THE NEW EU I-SIZE REGULATION – KEY ELEMENTS OF THE SIDE IMPACT TEST PROCEDURE

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ABSTRACT

Background

The Informal Group of UN GRSP* has developed a new standard for approving child restraint systems in Europe, called I-Size regulation. Key objectives for developing this regulation were 1/reducing misuse rate through promoting ISOFIX restraint and 2/enhancing compatibility between cars and child restraint systems and 3/introducing a side impact test procedure.

The latter is the focus of this paper. The aim of the procedure is to reproduce – with an intruding door concept – the door relative velocity between the door and the struck vehicle. The objective of this study is to investigate the key features of this test procedure.


INTRODUCTION

The i-Size regulation is described in details in documents (1) and (2). It is based on 5 key pillars:

- Universal Integral Isofix restraint
- Seat classification based on occupant size
- Mandatory extended rear facing installation up to 15 months of age
- New anthropomorphic test dummies
- Side impact test procedure with intruding door in addition to the frontal and rear impact.

Universal integral Isofix

The Universal integral Isofix restraint means that only Isofix seats with integral occupant restraint system are specified by this regulation. In addition to Isofix attachment, the CRS is secured with an anti-rotation device, i.e. a top tether or a support leg. To allow for universal approval, vehicle regulations ECE R16 (3) – seat-belts & vehicle space for Isofix restraints and ECE R14 (4 and 5) – safety-belt and Isofix anchorages – were updated. In particular the geometry and strength of the vehicle floor must fulfill new requirements to ensure adequate compatibility, as shown in Figure 1.

![Figure 1. Vehicle floor contact surface with the support leg - Geometrical specifications (3).](image)

In addition to the geometrical requirements the vehicle floor shall meet strength demands to ensure that a stable interaction between the floor and the support leg. Figure 2 describes the test procedure that will be applied to the vehicle structure to fulfill these requirements.

![Figure 2. Test method used in i-Size regulation for testing the floor strength (4), (5).](image)

To ensure child restraint to vehicle compatibility the Universal Integral Isofix comprises the following features:

- **ISOFIX**
  - 2 lower anchorages + 1 anti-rotation device:
    - Top Tether or
    - Support leg

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– No use of the adult safety belt for the restraint of the child seat

- Universal
  – F2X ISO fixture for forward facing seats and R2 ISO fixture for rear facing seats as shown in Figure 3
  – With top tether or support leg
  – Integral
    - Child is restrained only by the CRS restraint system

Figure 3. F2X (a) and R2 (b) ISOFIX envelops.

For the vehicle the i-Size will require the following demands:
- F2X and R2 envelopes
- Geometrical and strength requirements for vehicle floor in contact with the support leg of the child seat
- Top tether anchorages

The seat classification refers to the stature of the child to help the consumers in their purchasing choice. A seat will be classified according to the stature of the child that will be accommodated. The seat internal dimensions must meet defined values which are checked using a dedicated device.

Rear facing installation has been extended to an age of 15 months and this is why the i-Size regulation requires that both the vehicle and the child seat meet the R2 ISOFIX envelop.

The i-Size Side Impact Test Procedure

It is based on a test bench that is oriented 90° with respect to the sled displacement direction. The test bench is equipped with sliding Isofix anchorages that allow a 200 mm of free movement of the seat. During the test the bench and the child seat are accelerated to reach a velocity of 7 m/s. Then the child seat impacts a door which is fixed with respect to the laboratory. The door is covered with a 35 mm rubber cell and 20 mm Styrodur foam. The test procedure may be realized either with a deceleration sled or an acceleration sled. In the later case specific requirements shall be satisfied (6). Figure illustrates the main components of the procedure.

Figure 4. Overview of the i-Size side impact test method.

The test bench is described in Annex 6 of the regulation (1), (2). One of the main differences compared to the ECE R44 test bench is the back rest angle which is 25° (20° in the R44 case). Side and top views of the bench are shown in Figure 5. 
Figure 5. Side (a) and top (b) views of the test bench with corresponding dimensions.

The test bench cushion shall meet density requirements as well as mechanical characteristics.

**Adjustment of Top Tether or Support Leg**

Top Tether – The top tether in the side impact test must be adjusted to its shortest length.
Support Leg – This must be adjusted so that it reaches the floor plane.

**Tests and dummy sizes**

The child restraint is to be tested with the smallest and largest dummy in relation to the size that was indicated by the child seat manufacturer, as shown in Table 1.

<table>
<thead>
<tr>
<th>size range indication</th>
<th>≤ 60</th>
<th>60 &lt; x ≤ 75</th>
<th>75 &lt; x ≤ 87</th>
<th>87 &lt; x ≤ 105</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dummy</td>
<td>Q0</td>
<td>Q1</td>
<td>Q1.5</td>
<td>Q3</td>
</tr>
</tbody>
</table>

**Sled Pulse** In order to reproduce an intruding door effect, the Informal Group has defined a specification for the relative velocity between the door and the test bench. The corresponding velocity-time corridor is shown in Figure 6.

Figure 6. Relative velocity between the door and the test bench.

**Dummy installation and Positioning**

The dummy is installed in such a way that its position is stable at t0. The CRS is installed with the upright position.
Installation should be done as follows:
- The unoccupied CRS shall be attached to the ISOFIX anchorage system
- Adjustment of the top tether
- The dummy shall be placed in the CRS separate from the seat-back of the chair by a flexible spacer
- Adjustment of the belt
- After the installation the dummy centre line and the CRS center line shall be aligned exactly with the centre line of the test bench

In Figure 7 a Group I seat with a Q3 dummy is shown.

Figure 7. Test set up.

This procedure was used to evaluate the responses of Q1 and Q3 dummies when using ECE R44 approved rear facing as well as forward facing Isofix seats.
**Findings**

The i-Size regulation requires a number of performance requirements. These are:

- **Head containment**, which is defined by the following parameters:
  - (a) No head contact with the door panel.
  - (b) Head shall not exceed a vertical plane identified by a red line on top of the door (top view camera). This vertical plane is identified by a line on the impacted door as defined in Annex 6 Appendix 3 Figure 1 of the i-Size regulation.

- **Head protection criterion HPC 15ms**: 600 and 800 resp. for Q0, Q1, Q1.5 and Q3.

- **Head resultant 3ms acceleration**: 75G and 80 G resp. for Q0, Q1, Q1.5 and Q3.

Other parameters are considered in the i-Size regulation such as chest deflection and neck loads (tension and flexion moment) but only for monitoring purpose.

Three ISOFIX child seats were tested using the setup described previously in the paper. These were R44 approved seats, 2 forward facing, one with a support leg and one with a top tether. The 3rd seat was an infant carrier.

Head containment was analysed using high speed videos. In all 3 tests the head did not go beyond the vertical plane and therefore the head containment was met. It must be mentioned that all 3 seats were designed to meet an internal test procedure – with a fixed door – which required energy absorption in the seat lateral structure.

In Figure 9, Q1 and Q3 dummies’ maximum head 3ms accelerations and HPC are presented as a percentage of regulatory limits. It can be seen that Q3 head accelerations are just below the limit with values ranging from 86% to 90%. For Q1 dummy the values are higher ranging from 112% to 120%. If we consider the HPC 15ms parameter, Q3 responses are between 50% and 55% while Q1 responses range from 88% to 90%.

**Figure 8.** Head accelerations and HPC values obtained with Q1 and Q3 dummies.

As a first indication it appears that the test procedure defined in the i-Size regulation is a demanding one. In order to reduce the loads on occupant there will be a need for additional energy absorption. However we have to keep in mind that the design of the CRS must meet both internal and external dimensions (Isofix fixture) and this is where we see one of the key challenges of this regulation.

**CONCLUSIONS**

It is shown that the test procedure proposed is a severe one when considering the requirements for internal and external child seat dimensions. In particular the Q1 dummy head acceleration shows peak responses that will represent a significant challenge in terms of design for next generation of child restraint systems.

Limitation - The present study does not cover other key characteristics of the test procedure such as repeatability and reproducibility. Further investigations are needed to comprehend the full impact of this demanding procedure.

**REFERENCES**


