TECHNICAL REPORT

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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

Véhicules routiers — Essais de choc latéral pour systèmes de retenue pour enfants — Revue des données de référence et des méthodes d'essai, et conclusions du travail de l'ISO jusqu'en novembre 2005

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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

In exceptional circumstances, when a technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example), it may decide by a simple majority vote of its participating members to publish a Technical Report. A Technical Report is entirely informative in nature and does not have to be reviewed until the data it provides are considered to be no longer valid or useful.

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ISO/TR 14646 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 12, *Passive safety crash protection systems*.

Introduction

ISO/TC 22/SC 12/WG 1 has been working on the definition of a side impact test procedure for child restraint systems. After meeting the deadline for finalisation of a third DIS version and with disapprovals (by a small margin) of the previous two DIS votings, it was decided to finalise the current project with a Technical Report and to restart the process of developing an international standard.

The aim of this Technical Report is to summarise the work done within ISO, and to compile additional relevant information to form a solid base for the restarted project.

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

1 Scope

This Technical Report summarises the work within ISO to define a side impact test method for child restraint systems (CRS). It presents the main background data, and experiences from crash tests carried out during the process of development. Additional relevant data are also presented.

2 Accident statistics

The severity of injuries in side impacts depends on the seating position. It can be noticed that the severity of injuries is much higher for children sitting on the struck side than sitting on the non-struck side. The share of injuries on the non-struck side is comparable to frontal impacts, while the injury probability is much higher in struck side accidents, see Figure 1.

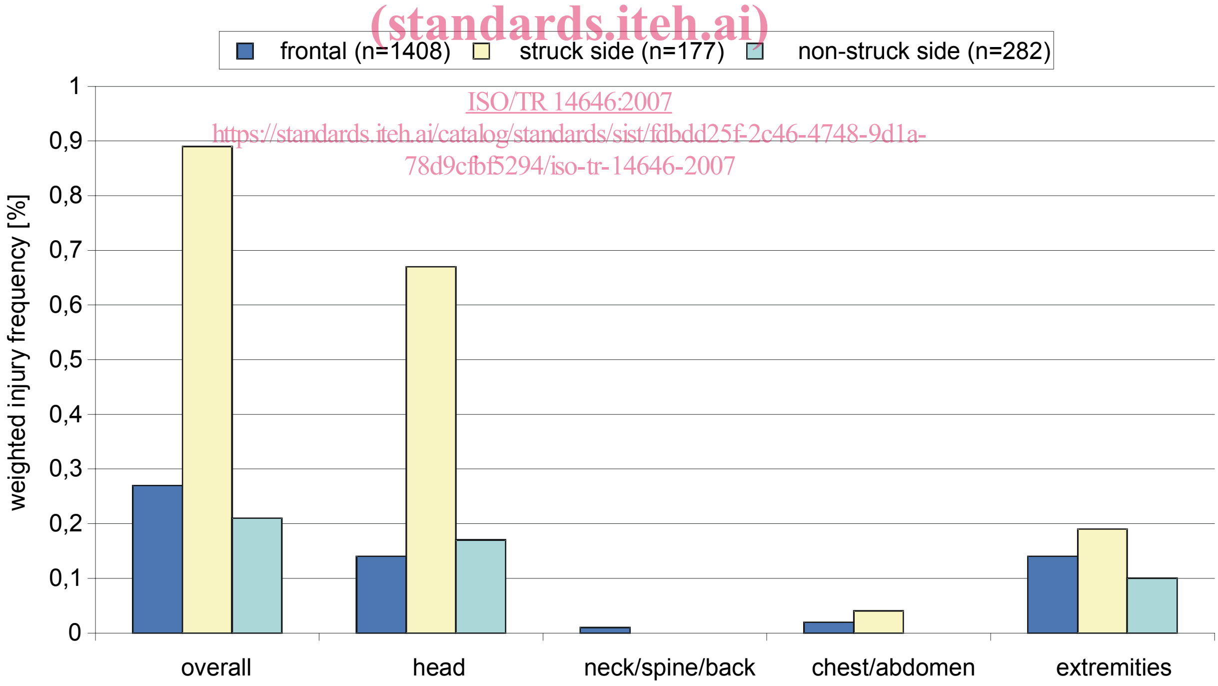

Figure 1 — Injury frequency depending on the impact direction [Arbogast, 2004]

Even when analysing all lateral impact accidents the relative number of children suffering MAIS 2+ injuries is much higher than for other impact directions, see Figure 2.

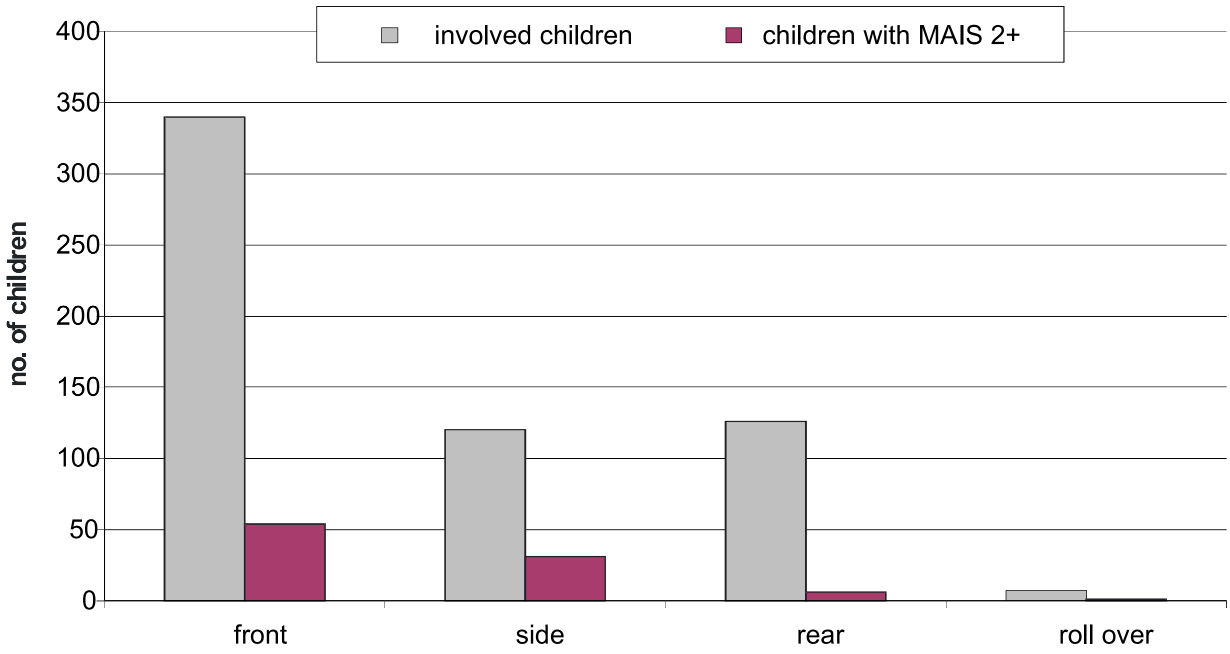

Figure 2 — Share of different impact directions [Langwieder, 2002]

Regarding the different body regions the risk for severe injuries decreases from the head down to the legs. The frequently observed injuries of arms and legs are not of high severity, but may cause long term impairments. The focus for investigations concerning improvements of CRS should be on the head, neck and thorax, see Figure 3.

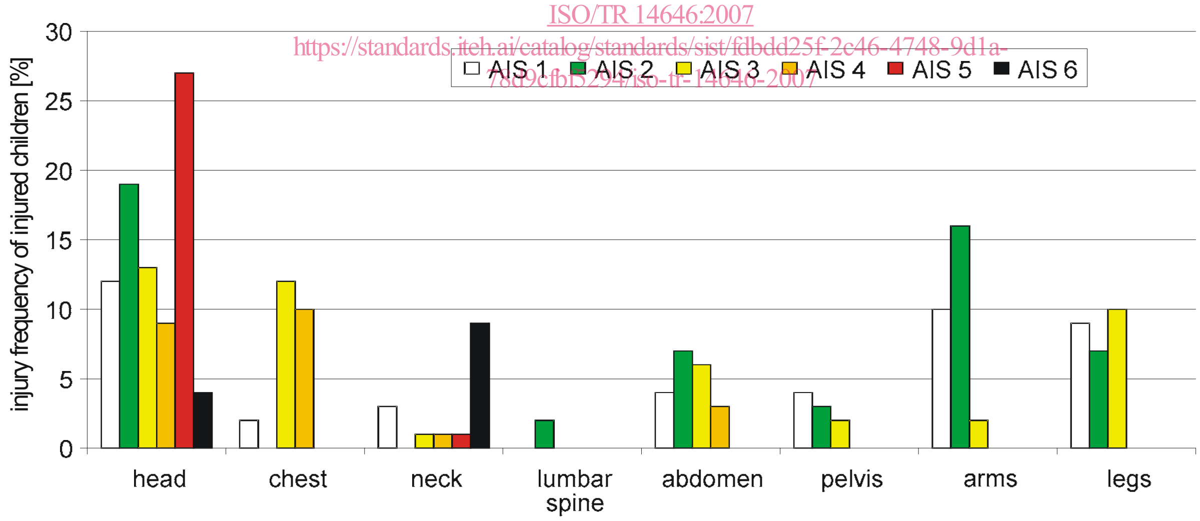

Figure 3 — Injury risk of different body regions of 68 injured children in side impacts [Langwieder, 1996]

Looking at the development of injuries in lateral impacts from 1985 to 2001 it is obvious that the injury probability decreased since 1985 while the risk to suffer neck injuries increased and the chest remained unchanged, see Figures 4, 5, and 6.

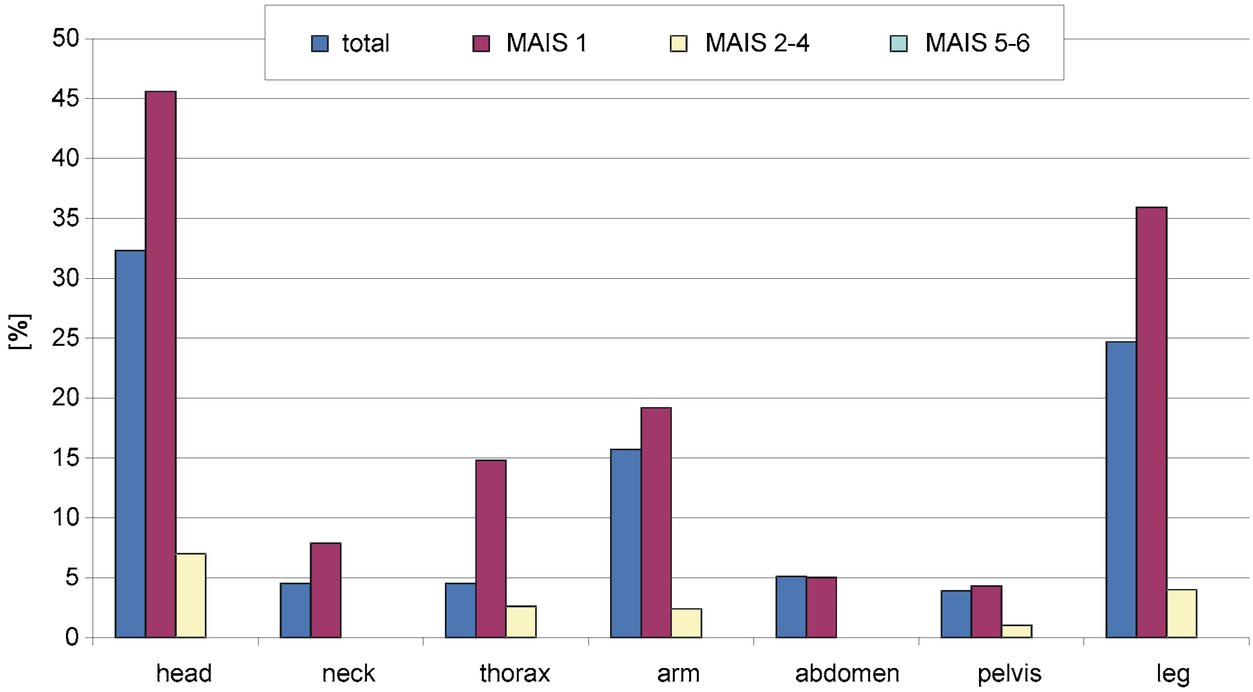

Figure 4 — Injury probability of different body regions in side impact accidents between 1985 and 1990 [Otte, 2003]

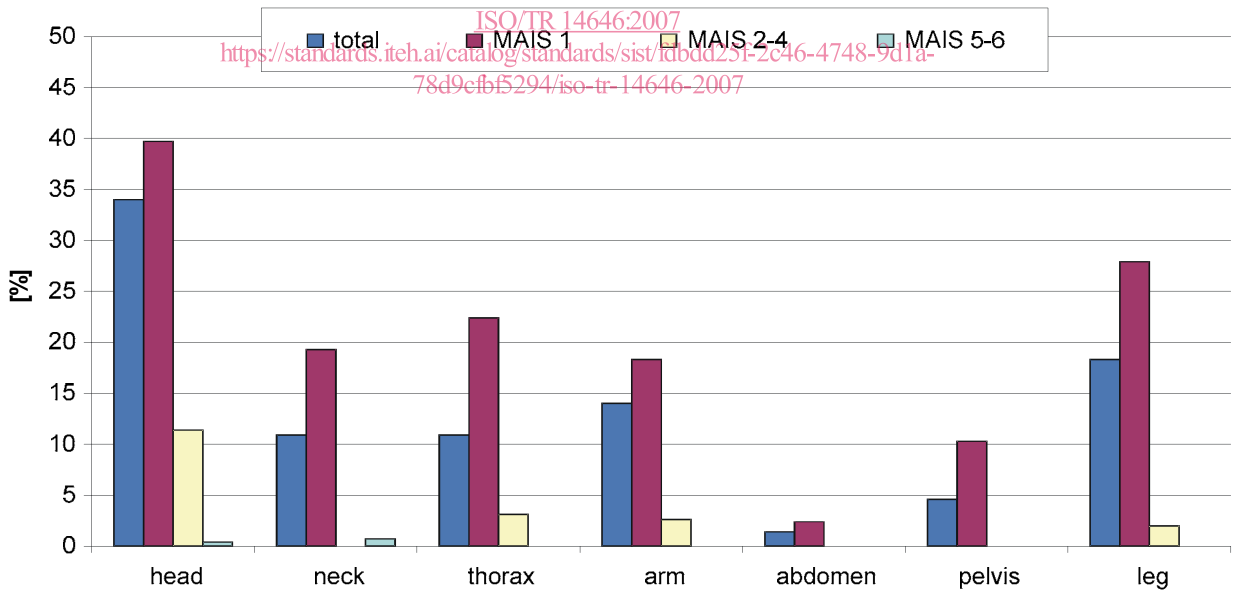

Figure 5 — Injury probability of different body regions in side impact accidents between 1991 and 1996 [Otte, 2003]

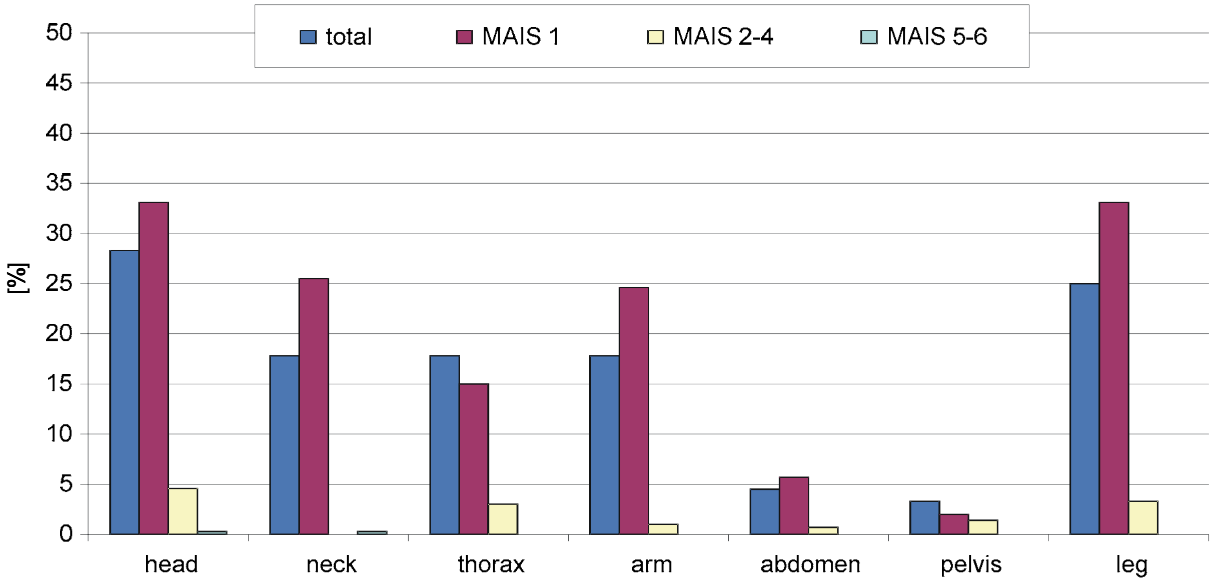

Figure 6 — Injury probability of different body regions in side impact accidents between 1997 and 2001 [Otte, 2003]

The presented accident shows that side impact accidents are severe ones especially for those children sitting at the struck side. Especially head, neck and chest need to be protected.

In a study of Swedish accident situation Jakobsson et al. [Jakobsson, 2005] did not find any moderate-severe (AIS2+) head injuries in children using rear-facing (RF) CRS involved in lateral impact accidents, while children using forward facing (FF) booster seats or the car belt only suffered from moderate-severe injuries (AIS2+) in side impacts. Comparing the injury risk for RF and FF CRS in frontal and lateral impact accidents of NASS Data (US American accident data base) of the years 1988 to 2003 Crandall et al. [Crandall, 2005] observed a ratio of 4,32 in favour of RF seats. The ratio was felt to be larger than expected.

3 Side impact test methods for cars

The full-scale test methods have been validated against the real world accident conditions in the specific regions. We can therefore utilise these test methods in the development of the child side impact test procedure.

3.1 European side impact test methods

In Europe the compulsory side impact test method is described in ECE Regulation No. 95. In addition Euro-NCAP defined a side impact test procedure, which is similar to ECE Regulation No. 95.

3.1.1 ECE Regulation No. 95

A moveable deformable barrier (MDB) strikes the test car with a velocity of 50 km/h in an angle of 90°. The barrier has a weight of 950 kg and a width of 1 500 mm. The deformable element has a ground clearance of 300 mm. The centre line of the MDB should match with the X position of the hip point of the 95-percentile dummy (R-point). A Euro SID dummy is positioned in the driver’s seat. No child dummies are prescribed for ECE Regulation No. 95.

3.1.2 Euro-NCAP lateral test

The Euro-NCAP side impact test protocol is in most parts similar to that of ECE Regulation No. 95. The most important differences to ECE Regulation No. 95 are that an ES2 dummy is used in the front driver's position and child dummies are used in the rear. The two following opportunities for the CRS installation are possible:

— P1.5 on the struck side and P3 on the non struck side;

— P1.5 on the middle rear seat and P3 on the struck side.

If a head protection system is available in the car, it can be tested in a pole test. The car travels with a velocity of 29 km/h laterally into a rigid pole with a diameter of 254 mm. No child dummies are used in this test.

3.2 US side impact test methods

The compulsory side impact test method in the US is defined in FMVSS 214. In addition consumer tests are defined by US-NCAP and IIHS.

3.2.1 FMVSS 214

A crabbed barrier hits with a velocity of 54 km/h the stationary test car, see Figure 7. Because of the 27° angle of the barrier the velocity has a component of 48 km/h in the car Y-direction and 25 km/h in car X-direction. The X component should simulate that the struck car is moving in normal lateral accidents. The barriers face has a width of 1 676 mm and a ground clearance of 279 mm. The "bumper part" of the deformable element has a ground clearance of 330 mm. The mass of the trolley is 1 368 kg. US SID dummies are used at the front and rear struck side seat. No child dummies are tested according to FMVSS 214.

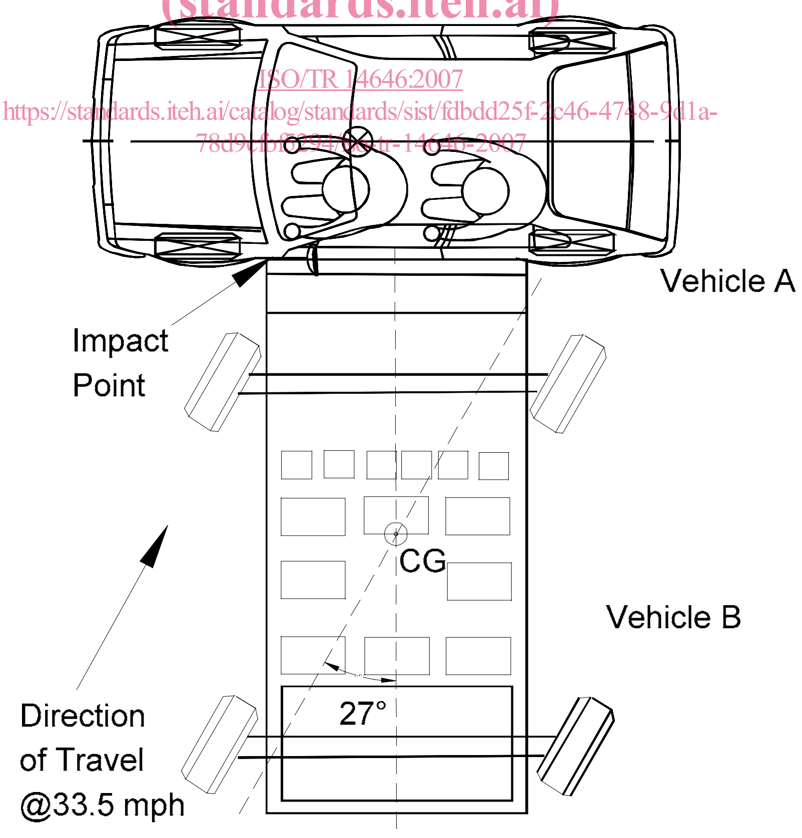

Figure 7 — Impact configuration according to FMVSS 214 [NHTSA, 2003]

FMVSS 201 describes a pole test, which formed the basis for the Euro-NCAP pole test described above.

3.2.2 US-NCAP lateral test

The US-NCAP side impact test procedure is analogous to the FMVSS 214 protocol. The main difference is that the impact speed is 5 mph higher in the NCAP test compared to FMVSS 214. This means an impact velocity of 62 km/h representing 55 km/h in car Y direction and 30 km/h in X direction.

3.2.3 IIHS lateral test

The Insurance Institute for Highway Safety (IIHS) defined a more severe side impact procedure, which should represent accidents with SUV.

A trolley with a mass of 1 500 kg hits the car in a purely lateral impact with a velocity of 50 km/h. The ground clearance of the barrier face is 379 mm, while the ground clearance of the bumper element is 430 mm. The shape of the barrier element shall comply with the front end shape of SUV's, see Figure 8. Two SID-II dummies are used in the front and rear seats on the vehicle struck side. No child dummies are used in the IIHS side impact test.

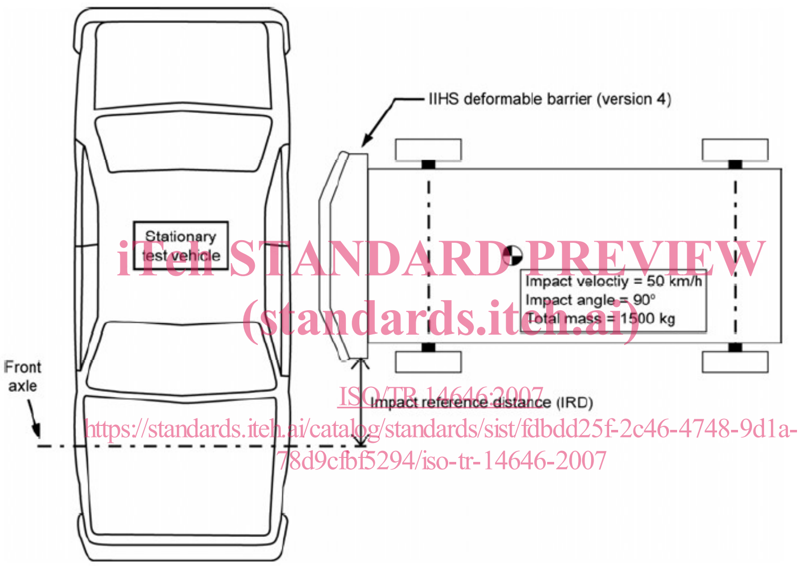

Figure 8 — Test configuration in IIHS side impact test [IIHS, 2005]

3.3 Japanese side impact test method

In Japan, ECE Regulation No. 95 (see above) is used for compulsory side impact tests. J-NCAP utilises Euro-NCAP side impact test method (see above) with some changes. The most important within this context are:

— Test speed is 55 km/h;

— No child dummies are prescribed.

3.4 Australian side impact test method

The compulsory side impact test for cars in Australia is defined by ADR72, which is equal to ECE Regulation No. 95 (as described above). The Australian consumer test programme (ANCAP) follows in most parts the protocols of Euro-NCAP (see above). However, no child dummies are tested in the rear seat.

4 Child related properties of car side impact test methods

4.1 Boundary conditions for a CRS side impact test procedure

In several full-scale crash tests according to regulation ECE Regulation No. 95 performed in the last ten years, dynamic lateral intrusions of front and rear doors were measured. The sample includes super minis, family cars, executive cars and mini multi-purpose vehicles of the model years from 1990 until 2004. Both two-door and four-door cars are included. In the last tests the revised deformable barrier face according to EEVC/WG 13 was used. In all test the lateral intrusion of the inner part of the doors was measured with a string potentiometer or a cross tube positioned at the middle of the door. Intrusion velocities (4.3) were calculated from the intrusion time history diagrams. For comparison, car-to-car test results are analysed in 4.4.

4.2 Door intrusion depth

The maximum intrusion depth of the front door varies from 180 mm to 310 mm, whereas the newer vehicles have lower intrusions (Figure 9).

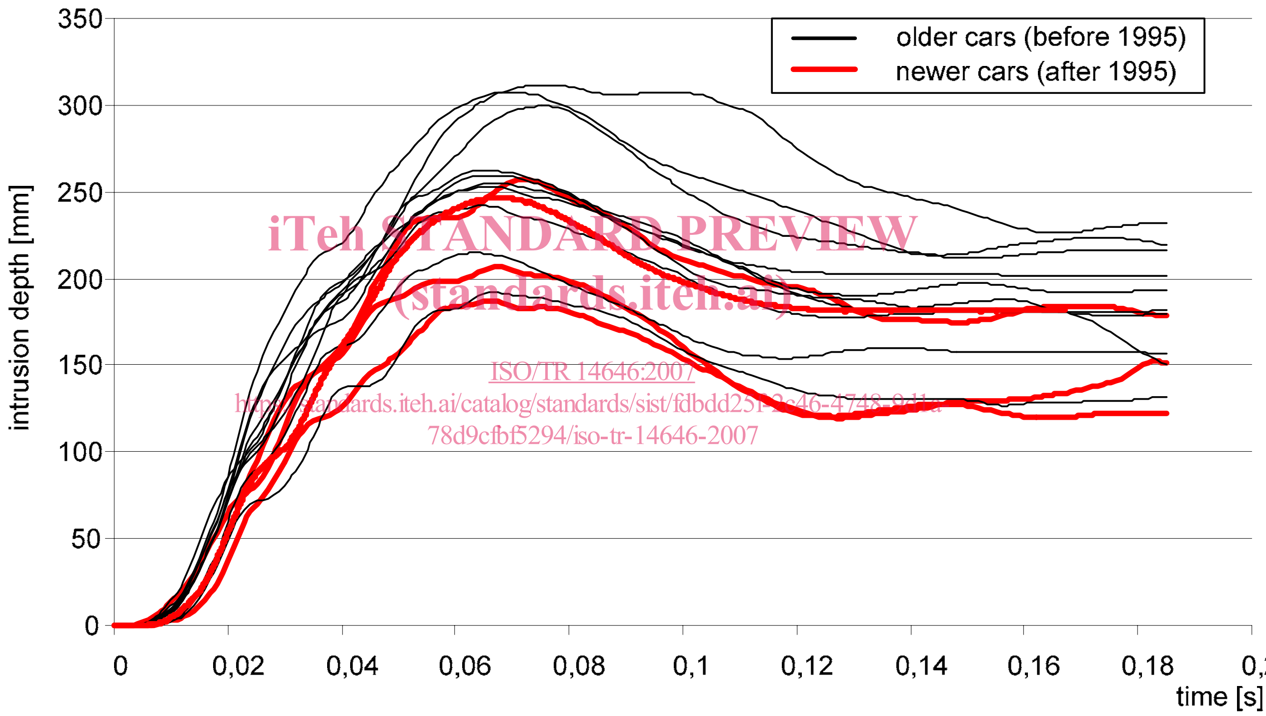

Figure 9 — Front door intrusion depth in side impact tests according to ECE Regulation No. 95 [Johannsen, 2005]

It can be seen that the maximum intrusion depth of the rear door varies from 170 mm to 280 mm, which indicates that the intrusion depth is lower at the rear door compared with the front door (Figure 10).

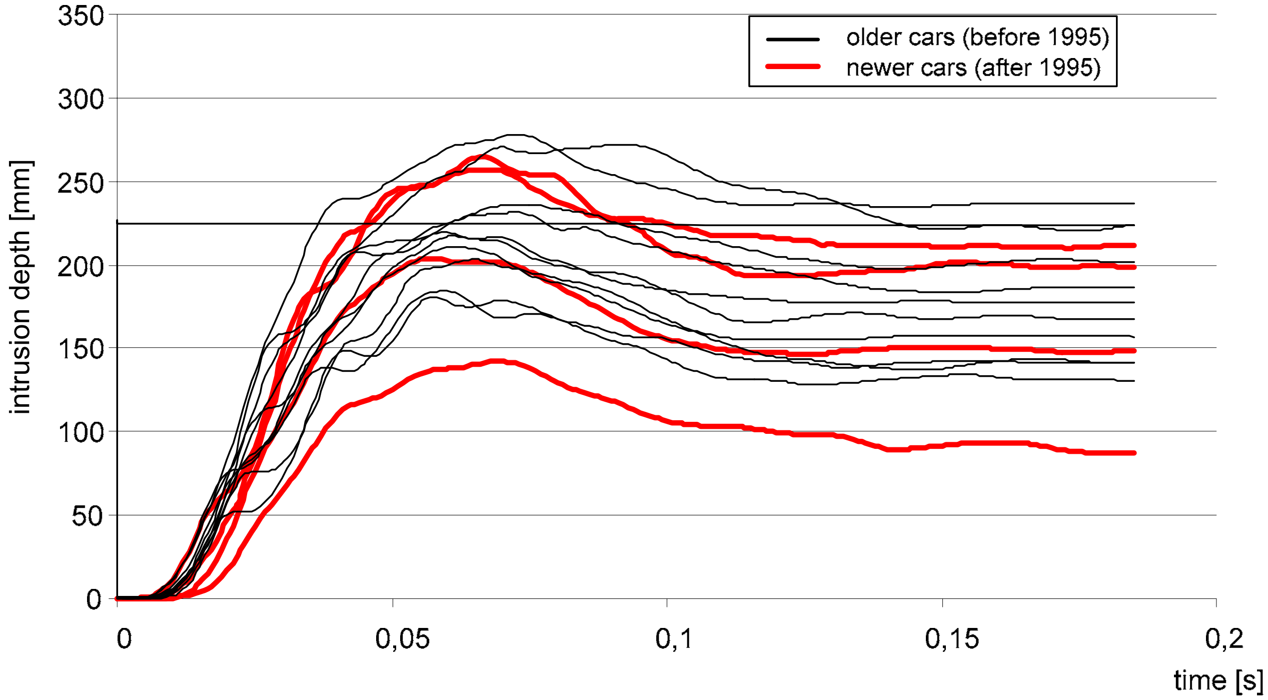

Figure 10 — Rear door intrusion depth in side impact tests according to ECE Regulation No. 95

4.3 Door intrusion velocity from ECE tests

Regarding the intrusion velocity a comparable result can be observed. The intrusion velocity is again lower at the rear door compared with the front door.

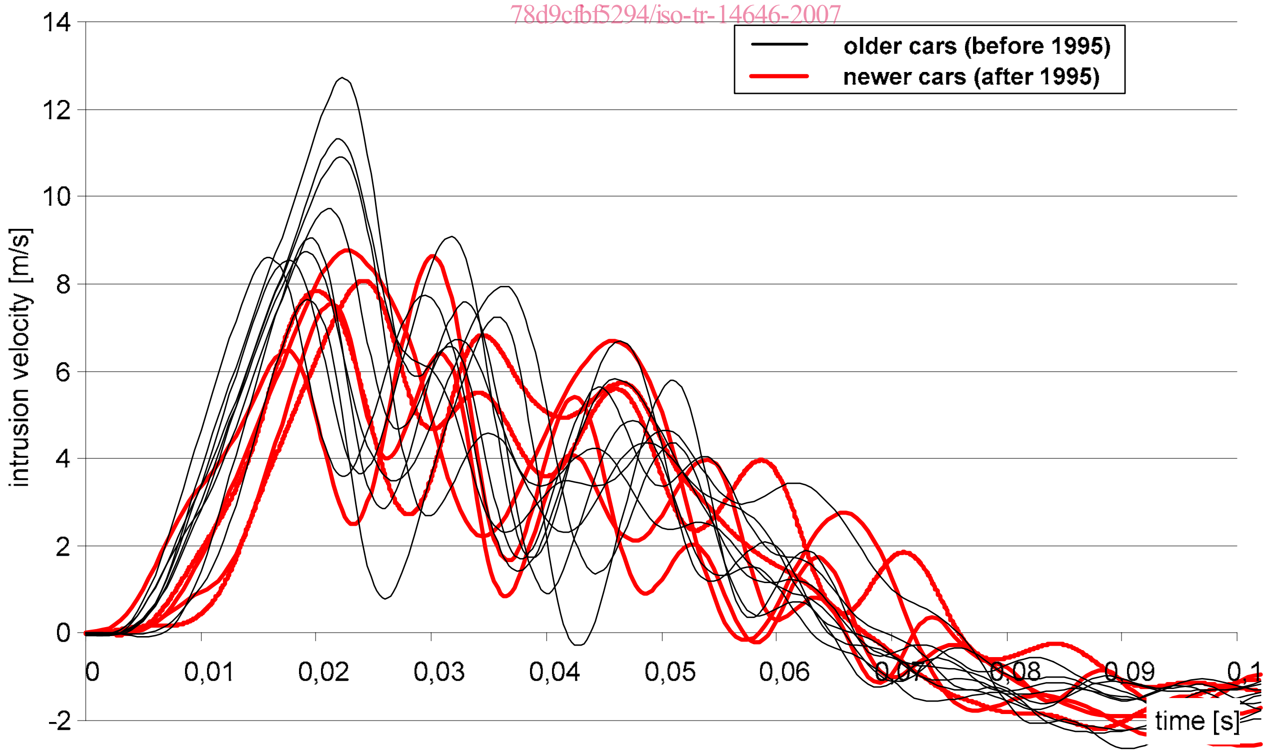

Figure 11 — Front door intrusion velocity in side impact tests according to ECE Regulation No. 95 [Johannsen, 2005]

The intrusion velocity at the front door shows a range between 8 m/s and 13 m/s (Figure 11), while the intrusion velocity at the rear door varies between 7 m/s and 13 m/s (Figure 12).

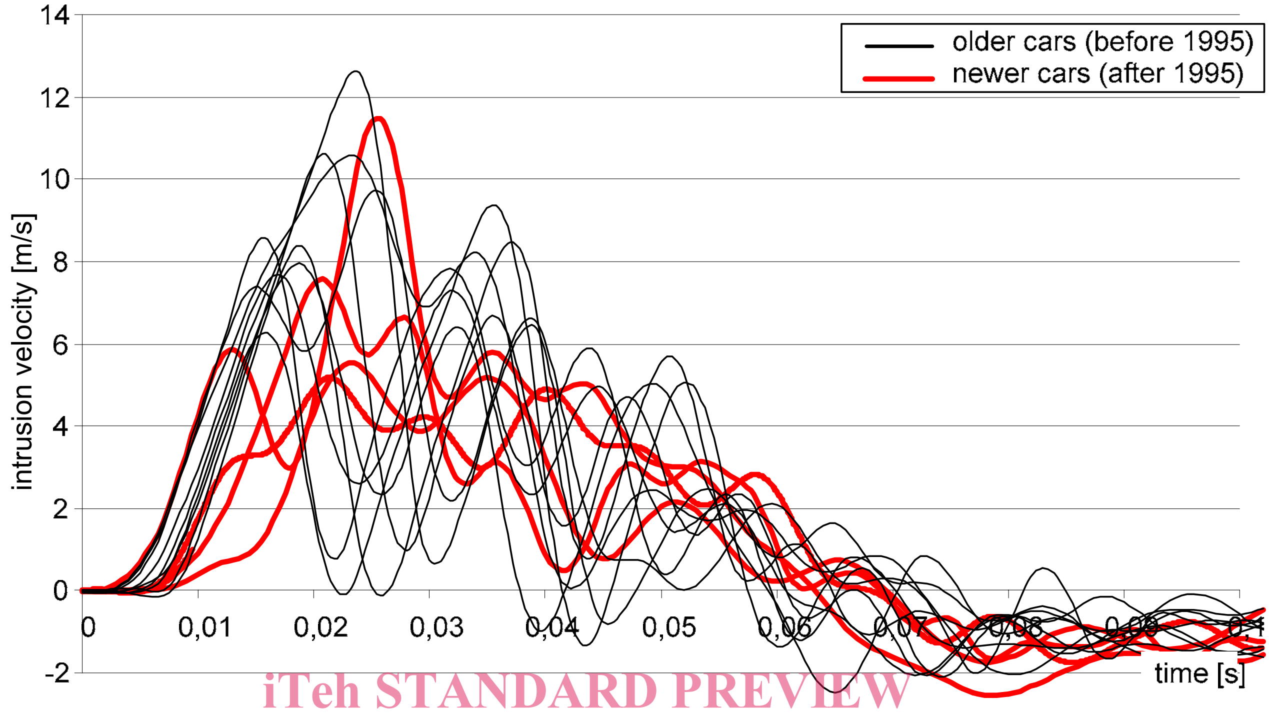

Figure 12 — Rear door intrusion velocity in side impact tests according to ECE Regulation No. 95

Taking into account the difficulties in positioning of the intrusion measurement device especially in smaller cars, a mean difference in intrusion velocity between front and rear door of 10 % can be observed (Figure 13). The difference could be caused either by vehicle design or the test procedure with the centre of impact located more in the front.

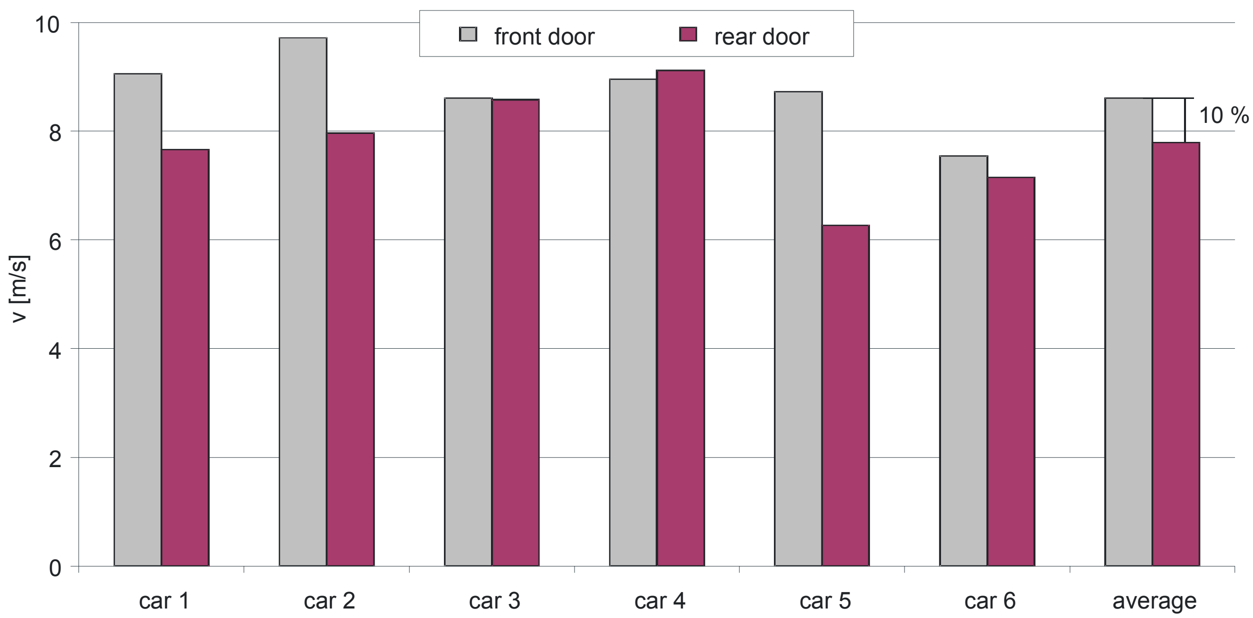

Figure 13 — Comparison of maximum intrusion velocity for front and rear seat