Frontal impact - a rearward facing HII 3 year old and a forward facing HIII 3 year old

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1. Introduction

Folksam Insurance company has previous made a 5 min long film about child safety in cars. Now, they are redoing the film and updating certain sequences in it in order to produce a film that will be used to educate parents in child safet in cars in cooperation with local child “hospital” care centers. They wanted to have a new crash sequence included in the film to show the difference in crash using a forward facing CRS and a rearward facing CRS. This crash test was conducted at Autoliv in Vårgårda, in June 2007.

1.1 Aim of the study

The aim of the study was to get a film showing the visual difference in loading between a rearward facing child and a forward facing child. The most importance was to get a good film of the two dummies, but the loading to the dummies was captured as well (as a bonus). This mini report includes the measurement results from the crash test.

2. Method

A body in white of a Volvo V70 (station wagon, model year 2007 – the updated V70) was used, with a rear seat and a front seat. The instrument panel was included as well. Standard belt for that vehicle was used. The average car today does not have a pretensioner triggered in the rear seat, therefore it was decided not to trigger the pretensioner (even though this specific car model has a pretensioner in the rear seat).

Figure 1 The test set up in the body in white.

A forward facing booster seat (with back), Acta Rally sport, was positioned in the rear seat. A rearward facing Acta duo flex was placed in the front seat.

Acta Rally Sport

Acta duo flex

Figure 2 The two different child seats that were used in the test.

A crash pulse of 50 km/h was used (see Appendix).

Unfortunately, there was not two HIII 3y available and a HII 3 year old had to be used as well. A HIII 3year old dummy was positioned in the forward facing seat and a HII 3 year old was positioned in the rearward facing seat.

3. Results

		HIII 3y - forward facing	HII 3y - rearward facing
Head acc max	g	78,9	NA
Head 3 ms	g	75,4	NA
HIC 15 ms	-	608	NA
Neck tension Fz	kN	1,88	-
Neck compression	kN	0,12	-
Neck Fx	kN	1,01	-
Neck moment Extension	Nm	31,7	-
Neck moment Flexion	Nm	20	-
Nij TE	-	1,45	-
Nij TF	-	1,19	-
Chest res max	g	66,8	62,2
Chest res 3 ms	g	66	60,1
Chest deflection	mm	38,2	
Chest VC	m/s	0,73	
Pelvis res max	g	63	-
Pelvis 3 ms	g	60,5	-
Shoulder belt force	kN	5,4	0,6

Table 1 The results from the sled tests.

3.1 HII 3y - rearward facing

The HII 3 y had very limited measurement capability, only head and chest acceleration. Unfortunately, the head acceleration sensor failed and the data was never captured.

The rebound of the rearward facing is limited, very limited head excursion. However, the legs impact the back of the front seat. This load was neither possible to measure.

3.2 HIII 3y – forward facing

The head did not impact anything except its own chest during the hyper flexion motion. The chest impact did not have any influence on the head loading values.

When calculating Nte (according to Merz et al. 1997) the risk was about 60% for a severe neck injury (AIS3+). In the same paper, the risk of severe neck injury (AIS3+) due to neck tension was 100%.

When calculating the risk for AIS3+ injury for the Nij neck/extension value, the risk was 32% (Kleinberger et al. 1998).

The risk for severe thoracic injury (AIS4+) was 20% according to the VC (Mertz et al. 1997). The chest deflection had a square loading, it stayed compressed around 38 mm for about 40 ms, just as if the belt was load limited.

The shoulder belt force for the forward facing dummy was 5,4 kN. Normally, this retractor should first pretension and then start to load limit around 4 kN. The load limiting was never activated, which could be due to the fact that the pretensioner was never activated.

3.2.1 NPAC

If NPAC frontal rating had been used (they use Q3 in their tests), the forward facing dummy in this test would have scored with 35% of 100% (not taking forward head excursion in consideration). It got 27 points out of 44 from the head loading, 15 out of 72 points from neck, chest and pelvis. It should be noticed that the dummy did not impact the head in anything except its own chest but it had no impact on the head acceleration.

It should be noticed that the crash pulse in this test was not as sever as the NPAC crash pulse (which should be conducted in 65 km/h). Also, it is not accurate to use the Q3 loading limits to the HIII 3y loadings.

4. Discussion

The dummy had high loadings to the neck, it exceeded the recommended Nij.

It has been discussed by various people that the biofideltiy of the neck of the child dummies are not satisfied, since it is only the neck bending and the back it self does not bend in any large extension due to its construction.

Still, by looking at the film it is obvious that there is a much larger loading to the forward facing child compared to the rear ward facing child. Severe or even fatal neck injuries have been found in children around 2 years that were forward facing (Malm, 2006). Malm also found that 8 out of 19 children (42%) age between 0-4 years would have survived if they had been properly restrained according to Swedish standard (rear ward facing), the other 11 children died due to problems with the road environment.

Figure 3 Above picture shows the time 0 ms and the second picture the time for maximum head excursion for the forward facing dummy (at 84 ms).

There was very limited measurement possibilities to the rearward facing dummy, therefore it is not possible to compare the loadings of the dummies placed in the two different child seats. By the film it is obvious that there is no neck flexion or extension, however there might be some neck tension.

The VC and the chest deflection should also be limited to the rearward facing dummy since it distributed its load by the whole the back against the seat back and not by the chest against the webbing.

5. Conclusion

The forward facing HIII 3y sustained high loading to the neck, exceeding suggested tolerance levels.

When comparing the films of the two different restraint systems the rearward facing child is kept in the same position during the loading phase, while the forward facing dummy is moving forward and has a hyper flexion of the neck.

6. Reference

Kleinberger M., Sun E., Eppinger R., Kuppa S., Saul R., „Development of Improved Injury Criteria for the assessment of advanced automotive restraint systems“, NHTSA, Sep. 1998.

Malm S., “Hur kan vi skydda barn I bil – olycksdata från 1996 till 2002”, Oral presentation at Autoliv, Jan 2006.

Merz H., Prasad P., Irwin A., “Injury risk curves for children and adults in frontal and rear collisions”, sae no 973318, 41st Stapp Conference, 1997.

7. Appendix A – Crash pulse

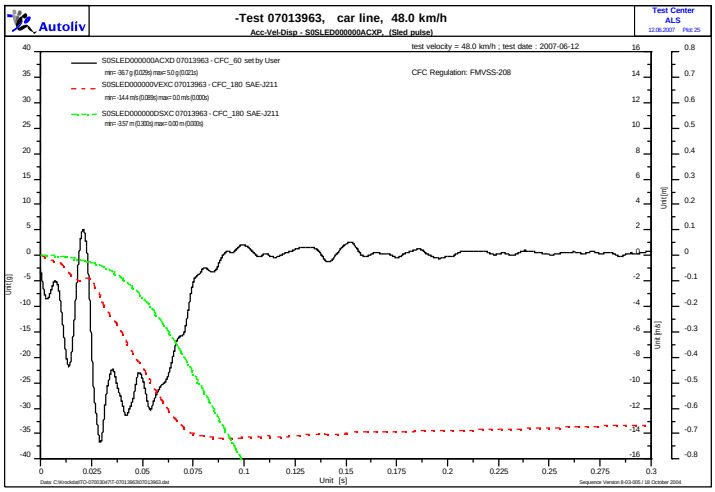

Figure 4 The crash pulse that was used.

8. Appendix B – NPAC frontal scoring protocol

	min. Points	max. Points	Lower Limit	Upper Limit	Modifier
FRONT IMPACT		**200**			
Head accelearation (3msec exceedance)		0	> 120		
	0	11	100	120	
	11	22	85	100	
	22	33	72	85	
	33	44	60	72	
	44	55	< 51	60	
Head Excursion		0	> 600		
	0	11	500	600	
	11	22	415	500	
	22	33	350	415	
	33	44	300	350	
	44	55	< 270	300	
Chest accelearation (3msec exceedance)		0	> 65		
	0	4	55	65	
	4	8	47	55	
	8	12	40	47	
	12	16	35	40	
	16	20	< 33	35	
Chest compression (Q1/Q1.5)		0	> 40		
	0	4	30	40	
	4	8	21	30	
	8	12	14	21	
	12	16	9	14	
	16	20	< 5	9	
Chest compression (Q3/Q6)		0	> 50		
	0	4	38	50	
	4	8	27	38	
	8	12	18	27	
	12	16	11	18	
	16	20	> 6	11	
Neck Moment		0	> 35		
	0	4	28	35	
	4	8	21	28	
	8	12	15	21	
	12	16	10	15	
	16	20	> 7	10	
Neck Force		0	> 3000		
	0	4	2200	3000	
	4	8	1600	2200	
	8	12	1200	1600	
	12	16	1000	1200	
	16	20	< 900	1000	
Pelvis acceleration		0	> 90		
	0	2	70	90	
	2	4	53	70	
	4	6	40	53	
	6	8	30	40	
	8	10	< 24	30	
Abdominal Penetration					Front Impact max. 80 pts
Collapsing System					Front Impact max. 80 pts
Ejection					Front Impact max. 80 pts

Table 2 The NPAC frontal impact scoring protocol.