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Road vehicles — Sled test method to enable the evaluation of side impact protection of child restraint systems — Essential parameters

Véhicules routiers — Méthode d'essai sur chariot pour permettre l'évaluation de la protection en choc latéral des dispositifs de retenue pour enfants — Paramètres essentiels

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ISO/PAS 13396 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 12, *Passive safety crash protection systems*.

Introduction

The UNECE/GRSP Working Group on Child Restraint Systems in April 2008 sent a request to ISO/TC 22/SC 12 to support their work on defining a side impact test procedure for CRS (child restraint systems) homologation based on state-of-the-art research and experience.

UNECE/GRSP specifically requested ISO/TC 22/SC 12 to define the essential parameters of a simplified test method, to ensure that a child restraint system has a sufficient capacity to contain the child and to absorb energy in case of side impact exposure.

The aim of this Publicly Available Specification is to answer the UNECE request.

Road vehicles — Sled test method to enable the evaluation of side impact protection of child restraint systems — Essential parameters

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1 Scope

This Publicly Available Specification mainly summarises the content of ISO/TR 14646[1] to assist the Informal Group on CRS of UNECE/GRSP in their development of a simplified side impact method based on commonly agreed input data. In addition to the content of ISO/TR 14646, new data and further recommendations have been included. Where not otherwise stated, ISO/TR 14646 is reference source.

The essential input parameters given in Clause 3 are applicable to accessory child restraint systems aiming to offer side impact protection.

2 Accident statistics

The accident data presented in ISO/TR 14646 shows that side impact is especially severe for those children (age up to 12 years) sitting on the struck side. Head, neck and chest are the body regions most frequently showing severe injuries, and the head in particular needs to be protected. Comparison of accident data from different years (1985 to 1990; 1991 to 1996 and 1997 to 2001), without any filter on product age shows, however, decreasing risk for head injuries and increasing risk for neck injuries in the recent data compared to the older data.

Based on results of the EC funded CHILD project and the EEVC/WG18 Report[5], non-head containment combined with intrusion loading are found to be one of the major reasons for head injuries in side impacts involving rearward facing and forward facing harness type CRS, as well as high back booster and backless booster (Johannsen et al.[4]; EEVC[5]).

Analysis of accident data involving children in side impacts from different sources and different regions of the world (Germany, Sweden and USA) indicates that the purely lateral impact (due to the accident data coding with ± 15° deviation) is possibly more severe than angled ones, while the share of perpendicular and angled impacts with forward component is nearly equal (Johannsen and Menon[3]). Although all three sources show the same tendency, final conclusions are not possible, as the number of children involved is too small to allow statistically significant results. These data regard all types of impact objects and restraint use.

Henary et al.[7], when comparing the risk of injury between children (aged 0-23 months) in side impacts, using US crash data (NASS-CDS), found a significantly higher benefit for children in rearward facing compared to forward facing harness type CRS. The authors conclude that this is likely because a forward component in the vehicle travel direction in many of the cases will move the head forward during the crash and will therefore improve the containment situation. The forward movement of the lead is directed towards the backrest of the CRS used.

The struck car is in many cases subjected to an angled acceleration due to its initial speed. The main expected influence of a possible forward component would be an increase in head forward motion. Head forward trajectory can also be influenced by pre-braking conditions. Maltese et al.[6] mapped probable head contact points for 4 year to 15 year old injured children (not using child seats) involved in a side impact, seated on the struck side in the rear seat. The contacts were mainly found adjacent to the likely initial position of the head of the in-position rear seat child occupant, and adjusted forward. The authors state this forward adjustment is likely due to the forward component.

3 Input parameters for side impact test procedure

3.1 General

Relevant input parameters for defining a side impact test procedure for CRS, based on experience from accident data analysis, full-scale tests and sled tests, as described in ISO/TR 14646, are presented below. These input parameters are divided into sections covering body regions to be protected, occupant kinematics, test severity, validation and field of application.

3.2 Body regions to be protected

Based on accident data, the body region to be protected with highest priority is the head, followed by neck and chest. Especially for the protection of the head, body kinematics as well as energy management capabilities of the CRS are important.

3.3 Occupant kinematics

As head containment and head loadings are crucial issues with respect to the assessment of the performance of a CRS in side impact, it is necessary to utilize a test procedure capable of simulating real world occupant kinematics and realistic loading conditions.

Containing the head within the CRS is more of a challenge for the larger dummies, representing the upper limit of the respective CRS group in a given CRS, than for the smaller ones, based on experience with different side impact test procedures within the development of ISO/TR 14646 and ISO/TS 29062[2].

The application of side impact test procedures needs to be defined carefully, taking into account the protection capabilities of today's cars.

3.4 Test characteristics

3.4.1 General

When designing a sled test method, the aim should be to replicate the characteristics of a full-scale side impact test situation, but in a simplified way and as generic as possible. The characteristics are derived from vehicle acceleration, vehicle velocity, intrusion depth and intrusion velocity, but also by geometrical measurements such as the distance of the CRS in relation to the structure and the coverage/profile of the intruding vehicle structure.

The analysis of full-scale side impact tests presented in ISO/TR 14646 shows that the performance of today's cars has been significantly improved, especially with respect to intrusion velocity during the last few years. However, the test severity of the full-scale test is subject to several discussions, as it is felt to be too moderate. One example of higher severity tests is the IIHS test procedure (see Reference [11]), where the mass of the barrier as well as the stiffness and shape of the barrier face cause a more aggressive contact with the car in comparison to ECE Regulation No. 95 and FMVSS 214 test conditions.

Summing up the results presented in ISO/TR 14646 and the statements above, the following properties defining the test characteristics are suggested as a generic and representative (for the majority of cars in use) side impact sled test method. The intrusion and intrusion velocity graphs shown in this document are measured at the front door close to the b-pillar. Data of the rear seat position for a P1.5 dummy in a rearward facing CRS can be found in ISO/TR 14646.

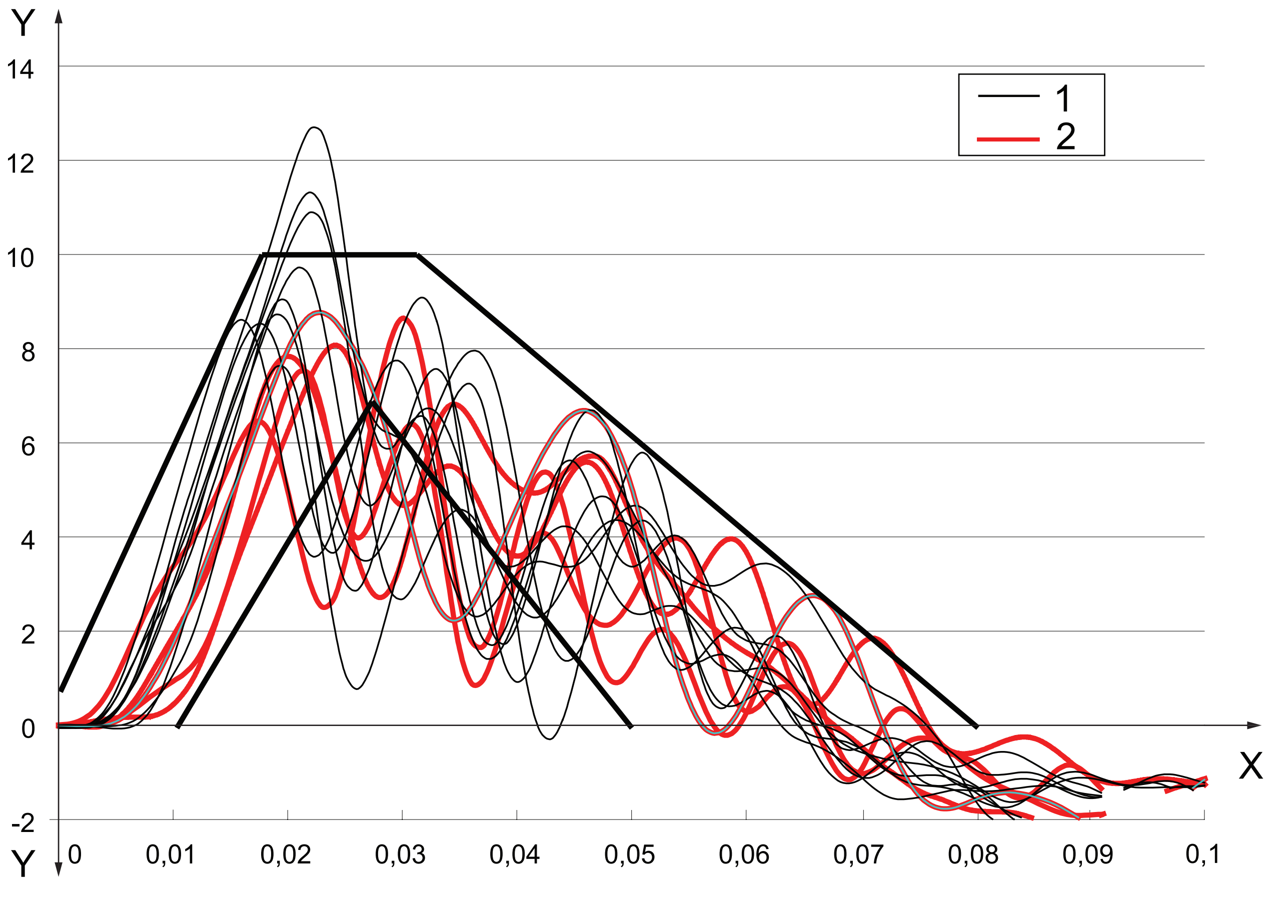
3.4.2 Intrusion velocity

Figure 1 shows the intrusion velocity characteristics measured in a large number of cars of different manufacturing dates in ECE R95 tests. In these tests the lateral intrusion was measured close to the dummy's head using either string potentiometers or cross tubes. The position of the measurement device was defined by the position of the Q3 dummy head in a forward facing CRS in the front seat. Intrusion velocity was computed from the intrusion. As parts of the available data represent quite old cars, the older cars (before 1995) can be easily identified.

The corridor lines shown in Figure 1 are meant as borders for defining a suitable intrusion velocity corridor. However, the allowed tolerance is too large to define a proper test procedure. It is crucial to define the intrusion velocity carefully, as it is an input parameter with considerable influence on the dummy measurements.

A maximum intrusion velocity between 7 m/s and 10 m/s at approximately 30 ms close to the dummy's head is required to represent realistic loading conditions.

For defining of a test procedure one has to take into account the combination of intrusion velocity and struck car velocity, defining the intrusion velocity relative to the ground.



Key

X time in seconds

Y intrusion velocity in metres per second

1 older cars (before 1995)

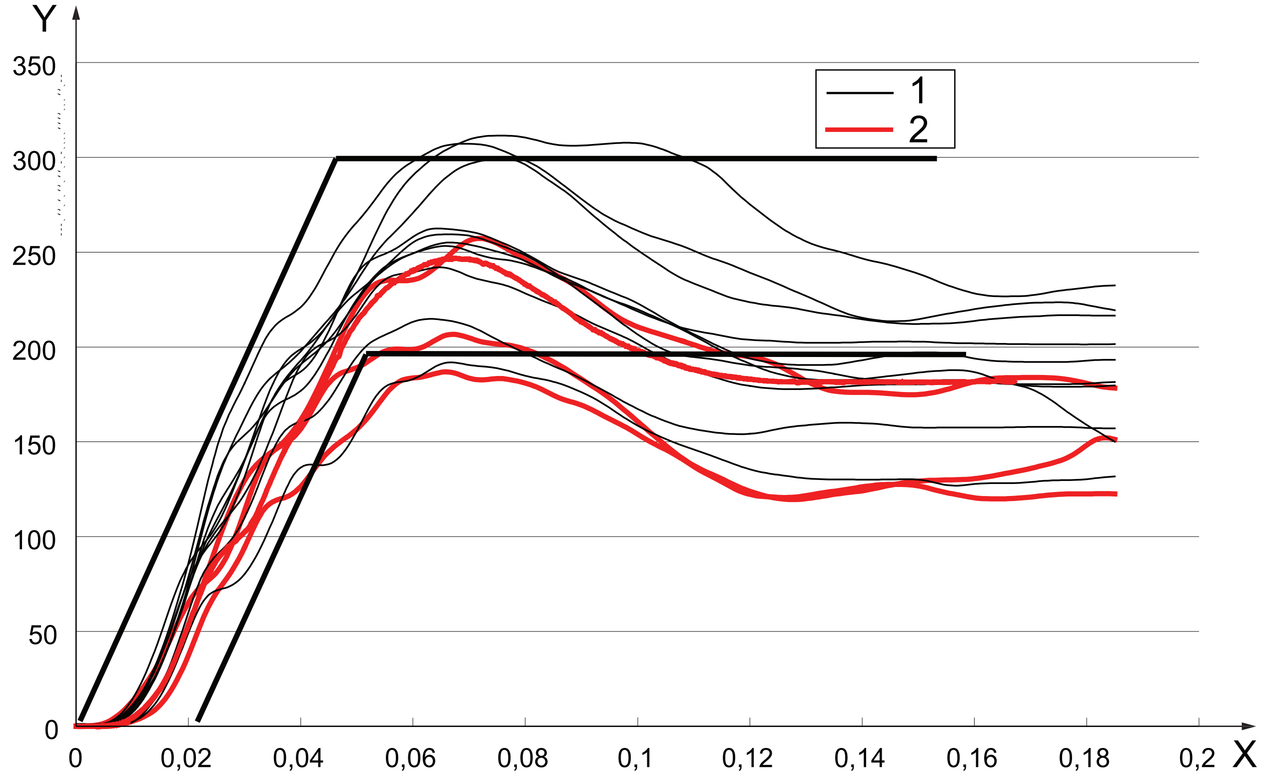
2 newer cars (from 1995)

Figure 1 — General requirements for intrusion specification

3.4.3 Intrusion depth

Figure 2 shows the intrusion depth characteristics measured in a number of cars representing different sizes and different manufacturing dates in ECE R95 tests. In these tests the lateral intrusion was measured close to the dummy's head using either string potentiometers or cross tubes. The position of the measurement device was defined by the position of the Q3 dummy head in a forward facing CRS in the front seat. As parts of the available data represent quite old cars, the older cars (before 1995) can be easily identified.

The dynamic intrusion depths should be between 200 mm and 300 mm to represent realistic loading conditions.



Key

X time in seconds

Y intrusion depth in millimetres

1 older cars (before 1995)

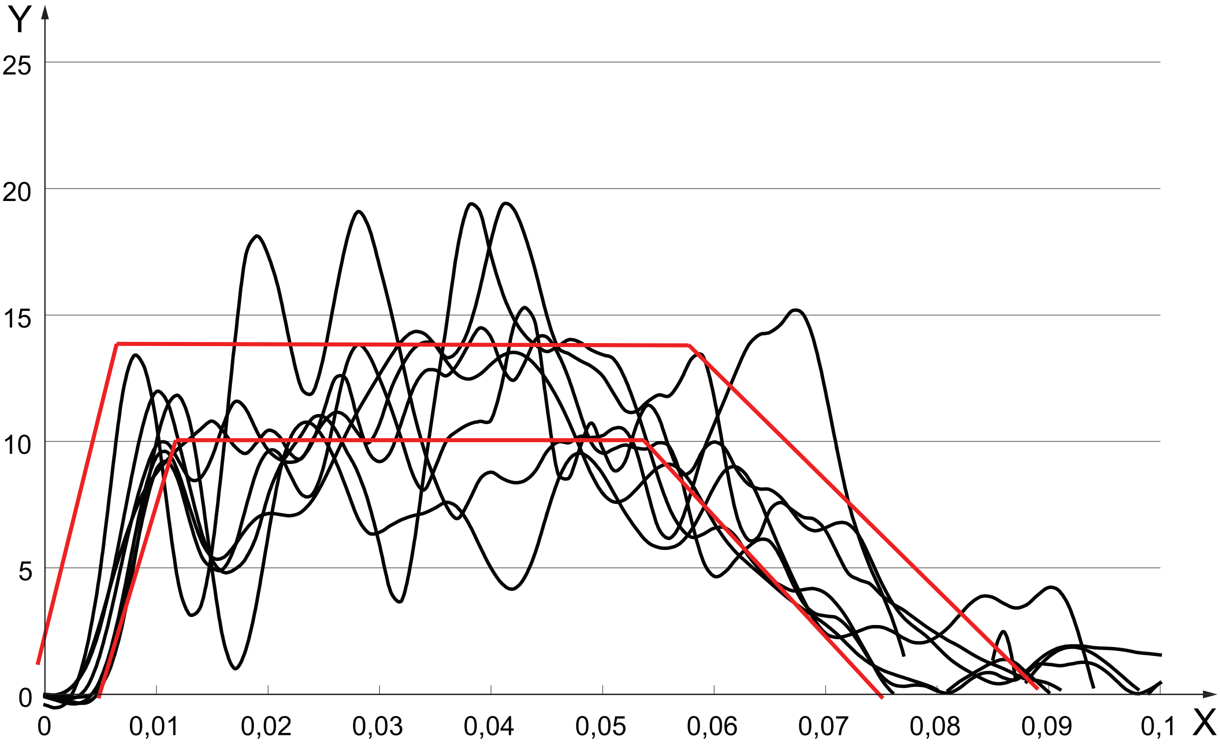
2 newer cars (from 1995)

Figure 2 — General requirements for intrusion depth

3.4.4 Struck car acceleration range and struck car Δ-v

Figure 3 shows the struck car acceleration measured at the non-struck side in a number of cars representing different sizes and different manufacturing dates in ECE R95 tests.

The sled acceleration should be between 10 g and 14 g to represent realistic loading conditions.



Key

X time in seconds

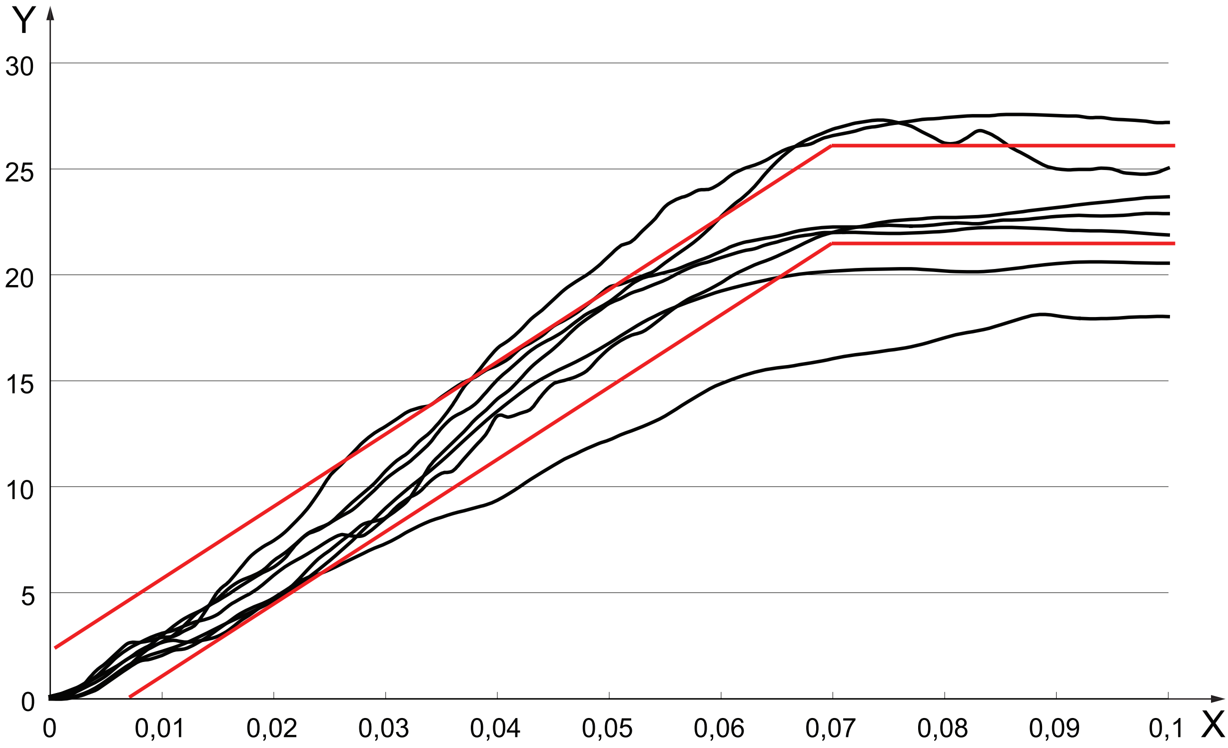
Y far side acceleration Y direction represented by *g* force

Figure 3 — General requirements for sled acceleration

Figure 4 shows the struck car velocity, Δv, computed from the acceleration presented in Figure 3.

The sled Δv should be approximately 25 km/h to represent realistic loading conditions. The Δv of 25 km/h represents the theoretical Δ-v if one car travelling at 50 km/h hits another car of the same mass.

Based on the results of the analysis of impact angles from real world accidents in combination with the results of tests with intrusion, the test procedure should focus on a perpendicular impact.



Key

X time in seconds

Y Δv in kilometres per hour

Figure 4 — General requirements for sled Δv

3.4.5 Geometry requirements

The initial distance between the CRS centre line and the intrusion surface should be approximately 300 mm.

The intrusion surface should have a height of approximately 500 mm with respect to the CR-point.

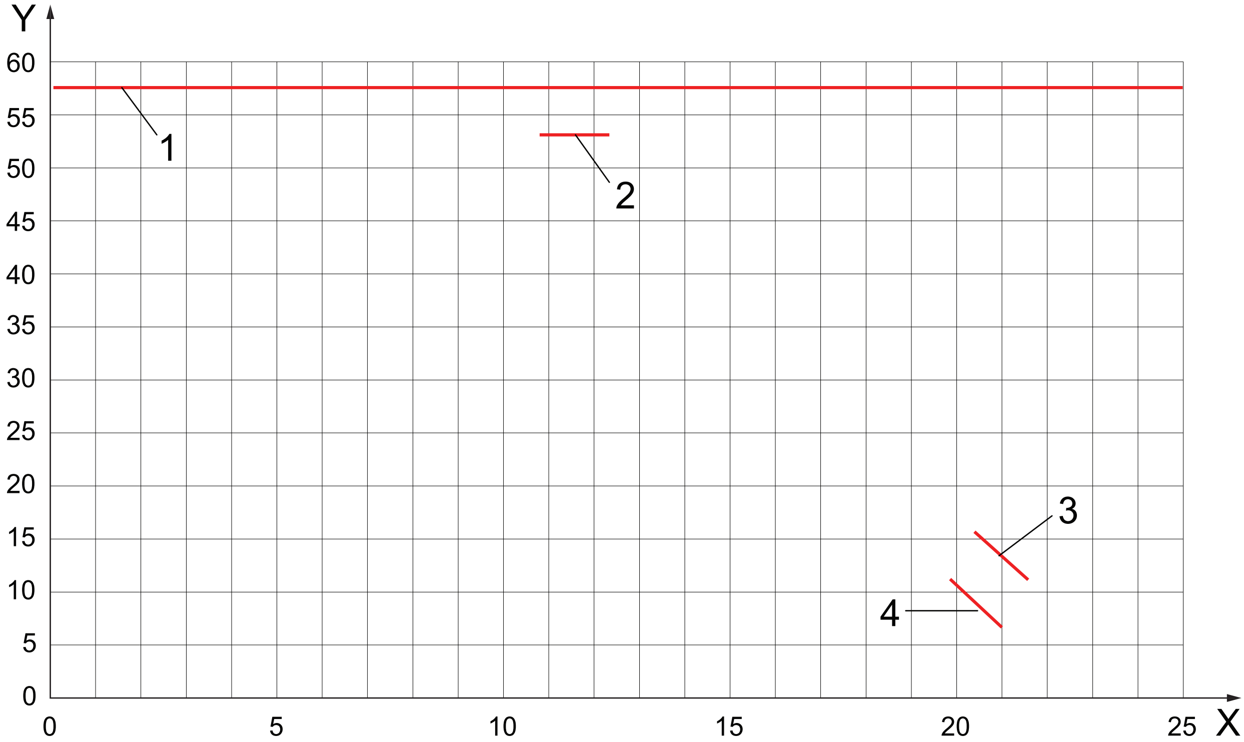
3.4.6 Intrusion surface properties

The rigid intrusion surface should be covered by 55 mm of deformable material, as described below.

The properties of the padding material for the intrusion surface are defined by performance criteria in a simple drop test. The test set-up consists of a simple drop test using a spherical head form. The spherical head form has a diameter of 150 mm and a mass of 6 kg (± 0,1 kg). The impact speed is 4 m/s (± 0,1 m/s). The instrumentation should allow the assessment of the time of first contact between the impactor and the sample, as well as the head form acceleration, at least in direction of impact (Z direction).

The material sample should have the dimensions of 400 mm × 400 mm. The sample should be impacted in its centre.

The time of first contact between sample material and head form, t_0, is 0 ms. The specification for the acceleration-time characteristics is shown in Figure 5.



Key

X time in milliseconds

Y acceleration represented by *g* force

1 upper limit of 58 *g*

2 lower limit for the maximum peak at 53 *g* (11 to 12 ms)

3 upper limit for the decline of acceleration (15 *g* at 20,5 ms to 10 *g* at 21,5 ms)

4 lower limit for the decline of acceleration (10 *g* at 20 ms to 7 *g* at 21 ms)

Figure 5 — Corridor for the padding material

3.5 Anchorages

Vehicle seat belt anchorages and ISOFIX anchorages are subject to deformation and displacement on side impact, resulting from displacement of the b-pillar, the complete seat, etc. In sled tests anchorages are normally strengthened to allow re-use and good repeatability. Taking into account the actual movement of anchorages in cars and the reinforcing of anchorages in sled tests, it is reasonable to allow dedicated movement of anchorages in a side impact test procedure.

3.6 Validation

The test procedure shall be repeatable, reproducible and impartial.

3.7 Field of application

The performance of test procedure needs to cater for all CRS types. However, it is important to specify in detail which “age groups” shall be considered, taking into account the protection capabilities of today's cars for older children.

4 Summary

Intrusion loading is the most frequent cause of injuries in side impacts. For the protection of children on car side impact, a combined assessment of body kinematics and energy management capabilities of the CRS is important.

Looking at the different body regions, the head needs to be protected with highest priority, followed by neck and chest.

The test input parameters are defined by the intrusion (specified by intrusion shape, intrusion depth and intrusion velocity), the bench acceleration and Δv, as well as by geometrical properties. The parameters are summarised below:

- intrusion velocity: maximum between 7 m/s and 10 m/s at approximately 30 ms close to the dummy's head;
- intrusion depth: dynamic intrusion depths should be between 200 mm and 300 mm;
- sled acceleration range: 10 g to 14 g (sled Δv should be approximately 25 km/h);
- intrusion surface height: approx. 500 mm with respect to CR point;
- initial distance between CRS centre line and intrusion surface: approximately 300 mm.

Based on the results of the analysis of impact angles, the test procedure should focus on perpendicular impact.

Table 1 lists the essential input parameters and their respective weight and is intended to support the assessment of different test procedures.

Table 1 — Matrix of essential parameters to support the assessment of side impact test procedures

Essential parameter	Reference value	Weighing factor	Method A	Method B	Method C	Method D
Loading conditions	intrusion loading	A				
Loading conditions	assessment of occupant kinematics and energy management	A				
Relevant body regions to be addressed	1. head 2. neck 3. chest	1: A 2: B 3: B				
Maximum intrusion velocity	7 m/s to 10 m/s at approx. 30 ms close to the dummy's head	A				
Maximum intrusion depths	200 mm to 300 mm	B				
Sled acceleration range	10 g to 14 g	C				
Sled Δv	approx. 25 km/h	B				
Intrusion surface height	approx. 500 mm with regard to CR line	B				
Initial distance between intrusion surface and CRS centre line	approx. 300 mm	B				

Bibliography

[1] ISO/TR 14646:2007, *Road vehicles — Side impact testing of child restraint systems — Review of background data and test methods, and conclusions from the ISO work as of November 2005*

[2] ISO/TS 29062:2009, *Road vehicles — Child restraint systems — Sled test method to enable the evaluation of side impact protection*

[3] JOHANNSEN, H. and MENON, R.A., *Short Report Forward Component in ISO Side Impact Test Procedure for CRS, ISO/TC 22/SC 12/WG 1/TF 1, 2007* (ref. ISO/TC 22/SC 12/WG 1 N 797)

[4] JOHANNSEN, H., WEBER, S. and SCHINDLER, V., *CHILD Technical Report Selection of Side Impact Test Procedure, 2006*

[5] EEVC Working Group 18: *Report Child Safety — February 2006*

[6] MALTESE, M.R., LOCEY, C.M., JERMAKIAN, J.S., NANCE, M.L. and ARBOGAST, K.B., Injury causation scenarios in belt-restrained nearside child occupants, *Stapp Car Crash Journal*, **51**, pp. 299-311, 2007

[7] HENARY, B., SHERWOOD, C.P., CRANDALL, J.R., KENT, R.W., VACA, F.E., ARBOGAST, K.B. and BULL, M.J., Car safety seats for children: rear facing for best protection, *Injury Prevention*, **13**, pp. 398-402, 2007

[8] BENDJELLAL, F. (on behalf of Clepa), *Side Impact Test Methods for Evaluating Child Restraint Systems — A Summary for GRSP Informal Group on Child Restraints*, 3rd meeting, London, 13 May 2008

[9] ARBOGAST, K.B., CHEN, I., DURBIN, D.R. and WINSTON, F.K., *Injury Risks for Children in Child Restraint Systems in Side Impact Crashes*, IRCOBI Conference, Graz, 2004

[10] CRANDALL, J. and SHERWOOD, C., *Factors Influencing the Performance of Rear Facing Restraints in Frontal Vehicle Crashes,* 3rd International Conference — Protection of Children in Cars, Munich, 2005

[11] IIHS: *Side Impact Crashworthiness Evaluation Crash Test Protocol (Version V), 2008*, http://www.iihs.org/ratings/protocols/pdf/test_protocol_side.pdf

[12] JAKOBSSON, L., ISAKSSON-HELLMANN, I. and LUNDELL, B., *Safety for the Growing Child — Experience from Swedish Accident Data*, 19th ESV Conference, Washington DC, June 2005

[13] JOHANNSEN, H., GEHRE, C., SCHOENEICH, O. and SCHINDLER, V., *Restrained Children in Side Impacts — Crash Tests and Simulation*, 1st Conference Protection of Children in Cars, Cologne, 2003

[14] JOHANNSEN, H., HUIJSKENS, C., SCHNOTTALE, B. and SCHINDLER, V., *Side Impact Test Procedure for Child Restraint Systems — Review of Existing Methods and Proposal for Continuation*, IRCOBI Conference, Prague, 2005

[15] LANGWIEDER, K., HELL, W. and WILLSON, H., *Performance of Child Restrain systems in Real-Life Lateral Collisions*, 40th Stapp-Conference, Albuquerque, NM 1996

[16] LANGWIEDER, K., *Verletzungsfolgen für Kinder als Insasse bei pkw-Unfällen,* Innovative Kindersicherungen im Pkw, 2002 (in German)

[17] NETT, R., *Testverfahren zur Bewertung und Verbesserung von Kinderschutzsystemen beim Pkw-Seitenaufprall,* Berichte der Bundesanstalt für Straßenwesen, Heft F43, 2003 (in German)

[18] OTTE, D., *Injury Risk of Children in Cars*, 1st Conference Protection of Children in Cars, Cologne, 2003

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