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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

IMPORTANT — The electronic file of this document contains colours which are considered to be useful for the correct understanding of the document. Users should therefore consider printing this document using a colour printer.

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.

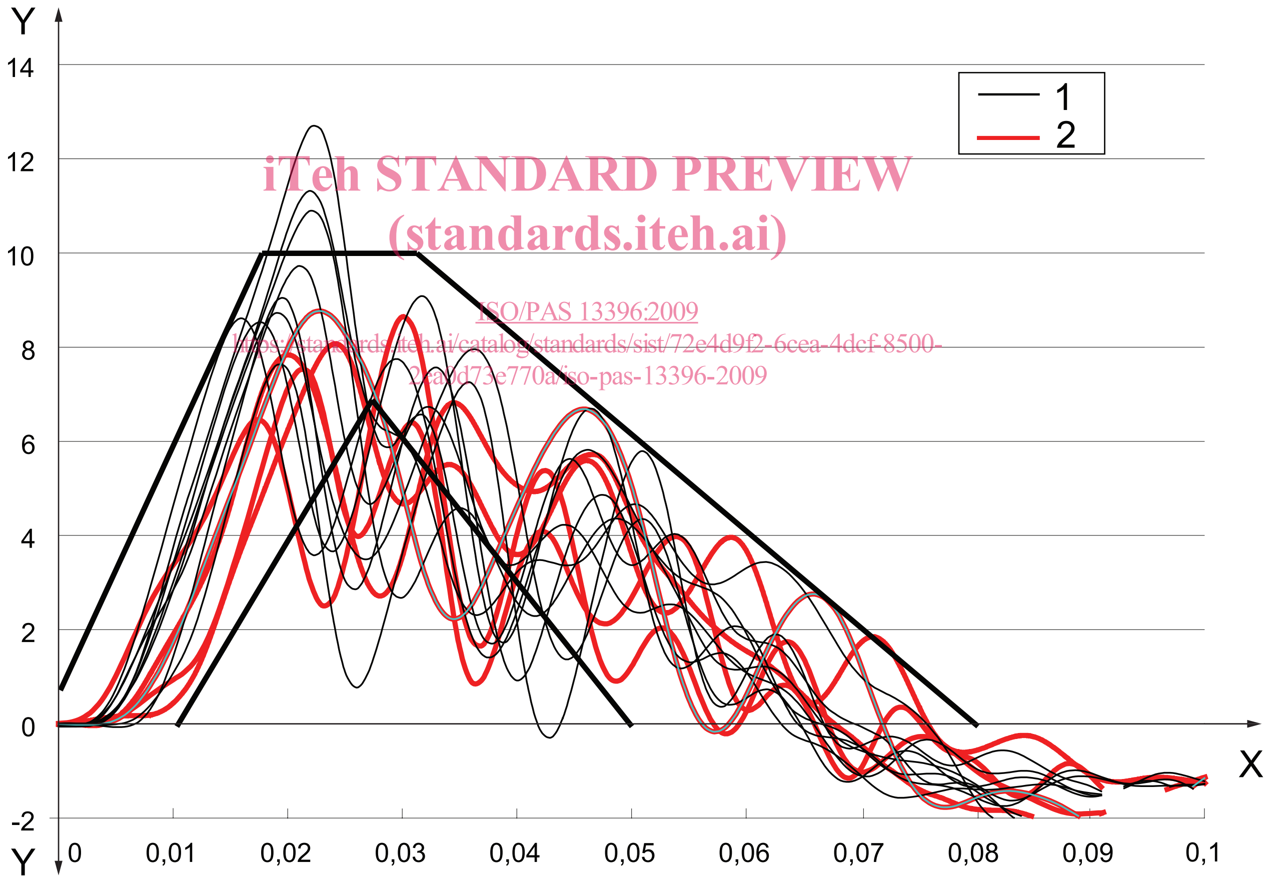
3.4.2 Intrusion velocity

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)

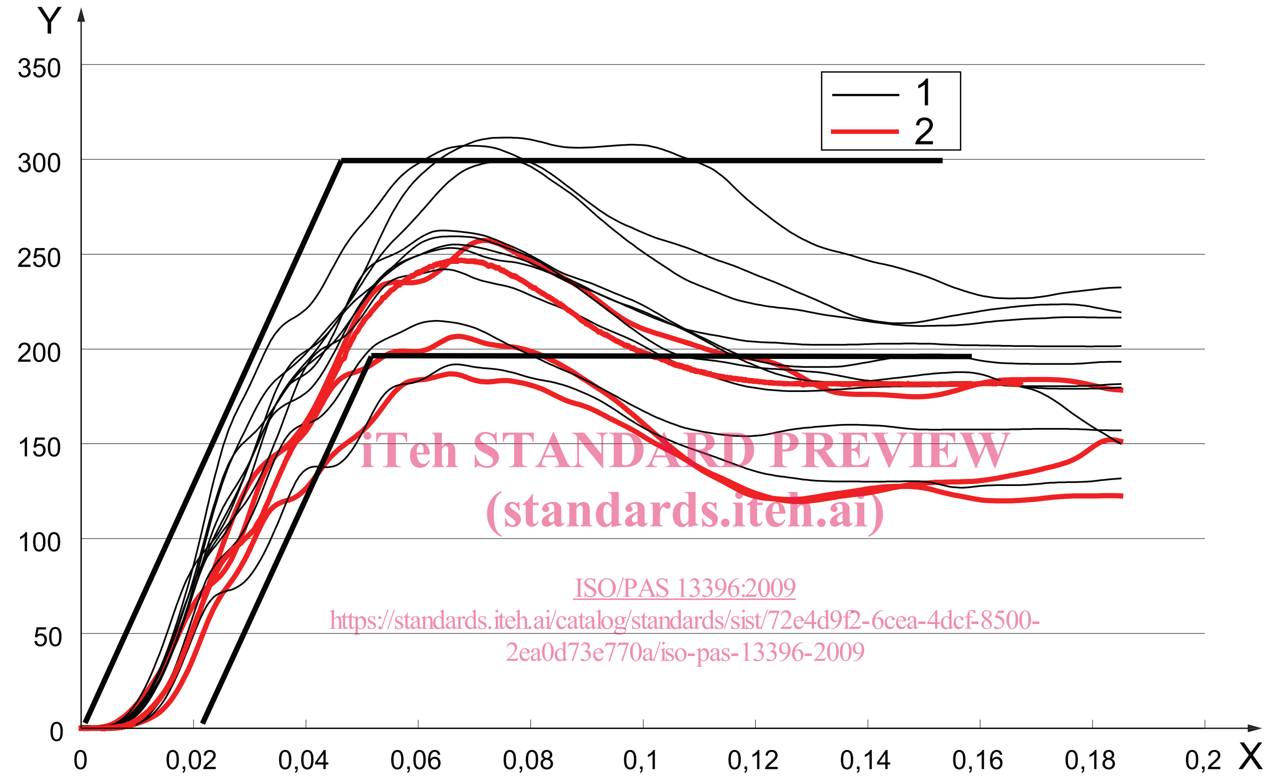
2 newer cars (from 1995)

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)

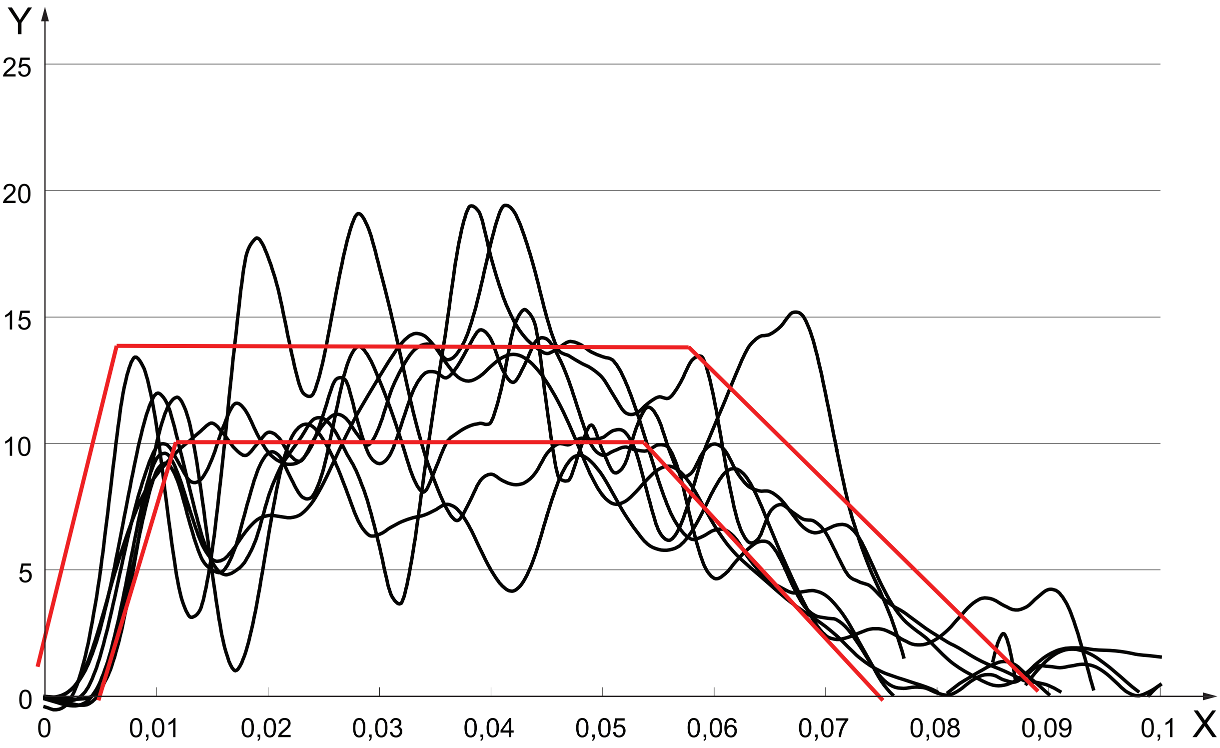
2 newer cars (from 1995)

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.