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Road vehicles — Test procedures — Evaluating small female dummy arm and forearm interactions with driver frontal airbags and side airbags

Véhicules routiers — Méthodes d'essai — Évaluation des interactions du bras et de l'avant-bras du mannequin femme de petite taille avec les sacs gonflables conducteur frontal et latéral

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Contents

Page

Foreword

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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/TS 15827 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 10, *Impact test procedures*.

Introduction

Driver frontal airbags and side airbags 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. During its inflation process an airbag generates a considerable amount of energy and, as a result, substantial forces can be developed between the deploying airbag and the nearby occupant. Preliminary laboratory tests indicate that these forces can potentially, in certain circumstances, be sufficient to injure the vehicle occupant. A considerable but unknown portion of the occupant population does not drive/ride in exactly the vehicle design position, but rather leans/rests in various ways against the steering wheel, armrest, door or vehicle side interior, where airbag reaction forces can be particularly high. Through normal occupant preferences or during turning manoeuvres, the hand/forearm can be in various locations on/across the steering wheel rim, and thus interact with a deploying driver frontal airbag. These test procedures were developed to improve the understanding of such interactions and to help aid in the assessment of future airbag designs.

References [2], [4], [5], [8], [9], [12], [13] and [18] in the bibliography give some background on human impact tolerance and criteria, while references [15] and [17] describe scaling techniques for different size occupants and offer interpretations of dummy responses relative to human injury potential that might be helpful in the evaluation. References [1], [3], [7], [10], [11], [14], [16] and [19-22] describe the dummies used, and references [6] and [23] describe the filtering techniques used, in this test procedure.

Road vehicles — Test procedures — Evaluating small female dummy arm and forearm interactions with driver frontal airbags and side airbags

1 Scope

This Technical Specification describes test procedures for evaluating the effects of the interactions between driver frontal airbags or side airbags (excluding curtains) and small female arms.

This Technical Specification recommends dummies, procedures, instrumentation and test configurations that can be used for investigating the interactions that occur between a deploying airbag and a vehicle occupant. Driver frontal airbags deploy from the steering wheel and side airbags can deploy from the door, side trim panel, armrest, seat back or seat cushion. Occupants can range in size from young children to very large adults. However, the small adult female is considered to be the most at risk of arm injury from airbags. Therefore, this test procedure only addresses the small adult female occupant.

Recommended measurements are summarized in Clause 5. This Technical Specification encourages the use of a wide range of test configurations and conditions, while recognizing that the range of possible airbag interactions is essentially limitless and beyond testing capability.

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, *Road vehicles — Measurement techniques in impact tests — Instrumentation*

ISO 7862, *Road vehicles — Sled test procedure for the evaluation of restraint systems by simulation of frontal collisions*

ISO TR 12349-1, *Road vehicles — Dummies for restraint system testing — Part 1: Adult dummies*

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

SAE J1733, *Sign convention for vehicle crash testing*

3 Terms and definitions

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

3.1
driver frontal airbag
airbag attached to the steering wheel designed primarily to help reduce occupant injury potential where the significant collision force vector is longitudinal and from the front of the vehicle

3.2
side airbag
SAB
seat or door-mounted airbag (excluding curtains) designed primarily to help reduce occupant injury potential where the significant collision force vector is lateral

3.3
SAE small female instrumented arm
fully instrumented arm developed to measure the impact response of the small female arm interacting with a deploying airbag(s)

NOTE See references [16] and [21] in the bibliography.

3.3.1
upper arm
portion of the dummy's arm between the elbow and the shoulder

3.3.2
forearm
portion of the dummy's arm from the elbow to the wrist, including the hand

3.4
enhanced airbag interaction arm
modified version of the SAE small female instrumented arm with additional measurement capabilities

NOTE See reference [3] in the bibliography.

3.5
midsagittal plane
imaginary vertical plane that separates the dummy into equal left and right halves

3.6
coronal plane
imaginary vertical plane that separates the dummy into front and back halves

4 Test devices

The Hybrid III small female dummy shall be used for driver frontal airbag interactions. It is briefly described in 4.1. The SID-IIs dummy shall be used for side airbag interactions. It is briefly described in 4.2. These dummies will be instrumented with one of the two optional small female instrumented arms described in 4.3.

4.1 Hybrid III small female dummy

The Hybrid III small female dummy [16, 20] is representative of the fifth percentile adult female, designed to evaluate injury potential to the head, neck, shoulder, arm, chest, abdomen, lumbar spine, pelvis, thighs and legs. For these tests, the Hybrid III small female dummy will be instrumented with the SAE small female instrumented arm or the enhanced airbag interaction arm on the outboard side of the dummy.

4.2 SID-IIs small adult/adolescent side impact dummy

The SID-IIs is representative of the fifth percentile adult female and also approximates the height and weight of a 12–13-year-old adolescent child. It is a generic dummy designed to indicate injury potential to the head, neck, shoulder, arm, chest, abdomen, lumbar spine, pelvis, thighs and legs [1, 7, 14]. For these tests, the SID-IIs will be instrumented with the SAE small female instrumented arm or the enhanced airbag interaction arm on the outboard side of the dummy.

4.3 SAE small female instrumented arm and the enhanced airbag interaction arm

The SAE small female instrumented arm [16, 21] and the enhanced airbag interaction arm [3] can be used to indicate injury potential to the upper arm, forearm, elbow and wrist. They were specifically designed to help evaluate the injury potential of driver frontal airbags and side airbags while being used with the Hybrid III small female or SID-IIs dummies, respectively.

5 Instrumentation

Measurements applicable to driver frontal airbag testing and to SAB testing can be made using the anthropomorphic test devices listed in 4.1 and 4.2, respectively. Both driver frontal airbag testing and side airbag testing will include the use of one of the two interchangeable small female instrumented arms listed in 3.3, 3.4 and 4.3. All measurements should be recorded and filtered according to the latest version of ISO 6487 and SAE J211, Part 1. These measurements should be continuous functions of time, so that other quantities referred to in the references can be derived.

As an option, the airbag deployment and dummy interactions may be monitored by high-speed cameras (or equivalent video equipment) operating at a minimum speed of 1 000 frames per second.

5.1 Hybrid III small female dummy

See ISO/TR 12349-1 and references [16] and [20] in the bibliography.

5.2 SID-IIs small adult/adolescent side impact dummy

See ISO/TR 12349-1 and references [1], [7] and [14] in the bibliography.

5.3 SAE small female instrumented arm

A recommendation for which arm to use is being developed by ISO/TC 22/SC 12/WG 5. Until such a recommendation becomes available the reader is referred to SAE Engineering Aid 36, which describes the SAE instrumented arm, and to ISO/TC 22/SC 12/WG 5/N622 and reference [17] in the bibliography, which describe the enhanced airbag interaction arm. These arms are available for the SID-IIs and the Hybrid III small female dummies.

5.4 Impact response measurements

5.4.1 Dummy instrumentation measurements

Data acquisition shall be in accordance with ISO 6487. Obtain the data specified in Tables 1 and 2 for driver frontal airbag tests and side airbag tests, respectively. The data not specific to the arm are used to evaluate the quality of the test and to obtain a view of the overall dummy–airbag interaction [11].

5.4.2 Dummy instrumentation filter classifications

Forces, moments and accelerations obtained with the instrumented arms are to be filtered using a CFC 600 filter [6, 23].

5.5 Dummy injury criteria

A recommendation for injury criteria for the arm and forearm has been developed by ISO/TC 22/SC 12/WG 6 and is specified in ISO/TC 22/SC 12/WG 6/N573. References [2], [4], [5], [8], [9], [12], [13] and [18] in the bibliography provide a resource recommended by ISO/TC 22/SC 12/WG 6 for further development of reference values. It should be noted that the forearm bending moment cited in N573 is the resultant forearm bending moment.

Table 1 — Required data for Hybrid III small female dummy measurements

Hybrid III small female dummy measurements	Directions
Required	
Head:	
Accelerations at centre of gravity	3 axes
Neck:	
upper – forces and moments[a]	F_y, F_z, M_x
lower – forces and moments[a]	F_y, F_z, M_x
Chest:	
accelerations	3 axes
Sternum:	
accelerations	x-axis
Thorax:	
displacement	x-axis
Arm:	
upper arm – forces and moments	6 axes
elbow – moments	2 axes
elbow – angular displacement	1 axis
elbow – accelerations	3 axes
forearm – forces and moments	6 axes
wrist – accelerations	3 axes

[a] The directions are defined in SAE J1733.

Table 2 — Required data for SID-IIs dummy measurements

SID-IIs dummy measurements	Directions
Required	
Head:	
accelerations at centre of gravity	3 axes
Neck:	
upper – forces and moments[a]	6 axes
lower – forces and moments[a]	6 axes
Thoracic spine:	
upper – accelerations	3 axes
lower – accelerations	3 axes
Shoulder:	
accelerations	3 axes
force	y-axis
displacement	y-axis
Thoracic ribs:	
accelerations	3 axes
displacement	y-axis
Abdominal ribs:	
accelerations	3 axes
displacement	y-axis
Arm:	
upper arm – forces and moments	6 axes
elbow – moments	2 axes
elbow – angular displacement	1 axis
elbow – accelerations	3 axes
forearm – forces and moments	6 axes
wrist – accelerations	3 axes

[a] The directions are defined in SAE J1733.

6 Condition of the test vehicle

The vehicle environment must consist of any component likely to interact with the arm and airbag or impose a boundary condition on it, such as the seat, door, door trim, A-pillar, A-pillar trim, B-pillar, B-pillar trim, side rail, side rail trim, instrument panel, steering column and/or steering wheel. The use of a partial vehicle body is acceptable as long as the appropriate interior trim components are used.

6.1 General conditions

The test vehicle doors shall be closed and latched, but not locked. Window(s) adjacent to the test dummy shall be closed for driver frontal airbag tests and open for side airbag tests.

6.2 Seat adjustment

6.2.1 Fully-forward seat-track position

Adjustable seats are in the fully-forward seat-track position, and if vertically adjustable, in the mid position. If on the same model, vertically adjustable and fixed seats exist, then the same vertical position as that of the fixed seat will be used. Adjustable seat pan tilts are in the mid position.

6.2.2 Mid seat-track position

Adjustable seats are in the mid seat-track position and, if vertically adjustable, in the position designated in 6.2.1. If a mid seat-track adjustment notch does not exist midway between the foremost and rearmost seat-track positions, then use the first seat-track adjustment notch rearward of the mid seat-track position.

6.2.3 Seat back adjustment

Set the seat back so that the torso of the dummy is as close as possible to the manufacturer's recommendations for normal use. In the absence of such recommendations, an angle of 25° towards the rear from vertical is to be used.

6.3 Steering wheel adjustment

Place tilt steering wheel so that the steering wheel hub is at the midpoint of the arc it describes when moved through its full range of driving positions. If there is no setting detent at the midpoint (e.g. if there is an even number of detent positions), lower the steering wheel to the detent just below the midpoint. If the steering column is telescopic, the adjustment should be in the mid position.

6.4 Pedal adjustment

If pedal adjustments exist, adjust the pedals to the fully-rearward and fully-up position.

6.5 Dummy test temperature

The temperature of the test dummy and instrumented arm should be within a temperature range of 20,6 °C to 22,2 °C at a relative humidity of 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.

6.6 Electrical grounding

The test dummy, vehicle and all related instrumentation must 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 during all testing. Between tests, the dummy shall be sprayed with anti-static spray. These are both very important due to the high likelihood of electrostatic discharges as a result of the inflating airbag.

7 Test configurations

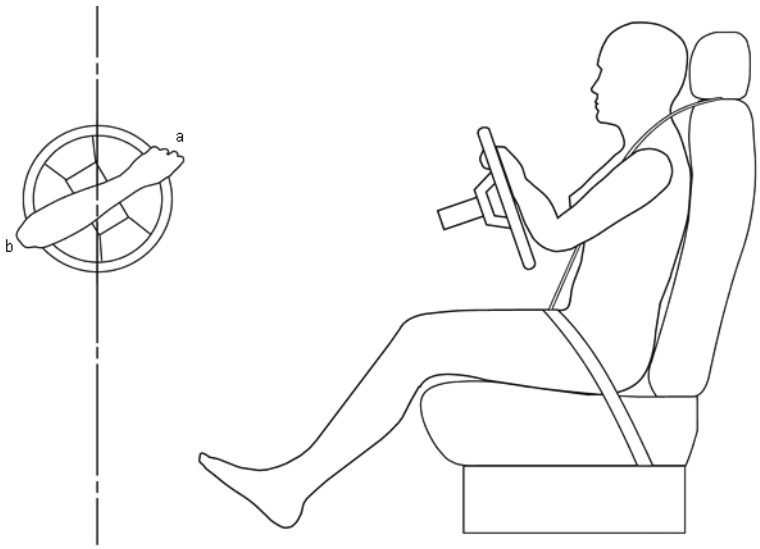
7.1 Driver frontal airbag tests

The following tests are suggested. Because of the relative inexperience in testing the small female arm interactions with deploying airbags, it is unknown if both are required or which represents the worst case.

7.1.1 Forearm across steering wheel static deployment test (Figure 1)

This test is meant to simulate a worst-case arm–airbag interaction with a driver frontal airbag. If another test condition is more severe, it should be used.

Position the midsagittal plane of the Hybrid III small female dummy on the centreline of the driver seating position with the outboard hand on the steering wheel. The seat should be in the fully forward seat-track position. The steering wheel is rotated 60° towards the centreline of the vehicle. For left-hand drive vehicles, position the outboard hand, with the fingers wrapped over the steering wheel rim, at the 2 o'clock position and the elbow at the 8 o'clock position. For right-hand drive vehicles, position the outboard hand, with the fingers wrapped over the steering wheel rim, at the 10 o'clock position and the elbow at the 4 o'clock position. The forearm lies directly across the airbag module cover opening. The module cover opening is perpendicular to the longitudinal axis of the forearm. The forearm is in the plane of the steering wheel rim. If this position cannot be achieved, rotate the dummy's torso forward until the forearm lies directly across the airbag module opening. The inboard hand shall rest on the dummy's thigh.



a 2 o'clock.

b 8 o'clock.

Figure 1 — Forearm across steering wheel static deployment test (left-hand drive shown)

7.1.2 Forearm across steering wheel dynamic sled deployment test (Figure 1)

This test is meant to simulate a worst-case arm–airbag interaction with a driver frontal airbag. If another test condition is more severe, it should be used.

Position the midsagittal plane of the Hybrid III small female dummy on the centreline of the driver seating position with the outboard hand on the steering wheel. The seat should be in the fully forward seat-track position. The steering wheel is rotated 60° towards the centreline of the vehicle. For left-hand drive vehicles, position the outboard hand, with the fingers wrapped over the steering wheel rim, at the 2 o'clock postion and the elbow at the 8 o'clock position. For right-hand drive vehicles, position the outboard hand, with the fingers wrapped over the steering wheel rim, at the 10 o'clock postion and the elbow at the 4 o'clock position. The forearm lies directly across the airbag module cover opening. The module cover opening is perpendicular to the longitudinal axis of the forearm. The forearm is in the plane of the steering wheel rim. If this position cannot be achieved, rotate the dummy's torso forward until the forearm lies directly across the airbag module opening. The inboard hand shall rest on the dummy's thigh.

This dynamic sled test will investigate the dynamic inertial effects of the entire occupant with the airbag using a generic moderate severity crash pulse (ISO 7862). The airbag firing time should be chosen to maximize arm–chest interactions and should be no later than 25 ms from the sled pulse initiation time.

7.2 Side airbag static deployment tests

Two test conditions are prescribed for the elbow on armrest since the more severe position is not always readily apparent — one with a 50 mm gap between the shoulder and the door trim and one with no gap. A review by ISO/TC 22/SC 10/WG 3 of test data obtained in both test conditions indicated that either test could present a more severe test condition, depending on the system being tested. Therefore, it is recommended that both conditions be evaluated unless engineering judgment indicates that one is more severe than the other.

7.2.1 Elbow on armrest — 50 mm gap between arm and door trim static deployment test (Figure 2)

Position the SID-IIs dummy outboard on the seat with the outboard elbow on the armrest. The forearm of the dummy rests on the armrest to the best of the armrest design capability. The seat is in the mid seat-track position.

The arm is at an angle so there is a 50 mm gap between the vertical centre of the upper arm and the door trim. The vertical centre of the upper arm is the midpoint between the elbow and shoulder joints. The upper arm is within the coronal plane in line with the dummy's torso. Positioning of the dummy is shown in Figure 1. The elbow should not exert a downward force greater than 5 N on the armrest. The test dummy pelvis may be propped up with foam to achieve these force and positioning requirements.

Dimensions in millimetres

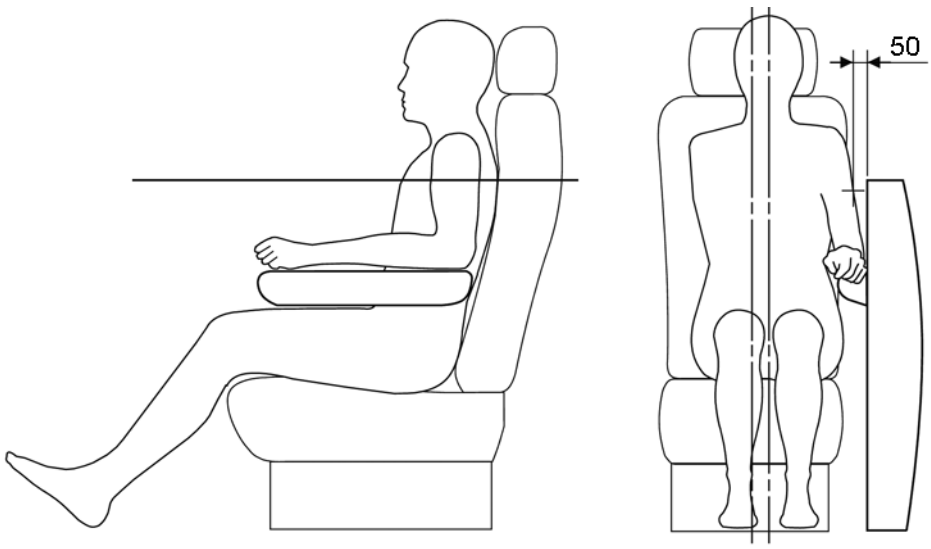


Figure 2 — Elbow on armrest — 50 mm gap between arm and door trim static deployment test (left-hand side shown)

7.2.2 Elbow on armrest — no gap between upper arm and door trim static deployment test (Figure 3)

Position the SID-IIs dummy outboard with the outboard elbow on the armrest. The upper arm will be vertical and positioned so there is no gap between the upper arm and the door trim above the armrest. The forearm of the dummy rests on the armrest to the best of the armrest design capability. The seat should be in the mid seat-track position.

The upper arm is vertical and within the coronal plane in line with the dummy's torso. The elbow should not exert a significant downward force greater than 5 N on the armrest. The test dummy pelvis may be propped up with foam to achieve these force and positioning requirements.

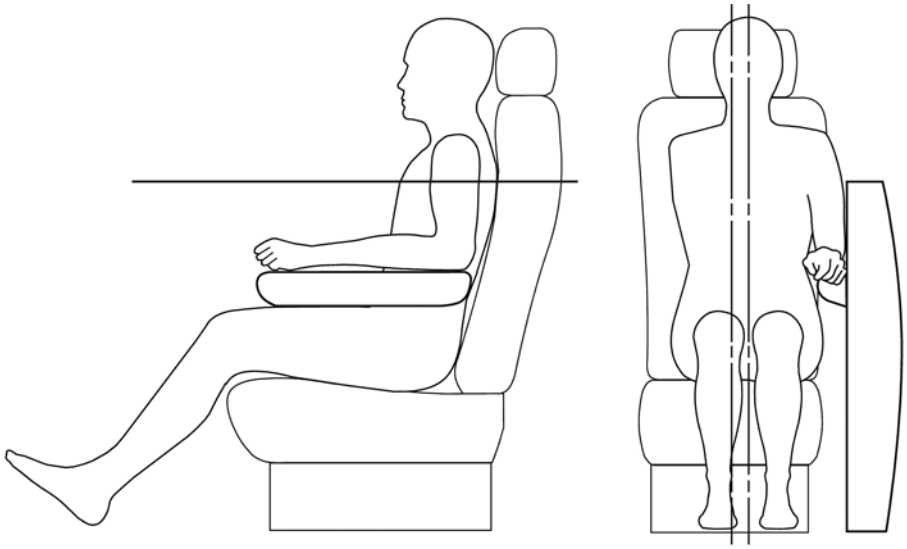


Figure 3 — Elbow on armrest — no gap between upper arm and door trim static deployment test (left-hand side shown)

8 Test procedure

Once the dummy is in position and the test is set up as referenced in Clause 7, the test should be initiated.

Completion of the test includes data analysis according to the criteria chosen from the references provided and, if taken, film analysis of the overall dummy–airbag interaction.

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