SEAT DESIGN DIFFERENCES AS A RESULT OF THE VARIETY OF GLOBAL WHIPLASH TEST PROCEDURES

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ABSTRACT

Whiplash injuries still are a major vehicle safety issue. Even though the medical community has still not agreed on the question of whether whiplash is a low severity physical injury or merely a physical complaint, the development of testing-procedures were delayed due to the high economic costs. In years past, the procedure development to test for whiplash performance was mainly driven by insurance institutes. Later it was adopted by several national and regional NCAP-Programs and other complete car evaluation programs before finally being adopted by national legislation. Meanwhile, the automotive industry developed different measures to improve seat safety. This paper summarizes the technical solutions for seats with good whiplash performance that manufacturers have in their cars today. It also describes in particular the differences that can be derived from differences in testing procedures. The market-specific differences between these solutions directly tie back to different national and regional rating procedures.
Starting with the IIWPG–initiative, a significant number of different test criteria and procedures have been developed. By now, most of these criteria and procedures have been integrated in complete car safety ratings. Additionally, the test equipment necessary to evaluate whiplash performance has been developed in parallel with the procedures.
This brings up three major influences in procedure definition. First, the definition of criteria from the correlation of robust dummy behavior in specific seats to the data accumulated about the performance of the same seats in accidents. Second, the derivation of criteria from biomechanical injury mechanism while assuming a dummy with sufficient biofidelity. Third the accumulation of measurable dummy-performances to a cumulative low-level force on the dummy's spine. As a result of these different evaluation development processes, the different testing procedures deliver extreme rating differences for the same seat. Thus, the common goal of increasing whiplash performance for human passengers lead to different evaluation schemes and even contradictory criteria being used. At present there are test criteria that have to be actively declined to achieve an increased overall rating according to a different testing procedure.
Regarding these conceptual procedure differences, the actual test proceduresfocus on different results. As a result of these different testing procedures, vehicle manufacturers optimized their seat design based on different criteria. It is important to note that local tests have the strongest effect on design details and optimization differences. Accordingly, many North American seat designs focus mainly on the reduction of head to head-restraint contact time in the test environment. In the meantime, Asian seat designs focus on neck-force minimization during the tests of head to head-restraint contact while the European manufacturers' seat designs focus on robustness with respect to differences in the test pulses.
The common agreed-upon goal has to be one single testing procedure that correlates with accident data and can be reproduced with existing test-equipment.

HISTORY

When professional whiplash performance comparison started in the mid 90ies driven by different insurance institutes , there were few

vehicles on the market which showed a statistically significant positive behavior in accident data. With the assumption that the direct correlation of the seat performance in a sled-test to the road data of a vehicle is feasible, a set of fairly repeatable dummy values were derived to distinguish a good seat from a poor one. This background lead to different whiplash tests by different insurance institutes. Since then a lot of effort has been put into research and development on rear impact dummies, seats and crash procedures. These research results produced a continuing stream of updates to the insurance testing procedures of which the IIWPG procedure is the most recent insurance procedure which is still in use.

Figure 1. Optimized passive seat (Renault Scenic)

About ten years after the insurance institutes began their effort in whiplash classification, different NCAP programs started to look at the issue. In a very short period of time, EuroNCAP, K-NCAP and J-NCAP published whiplash testing procedures and rating schemes. All of these show significant differences between each other and (as might be expected) to the IIWPG procedure as well. Finally C-NCAP finalized its whiplash testing procedure in 2011. As we are struggling with a harmonized testing and rating scheme to be used in GTR 7 phase II, the pros and cons of all these existing procedures must be worked out. Since there are some seats that perform better in a first and worse in a second test procedure while other seats perform better in the second and worse in the first procedure, the question arises which of all these ratings and parameters conclusively rate a seat's capacity for whiplash protection while assuming a comparable vehicle environment.

DATA SAMPLES

Just by changing the data sets of a given test, one single set of results can lead to different ratings in whiplash tests:
Comparing the 16 km/h monowave tests, the following parameters influence some rating schemes strongly and others not at all. A contact time above 70 ms leads to a degradation in the IIWPG protocol whilst it has limited effect in other ratings. A rebound velocity above 5.2 km/h zeroes one Euro-NCAP rating and the K-NCAP test, but has no effect on other ratings. The lower forces and torque are completely evaluated in China and Japan. In addition to the ratings, the FMVSS 202a testing scheme forces an entirely different seat behavior from that of the other tests (- this is due to the other dummy).
These sample differences still neglect the main problem of testing whiplash: The variation of results due to the actual repeatability and reproducibility of tests with the BioRID Dummy.

Figure 2. Optimized passive seat (Volkswagen Touran)

SAMPLE TESTS

Tables 1and 2 list the results of several real tests performed at different sleds with the 16 km/h pulse. This shows both single tests with significantly better ratings according to the Euro-NCAP protocol and others with a significantly better rating according to the IIWPG protocol. Table 1 shows seats with a good IIWPG rating while the EuroNCAP rating is worse.

Table 1.
IIWPG-seats

#	1	2	3
NIC	20,9	24,8	18
NKM	0,33	0,24	0,41
V-Reb.	4.68	5.62	4.81
Fx	115	59	107
Fz	509	654	557
HRCT	80	69	68
IIWPG	good	good	good
NCAP	1,02 / 3	1,18 / 3	1,19 / 3
Seat	passive	passive	reactive

The tested seats are different internal prototypes and benchmark seats. Their test results prove that a well performing seat – according to one protocol – does not necessarily do well according to a different protocol. Even more, as the seats do not even reach 40% of the possible Euro-NCAP points in the medium test, a singular rating would probably not even be acceptable.

Figure 3. Active seat
(Hyundai i20)

The other way around, there are seats that perform quite well in the Euro-NCAP rating but inadequate in the IIWPG rating – based on one single test, as shown in Table 2.
Here the rating differences are not as significant as in Table 1, but the Euro-NCAP points are in a range where a seat is usually acceptable to good, whilst its IIWPG rating is merely marginal. This shows that there are no more stringent and difficult vs. less challenging rating schemes, but rather just different competing philosophies.

Similar pictures can be drawn by including other ratings in the comparison. Only the K-NCAP and the Euro-NCAP results are always very close (as the K-NCAP rating resembles the Euro-NCAP medium pulse rating).

CONTINENTAL SEAT DESIGNS

As most manufacturers focus on their home market and the local approach to whiplash testing in these regions, seat designs now begin to differ in particular between European, Japanese and North American manufacturers.

Table 2.
Euro-NCAP-seats

#	1	2	3
NIC	16,6	18,9	18,66
NKM	0,15	0,18	0,28
V-Reb.	4,58	4,2	4,35
Fx	14	1	74
Fz	769	770	10,9
HRCT	72	71	121,62
IIWPG	marginal	marginal	marginal
NCAP	1,57 / 3	1,55 / 3	1,27 / 3
Seat	Passive	passive	passive

These different performance optimizations all result in well performing seats – according to the respective different national criteria. Of course, all markets still show different approaches to good whiplash performances, but the details are different.

Figure 4. Active seat
Nissan Qashqai

In general, good whiplash performance can be achieved with (1) geometrically optimized passive seats, (2) with reactive seats where the accelerated

body initializes a geometry change in the seat or (3) with proactive seats where an external sensor triggers a geometry change of the seat.
For example, in Asia manufacturers tend to bring more and more reactive seats, while North America manufacturers focus on proactive seats and in Europe most manufacturers focus on geometrical optimizations.

Figure 5. Active seat
(Chrysler Town & Country)

SUMMARY

Today good whiplash performance is regarded differently by different testing institutions in various countries. Depending on which test results are the main focus of the local market and the manufacturer, the manufacturers deliver different technical solutions as well performing seats. Due to this focus, these seats that perform well in local test, often do not perform as well once they are tested in a different market. As a result some manufacturers even build different seats for different markets – seats that perform well in the local tests.

CONCLUSION

One solution for harmonizing the seat design for a good global whiplash performance is to create a globally accepted whiplash procedure. Therefore, the approach of the GTR 7 Phase II is one important step towards defining standardized and robust criteria. In a second step a test dummy must be created, which can measure this criteria with a high repeatability and reproducibility.

For a global robust whiplash procedure, only criteria can be used which are both robust and that correlate with to field data.

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