PD ISO/TR 14645:2015

BSI Standards Publication

Road vehicles — Test procedures for evaluating child restraint system interactions with deploying air bags

bsi.

...making excellence a habit.™

National foreword

This Published Document is the UK implementation of ISO/TR 14645:2015.

The UK participation in its preparation was entrusted to Technical Committee AUE/15, Safety related to vehicles.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Published by BSI Standards Limited 2015

ISBN 978 0 580 84008 1

ICS 43.040.80

Compliance with a British Standard cannot confer immunity from legal obligations.

This Published Document was published under the authority of the Standards Policy and Strategy Committee on 31 March 2015.

Amendments/corrigenda issued since publication

Date	Text affected

TECHNICAL REPORT

ISO/TR 14645

Second edition
2015-03-01

Road vehicles — Test procedures for evaluating child restraint system interactions with deploying air bags

Véhicules routiers — Méthodes d'essais pour l'évaluation des interactions des systèmes de retenue pour enfants et des sacs gonflables en cours de déploiement

Reference number
ISO/TR 14645:2015(E)

Contents

Page

Contents

Page

Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work. In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1.

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 document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO and IEC shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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

For an explanation on the 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 36, *Safety aspects and impact testing*.

This second edition cancels and replaces the first edition (ISO/TR 14645:1998), which has been technically revised.

This document is published as a Technical Report, rather than as an International Standard, because of the general inexperience in testing the interaction between child restraint systems (CRS) and deploying air bags, and the lack of real-world accident data. When statistically significant, real-word data are available, in which air bags have contacted a variety of child restraints, and there is more testing experience with this interaction, it may be appropriate to develop an International Standard.

Introduction

During its 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 child restraint system (CRS). (For background on air bag design and deployment, see References [1] and [2]. With passenger air bags, laboratory tests have indicated that these forces can be sufficient to produce serious injury to the CRS occupant. The National Highway Traffic Safety Administration has recommended that rear-facing child restraints of current design be used only in the rear seat of vehicles equipped with such air bags (see Reference [3]). Even so, many children can be restrained in either rear- or forward-facing CRSs in the front seat of such vehicles, and the child and/or the CRS can interact with the air bag. These guidelines were developed to improve the understanding of such interactions and to aid in the assessment of future designs.

A mild-severity crash pulse is described in this Technical Report. This pulse is not vehicle-specific, but represents general acceleration-time histories. This mild-severity pulse approximates a crash that would just deploy a typical air bag. This pulse is used to evaluate the effect of the energy of the deploying air bag when the CRS and dummy are exerting the least amount of inertial force in the forward direction, but the dummy and/or CRS is moved forward by that inertial force. This generic pulse or other vehicle-specific pulses can be used as appropriate. Differences in shape between the generic and the vehicle-specific pulses are expected with corresponding differences expected in dummy responses.

This Technical Report encourages the use of a wide range of test configurations and conditions, while recognizing that the range of possible interactions is essentially limitless and beyond testing capability. Furthermore, measurements of primary importance for the various configurations are given in Table 1, but performance limits are not specified. References [4] to [9] give some background on human impact tolerance and criteria, describe scaling techniques for different size occupants, and offer interpretations of dummy responses relative to human injury potential that can be helpful in the evaluation. These and additional background papers on air bag development and deployment can be found in References [10] and [11].

Road vehicles — Test procedures for evaluating child restraint system interactions with deploying air bags

1 Scope

This Technical Report describes dummies, procedures, and configurations that can be used to investigate the interactions that occur between a deploying air bag and a Child Restraint System (CRS) that would have been considered properly installed and used in the outer and centre front passenger positions. Static tests can be used to sort CRS/air bag interaction on a comparative basis in either an actual or a simulated vehicle environment. Systems that appear to warrant further testing can be subjected to an appropriate dynamic test at a speed near that needed to deploy an air bag or at a higher speed commonly used to evaluate CRS performance. No test matrix is specified at this time for evaluating either a CRS or an air bag during interaction with each other. Instead, engineering judgment based on prior experience with CRS and/or air bag testing should be used in selecting the tests to be conducted with each individual system. Such tests can be aimed not only at producing interactions with the most severe results but also at identifying those conditions that produce the least interaction and/or satisfactory CRS performance results. Baseline tests to indicate the performance of a CRS in the absence of air bag deployment are also recommended for comparison purposes.

2 Normative references

There are no normative references.

3 Terms and definitions

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

3.1
rear-facing
R
child restraint that positions the child to face the rear of the vehicle

3.2
laterally-positioned
L
child restraint that positions a prone or supine child perpendicular to the direction of vehicle travel

3.3
forward-facing
F
child restraint that positions the child to face the front of the vehicle

3.4
booster
B
normally used to better position adult belt restraints on the child

3.5
ISOFIX/LATCH
"plug-in" system designed for fitting child safety seats in cars quickly and with ease per ISO 13216

4 Test device

4.1 General

Five sizes of child dummies, from six-month to age six, are available for CRS/air bag investigations. However, the recommended dummies for use in this testing are listed in Reference [19].

4.2 Six-month-old infant dummies

4.2.1 CRABI 6-month

With specifications from the SAE Infant dummy task group, a six-month size dummy has been developed that allows measurement of head, chest, and pelvic accelerations, as well as upper and lower neck and lumbar spine forces and moments. A special six-channel transducer has also been developed for use in any of the spinal locations.

4.3 Nine-month-old infant dummy

4.3.1 P-3/4

This dummy is specified in UN-ECE Regulation 44, annex 8, and has been incorporated without instrumentation in 49 CFR, Part 572, subpart J. It has main-joint articulation and has provision for head and chest accelerometers and for modeling clay in the abdomen to detect penetration. A three-channel neck transducer has been developed for use with this dummy.

4.4 Twelve-month-old infant dummy

4.4.1 CRABI 12-month

With specifications from the SAE Infant dummy task group, a twelve-month size dummy has been developed that allows measurement of head, chest, and pelvic accelerations, as well as upper and lower neck and lumbar spine forces and moments.

4.5 Three-year-old child dummies

The standard child dummy for FMVSS and CMVSS 213 testing is specified in 49 CFR Part 572, subpart C. This dummy has provision for head and chest accelerometers. Use of the “new” vinyl-covered fiberglass head, specified in part 572.16(a) (1), is recommended over the old head.

4.5.1 Three-year-old child Hybrid III

This dummy was developed for passenger air bag testing (see Reference [16]) by a task force of the SAE Human Biomechanics and Simulation Standards Committee and is commercially available.

4.5.2 P-3

This dummy is specified in UN-ECE Regulation 44, annex 8. It has main-joint articulation and provisions for head and chest accelerometers and for modelling clay in the abdomen to detect penetration.

4.5.3 Q-3

In 1993, the International Child Dummy Working Group started the development of a new series of child dummies as a successor to the P-series. This new series was called the Q-series. The development of the Q-series, directed by the International Child Dummy Working Group, resulted in a Q3 dummy in 1998, followed by the addition of the Q6 dummy in 1999, and the Q1 in 2000.

Part of the development of the Q-dummies has taken place within the European Research programs CREST (see Reference [1]) and CHILD (see Reference [2]), both aimed at improving child safety in cars.

4.6 Six-year-old child dummies

4.6.1 P-6

This dummy is specified in UN-ECE Regulation 44, annex 8. It has main-joint articulation and has provision for head and chest accelerometers and for modelling clay in the abdomen to detect penetration.

4.6.2 Hybrid-III six-year

This dummy was developed under a grant from the Centers for Disease Control (CDC), with input from SAE committees, and allows measurement of head, chest, and pelvic accelerations; neck, lumbar, and femur forces and moments; and chest displacement.

4.6.3 Q-6

The development of the Q-series, directed by the International Child Dummy Working Group, resulted in a Q3 dummy in 1998, followed by the addition of the Q6 dummy in 1999, and the Q1 in 2000.

Part of the development of the Q-dummies has taken place within the European Research programs CREST (see Reference [1]) and CHILD (see Reference [2]), both aimed at improving child safety in cars.

5 Instrumentation

5.1 Measurements

Measurements that can be made or calculated using the anthropomorphic test device for each age group as listed in 5.2 to 5.9. All measurements should be recorded and filtered according to ISO 6487 and SAE J 211 for body regions. These measurements should be continuous functions of time, so that other quantities referred to in the references may be derived.

5.2 CRABI 6-month and 12-month

- Head triaxial acceleration
- Head angular acceleration (one channel)
- Upper neck forces and moments (six channels)
- Lower neck forces and moments (six channels)
- Chest triaxial acceleration
- Lumbar spine forces and moments (six channels)
- Pelvic triaxial acceleration

5.3 P-3/4 nine-month

- Head triaxial acceleration (three channels)
- Upper neck forces (Fx, Fz) and moment (Fy)
- Chest triaxial acceleration

5.4 Hybrid III three-year

— Head triaxial acceleration
— Head angular acceleration in sagittal plane (one channel)
— Upper neck (C-1) forces and moments (six channels)
— Lower neck (C-1/T-1) forces and moments (six channels)
— Shoulder forces (Fx, Fz; four channels)
— Sternal acceleration (ax; two channels)
— Sternal deflection (one channel)
— Spine tri-axial accelerations (T-1, T-4, T-12; nine channels)
— Lumbar forces and moments (six channels)
— Pubic forces (Fx, Fz; two channels)
— Pelvis tri-axial acceleration (three channels)

5.5 P-3 three-year

— Head tri-axial acceleration (three channels)
— Upper neck (C-1) forces and moments (six channels)
— Spine (T-12) tri-axial acceleration (three channels)

5.6 Q-3 Three-year

— Head triaxial acceleration (three channels)
— Upper neck (C-1) forces and moments (six channels)
— Spine (T-12) triaxial acceleration (three channels)

5.7 Hybrid III six-year

— Head triaxial acceleration
— Head angular acceleration in sagittal plane (one channel)
— Upper neck forces and moments (six channels)
— Lower neck forces and moments (five channels)
— Chest triaxial acceleration
— Chest mid-sternum displacement (one channel)
— Sternal acceleration (ax; two channels)
— Lumbar spine forces and moments (five channels)
— Pelvic triaxial acceleration
— Pelvic submarining (four channels)
— Femur forces and moments (six channels)

5.8 P-6 six-year

— Head triaxial acceleration (three channels)

— Spine (T-12) triaxial acceleration (three channels)

— Pelvis triaxial acceleration (three channels)

5.9 Q-6 six-year

— Head triaxial acceleration (three channels)

— Spine (T-12) triaxial acceleration (three channels)

— Pelvis triaxial acceleration (three channels)

5.10 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 pulse

6.1 General

For sled tests, a mild-severity crash pulse is defined in 6.2. A vehicle-specific pulse may also be used as appropriate.

6.2 Mild-severity crash pulse

The mild-severity pulse is intended to be just severe enough to position the dummy and/or the CRS forward and to deploy the air bag. This pulse is a half-sine type with a peak acceleration occurring near the centre of the time duration of (8 ± 1) g, where g = 9,806 65 m/s2 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 are shown in Figures 1 and 2.

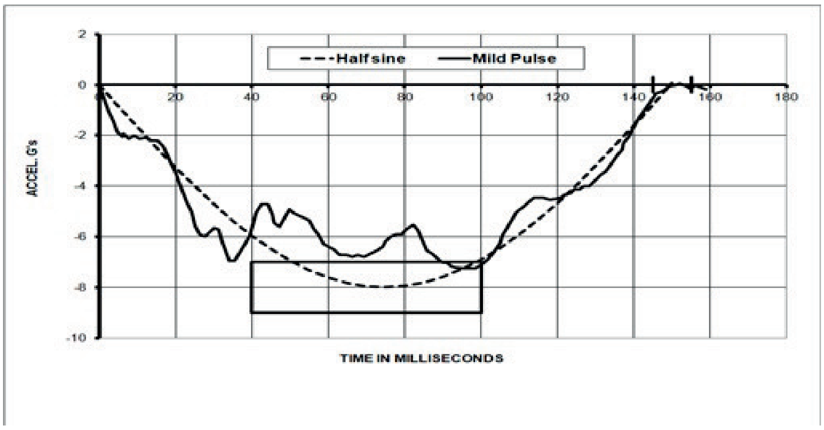


Figure 1 — Generic HYGE sled pulse for a mild-severity crash

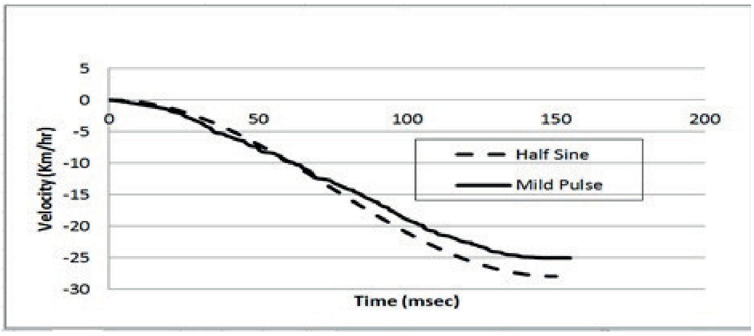


Figure 2 — Velocity-time history of the generic mild-severity crash sled pulse

7 Static tests

7.1 General

Static tests can be used for preliminary evaluation of CRS/air bag interactions and to select configurations that appear to warrant further dynamic testing.

7.2 Test set-up

Using a vehicle, a vehicle buck, the CRABI fixture (see Clause 11 and Figure 3) or another fixture simulating a particular vehicle/air bag geometry, mount the air bag to the instrument panel, or simulation thereof, in a manner at least as rigid as an actual vehicle mount.

When using a vehicle buck or fixture, use all hardware that might affect how or in what direction the air bag is likely to deploy. Also use any surrounding hardware, such as the windshield or simulation thereof, that might affect the air bag's deployment direction, velocity, pattern of deployment, or shape. Mount the vehicle seat with the longest track available in its design position, so that it is in the same geometrical position relative to the air bag as in the actual vehicle.

For all test environments, move the seat to the position appropriate for the desired interaction under study. For example, full forward may produce the most severe interaction, while the full rear position may produce the least severe interaction, at least initially. Install and restrain the CRS and dummy according to the CRS manufacturer's instructions and vehicle owner's manual, if appropriate.

If the dummy and/or CRS is expected to move forward under dynamic conditions, forward prepositioning may be advisable prior to air bag deployment. If so, hold the CRS/dummy in the desired position using one layer of paper masking tape. Loosening the belt and/or harness prior to forward prepositioning can also be considered to more closely simulate dynamic positioning.

8 Dynamic tests

8.1 General

Dynamic tests, which better represent real-world crash conditions, may be conducted to further investigate CRS/air bag interactions or to compare the performance of a CRS with and without a deploying air bag.

8.2 Test set-up

Use the same test set-up as described in 7.2 for full-scale vehicle crash tests or for tests with a vehicle buck, the CRABI fixture, or another fixture mounted on a sled, with the omission of the forward prepositioning of the dummy and/or the CRS. Ensure that all surfaces are present which the CRS/dummy may contact during the impact, such as an instrument panel eyebrow or simulation thereof.

8.3 Simulation of sensing time

For tests with an impact sled simulating a specific system, the interval between impact and air bag triggering should be similar to that of the specific system. When using the sled pulse, an interval of 30 ms is suggested, but the interval should be tuned to the particular air bag sensor system used.

9 CRS configurations and dummy combinations

9.1 General

To facilitate selection of CRS models and dummies for evaluation by vehicle and air bag manufacturers, configurations of child restraint systems currently sanctioned by national or international standards are described as follows, and suitable dummy sizes are indicated. Boosters, which are primarily belt-positioning and adapting devices rather than actual restraint systems, are treated separately. The types of CRSs and boosters currently available in the USA are described in more detail in Reference [14].

CRSs and vehicles that are equipped with ISOFIX/LATCH should use the ISOFIX/LATCH mechanism to install the CRS to the seat as opposed to using the seatbelt. There are two versions of ISOFIX/LATCH: Universal and Semi-Universal. Semi-Universal seats have two strikers in the seat bite at the back of the seat bottom cushion. The ISOFIX/LATCH CRSs have two latches that lock onto these strikers. Semi-Universal CRSs employ a third support or anti-rotation device to control the rotation of the CRS in a crash event. Typically, this third support may take the form of a support leg that attaches to the front of the CRS and attaches to the floor. Universal ISOFIX/LATCH CRSs require three anchorage points, with the third anchorage point being behind the seat that connects to the top of the CRS. For the CRS being assessed, read the owner's manual of both the CRS and the vehicle to determine the proper fitment of an ISOFIX/LATCH seat. More information on ISOFIX/LATCH employed in CRS systems can be found in References [17] and [18].

ISOFIX anchor points under removable cover

9.2 Rear-facing CRSs

9.2.1 General

For CRSs that position the child to face the rear of the vehicle, there are three installation methods that result in different impact kinematics.

9.2.2 CRS configuration R1

Anchored with a lap belt, usually over the CRS, and supported at the back of the shell with a shoulder belt. May be one- or two-piece unit. Use with a new-born, six-month, or nine-month dummy.

9.2.2 R1

9.2.3 CRS rear facing ISOFIX/LATCH configuration R2

Anchored at the back of the seat cushion using the two ISOFIX/LATCH attachments at the seat bite. If available, the third overtop attachment should be used. If not available, follow the owner's manual of the CRS and vehicle for proper deployment of a third attachment/anti-rotation device

9.2.3 R2

9.2.4 CRS configuration R3

Anchored with a lap and shoulder belt, supported by the instrument panel, and held against rearward rotation with straps to the seat track or a special anchor to the instrument panel or the foot well area. Use with a nine-month or three-year dummy.

9.2.4 R3

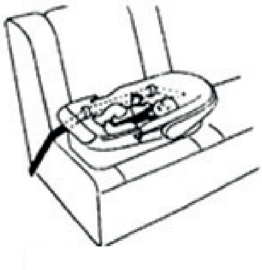
9.3 Laterally-positioned CRSs

9.3.1 General

For CRSs that position the prone or supine child perpendicular to the direction of vehicle travel, there are three installation methods which result in different impact kinematics. This type of CRS is called a car-bed (USA) or a carry-cot (ECE).

9.3.2 CRS configuration L1

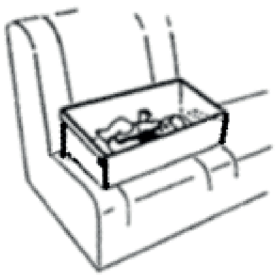
Anchored with a lap belt only or a lap and shoulder belt (routed through the same path), with the anchor location at or near the upper edge of the rear surface of the car-bed. The bed normally rotates around the belt during impact rebound. Use with a newborn, six month, or nine-month dummy.



9.3.2 L1

9.3.3 CRS configuration L2

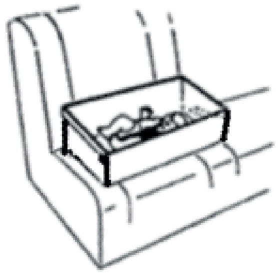
Anchored with a lap belt only around the front surface of the restraint; or anchored as in 9.3.2 with an additional front tether or a bracket for the shoulder belt (outside North America only). Rebound rotation can be restricted. Use with a new-born, six-month, or nine-month dummy.



9.3.3 L2

9.3.4 ISOFIX/LATCH L3

Anchored at the back of the seat cushion using the two ISOFIX/LATCH attachments at the seat bite. If available, the third overtop attachment should be used. If not available, follow the owner's manual of the CRS and vehicle for proper deployment of a third attachment/anti-rotation device.



9.3.4 L3

9.4 Forward-facing CRSs

9.4.1 General

For CRSs that position the child to face the front of the vehicle, there are three installation methods which result in different impact kinematics. These differences may not, however, be significant relative to interaction with a deploying air bag.

9.4.2 CRS configuration F1

Anchored with a lap belt only or with a lap and shoulder belt (routed through the same path), or with two special side anchor straps. Use with a three-year dummy.

9.4.2 F1

9.4.3 CRS configuration F2

Anchored as in 9.4.2 plus one or two additional top tether straps. Use with a three-year or six-year dummy.

9.4.3 F2

9.4.4 CRS configuration F3

Anchored at the back of the seat cushion using the two ISOFIX/LATCH attachments at the seat bite. If available, the third overtop attachment should be used. If not available, follow the owner's manual of the CRS and vehicle for proper deployment of a third attachment/anti-rotation device.

9.4.4 F3

9.5 Boosters

9.5.1 General

There are three different types of boosters, which are normally used with different types of belt systems, and which are associated with very different child occupant kinematics. In addition, the second type may be equipped with a back for comfort, belt fit, and/or rear impact protection on lower rear vehicle seats. This feature is not, at this time, considered significant relative to front seat use with a deploying air bag.

9.5.2 CRS configuration B1

Shield booster: anchored with a lap belt only across the front of the shield or through the base to the booster. The shoulder belt can follow the path of the lap belt or be routed behind the dummy. (Routing the shoulder belt across the dummy's chest is not recommended for this configuration.) Use with a three-year or six-year dummy.

9.5.2 B1

9.5.3 CRS configuration B2

Belt-positioning booster: anchored along with the dummy with a lap and shoulder belt, using normal belt placement with the aid of belt-positioning guides. Use with a three-year or six-year dummy.

9.5.3 B2

9.5.4 CRS Configuration B3

Similar to B2 but with a high seatback and side support. It relies on using normal belt placement with the aid of belt-positioning guides.

9.5.4 B3

10 Primary dummy measurements

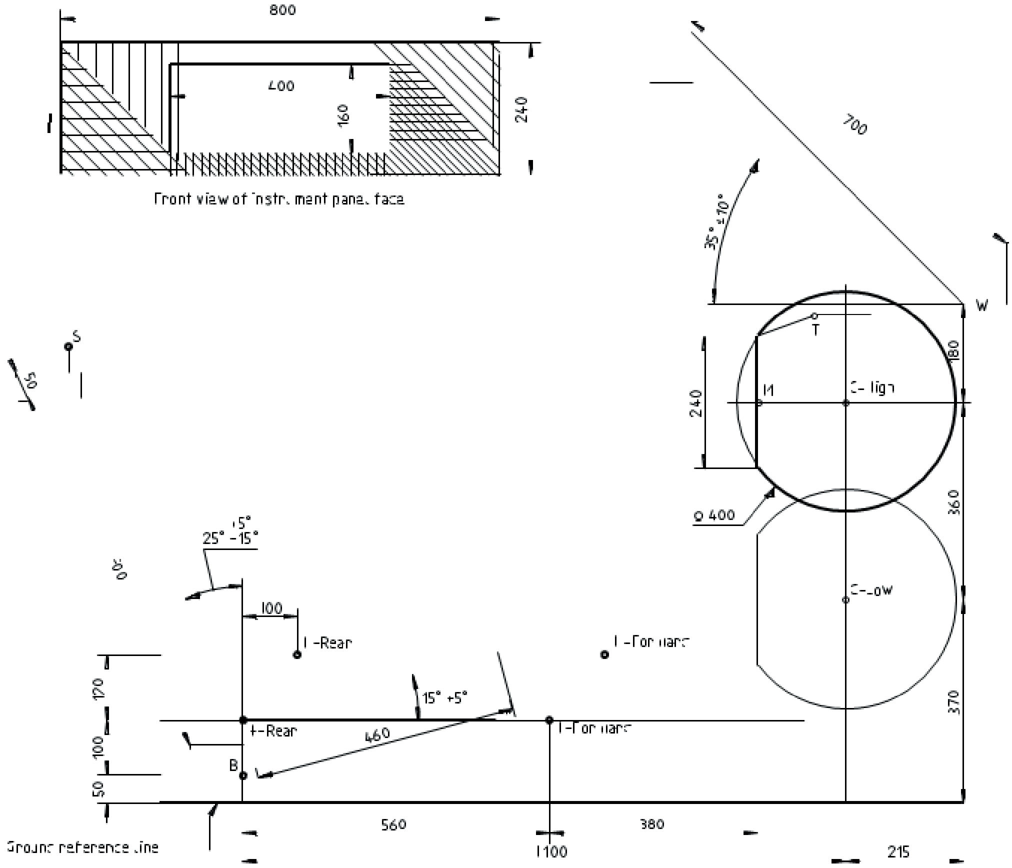
Dummy response measurements which are of primary importance for each combination of CRS configuration and air bag location are listed in Table 1. Other potentially important post-impact factors are also indicated.

11 CRABI fixture

A schematic for a test fixture is shown in Figure 3. This fixture has been designed to simulate the geometry of a range of vehicle/air bag systems, in order to facilitate the evaluation of CRSs with deploying air bags. The fixture includes a simulated partial instrument panel and a partial vehicle bench seat. The seat moves longitudinally (from A-rear to A-forward), and the instrument panel moves vertically (from C-high to C-low), so that a wide range of geometric relationships can be accommodated. The range-of-motion limits reflected in Figure 3 are based on a manufacturer survey of April 1991 and could be modified to adhere to manufacturer design recommendations.

The seat back and bottom cushions pivot independently within 20° and 10° ranges, respectively. Although only the surface of the seat back and bottom cushions are shown in the schematic, the seating foam and depth (150 mm) specified in FMVSS 213 are recommended. The width of the partial bench may vary, but 900 mm is recommended in order to accommodate both a right and a centre seat position. The vertical centreline of the instrument panel should coincide with the centreline of the right seat position.

Dimensions in millimetres



Key

A	Intersection of back and bottom cushions	**M**	Centre of air bag deployment at 0° (mid-mount)
B	Lap belt anchorage	**S**	Shoulder belt anchorage
C	Centre of instrument panel rotation	**T**	Centre of air bag deployment at 70° (top-mount)
H	Estimated H-point of fixture seat	**W**	Intersection between instrument panel and windshield

Figure 3 — CRABI test fixture

Table 1 — Primary dummy response measurements and evaluation factors for CRS/air bag combinations

CRS configuration	**Low-mounted air bag module**	**Mid-mounted air bag module**	**Top-mounted air bag module**
Rear-facing R1-R3	head, neck, chest	head, neck, chest	head, neck, deflated air bag
Lateral L1-L2	head, chest	head, chest, deflated air bag	deflated air bag
Forward-facing F1-F2	legs	head, neck, legs	head, neck (especially late deployment)
Booster B1	legs	head, neck, legs	head, neck (especially late deployment), legs

Table 1 *(continued)*

CRS configuration	Low-mounted air bag module	Mid-mounted air bag module	Top-mounted air bag module
Booster B2, B3	legs	lower legs	legs

The cylindrical or similarly-shaped instrument panel, within which the passenger air bag module is mounted, rotates to simulate a range of air bag mounting locations and deployment angles. An opening is provided on the flat face of the instrument panel through which the air bag is deployed. It is expected that a supplementary mounting plate will be needed to accommodate the front brackets of the particular air bag module used. This plate would in turn be affixed to the flat face. Further structure within the instrument panel will also be needed to mount each air bag module. A flat surface simulating a windshield pivots about an edge that is fixed with respect to the instrument panel and thus moves up and down with the instrument panel. A flat panel between the instrument panel and the floor and a transparent partial side panel are also recommended to help contain the air bag during deployment.

Unless the particular configuration being studied has different requirements, lap belt anchorages, which move with the seat, should be located directly below point A with the inboard anchor 400 mm from the outboard anchor. A shoulder belt anchor, if needed, should be located above the top right corner of and along the same line as the seatback.

Bibliography

[1] CREST-project final report, CHEST — Child Restraint System for Cars, EC-Project number SMT4-CT95-2019

[2] CHILD-project final report, CHILD Injury Led Design, EC-Project number G3RD-CT-2002-00791

[3] Automatic Crash Protection: Your Choice in 1992. Consumer Information. National Highway Traffic Safety Administration, July 1992.

[4] Human Tolerance to Impact Conditions as Related to Motor Vehicle Design. SAE Information Report J 885. Society of Automotive Engineers, Warrendale, PA, July 1986.

[5] Review of Biomechanical Impact Response and Injury in the Automotive Environment. J.W. MELVIN, K. WEBER, eds. Task B Final Report on NHTSA contract DTNH22-83-C-07005, DOT HS 807 042 (1986) or in DOT HS 807 224, 1988. University of Michigan Transportation Research Institute, Ann Arbor, March 1985.

[6] MELVIN J.W., KING A.I., ALEM N.M. AATD System Technical Characteristics, Design Concepts, and Trauma Assessment Criteria. Task E-F Final Report on NHTSA contract DTNH22-83-C-07005, in DOT HS 807 224, 1988. University of Michigan, Ann Arbor, September 1985.

[7] MERTZ H.J. A Procedure for Normalizing Impact Response Data. SAE 840884. Society of Automotive Engineers, Warrendale, PA, 1984

[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, Kyoto, Nov. 1-4, 1982. National Highway Traffic Safety Administration, Washington, D.C., 1984, pp. 368-376. (Also published as SAE 826048.)

[9] 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, Chicago, November 6-7, 1984. Society of Automotive Engineers, Warrendale, PA, 1984, pp. 25-40 (SAE 841656).

[10] Systems P.C.I.R.. A Compendium of Published Safety Research. D.C. Viano, ed., SAE-PT-31. Society of Automotive Engineers, Warrendale, PA, 1987.

[11] Automatic O.P.S. SAE-SP-736, Society of Automotive Engineers, Warrendale, PA, 1988.

[12] Guidelines for Evaluating Out-of-Position Vehicle Occupant Interactions with Deploying Airbags. SAE Information Report J 1980. SAE Human Biomechanics and Simulation Standards Committee, Warrendale, PA, November 1990.

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

[14] WEBER K. Child Passenger Protection. Accidental Injury: Biomechanics and Prevention. Papers presented November 16-17, 1991, San Diego, CA. New York: Springer-Verlag, 1993, pp. 493-511.

[15] Guidelines For Evaluating Child Restraint System Interactions with Deploying Airbags. SAE Information Report J 2189. SAE Human Biomechanics and Simulation Standards Committee, Warrendale, PA, August 1993.

[16] IRWIN A.L., & MERTZ H.J. Biomechanical Bases for the CRABI and Hybrid III Child Dummies. 41st Stapp Car Crash Conference Proceedings, Lake Buena Vista, November 13-14, 1997. Society of Automotive Engineers, Warrendale, PA, 1997, pp. 1-12 (SAE 973317).

[17] "Information on LATCH (Lower Anchors and Tethers for Children)". *Car-Safety.Org*. February 29, 2008. http://www.car-safety.org/latch.html. Retrieved 2008-07-06.

[18] "Information on ISOFIX/LATCH". *Car Safety for Kids Blog*. May 8, 2008. http://kidsincars.blogspot.com/search/label/LATCH. Retrieved 2009-08-03

[19] ISO/PD/TR 12349-2/WD, 12349-2, *Road vehicles — Dummies for restraint system testing — Part 2: Child dummies*

[20] ISO 6487, *Road vehicles — Measurement techniques in impact tests — Instrumentation*

[21] ISO 13216, *Road vehicles — Anchorages in vehicles and attachments to anchorages for child restraint systems*

[22] SAE J 211: *Instrumentation for impact test — Part 1: Electronic instrumentation*

[23] SAE J 211: *Instrumentation for impact test — Part 2: Photographic instrumentation*

[24] Regulation No UN-ECE 44, *United Nations Agreement Concerning the Adoption of Uniform Conditions of Approval and Reciprocal Recognition of Approval for Motor Vehicle Equipment and Parts*

[25] 49 CFR Part 572, *Anthropomorphic Test Dummy*[1].

1) CFR: Code of Federal Regulations, issued by the National Highway Traffic Safety Administration, Department of Transportation, USA.

This page deliberately left blank

British Standards Institution (BSI)

BSI is the national body responsible for preparing British Standards and other standards-related publications, information and services.

BSI is incorporated by Royal Charter. British Standards and other standardization products are published by BSI Standards Limited.

About us

We bring together business, industry, government, consumers, innovators and others to shape their combined experience and expertise into standards -based solutions.

The knowledge embodied in our standards has been carefully assembled in a dependable format and refined through our open consultation process. Organizations of all sizes and across all sectors choose standards to help them achieve their goals.

Information on standards

We can provide you with the knowledge that your organization needs to succeed. Find out more about British Standards by visiting our website at bsigroup.com/standards or contacting our Customer Services team or Knowledge Centre.

Buying standards

You can buy and download PDF versions of BSI publications, including British and adopted European and international standards, through our website at bsigroup.com/shop, where hard copies can also be purchased.

If you need international and foreign standards from other Standards Development Organizations, hard copies can be ordered from our Customer Services team.

Subscriptions

Our range of subscription services are designed to make using standards easier for you. For further information on our subscription products go to bsigroup.com/subscriptions.

With **British Standards Online (BSOL)** you'll have instant access to over 55,000 British and adopted European and international standards from your desktop. It's available 24/7 and is refreshed daily so you'll always be up to date.

You can keep in touch with standards developments and receive substantial discounts on the purchase price of standards, both in single copy and subscription format, by becoming a **BSI Subscribing Member**.

PLUS is an updating service exclusive to BSI Subscribing Members. You will automatically receive the latest hard copy of your standards when they're revised or replaced.

To find out more about becoming a BSI Subscribing Member and the benefits of membership, please visit bsigroup.com/shop.

With a **Multi-User Network Licence (MUNL)** you are able to host standards publications on your intranet. Licences can cover as few or as many users as you wish. With updates supplied as soon as they're available, you can be sure your documentation is current. For further information, email bsmusales@bsigroup.com.

Revisions

Our British Standards and other publications are updated by amendment or revision.

We continually improve the quality of our products and services to benefit your business. If you find an inaccuracy or ambiguity within a British Standard or other BSI publication please inform the Knowledge Centre.

Copyright

Useful Contacts:

Customer Services
Tel: +44 845 086 9001
Email (orders): orders@bsigroup.com
Email (enquiries): cservices@bsigroup.com

Subscriptions
Tel: +44 845 086 9001
Email: subscriptions@bsigroup.com

Knowledge Centre
Tel: +44 20 8996 7004
Email: knowledgecentre@bsigroup.com

Copyright & Licensing
Tel: +44 20 8996 7070
Email: copyright@bsigroup.com

BSI Group Headquarters

389 Chiswick High Road London W4 4AL UK

bsi.

...making excellence a habit.™