

Assessment criteria for CRS testing

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1 Background

During the 13th meeting of the Informal Group on Child Restraint System it was decided to discuss assessment criteria for CRS testing in a smaller group. Various participants volunteered to join the discussions. During three telecalls (held 26 Oct, 6 Nov and 13 Nov) assessment criteria for front, rear and side impacts were identified as well as threshold values for injury related criteria.

2 Approach

The assessment criteria were discussed using a matrix of possible criteria in vertical direction and possible test set-ups in horizontal direction. As a first step possible criteria and relevant test set-ups were defined. This was followed by discussions on the applicability of each criterion for each test set-up. Finally threshold values were determined for each injury related criterion.

3 Assessment criteria for front, rear and side impact applications

The table below shows the results of the effort indicating applicability of various criteria for the different test set-ups.

Applicability of different criteria depending of test set up											
		Frontal Impact				Rear Impact				Side Impact	
		Test on trolley + standard chair		Test in car body		Test on trolley + standard chair		Test in car body		Test on trolley + standard chair	
		Forward facing	Rearward facing	Forward facing	Rearward facing	Rearward facing	Rearward facing	Forward facing	Rearward facing	Forward facing	Rearward facing
Head Impact Criterion	HIC	NA	NA	A*	A*	A*	A*	A	A	A	A
Head Acceleration 3ms	A3ms	tbd	tbd	tbd	tbd	tbd	tbd	tbd	tbd	tbd	tbd
Head excursion horizontal		A	A	NA	NA	A	NA	NA	NA	NA	NA
Head excursion vertical		A	A	NA	NA	A	NA	NA	NA	NA	NA
Head exposure (containment)		R	A	NA	NA	M	NA	A	A	A	A
Upper Neck Tension Force	Fz	A	A	A	A	A	A	M	M	M	M
Upper Neck Flexion Moment	My / (Mx side)	A	A	A	A	A	A	M	M	M	M
Thorax Chest Deflection	Dchest	M	M	M	M	M	M	tbd	tbd	tbd	tbd
Chest Acceleration	A chest 3 ms	A	A	A	A	A	A	tbd	tbd	tbd	tbd
Abdomen		tbd	NA	tbd	NA	NA	NA	NA	NA	NA	NA
Pelvis Acceleration								tbd	tbd	tbd	tbd

A = Applicable

NA = Not Applicable

A* = applicable if contact with vehicle interior / simulated vehicle interior

R=Rebound only

M=Monitoring purposes

tbd = To be Decided

HIC Criterion: This criterion is applicable to most test conditions related to head impacts with the CRS and (simulated) car body parts. In case of test in a car body or applications on a trolley (rear and side) it should be ensured that HIC values resulting from contact with attachment points of the car body or trolley parts are excluded. Also for frontal test in a car body the front seat should be in mid position and not in the position closest to the CRS (worst case condition). For this purpose a

detailed description of vehicle surroundings has been (is to be) defined allowing to exclude contact with such parts using video analysis. See appendix 1.

Head 3ms: The head 3ms might be applicable to identify “over-restraining the dummy” to reduce excursions. However, neck tension might as well be applied for that purpose. Moreover as shown in the EEVC WG12 report on Q dummies the 3ms criterion is not very discriminative (CRS-1-4). At this stage the group could not make a final decision and therefore head 3ms is indicated as *to be decided* for all applications.

Horizontal head excursion: This criterion is regarded applicable for tests on a trolley in front and rear applications. For rear impact the criterion is included w.r.t. exceeding line DE as shown in the figures 3 and 4 from ref. CRS-12-03. See figure below. For rear impacts notice should be made if the head gets outside simulated vehicle environment in a sled set-up. The horizontal head excursion is not applicable for side impacts.

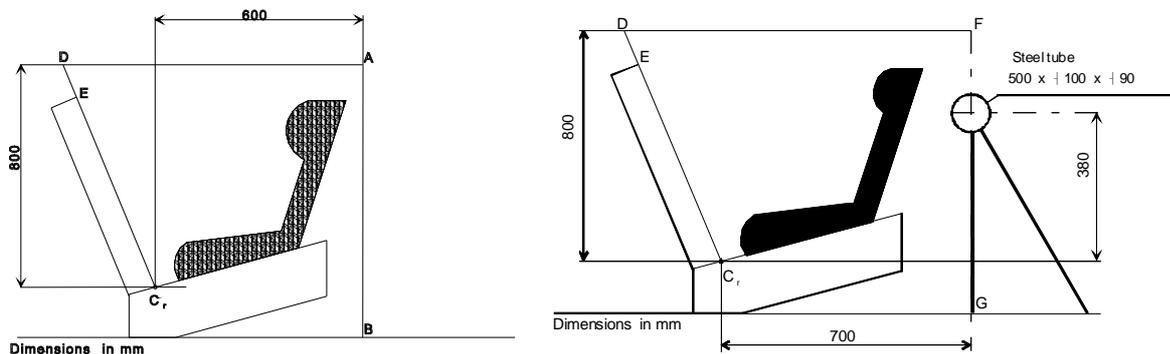


Figure 3 and 4 from document CRS-12-03e: Arrangement for testing child restraint devices group 0, not supported by the dashboard (left) and Arrangement for testing child restraint devices except group 0 not supported by the dashboard (right)

Vertical head excursion: Is applicable in trolley tests for front and rear impacts. Criterion is 800 mm above C_r point. See also above figure. Note that the vertical head excursion for the Q10 is still to be defined. This criterion is not applicable in side impacts.

Head exposure (containment): This criterion is related to the head going out of the CRS shell. It is applicable to side impacts and to frontal impacts. As far as side impacts are concerned this is the most relevant criterion for evaluation of the CRS. For frontal impacts it is relevant for addressing ramping up in rearward facing seats or rebounds in forward facing seats (although HIC might be applied as well for the latter). In case of rear impacts it is expected that the rebound energy is much less compared to frontal impacts. As far as ramping up under rear impacts is concerned there was insufficient experience in the group to determine whether or not this is really relevant. Therefore it was decided to have this in as Monitoring for the trolley tests.

Neck Fz: This criterion is applicable to all front and rear configurations. As far as side impact is concerned no criteria for neck Fz of neck Mz are available. Therefore no threshold values can be defined. It is expected that the neck loads will be fairly low when the head remains contained in the seat whereas higher values will occur when the head moves out of the CRS. Since neck injuries are the second most important injury in side impacts it was decided to keep both neck criteria in as Monitoring.

Neck My: Regarded as applicable to all frontal and rear test situations, however, current threshold values based on limited number of data. For side impact the situation is the same as for neck Fz. Note that for front and rear My is used whereas for side impact Mz is relevant.

Chest deflection: This criterion could be applicable but there seems to be lack of sufficient data to develop injury risk curves and threshold values. Therefore this criterion was maintained as monitoring for all configurations. This will support collection of data for future knowledge development for this criterion which has proven value for adults.

Chest accelerations: Applicable to all front and rear test conditions. There is a lot of experience with this criterion from the P-dummies however there is no scientific background of the threshold or limit values available. A reasonable correlation between chest accelerations was observed in comparative tests between P and Q dummies (CRS-1-4) and therefore this criterion is also regarded applicable when using Q dummies.

Abdomen: Although the abdominal penetration seems less of a problem when using a harness configuration something should be taken on board to ensure that for the tilted (sitting versus sleeping) configurations the abdominal loads are monitored as far as forward facing seats in frontal impacts are concerned. Therefore this criterion is marked as tbd in these cases. For all other cases this criterion was regarded not applicable.

Pelvis: This criterion could be relevant for side impact. However, there is no indication from field data that pelvis injuries are a main problem. As for regulatory purposes monitoring normally is included if there is a known problem in the field it was decided to consider this criterion in the evaluation phase and make a decision afterwards. Therefore this criterion is indicated as tbd for side impacts.

4 Injury risk values

Basis for the discussions on the injury risk was the proposal tabled in section 7.1.4.3.2 of document CRS-12-03. These values and the explanations are included below. The group agreed that for clarity reasons a single value per body region should be used. This value should be identical to all ages.

Injury assessment criteria per dummy as included in CRS-12-03							
Criterion	Abbr.	Q0	Q1	Q1.5	Q3	Q6	Risk values CRS-12-03
Head Impact Criterion (only in case of hard contact during in-vehicle testing)	HIC	523 - 671	491 - 629	578 - 741	780 - 1000	1083 - 1389	20% - 50%
Head Acceleration 3ms	A head 3ms	85	72	76	81	89	20%
Upper Neck Tension Force	Fz	546	1201	1364	1705	2304	50%
Upper Neck Flexion Moment	My	17	53	61	79	118	20%
Thorax Chest Deflection	D chest	NA	40	38	36	33	20%
Chest Acceleration 3 ms	A chest 3ms	55	55	55	55	55	R44 values

Head:

Background values taken in CRS-12-03:

- *HIC*: the values in CRS-12-03 were given as a window that varies between the values counting for 20% and 50% chance on AIS 3+ LR injury.
- *A 3 ms*: these were from AIS 3+ 20 % LR injury. Less than 10 % of CRSs tested in the EEVC work failed these criteria. This seems a reasonable level.

The HIC values mentioned in CRS-12-03 are lower and upper borders and an adequate value in between could be taken. Also the EuroNCAP value of HIC 1000 used for adults is related to 20% risk at AIS 3+ to surpass this border means a red score.

All agreed that the risk value of 20% should be adopted for the head.

Neck:

Background values taken in CRS-12-03:

- *Fz*: Using AIS 3+ 50% injury (read from page 109) of the CRSs tested in the EEVC work still failed this. This seems a difficult level to meet.

- My: these are from the AIS 3+ 20% LR injury criteria. All CRSs seem to be successful with regard to these criteria.

Although the neck My values at 20% risk are fairly easy to meet (see EEVC report) the value of 50% for the Fz seems to be challenging. Based on this it was decided to have the **risk value for the neck set at 50%**.

Chest:

Background values taken in CRS-12-03:

- D chest: these are from the AIS 3+ 20% injury, and 20% of the products tested in the EEVC work would have failed these criteria. Taking account of the fact that this is a new criterion for CRS-testing this seems promising.
- A chest 3 ms: Values taken from R44 as there seems to be good correlation between what is measured with P dummies and Q-dummies.

At this stage there is a lack of data to provide sufficient evidence for any risk value. As chest displacements are included as M and values for 3 ms are taken from R44 because of correlation between Q and P dummies for this criterion **it was decided not to put any value for this body region at this stage.**

The resulting thresholds are included in the table below

Injury assessment criteria per dummy							
Criterion	Abbr.	Q0	Q1	Q1.5	Q3	Q6	Proposed risk
Head Impact Criterion (only in case of hard contact during in-vehicle testing)	HIC	523	491	578	780	1083	20%
Head Acceleration 3ms	A head 3ms	85	72	76	81	89	
Upper Neck Tension Force	Fz	546	1201	1364	1705	2304	
Upper Neck Flexion Moment	My						50%
Thorax Chest Deflection	D chest						tbd
Chest Acceleration 3 ms	A chest 3ms	55	55	55	55	55	R44 values

Appendix 1 Definition target zone rear impact rwd CRS

Definition target zone rear impact rwd CRS

(background: HIC will be applied in case of contact with the vehicle interior but also in case of contact with the simulated vehicle interior when rear impact testing on trolley + standard test seat equipped with rearward CRS)

As simulated vehicle interior is regarded the seat back of the standard test seat and also the CRS itself (e.g. the carrying handle), all being targets that can be hit during the first movement.

(remark: when will be decided to add a head restraint this item should also be taken on board)

The present draft standard seat back design has the following dimensions (data from NPACS output for task C5):

- width of the seat back cushion on the standard test seat = 485 mm
- height of the standard seat back cushion measured alongside it (from the Cr point) = 508 mm (see calculation)

Calculation of the height of the seat back cushion (and seat back plate) beginning at the top edge of the seat back cushion (and seat back plate):

+115 mm	from top edge down to highest fixation holes on seat back plate
+475 mm	further down to the fixation hole linking both the seat back fabrication and the seat base fabrication
+200 mm	further down to the bottom of the seat base fabrication
-70/cos.10 mm	thickness of seat back cushion 1
-135/cos.10 mm	thickness of squab cushion
-67/cos.10 mm	thickness of 67 mm squab spacer
-3/cos.10 mm	thickness of squab spacer top plate
-3/cos.10 mm	thickness of squab spacer bottom plate