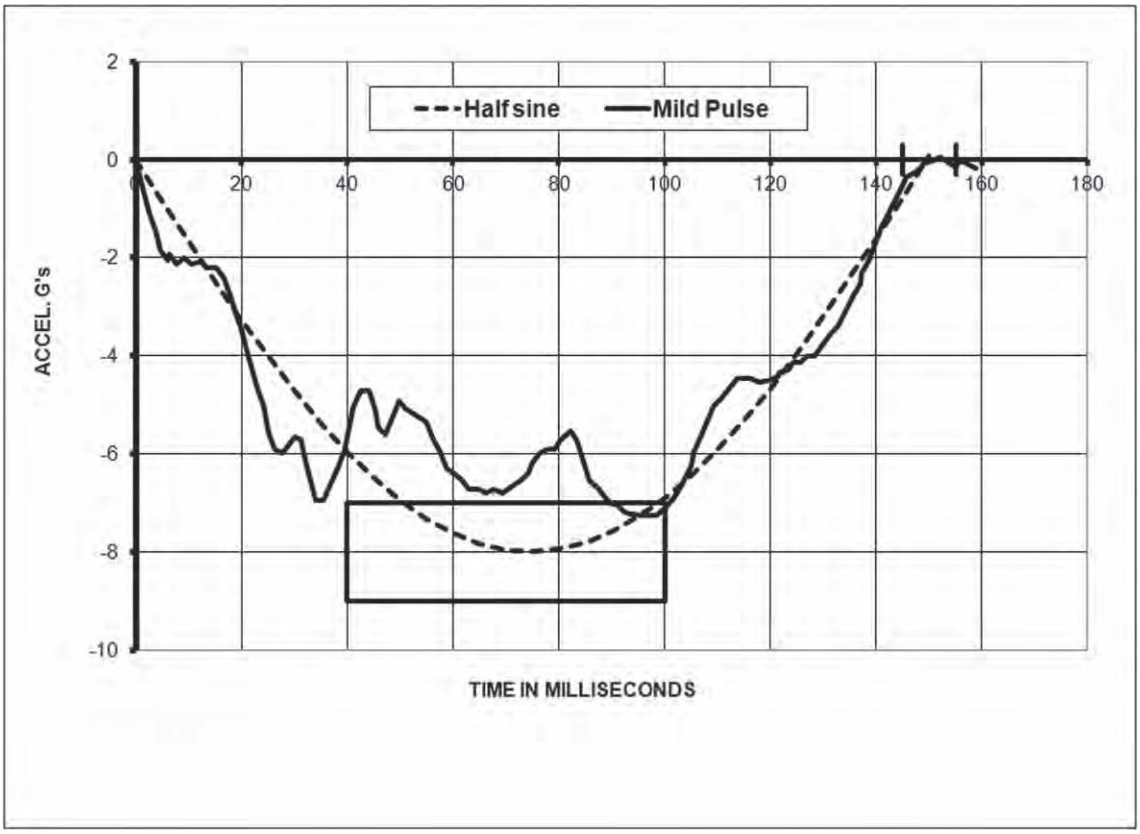

Figure 1 — Generic Hyge sled pulse for a mild crash severity

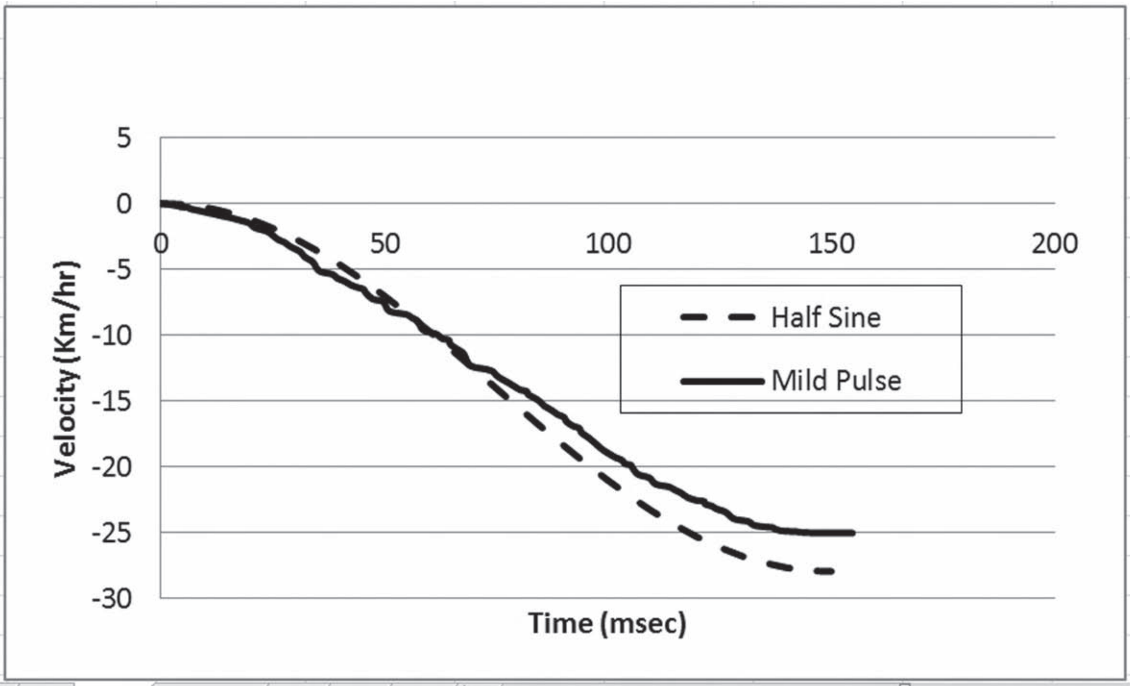

Figure 2 — Velocity-time history of the generic mild crash severity sled pulse

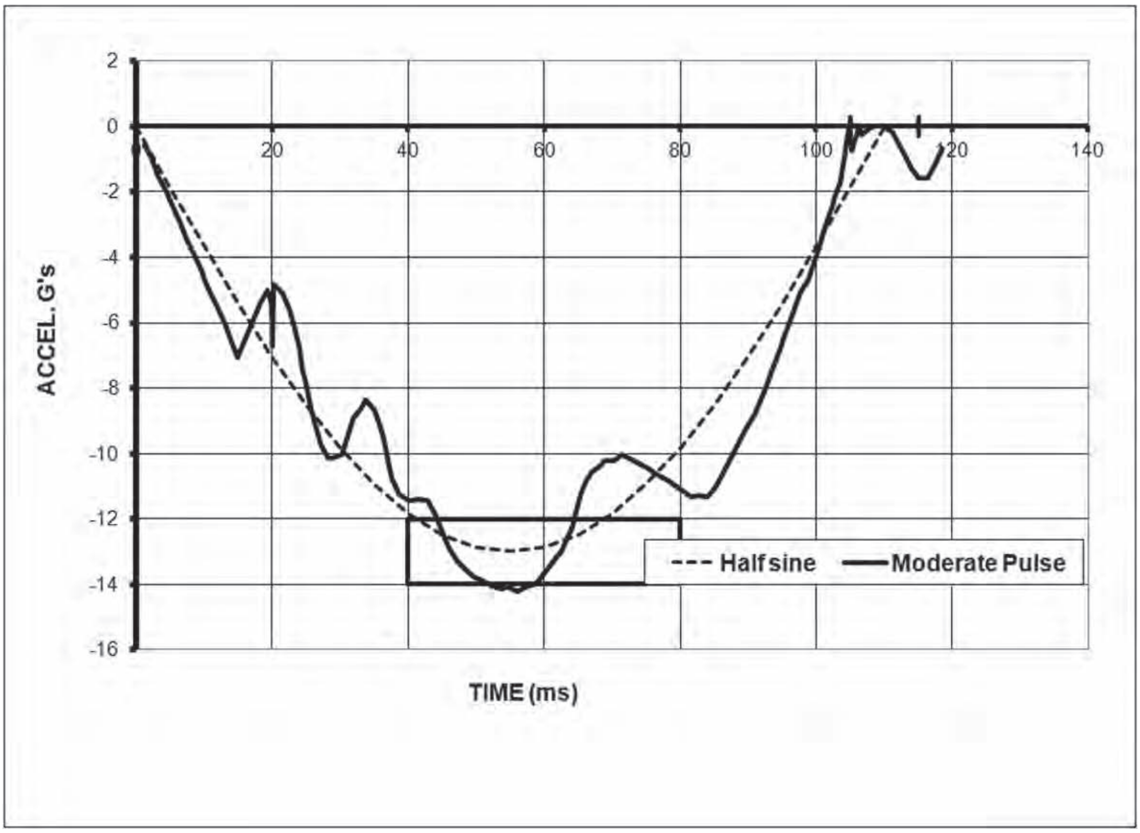

Figure 3 — Generic Hyge sled pulse for a moderate crash pulse

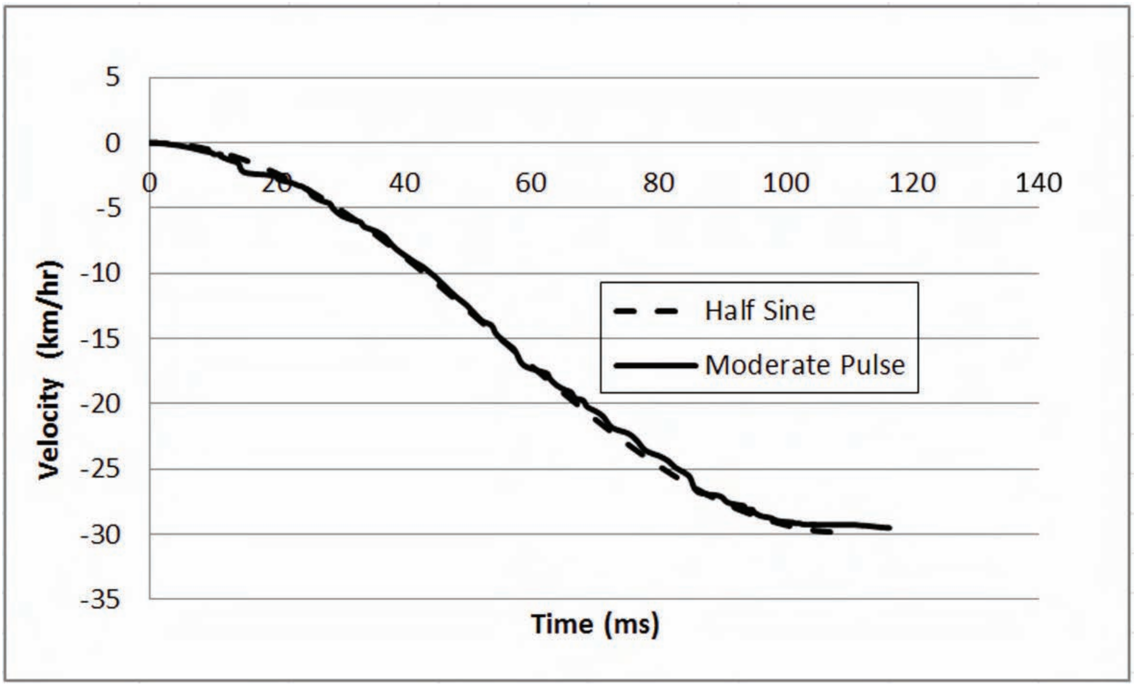

Figure 4 — Velocity-time history of the generic moderate crash severity sled pulse

7 Static and dynamic test for driver air bag systems

Two static prepositioned out-of-position driver tests and three acceleration-induced out-of-position driver dynamic tests are described in this clause. No priority is assigned to any of these interactions.

7.1 Test set-up

Mount the steering wheel, air bag module and steering column to an open structure or body buck by the normal column mounting means, so the mounting is at least as rigid as the actual vehicle mounting. The column should be mounted at the design column angle. The steering wheel may be in any desired rotated position (i.e. straight ahead, rotated 90°, 180°, etc.). If practicable, use the actual instrument panel. If not, knee bolsters with performance characteristics near those expected in production should be mocked into the buck at package location. If the windshield is expected to play any part in the deployment, then it or a mock-up must be included. Any on-vehicle hardware that might restrict column axial movement during inflation should be included. This buck should be mounted to any suitable sled or other test mechanism that produces the desired acceleration-time pulse.

7.2 Prepositioned driver tests

7.2.1 General

Place the test device on any suitable seating surface so the chest and head are in the desired locations in relation to the air bag. One or two layers of paper tape may be used to retain the dummy in the desired location. Dummy positions to be investigated are described in 7.2.2 and 7.2.3. Any of the adult dummies described in Clause 4 can be used. For these static tests, the dummy is prepositioned in the desired location and air bag is deployed.

7.2.2 Chin on top of module

This position is intended to investigate one of the possible neck and head loadings during the inflation event. Place the head of the dummy as far forward as permitted by the steering wheel rim, and centre the chin on the top edge of the module as shown in Figure 5. Align the torso so the torso angle is parallel to the plane of the wheel in side view.

Dummy responses of interest are head and neck measurements. Other responses might include chest measurements.

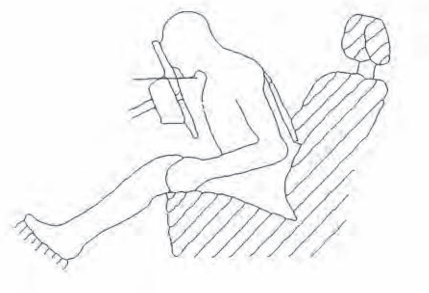

Figure 5

7.2.3 Chin on upper rim

This position is intended to investigate one of the possible neck loadings as the head is pushed upwards and rearward by the inflating bag. For this position the dummy's chin is placed against the upper rim and its chest is allowed to lie on the rim-module as shown in Figure 6. It should be noted that this position may not be attainable. A possible solution would be to use a smaller size dummy.

Dummy responses of interest are the neck and chest measurements. Other responses might include head measurements.

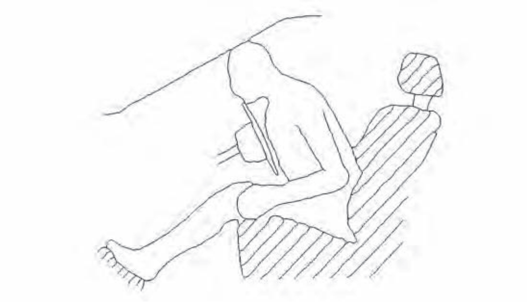

Figure 6

7.3 Acceleration-induced out-of-position driver dynamic tests

7.3.1 General

The object of these tests is to investigate possible interactions between deploying air bag and the part of the dummy of interest when the dummy is seated in its normal driving position and allowed to move forward as a result of sled acceleration. The air bag is deployed (in different tests) at various times during the sled pulse to determine the maximum bag interaction with the dummy. Any of the adult dummies defined in Clause 4 can be used.

7.3.2 Normally seated driver with normal steering position (unbelted)

Adjust the seat and steering wheel for the nominal driving position for the dummy size selected. Place the dummy in the nominal driving posture. Do not use any belt restraints. Subject the sled to the desired pulse crash and allow the dummy to translate forward toward the steering wheel. Deploy the system at various times (in different tests) during the pulse to determine maximum dummy interaction with the deploying bag.

Dummy responses of interest are head, neck and chest measurements. Other responses might include femur, knee and tibia measurements.

7.3.3 Normally seated driver with normal steering position (belted)

This test is the same as 7.3.2 except that all available belts are used.

Dummy responses of interest are head, neck and chest measurements. Other responses might include femur and knee measurements.

7.3.4 Chest interaction test (unbelted)

The purpose of this test is to investigate one of the possible interactions between the deploying air bag and the chest. Position the dummy in its nominal seated position and adjust the steering wheel system or seat height so the dummy's chest will contact the centre of the air bag module. The dummy's chin would have passed over the top of the rim, if the air bag is not deployed during the sled pulse. Subject the sled to the desired pulse and allow the dummy to translate forward. Deploy the air bag at various times (in different tests) during the pulse when the chest is near or in contact with the module.

Dummy responses of interest are the neck and chest measurements. Other responses might include head and femur measurements.

8 Static and dynamic tests for passenger air bag systems, using child dummy

8.1 General

The location of the passenger module on the instrument panel is an important consideration in choosing the child position and posture to be investigated. Three generic instrument panel locations of the passenger module are used: low (see 3.1.1), mid (see 3.1.2) and top (see 3.1.3). For any combination of module location and child position to be investigated, tests may have to be conducted to determine the child dummy positions that produce maximum interaction with the deploying air bag.

8.2 Test set-up

Mount the instrument panel or panel mock-up and the air bag module to an open structure or body buck by the normal mounting means or by similar mounting means so the mounting is at least as rigid as the actual vehicle mounting. If the windshield is expected to play any part in the deployment, then it or a mock-up must be included. Any on-vehicle hardware that might restrict or deflect the deployment should be included. For dynamic tests, this buck should be mounted to any suitable sled or other test mechanism that produce the desired acceleration pulse.

8.3 Child dummy test positions

8.3.1 Background

Montalvo, et al.[1] reported that 34 % of unrestrained front seat children in air bag deployment collisions would be near the instrument panel at the time of deployment. These children would either be initially near the instrument panel immediately before the collision or be propelled toward it by preimpact braking and/or collision forces. They categorized the possible positions into 13 (13) "Z"-positions. Seven of these "Z"-positions (Z-1, Z-2, Z-4, Z-5, Z-6, Z-7, Z-12) involve children who are facing forward, five (Z-8, Z-9, Z-10, Z-11, Z-13) involve sideways facing children, and one (Z-3) involves a rearward facing child.

Mertz, et al.[7] have shown that forward facing and sideways facing animals experienced similar injury types and severities when exposed to similar air bag deployments. They concluded that it was only necessary to expose forward facing surrogates in various child positions to assess the injury potential associated with deploying the air bag when the child is near the instrument panel. For this reason, the side and rear facing positions have been grouped with their corresponding forward facing positions, which result in the following seven primary child dummy test positions. In all positions, the arms of the dummy should be positioned not to interfere with the cushion's interaction with the body region of interest. Note the arm position in these figures. The figures should be taken as a general guide which may not be applicable for all packages. In all cases, the dummy is centred in plan view on the module.

8.3.2 Child position number 1

This child position is the Z-4 position (or its side facing, Z-13, equivalent) described in reference.[1] The child dummy may be seated on the front edge of the seat or stood on the floor. In either case, its chin should be above the top surface of the instrument panel and its thoracic spine should be vertical. The dummy's vertical height can be raised to obtain worst case condition as shown in Figure 7.

Figure 7

8.3.3 Child position number 2

This child position is the Z-1 position (or its side facing, Z-8, equivalent) described in reference.[1] Place the child dummy so its head is against the mid-face of the instrument panel and its buttocks on the seat as shown in Figure 8.

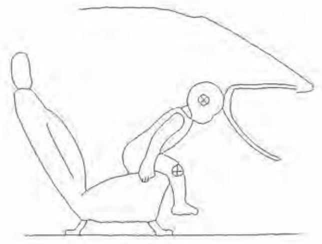

Figure 8

8.3.4 Child position number 3

This child position is the Z-7 position described in reference.[1] Place the child dummy in either a kneeling or sitting position on the floor. The thoracic spine should be vertical and the head should be against the face of the instrument panel as shown in Figure 9.

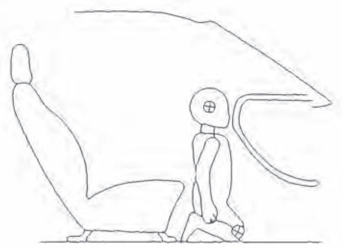

Figure 9

8.3.5 Child position number 4

This child position is the Z-6 position (or its side facing, Z-11, and rear facing, Z-3, equivalent) described in reference.[1] Place the child dummy so its head is against the midpanel surface and the body wrapped around the panel, with the torso against the lower instrument panel surface. Foam blocks and/or paper tape may be used to hold dummy in position as shown in Figure 10.

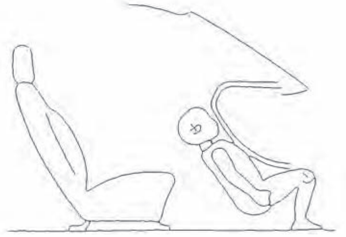

Figure 10

8.4 Child dummy static tests for passenger air bag systems

The choice of child dummy position to be used will be dependent on the instrument panel location of the passenger air bag system. It may be impossible to perform certain tests because of vehicle geometry. Table 1 gives possible child dummy positions for low, mid and top mounted passenger air bag modules. Dummy response measurements of primary importance are listed for each applicable combination.

Table 1 — Child dummy primary measurements for various combinations of dummy positions and passenger module locations

Dummy position	Passenger module location		
	Low	Mid	Top
1	N.A.	chest, neck	head, neck
2	head, neck	N.A.	N.A.
3	N.A.	head, neck, chest	N.A.
4	chest, abdomen, neck	N.A.	N.A.
NOTE "N.A." indicates dummy position is not applicable to module location.			

8.5 Child dummy dynamic tests for passenger air bag systems

8.5.1 Unrestrained child dummy out-of-position tests

The child dummy positions described in 8.3 and 8.4 can be investigated by dynamic testing. For these tests the fixture is mounted to a suitable crash sled. The dummy is placed in the desired position and the sled is subjected to the desired crash pulse. The air bag is deployed at any desired time during the simulated collision event.

8.5.2 Lap belted child dummy out-of-position test — Delayed deployment

Place the child dummy in the full forward seated position, restrained by the lap belt only. When the sled is accelerated the torso and head of the dummy will pitch forward. Deploy the air bag at various times (in different tests) to determine maximum head-neck interaction with the deploying bag.

9 Static and dynamic tests for passenger air bag systems using adult dummies

9.1 General

The location of the passenger module on the instrument panel is an important consideration in choosing the adult position and posture to be investigated. Three generic instrument panel locations of the passenger module are used: low (see 3.1.1), mid (see 3.1.2) and top (see 3.1.3). For any combination of module location and adult position to be investigated, tests may have to be conducted to determine the adult dummy positions that produce maximum interaction with the deploying air bag.

9.2 Test set-up

Mount the instrument panel or panel mock-up and the air bag module to an open structure or body buck by the normal mounting means or by a similar mounting means, so the mounting is at least as rigid as the actual vehicle mounting. If practicable, use the actual instrument panel. If not, knee bolsters with performance characteristics near those expected in production should be mocked into the buck at package location. If the windshield is expected to play any part in the deployment, then it or a mock-up must be included. Any on-vehicle hardware that might restrict or deflect the deployment should be included. For dynamic tests this buck should be mounted to any suitable sled or other test mechanism that produce the desired acceleration pulse.

9.3 Adult dummy positions near instrument panel

The adult dummy positions described can be produced in collisions by a number of factors such as preimpact braking and/or collision forces. It may be impossible to perform certain tests because of vehicle geometry. Any of the adult dummies described in Clause 4 can be used. One or two layers of paper tape can be used to hold the dummy in the desired position. Blocks can be placed under the buttocks to maintain desired height. In all tests the dummy will be centred on the module in plan view.

9.3.1 Adult position

This adult position is with the seat positioned fully forward on the seat track. The legs are in normal posture. The dummy is bend forward until its head contacts the instrument panel (or windshield) as shown in Figure 11. Paper tape may be used to hold the dummy in position.

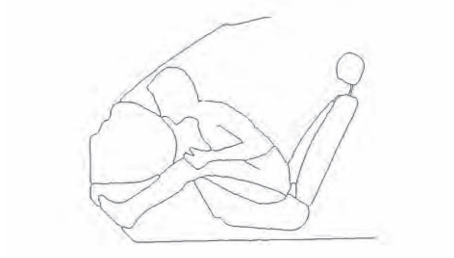

Figure 11

9.4 Adult dummy static tests for passenger air bag systems

The choice of adult dummy position will depend on the instrument panel location of the passenger air bag system. It may be impossible to perform certain tests because of vehicle geometry. Table 2 gives adult dummy positions for low, mid and top mounted passenger systems. Dummy response measurements of primary importance are listed for each applicable combination.

9.5 Adult dynamic tests for passenger air bag systems

9.5.1 General

The adult dummy positions described in 9.3 and 9.4 can be investigated by dynamic testing. For these tests the fixture is mounted to a suitable crash test sled. The dummy is placed in the desired position and the sled is subjected to the desired crash pulse. The air bag is deployed at any desired time during the simulated collision event.

Dynamic tests also can be conducted when the dummy is allowed to move toward the instrument panel as a result of vehicle acceleration. Four such sled test configurations are described in 9.5.2 to 9.5.5. For these tests any of the adult dummies described in Clause 4 can be used. The sled is subjected to the desired crash pulse.

9.5.2 Unrestrained dummy tests — Delayed deployment

Place the dummy in its normal seated position. Do not use any belt restraint. When the sled is accelerated, the dummy will translate forward toward the instrument panel. Deploy the air bag at any desired time when the dummy is near or against the instrument panel. The dummy measurements will depend on the location of the passenger module. Some guidance may be obtained by studying Table 2, but it is suggested that all available dummy measurements be recorded, including leg and lower spine data.

9.5.3 Three-point restrained dummy tests — Delayed deployment

Place the dummy in its normal seated position and restrained by the three-point harness (or other similar belt system). When the sled is accelerated, the dummy's head will pitch forward toward the instrument panel. Deploy the air bag at various times (in different tests) to determine maximum head-neck interaction with the deploying bag.

Table 2 — Adult dummy primary measurements for various combinations of dummy positions and passenger module locations

Dummy position	Passenger module location		
	Low	**Mid**	**Top**
Adult	legs	chest	head

9.5.4 Lap belted dummy tests — Delayed deployment

Place the dummy in its normal seated position, restrained by the lap belt only. When the sled is accelerated the torso and head of the dummy will pitch forward. Deploy the air bag at various times (in different tests) to determine maximum head-neck interaction with the deploying air bag.

9.5.5 Oblique-facing legs test — Unrestrained dummy — Low mounted passenger module only

This test produces a non-symmetrical loading of the legs. Such loading is of concern for low mounted systems with deploying knee restraints.

Place the dummy in its normal seated position. Rotate femurs 15° inboard of vehicle longitudinal centreline. Extend outboard leg forward of inboard leg. When the sled is accelerated, the dummy will translate forward with its outboard leg nearest the instrument panel. Deploy the air bag at any desired time during the pulse. Leg measurements, especially knee clevis loads on the outboard leg, are of primary importance.

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