# UPDATE ON LATERAL IMPACT TEST PROCEDURE FOR CHILD RESTRAINT SYSTEMS

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Paper Number 11-0291

## ABSTRACT

After years of research and discussion ISO published a side impact test procedure for CRS as Technical Specification ISO/TS 29062:2009. At the same time of the finalisation of the technical specification, the GRSP Informal Group on CRS decided to establish a more simple approach than specified in ISO/TS 29062:2009 and asked ISO for support. As a response to this request ISO prepared the Publicly Available Specification ISO/PAS 13396:2009 which summarises the most important input data for the development of a side impact test procedure. That represented a significant input to the Informal Working Group on CRS to develop their own test procedure. The new GRSP lateral impact test procedure is currently under validation. It is expected that the validation will be completed by spring 2011.

The new test procedure will become mandatory as part of the planned new regulation for the homologation of CRS.

## INTRODUCTION

In lateral impact accidents two mechanisms are causing injuries; on the one hand the lateral acceleration and on the other hand intrusion of the side structure. This combination makes the development of a suitable test procedure more difficult compared to frontal impact test procedures. Proposals for lateral impact test procedures considered lateral intrusion only, lateral acceleration only and the combination of both. One of the problems for the combination was that the intrusion velocity in cars was higher than the delta-v following the lateral acceleration. TRL developed the hinged door principle to address this issue which was the base for ISO and NPACS activities. However, the hinged door principle is considered by a large number of organisations to be too complicated. In the following the latest developments with respect to lateral impact test procedures are summarised.

## ACCIDENT ANALYSIS

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.

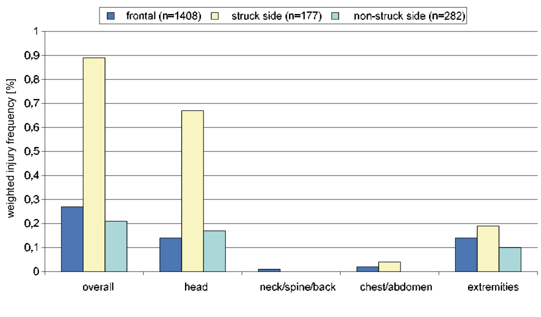


**Figure 1. Injury frequency depending on the impact direction [Arbogast, 2004].**

The relative number of children suffering MAIS 2+ injuries is much higher in lateral impact accidents than for the other impact directions, as shown in Figure 2.

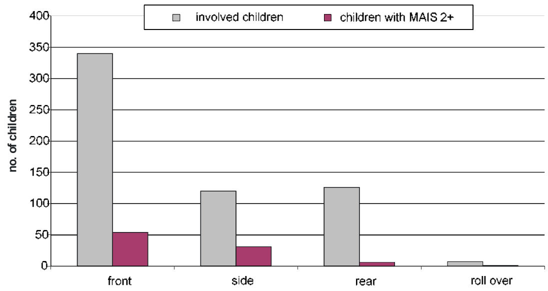


**Figure 2. Share of different impact directions [Langwieder, 2002].**

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 primarily on the head but to certain extent also on neck and thorax/thorax, see Figure 3.

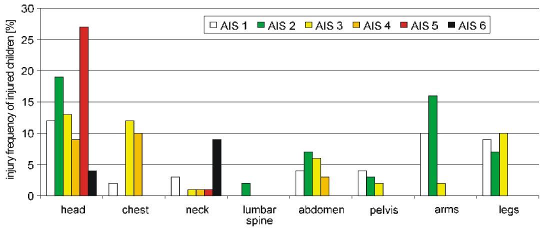


**Figure 3. Injury risk of different body regions of 68 injured children in side impacts [Langwieder, 1996].**

Looking at the distribution 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.

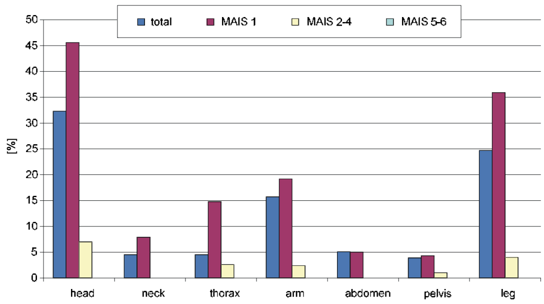


**Figure 4. Injury probability of different body regions in side impact accidents between 1985 and 1990 [Otte, 2003].**

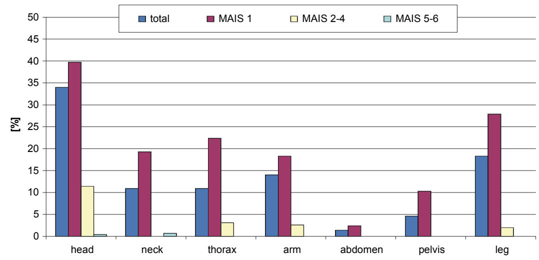


**Figure 5. Injury probability of different body regions in side impact accidents between 1991 and 1996 [Otte, 2003].**

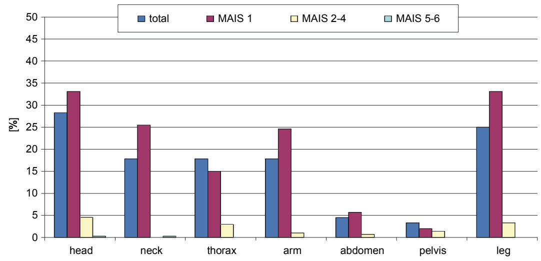


**Figure 6. Injury probability of different body regions in side impact accidents between 1997 and 2001 [Otte, 2003].**

These accident data show that side impact accidents are severe ones especially for those children (age up to 12 years) sitting at the struck side. Especially head, and to some degree neck and chest need to be protected.

In a study of the 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.

Based on results of the EC funded CHILD project and the EEVC/WG18 Report (Feb 2006), non-head containment combined with intrusion loading is found to be 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, 2006; EEVC, 2006].

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, 2007a]. Although all three sources show the same tendency, final conclusions are not possible as the number of involved children is too small to allow statistical significant results. This data regards all types of impact objects and restraint use.

Henary et al [Henary, 2007] found when comparing the risk of injury between children (aged 0-23 months) in side impacts, using US crash data (NASS-CDS), a significant 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.

The struck car is in many cases subject 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 [Maltese, 2007] mapped probable head contact points for 4 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.

## ACTIVITIES OF THE DIFFERENT WORKING GROUPS

### ISO TC22 SC12 WG1

The ISO Working Group on Child Safety of Sub committee on Passive Safety and Crash Protection started in the nineties with the development of a side impact test procedure.

**ISO 14646** was the first project concerning the standardisation of a lateral impact test procedure. After the disapproval of ISO DIS 14646 by a small margin ISO working group on child safety decided to summarise the knowledge gained for the development as a Technical Report. The ISO/TR 14646:2007 was published in 2007. A summary of the Technical Report is given in [Johannsen, 2007b].

**ISO/TS 29062:2009** was the follow up project of ISO 14646 which concluded as a Technical Specification. In parallel to the ISO/TR 14646:2007 ISO restarted the project to publish a side impact test procedure. ISO/TS 29062:2009 was published in 2009. The test procedure is comparable to the NPACS test procedure. Similar to the original DIS 14646 procedure a hinged door test procedure was utilised.

Figure 7 shows the set-up according to ISO/TS 29062:2009 for FF CRS. In order to avoid a gap between backrest and panel the backrest is moveable in Y direction.

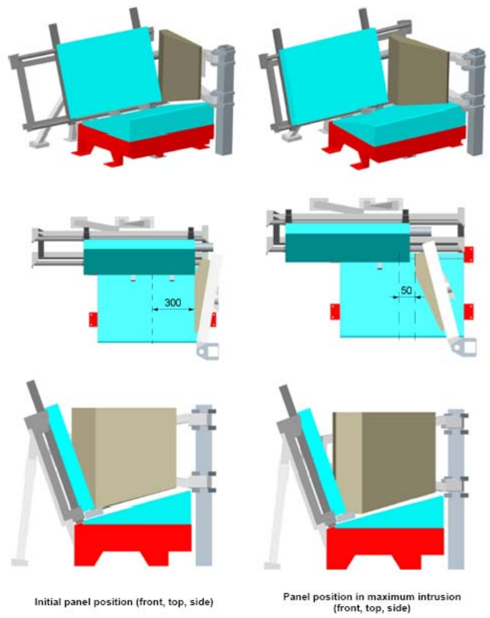


**Figure 7. Side impact test bench according to ISO TS 29062 for FF CRS.**

In order to test RF and FF CRS in comparable severity conditions the set-up is different for both CRS types. Using a hinged door test procedure it is important to have the maximum intrusion close to the dummy's head. The set-up for RF CRS is shown in Figure 8.

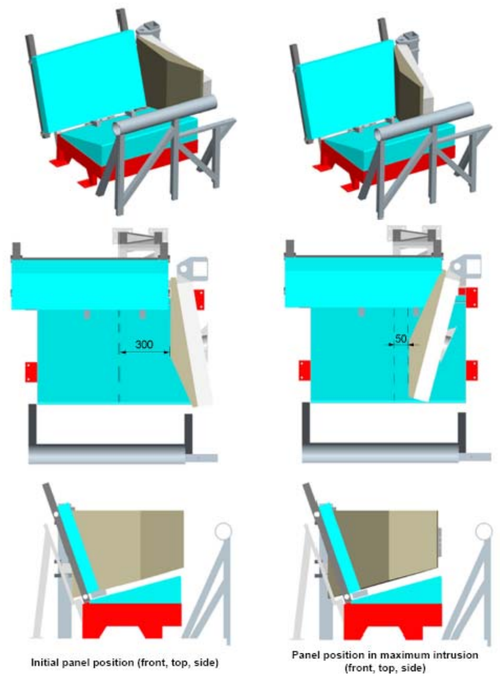


**Figure 8. Side impact test bench according to ISO TS 29062 for RF CRS.**

During the ISO voting process for the test procedure mentioned above the GRSP Informal Group on CRS reviewed several existing side impact test procedures for CRS and came to the conclusion that the ISO one would not be acceptable for ECE regulation. This finding resulted in two implications:

- GRSP decided to develop a suitable test procedure based on existing (and draft) procedures and asked ISO to provide essential input parameters for this development (see below).
- The ISO test procedure has scarcely been used since the publication of ISO/TS 29062:2009

**ISO/PAS 13396:2009** is the ISO TC22 SC12 WG1 reaction to the official request for assistance expressed in April 2008 by GRSP IG CRS, ISO working group on child safety compiled a summary of ISO/TR 14646:2007 and added recent research results. A draft of the document was presented to GRSP IG CRS in April 2009. ISO/PAS 13396:2009 was published in November 2009.

In summary the ISO PAS stated the following:

Intrusion loading is the most frequent cause of injuries in side impacts. For the protection of children in 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 as a proposed tool to assess different test procedures.

**Table 1.**
**Matrix of essential parameters to support the assessment of side impact test procedures [ISO/PAS 13396:2009, 2009]**

| Essential parameter | Reference value | Weighing factor |
|---|---|---|
| Loading conditions | intrusion loading | A |
| Loading conditions | assessment of occupant kinematics and energy management | A |
| Relevant body regions to be addressed | 1. head<br>2. neck<br>3. chest | 1: A<br>2: B<br>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 Δ*v* | 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 |

**GRSP IG CRS**

In order to develop a new regulation for the homologation of CRS to replace current ECE R44, UNECE Working Party on Passive Safety (GRSP) formed an Informal Group on CRS to prepare the new standard. One of the aims of this group is the introduction of a lateral impact test procedure. Analysis of several lateral impact test procedures for CRS resulted in the judgement that these are either not reflecting enough real world needs (fixed door), are in development (NHTSA) or are too complicated so that repeatability and reproducibility issues can be expected (ISO and NPACS). Following that, the group decided to develop its own test procedure. As considerable experience was gained during the development of the ISO test procedures, GRSP sent a formal request to ISO to support this activity by summarising the most important parameters that need to be considered for the development (see above). The specifications described in ISO/PAS 13396:2009 were considered as important input data for the GRSP test procedure. The intrusion velocity profile was considered as the most important parameter, as shown in Figure 9.

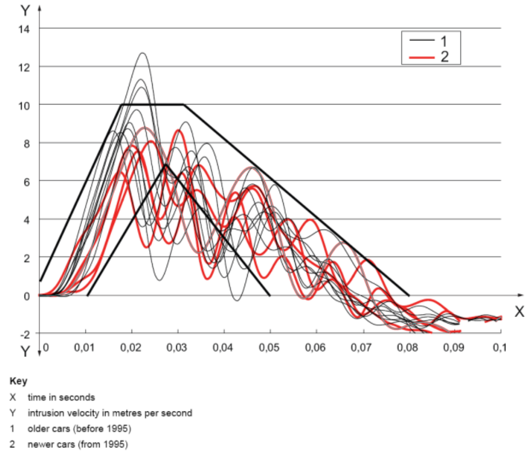


**Figure 9. Intrusion velocity profile according to ISO/PAS 13396:2009.**

<u>**Design requirements for the GRSP side impact test procedure**</u> were defined in order to fulfil the following characteristics:

- simple in order to ensure good:
  - repeatability
  - reproducibility
- reasonable cost
- potential to be used in different sled systems
  - deceleration sleds with different braking systems
  - acceleration sleds
- capable to replicate the basics of lateral impact

Following the advice of ISO/PAS 13396:2009 it is essential for a lateral impact test procedure for CRS to replicate intrusion loading and acceleration loading.

In addition the dimensions of the intrusion surface, the allowed degree of freedom of the ISOFIX anchorages amongst others were considered. As a first step the group decided to focus on the head: namely head containment with addition of parameters such as head acceleration and HIC. Given the lack of scientific validated criteria and limits for lateral impact it was decided to use the head criteria and limits as defined for frontal impact. This approach was deemed to be pragmatic. Table 2 shows the current proposal for the lateral impact criteria to be used for the new ECE regulation.

**Table 2.**
**Current proposal for lateral impact criteria**

| | Q0 | Q1 | Q1.5 | Q3 | Q6 |
|---|---|---|---|---|---|
| HIC | 600 | 600 | 600 | 800 | 800 |
| $a_{3ms}$ head | 75g | 75g | 75g | 80g | 80g |
| head contain-ment | Head shall not pass through head containment plane which is positioned in a distance of [55] mm from panel outside | | | | |

Following the experience of ISO TC22 SC12 WG1 the GRSP group considered the intrusion velocity as the main loading parameter which needs to be controlled precisely at the time of dummy loading. The intrusion velocity characteristics displayed in Figure 9 shows a fast increase of intrusion velocity in the beginning and a decreasing part of the velocity after the maximum. Figure 10 shows the general velocity change during lateral impact.

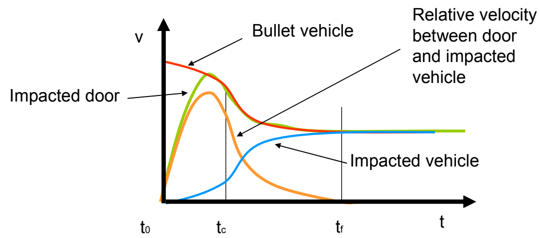


**Figure 10. Velocity change during lateral impact ($t_c$: time of contact between CRS and side structure, $t_f$: time of end of crash phase).**

As the velocity characteristic before the contact between CRS and side structure is felt to be irrelevant for the test procedure the idea of the GRSP method was to replicate only the period after the contact ($t_c$ to $t_f$). Figure 11 shows the part of velocity characteristic that is considered for the GRSP test procedure.

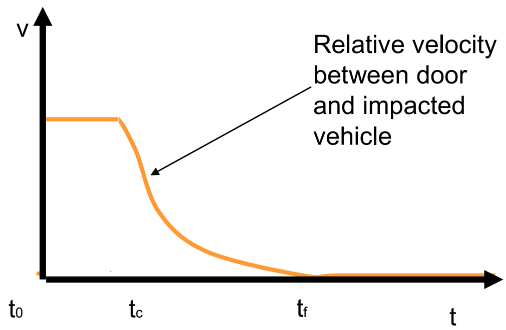


**Figure 11. Velocity characteristics to be considered for the GRSP side impact test procedure for CRS.**

In order to ensure the new test procedure can easily be installed in different labs the ECE R44 rear impact test procedure (initial velocity and stopping distance) was considered as a starting point. The (new) frontal impact test bench is mounted in an angle of 90° relative to the sled. A velocity change corridor between test bench and intrusion plane defines the test severity. Figure 12 shows an example for the practical realisation of the test procedure.


**Figure 12. Example for test set-up realisation.**

<u>**Analysis of test severity**</u> became relevant because testing showed considerable high dummy readings especially looking at the smallest dummy for each CRS group. Initially the delta-v corridor was using the maximum intrusion velocity as observed in the ISO research as the start velocity. In addition to the high dummy loading observed in the testing programme the optimisation of a group 1 FF CRS with a support leg for Q1 dummy to reduce the head acceleration resulted in worse head acceleration in a car-to-car test, although the head acceleration was reduced by 20% in the test procedure. Following that the test results were compared with results from recent car tests.

In an ECE R95 like test with a small family car produced between 2002 and 2009 the same baby shell as in the test procedure was used. The comparison of test results show considerable higher dummy readings in the test procedure compared to the car test, see Figure 13.

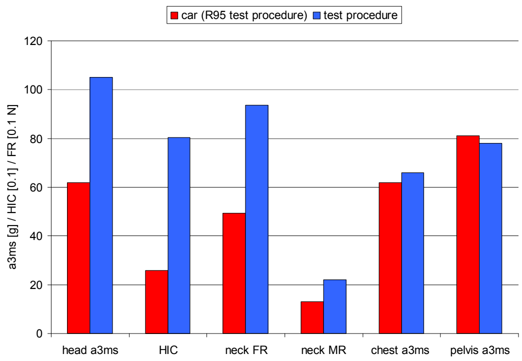


**Figure 13. Comparison of dummy readings between test procedure and small family car test.**

In a more severe lateral impact test involving the AEMDB, i.e. using a heavier trolley and a stiffer barrier face compared to ECE R95, and a small van introduced in 2006, a comparable situation can be observed. For a infant carrier (baby shell) at the rear seat head loads and neck forces were considerably higher in the test procedure than in the car, while neck moments and chest and pelvis accelerations were at a comparable level, see Figure 14.

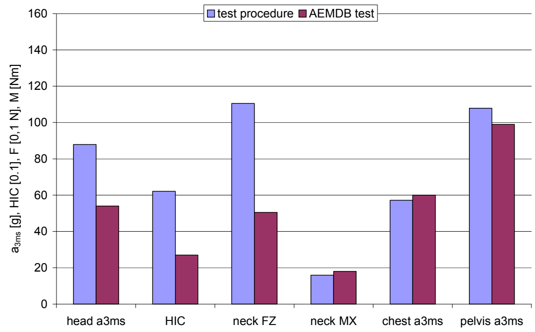


**Figure 14. Comparison of dummy readings between test procedure and small van AEMDB car test RF CRS.**

In a forward facing group I CRS with top tether and installed at the front passenger seat, the dummy readings were comparable, see Figure 15.

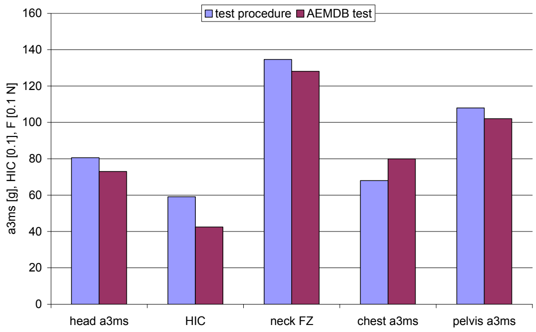


**Figure 15. Comparison of dummy readings between test procedure and small van AEMDB car test FF CRS.**

From past testing it is well known that the acceleration loading is smaller with heavier dummies, which is mainly caused by the higher mass in conjunction with a comparable force level defined by the padding stiffness of intrusion surface and CRS. In contrast it becomes more challenging to keep the head inside the CRS with larger dummies. That means that the validation results with smaller dummies are more important than those with larger ones with respect to dummy readings such as accelerations, forces and moments.

The analysis of the reasons for the higher severity indicated that the main idea of the test procedure (to consider the intrusion velocity profile for the loading relevant period only) was not considered correctly. Indeed no analysis of the timing issue took place before.

Analysis of videos and time histories from different barrier-to-car and car-to-car lateral impact tests involving child dummies indicated that the time of maximum head loading would be the best reference.

Maximum head loading was identified in these tests between 35 and 70 ms with average at 50 ms, see Figure 16.

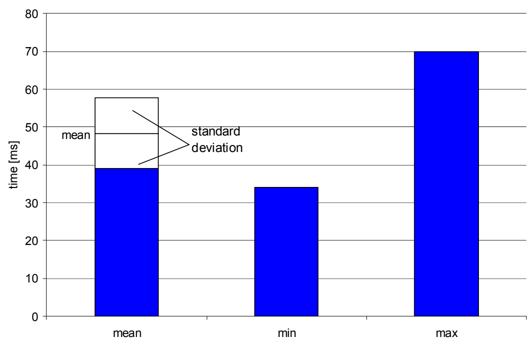


**Figure 16. Time of maximum head acceleration in lateral impact tests with 6 different car models and 2 to 6 different CRS per car model.**

As a result the average intrusion velocity at the time of maximum head acceleration (50 ms) would be approx. 3 m/s, see Figure 17.

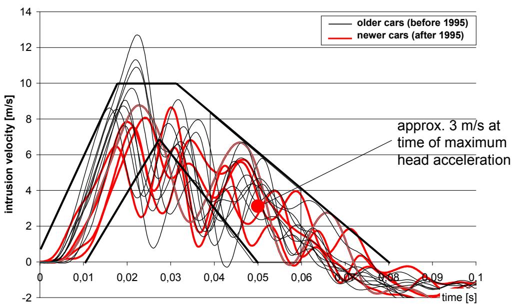


**Figure 17. Relevant loading time in intrusion velocity characteristics proposed by ISO/PAS 13396:2009.**

**Description of the test procedure.** Taking into account the new requirement for the relative velocity between the test bench and the intruding panel the following corridor was plotted, Figure 18. In order to adjust the severity in accordance with the findings mentioned above the timing of head acceleration was analysed in the test procedure. While in car tests the maximum head acceleration occurs at approx. 50 ms head loading takes place in the test procedure at approx. 40 ms. Following that the corridor was designed to reach an average delta-v of 3 m/s at 40 ms.

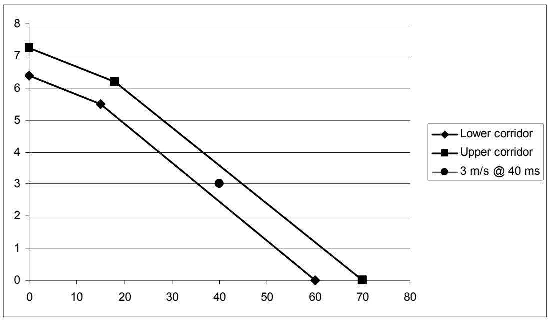


**Figure 18. New lateral impact delta-v corridor.**

Originally the corridor with reduced severity was more open in the beginning. However, based on numerical simulation results (see below) the corridor was made smaller. The stopping distance shall be 250 mm and the deceleration shall start when the distance between intruding surface and test bench centre line is 350 mm.

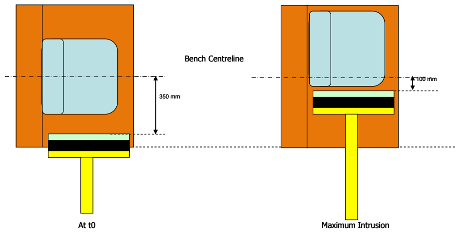


**Figure 19. Definition of $t_0$ and intrusion.**

The intrusion surface is defined to meet the requirements proposed by ISO/PAS 13396:2009 (height 500 mm above CR point) and covers the length of ISO R3 fixture in order not to miss any part of CRS, see Figure 20.

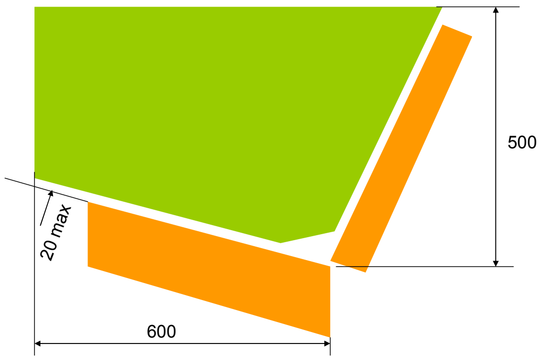


**Figure 20. Dimensions of the intrusion surface.**

The intrusion panel padding follows the ISO/PAS 13396:2009 proposal. In addition to the dummy readings the head containment will be determined. In order to have an objective criterion a head containment plane with a distance of 55 mm to the intrusion surface was defined. The dummy's head shall not pass beyond that plane, see Figure 21.


**Figure 21. Head containment plane marked with red line, CRS failed criterion.**

In addition to the technical parameters of the test procedure, CRS and dummy installation are of high importance in order to reach repeatable and reproducible test results. Therefore an installation procedure was defined. Key aspects of this installation procedure are summarised below:

- exact alignment of CRS with test bench centre line,
- exact alignment of dummy centre line with CRS centre line,
- arms shall be positioned symmetrical with elbows aligned with sternum,
- legs shall be positioned symmetrical,
- pre-impact dummy stability shall be controlled.

**Validation of the test procedure** took place considering the following areas to be important:

- feasibility,
- appropriate test severity,
- repeatability,
- reproducibility.

Concerning feasibility it was considered to be important that the test procedure is usable with different types of CRS (i.e., infant carriers, large RF CRS, CRS with top tether and CRS with support leg) and with different types of test facilities (i.e., acceleration vs. deceleration sled systems and different braking systems). These parameters were considered when preparing the test matrix for the check of repeatability and reproducibility.

Up to date the following labs have contributed to the validation programme:

- Britax (Deceleration - PU tubes),
- Dorel (Deceleration - hydraulic brake),
- IDIADA (Acceleration sled)
- TUB (Deceleration - bar brakes).

While the original delta-v corridor caused problems with PU tubes this issue was solved by the updated corridor. No other problems were observed with the other deceleration sled systems. The test procedure is less simple with acceleration sled systems. While the intrusion surface can be fixed at the brake system of deceleration sleds, a double sled system is needed for an acceleration sled device. IDIADA decided to use a so called sled on sled system. The facility accelerates the main sled to which the intrusion surface is fixed. The test bench is fixed to another sled which is fixed to the main sled by a translational joint. In addition to the complexity of the sled system the interpretation of the input parameter is also less simple. While in deceleration sled devices the sled velocity is equal to the relative velocity between intruding surface and test bench, in the acceleration sled device both intrusion surface and test bench are moving. However, it was possible to install the lateral impact test procedure on an acceleration sled system and the test results are highly comparable with those of deceleration sled systems.

None of the tested CRS models (babyshell with base and support leg, group I RF with support leg, group I FF with support leg and group I FF with top tether) showed any issue to be reported.

That means that the feasibility of the test procedure is quite acceptable.

In order to check the severity level the AEMDB tests mentioned above are considered as reference.

The tests with an infant carrier even with the updated severity level indicate a considerably high dummy loading for the head in the test procedure. The other values are at a more comparable level, see Figure 22.

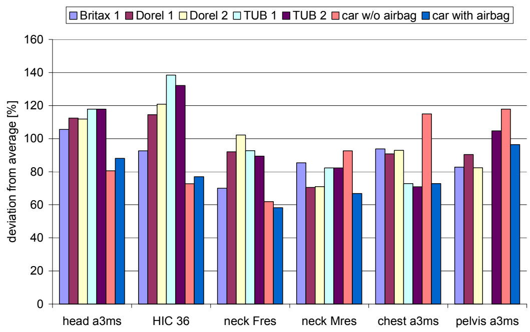


**Figure 22. Comparison of results of test procedure and car tests for the baby shell.**

In contrast to the infant carrier dummy readings in the group 1 FF CRS with top tether are at a comparable level, see Figure 23.

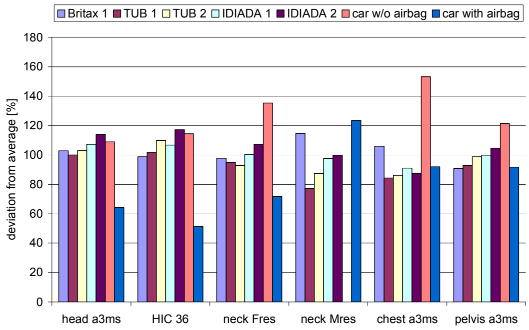


**Figure 23. Comparison of results of test procedure and car tests for the group I CRS with TT.**

A comparison of tests with old and new corridor with different CRS and different dummies shows that even the new corridor is challenging for industry especially when looking at the smallest dummy per CRS size group, Figure 24.

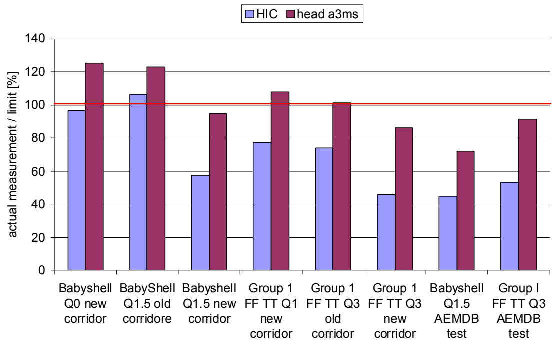


**Figure 24. Comparison of head loading depending on severity level, dummy size and tested product.**

During the tests for the validation of the protocol several products were found showing shortcomings with respect to the head containment criterion which is a must to protect children in lateral impact accidents.

Repeatability was analysed by running 5 tests with the same product in one lab. For different CRS products different labs were running the repeatability tests. The tests were performed using the original higher severity pulse. The coefficient of variation was used to assess repeatability. In well controlled dummy tests (e.g., pendulum tests) a coefficient of variation of 5% is considered to be good [Mertz, 2005]. For sled testing where variation is coming from the CRS, the dummy and CRS installation as well as variation in the sled behaviour higher variations can be expected. For head and pelvis acceleration the 5% limit is passed for all labs and CRS types. HIC and chest acceleration variation are close to 5% but exceed the threshold for one CRS type or in one lab, see Figure 25.

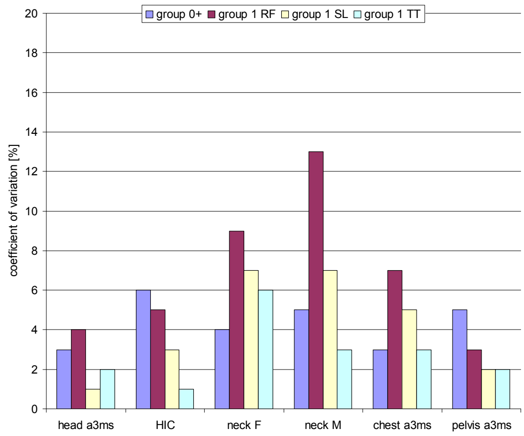


**Figure 25. Analysis of repeatability.**

The analysis of reproducibility took place using the new test severity. The plan was to test different types of CRS in at least 3 different labs. Unfortunately the programme has not been finalised. In these three labs at least 2 tests for each product were conducted. Again the coefficient of variation was used to assess reproducibility. For most of the body regions, except the head, the coefficient of variation in the reproducibility tests exceeded 10%, see Figure 26.

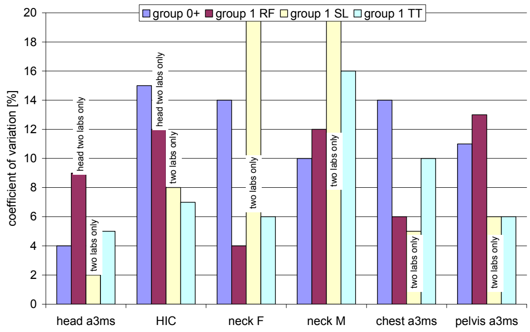


**Figure 26. Analysis of reproducibility.**

The analysis of repeatability and reproducibility indicates that the test procedure is sufficiently repeatable and reproducible for the main target body region, the head. Following the observation that reproducibility of head $a_{3ms}$ is much better than HIC it is recommended to take only head $a_{3ms}$ as head criterion into account.

In parallel to the testing validation programme parameter studies using numerical simulation and sled testing took place. The main aim of the parameter studies by simulation was to assess the influence of CRS position and delta-v characteristics on the test results. A group 0+ model in combination with Q1.5 dummy model was used for this study. Generally the dummy readings of physical tests and simulation runs were in a comparable level although the CRS model was not explicitly validated for lateral impact conditions.

The variation of the sled pulse showed considerable differences in the dummy readings. The sled pulse was varied in a way that borders of the corridor were used. The delta-v curves used for this study are shown in Figure 27. The time of "engagement" of the head is visualised for information.

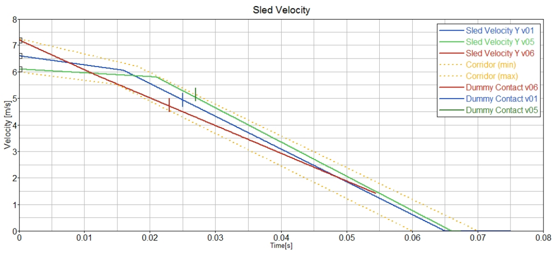


**Figure 27. Sled velocity variation for numerical parameter analysis.**

In the study the head a3ms varied between -20 and +40% compared to the baseline test, see Figure 28.

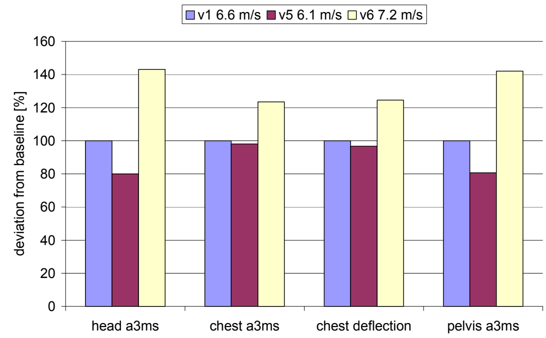


**Figure 28. Influence of pulse variation on dummy readings.**

The main reason for the variation seems to be the CRS velocity at the time of impact as shown in Figure 29.

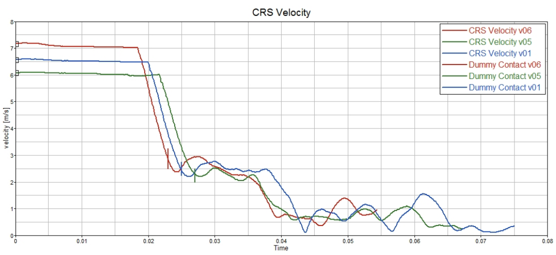


**Figure 29. CRS velocity profiles for the sled delta-v variation.**

Small Deviations in the positioning of the CRS with respect to the bench centre line seems to cause a smaller variation, see Figure 30 and Figure 31.

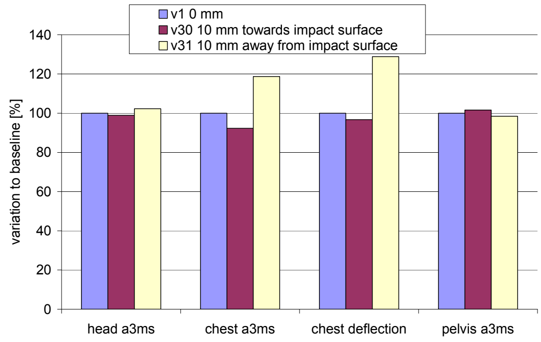


**Figure 30. Dummy readings depending on CRS positioning.**

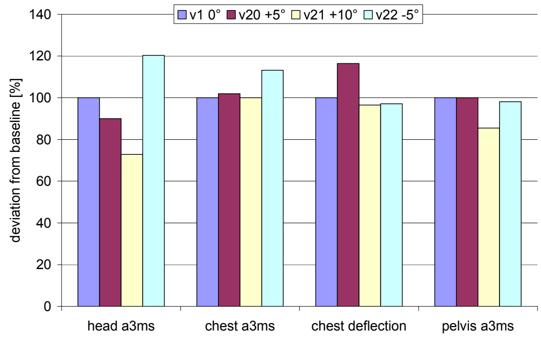


**Figure 31. Dummy readings depending on CRS angle from upright to reclined.**

In further sled tests the influence of the variable ISOFIX anchorages was checked and angled tests with 10° impact angle were analysed.

Restricting the ISOFIX anchorage points seems not to have major influence on the dummy readings for the tested products, see Figure 32. Earlier analysis of the timing of the movement of the anchorages is supporting this result. The movement of the ISOFIX anchorages seems to start after maximum dummy readings.

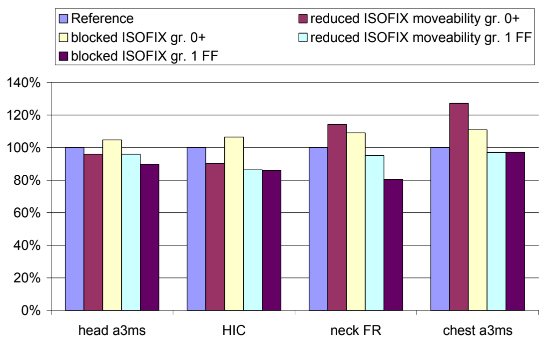


**Figure 32. Dummy readings depending on the allowed travel amount of ISOFIX anchorages.**

The influence of introducing an impact angle depends mainly on the individual product. However, for most of the tested CRS the influence was small, see Figure 33.

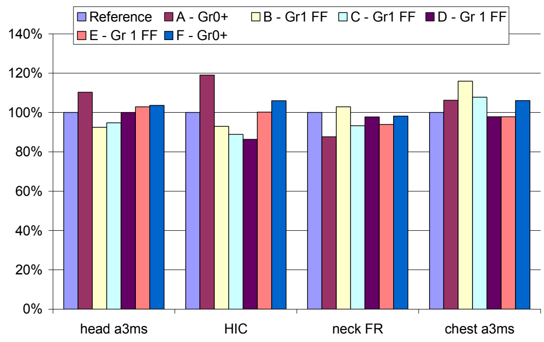


**Figure 33. Dummy readings depending on impact angle.**

## CONCLUSIONS

Existing test procedures for the assessment of the lateral impact performance of child restraint systems were felt to be either too complicated to be used for the homologation of CRS or do not represent real world side accidents in a sufficient way. Following that the GRSP Informal Group on CRS developed a new test procedure utilising the knowledge gained in ISO TC22 SC12 WG1. This test procedure has been analysed in order to check the feasibility with different sled systems and different CRS types, test severity as well as repeatability and reproducibility. The results to date indicate that the procedure is feasible at different sled systems (deceleration sleds: PU tubes, bar brake and hydraulic brake; acceleration sled: sled on sled were tested so far) with different ISOFIX integral harness CRS types. The severity level tends to be higher than in reference tests for infant carriers and at an equal level for larger CRS. However, for larger CRS the fulfilment of the head containment criterion is more challenging. Good repeatability and reproducibility were obtained at least for the head acceleration, which is rated as the target body region. Although validation of the test procedure is still ongoing, it is expected that the procedure will be ready on time for introduction into ECE regulation.

## ACKNOWLEDGEMENTS

Part of the work presented in this paper was co-funded by the European Commission within the 7th Frame Work Programme (CASPER project, Grant Agreement no. 218564).

Further information concerning the CASPER project is available at the CASPER web site www.casper-project.eu.

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