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”Whiplash“ Testing and Assessment – Summary of Current Activities in Europe

Abstract

This paper aims to present a comprehensive summary of current activities of how “whiplash” testing and assessment is addressed in Europe by various institutions and consumer organisations such as:

Folksam/SNRA, Thatcham/IIWPG, ADAC, ACEA, Euro NCAP and EEVC WG 20.

Introduction

The comparison of major accident samples from the German motor insurers shows that the incidence of cervical spine injuries (also denoted as whiplash injuries, cervical spine distortion injuries, CSD, or whiplash associated disorders, WAD) in motor vehicle accidents has almost doubled in the last 20 years (HELL 1999 [1]). MORRIS and THOMAS (1996 [2]) also show similar figures from UK. Swedish insurance data show that the risk of whiplash injuries leading to long-term disability is found to have doubled comparing recent car models with car models introduced 20 years ago (FOLKSAM 2001 [3]), and do to date in Sweden account for nearly 60% of injuries leading to long-term disability (KRAFFT 1998 [4]). The main public health problems concerning WAD are those leading to long-term disability. Between 5-20% (depending on accident data source and definition of long-term injury) of all cases will end as long-term cases, these few long-term cases are responsible for a majority of the costs (SPITZER et al. 1995 [5]). Since most impacts lead to no injury or to temporary symptoms, the duration of symptoms needs to be separated in order to isolate representative crash conditions in which more long-lasting whiplash injuries occur.

A Swiss study on CSD in cases with long sick leave times showed that a history of neck injury (pre-existing damage or pre-existing signs and symptoms) has a significant influence on the overall assessment (SCHMITT et al. 2002 [6]).

The assumed socio-economic losses for rear-end collisions in Germany (calculated after German Injury Cost Scale) would amount up to 1100 Million € for the year 1990 in the Federal Republic of Germany (West). At that time in about 54% of all car-to-car accidents with personal injury the accident pattern had been a rear-end collision. An estimation based on the insurance statistics in Germany came to about 200,000 reported cervical spine injuries after rear-end collisions for the year 1990 only in former Western-Germany. For 2000 a higher amount of 2 Billion € for Germany can be assumed because of increased incidence (HELL et al. 2001 [7]) and the inclusion of former East Germany. Estimations of annual costs from other countries regarding whiplash injuries were also very high:

- USA, 10 Billion US$ (IIHS)
- UK, 800 Million Pounds (Direct Line)
- Canada, British Columbia/CDN 270 Million US$ (ICBC)
- European Union, roughly at least 10 Billion € (Whiplash 1)

The medical and societal consequences of neck injuries due to rear impact are very important and the neck injury risk is the highest with this type of impact (see for example MURRAY et al. 1993 [8] and KRAFFT 1998 [4]). The Institute for Vehicle Safety, Munich, has established a large accident material of 15,000 car to car crashes representing every fifth collision from one year in Germany. A sub sample of 517 rear-end collisions with passengers suffering from cervical spine distortion (CSD) injury had been analysed technically and medically. From the accident reconstruction a typical accident scenario was evaluated, which should define requirements for improved seat/head-restraint systems and proposes to set up a dynamic seat test standard, which should be integrated in existing safety crash tests. The data material show that the typical accident configuration is a 0+/-5° angled impact with almost full overlap and a delta v between 10 and 20km/h. Comparable results were found in an independent

MHH Hannover accident investigation on behalf of VW (TEMMING 1998 [9]).

Females tend to have a higher injury risk compared with males (risk factor: small neck circumference) (HELL et. al. 1999 [1], MAAG et al. 1993 [10], KRAFFT 1998 [4], YDENIUS and KULLGREN 2001 [11], BERGLUND 2002 [12]).

Especially the risk of permanent disability was four times higher for females than for males in the rear seat (KRAFFT et al. 2002 [13]).

In Germany, females show a higher injury occurrence (x 1.4 in GDV investigations, x 2.0 in VW investigations (Final report Whiplash I 2003)). Older people showed an increased risk for higher level CSD injuries (Final report Whiplash I 2003).

VIANO (2003 [14]) points to the importance of seat stiffness and torso mass in the early neck responses and differences between male and female related to whiplash.

The dynamic behaviour of seat backs seems to influence the risk of WAD. Stiffer seat backs produce higher risk of WAD (HELL et al. 1999 [15], PARKIN et al. 1995 [16], FORET-BRUNO et al. 1991 [17]). A low positioned head-restraint increases injury frequency, even compared with seats with no HR (HELL et al. 1998 [7]).

The risk of CSD rises with decreasing car mass and increasing opponent mass (EICHBERGER 1996 [18], RYAN 1993 [19], OLSSON et al. 1990 [20], KRAFFT 1998 [4]). Differences in mass reflect differences in change of velocity. A correlation between change of velocity and risk of both long-term and reported WAD has been shown (KRAFFT et al. 2001 [21]). Furthermore it has been shown that cars with similar weights may have large differences in risk of WAD (KRAFFT 1998 [4]), indicating that other factors than mass, such as car structure and seat stiffness, are strongly influencing the risk of WAD.

Influence of crash severity or change of velocity for reported whiplash injuries have been presented in several studies. German figures show for rear-end collisions an average value of 15km/h. Results from FOLKSAM have been presented where crash severity, recorded with crash pulse recorders, have been correlated to injury risk (KRAFFT et al. 2001 [21] and 2002 [22], KULLGREN et al. 2003 [23]). However, only a few car models of one car make were involved. Average change of velocity and mean acceleration for occupants reporting a whiplash injury was found to be 14km/h and 4,4g respectively, while occupants not reporting an injury had corresponding values of 7,7km/h and 3,0g, see table 1.

Neck injury has been studied both with respect to duration of WAD symptoms and to different grades of WAD, according to the Quebec Task Force (SPITZER et al. 1995 [5]), versus different crash severity parameters (KRAFFT et al. 2002 [13]). Crash severity was found to have a large influence on the duration of symptoms. Also grades of WAD were directly correlated to crash severity. Acceleration was found to be more important in explaining the risk of whiplash injury than change of velocity, indicating that when designing a crash test, focus should also be set on acceleration. It was also found that no one in the sample had WAD symptoms for more than 1 month as long as the mean acceleration was below 3g. This finding is also supported from several volunteer tests (Mc CONNELL et al. 1995 [24], ONO and KANEOKA 1997 [25], SIEGMUND et al. 1997 [26]).

In the study by KRAFFT et al. (2002 [13]) the average change of velocity and the mean acceleration for those occupants with symptoms

Injury classification	Category	Number of occup.	Delta-V (km/h)	Mean acc. (g)	Peak acc. (g)
All		94	10.4 +/- 2.0	3.6 +/- 0.3	7.9 +/- 0.7
Reporting	No reported neck injury	53	7.7 +/- 1.2	3.0 +/- 0.3	6.7 +/- 0.7
	Reported neck injury	41	13.9 +/- 2.6	4.4 +/- 0.4	9.5 +/- 1.0
Duration of symptoms	Symptoms < 1 month	26	10.3 +/- 2.1	3.9 +/- 0.5	8.7 +/- 1.3
	Symptoms > 1 month	15	20.0 +/- 4.8	5.3 +/- 0.6	10.8 +/- 1.4
Grade of WAD (Quebec Task Force)	WAD Grade 0	53	7.7 +/- 1.2	3.0 +/- 0.3	6.7 +/- 0.8
	WAD Grade 1	20	10.1 +/- 2.3	3.9 +/- 0.6	8.6 +/- 1.5
	WAD Grades 2 and 3	18 (13+5)	16.2 +/- 3.8	4.8 +/- 0.6	10.1 +/- 1.5

Tab. 1: Average values in crash severity for different injury classifications and categories for rear-end car collisions with 4 car models from one manufacturer, model year 1995-2001 (from KRAFFT et al. 2002 [13])

more than 1 month, were found to be 20km/h and 5.3g respectively. The average peak acceleration was approximately 11g. Regarding different grades of WAD, occupants classified as WAD Grade 2 or 3 were found to have values of 16km/h, 5g and 11g.

Injury risk versus change of velocity and mean acceleration has also been compared to duration of WAD symptoms as well as to different grades of WAD (KRAFFT et al. 2002 [13]). When designing a crash pulse for crash testing, the crash recorder results suggest that acceleration should typically be between 5 and 7g for 80ms to represent occupants with symptoms more than 1 month.

Test Methods Based on Real World Accident Data

To test the utility of the previously discussed test criteria and parameters taken to evaluate different seat/head-restraint constructions, proposals of dynamic sled test programmes or standards have been developed and are described below.

FOLKSAM/SRA Test Series 2003 and 2004

In total two test series have been conducted by FOLKSAM/SRA using car seats on a sled. The first one in 2003 included 13 driver seats and the second test series in 2004 included 13 additional seats. In addition to that one seat with and without after market whiplash protection were tested according to the test procedure 2004. All seats were mounted at a test sled. The crashes were made at three crash severities to measure the protective effect at several crash conditions. Based on the results from crash recorders described above, 3 test conditions at different velocity and acceleration were chosen, 4.5g represents low risk but where many crashes occur, 5.5g represents medium risk and medium exposure, while 6.5g represents high risk but low exposure (cf. table 2).

The crash pulses of the two test series, 2003 and 2004, are presented in figures 1 and 2. The 2nd test pulse was changed in the 2nd test series from trapezoidal shape to triangular shape, but with the same test speed and mean acceleration. The test series should not be directly compared because of this change. However, the results should be very close to one another.

Test	Speed	Mean acceleration
1 – Low severity	16km/h	4,5g
2 – Mid severity	16km/h	5,5g
3 – High severity	24km/h	6,5g

Tab. 2: Test speed and acceleration FOLKSAM/SRA test series

Other Test Specifications

- Dummy: BioRID (Denton, version E)
- Measurements: acceleration in head, chest, T1 and pelvis, forces and moments in upper and lower neck, belt load, head and chest velocity from film analysis.
- Head restraint in mid positions.
- Seat back angle: 25 degrees using an H-point dummy
- Seat belt: generic seat-belt (non-car specific but geometry close to car geometry)

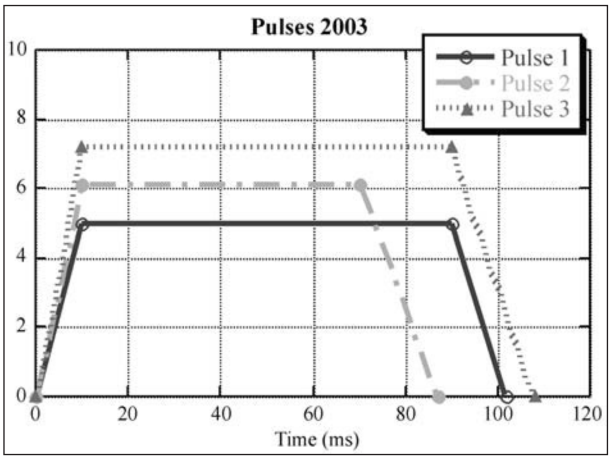

Fig. 1: Pulses used in the first test series (2003)

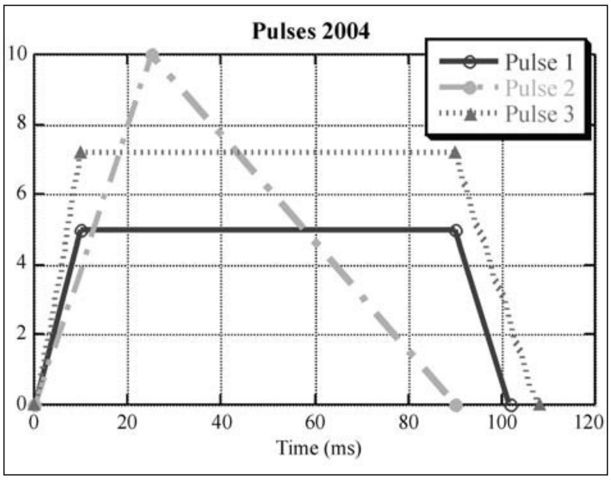

Fig. 2: Pulses used in the second test series (2004)

Measurements and Criteria FOLKSAM/SRA

To rate the various seats regarding risk of whiplash injury 3 parameters were measured and used, NIC_{max}, N_{km} and head rebound velocity. The overall rating is based on point scores. In the calculation of points, the seats got points if each measured parameter exceeded critical limits as described in table 3. Two limits per injury criteria were used and maximum 2 points for NIC_{max} and N_{km} were given, while maximum 1 point was given for head rebound velocity. High point scores indicate poor protection levels.

For each car model all points were summed for all three tests. To be regarded as a low risk seat maximum 5 point were allowed (labelled green). Between 5.1 and 10 points the seat was regarded as having average risk (labelled yellow), and above 10.1 points the seat model was regarded as having high risk (labelled red).

Results

All test results from 2004 and 2003 using the crash test pulses described in figure 1 and 2 and the limits of table 3 are published and available via the internet (www.folksam.se or www.vv.se). The tests were carried out at Autoliv using a Hyge-sled.

In average cars fitted with whiplash protection scored better results, see table 4, but there are also large differences within those seats with whiplash protection. Some of these seats did not get good ratings.

IIWPG/Thatcham

The rating procedure used by the International Insurance Whiplash Prevention Group (IIWPG) and Thatcham for evaluating and rating the ability of seats and head restraints to prevent neck injury in moderate and low-speed rear-end crashes is a two-stage process, starting with measurements of the static geometry of head restraints and followed by a dynamic evaluation of those seats in a simulated rear-end crash. Note: the final rating procedure is still under discussion.

Measurement and Rating of Static Head Restraint Geometry – the Initial Evaluation

Static geometry evaluations are based on measurements of height and backset that are made with a dummy representing an average-size adult male (HRMD). To be rated at least marginal, the top of a restraint should be no lower than the center of gravity of the head (no more than 10cm below the top of the head) and no farther behind the head than 11cm. Otherwise, the head restraint geometric evaluation is poor. Higher head restraints provide protection for even taller occupants, and closer head restraints can reduce the time the head is unsupported in a rear crash. An acceptable geometric rating implies a head restraint no farther than 8cm below the top of the head and no farther than 9cm behind it. Good geometry implies a head restraint no farther than 6cm below the top of the head and no farther than 7cm behind it (see figure 3).

	NIC_{max}	N_{km}	Rebound velocity
Seats with whiplash protection	16.6	0.34	4.4
Seats without whiplash protection	21.5	0.43	4.6

Tab. 4: Average of measurements for cars with and without whiplash protection

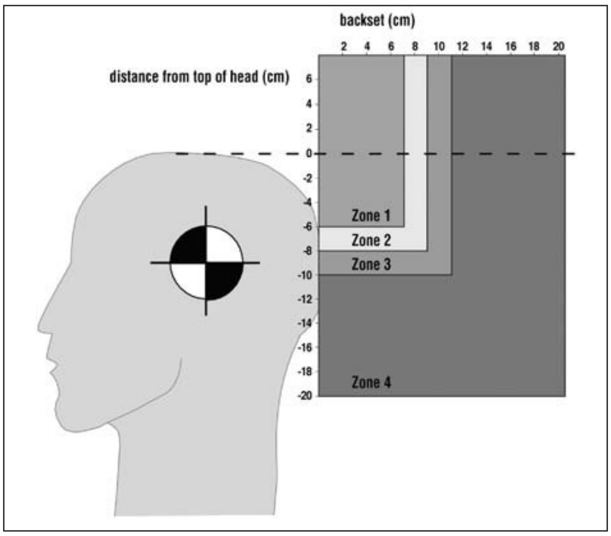

Fig. 3: Diagram of geometric head restraint rating

Criterion	Lower limit	Upper limit	Green Low risk	Yellow Medium risk	Red High risk
NIC_{max}	> 15m²/s²	> 18m²/s²	≤ 15 m²/s²	15 < NIC_{max} ≤ 18	> 18
N_{km}	> 0,3	> 0,4	≤ 0,3	0,3 < N_{km} ≤ 0,4	> 0,4
Rebound velocity	> 4.5m/s	> 6.0m/s	≤ 4.5 m/s	4.5 < Vel. ≤ 6,0	> 6.

Tab. 3: Critical limits and points

Seats with fixed geometry are rated using the measured height and backset when the seat is adjusted to a typical driving position. Seats with adjustable head restraints that cannot be locked into the adjusted position are rated based on measurements from the unadjusted (lowest and rearmost) position of the head restraint. Seats with locking head restraint adjustments are rated using the midpoint between the lowest/rearmost adjustment and the highest/foremost adjustment.

The rating procedure is detailed in the Research Council for Automobile Repairs (RCAR) publication, Procedure for Evaluating Motor Vehicle Head Restraints (2001). However, although this RCAR procedure assigns a good evaluation to all active head restraints, the IIWPG static evaluation will reflect the same measurement criteria as for nonactive head restraints. The additional benefits of active head restraints, if any, will be assessed through dynamic testing.

For head restraints with marginal or poor geometry, the geometric rating becomes the final rating. Head restraints with acceptable or good geometry undergo dynamic testing, as described below.

Dynamic Test Requirements

The dynamic test consists of a simulated rear crash on an acceleration sled using a BioRID IIe dummy positioned in the seat to be tested. The acceleration profile (delta V 16km/h) is roughly triangular, with a peak of 10g and a total duration of 92ms (figure 4). Seats with adjustable head restraints are tested with the restraints adjusted to match the position on which the seat's geometry is rated.

The specific details of the test procedure are described in IIWPG Protocol for the Dynamic Testing of Motor Vehicle Seats for Neck Injury Prevention.

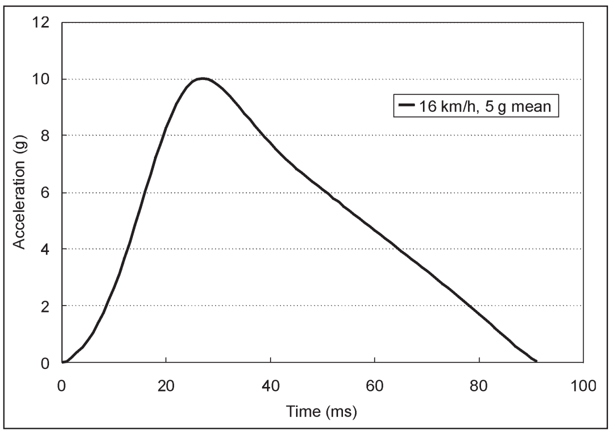

Fig. 4: IIWPG 16km/h test pulse

Dynamic Test Criteria

The dynamic test criteria are divided into two groups:

- seat design parameters and
- test dummy response parameters.

If one or both of the seat design parameters are below the specified thresholds, then the dummy response parameters are used to assure that the head and neck are supported without excessive stresses or neck distortion. To pass the dynamic test, all seats must meet criteria for neck forces (shear and tension) and neck distortion (retraction of the head relative to first thoracic vertebra, T1; this parameter may be discarded if research indicates that it fails to add useful information).

Seat Design Parameters

There are two seat design parameters:

- Time to head restraint contact must be less than 70ms (preliminary threshold) to pass this requirement. Time to head restraint contact is the time after the sled acceleration/deceleration reaches 1.0g that the dummy's head contacts the head restraint, as indicated by an electrical contact switch attached to either the dummy's head or the head restraint.
- Alternately, the maximum T1 forward acceleration must be less that 9g (preliminary threshold). This limit is based on the maximum T1 accelerations recorded in tests of Volvo Whiplash Injury Prevention System (WHIPS) seats, which include energy-absorbing/force-limiting seatback hinges. Maximum T1 forward acceleration is the highest acceleration recorded by an SAE J211-compliant (CFC 60Hz) and horizontally oriented accelerometer attached to BioRID's T1 vertebral unit anytime between the beginning of the test and the time the dummy's head first leaves contact with the head restraint at the beginning of the rebound phase of the simulated crash.

The first seat design parameter, time to head restraint contact, requires that the head restraint or seatback contact the seat occupant's head early in the crash. The main purpose of requiring a head restraint to have only a small distance behind the head is to reduce the time until the head is supported by the restraint. Thus, the time-to-head-restraint-contact parameter assures that initially acceptable and good static geometry is not made irrelevant by poor seat design.

Some seats are designed to absorb some of the cash energy so that occupants experience lower forward accelerations. This aspect of performance is measured by the forward acceleration of the seat occupant's torso (T1 acceleration), which is the second seat design parameter. In some cases these designs may result in later head contact times.

Seats with features that reduce head restraint contact time or have effective energy-absorbing characteristics have been shown to provide better protection from neck injury in rear crashes than seats with reasonably similar geometry fitted to the same car models (FARMER et al., 2003). To pass the dynamic test, a seat must meet at least one of the thresholds for the seat design parameters, i.e., time-to-head-restraint-contact or the T1 acceleration.

The final rating of any seat design that fails to meet at least one of these criteria will be one category lower than its initial static geometry rating — that is, marginal or acceptable for seats with acceptable or good geometric ratings, respectively.

Test Dummy Response Parameters

There are two dynamic test requirements based on BioRID response parameters. These are maximum neck shear force and maximum neck tension.

To pass the dynamic test, a seat must meet both of the following requirements:

- The maximum neck shear force must be less than 130N (preliminary threshold), and
- the maximum neck tension force must be less than 600N (preliminary threshold)

during the time between the beginning of the test and when the dummy's head first leaves contact with the head restraint at the beginning of the rebound phase of the simulated crash. These limits represent performance achievable by a range of seat designs current in the 2003 model year when the test set-up represents good static geometry.

Any seat design that fails to meet either of these dummy force criteria will be rated one category lower than its initial geometric rating — that is, marginal or acceptable for seats with acceptable or good geometric ratings, respectively.

Results of a current test series with about 200 car seats are expected to be published in November 2004.

ADAC 2003

The ADAC test procedure is similar to IIWPG test procedure and also uses the BioRID II dummy.

ADAC is performing a second whiplash test (25km/h, max. 16g) and an additional seat stability test (30km/h, max. 17g, with a Hybrid III 95%-Dummy). For the fixation of the BioRID dummy a head and neck holder to fulfil the requirement to the pre-test position of the dummy (deceleration sled).

Assessment Criteria

To rate the various seats regarding risk of whiplash injury 5 parameters are measured and used, NIC, N_{km}, LNL, extension rotation and retraction.

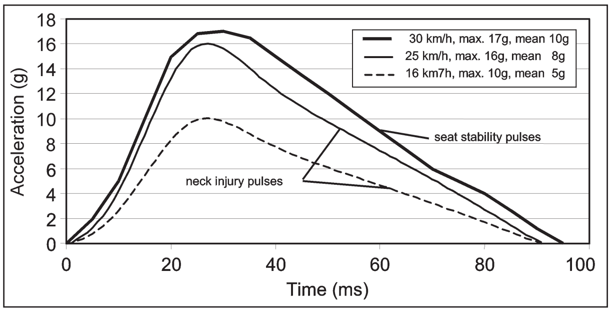

Fig. 5: Pulses for STNI and seat stability testing

Criteria	lower limit	upper limit
NIC	10	20
NKM	0,3	0,5
LNL	1,5	3
Extension Rotation	5	25
Retraction	10	15

Tab. 5: Seat assessment criteria

mark	classification	
0.6 ... 1.5	++	very good
1.6 ... 2.5	+	good
2.6 ... 3.5	O	sufficient
3.6 ... 4.5	T	marginal
4.6 ... 5.5	-	poor

Tab. 6: Final rating of ADAC

Effects such as failure of active head restraints, dummy ramping and fractures of the seat are monitored as well.

The lower limits apply to the best possible mark 0.6, the upper limits to the worst possible mark 5.5. Within these limits a sliding scale is used.

For the total rating the neck injury protection is weighted with 70%, and seat stability with 30%.

If one of the individual marks is >4,5 a penalty of 1 mark is applied.

ADAC published a test series with 10 B-class cars in November 2003 and will probably publish a new test series early 2005. The results of the 2003 test series are available under www.adac.de.

As soon as the EuroNCAP test and assessment protocol will be released ADAC will adopt the test procedure.

ACEA

ACEA has performed a study regarding whiplash testing. The purpose of the ACEA study was to examine the repeatability and reproducibility of some proposed test designs and seat assessment criteria.

The test program was conducted in two phases:

- phase 1 is addressing the repeatability and
- phase 2 the reproducibility issue.

In phase 1 three different seat models were used (Saab 9-3, Skoda Fabia, BMW 3). Three repeat tests of each seat have been performed using a delta v 16km/h pulse (IIWPG pulse). All repeat testing was conducted at Thatcham.

In phase 2 the same three different seat models were used. The testing was conducted in five different labs (using the same test protocol). One test per configuration was performed (delta v 16km/h (IIWPG) and 25km/h (ADAC)).

Results of the ACEA Study

Regarding the HRMD measurements and set-up procedure (cf. figures 6 and 7) a first sight analysis shows that reproducibility issues still exist. The repeatability of the HRMD measurement is acceptable.

However, the use of the set-up procedure by the different labs caused seat back angle (stem angle) differences of up to 4deg. This could be seen as significant. One degree change in the stem angle will lead in theory to 15mm increase in backset.

Fig. 6: HRMD (Head Restraint Measurement Device)

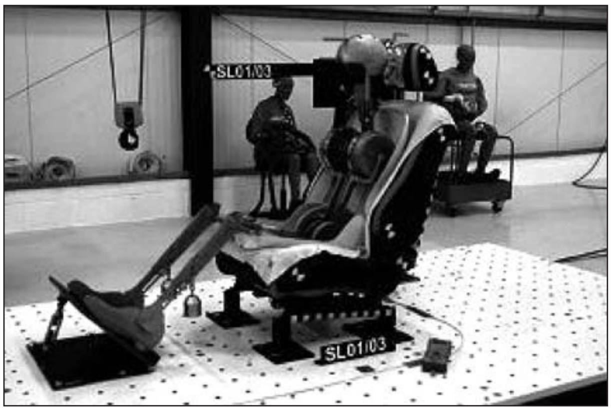

Fig. 7: HRMD (Head Restraint Measurement Device)

In the practical measurement the maximum differences of backset and height for reproducibility were more than 20mm and would automatically lead to different ratings.

Regarding the sled and pulse parameters significant variation in pulse and set up have been documented. The repeatability of sled pulses appears to be acceptable. A corridor for the 25km/h needs to be defined (only seat stability). A general accepted definition of t_0 is needed. No clear influence of sled type (deceleration or acceleration sled) on the initial dummy (head) position was observed.

Analysis of Criteria for Reproducibility (16km/h)

Figure 8 and 9 show the maximum scattering for different seat assessment/rating criteria that were recorded during the test series. Figure 8 shows the results for the IIWPG pulse (16km/h) and figure 9

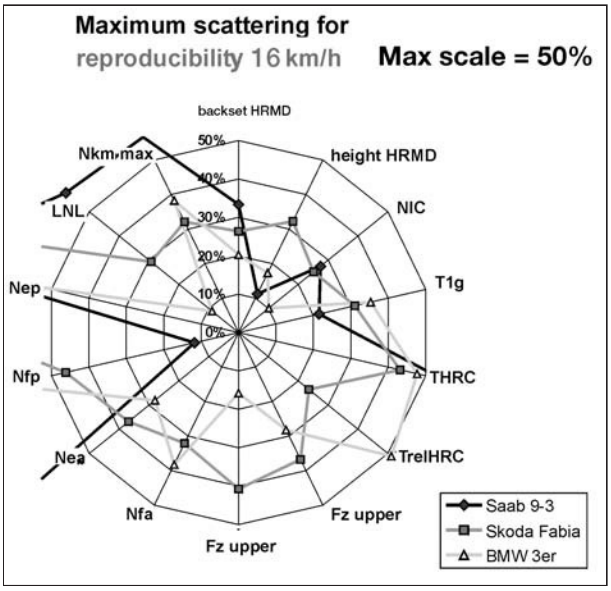

Fig. 8: Scattering for reproducibility (16km/h)

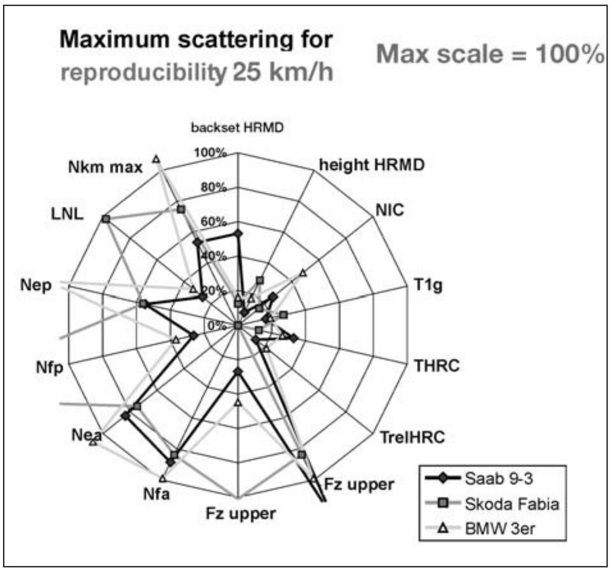

Fig. 9: Scattering for reproducibility (25km/h)

for the 25km/h ADAC pulse. Note that the max. scale in figure 9 (100%) is the double of the max. scale in figure 8 (50%).

The following conclusions on the rating criteria can be drawn:

- Repeatability (16km/h) is acceptable, with the exception of the Nep value (no influence on Nkm max for these tests).
- For the delta v 16km/h tests Nkm (all) and HRC show variations of more than 50%. Forces (Fx/Fz), LNL and T1 show a variation between 20-40%. NIC shows the lowest variation with values below 30%.
- Reproducibility is significantly degraded when delta v 25km/h pulse is used compared to delta v 16km/h.
- In particular the forces and force based criteria show extreme variations (>100%) with delta v 25km/h pulse.
- Result variations clearly question the suitability using this measures at the high severity pulse (delta v 25km/h).

EuroNCAP Whiplash Subgroup

The EuroNCAP whiplash subgroup has discussed various proposals for test procedures (IIWPG, ADAC, SRA, ACEA). The subgroup will make/has made decisions on the basis of these test results. Many parameters like pulse shape, assessment criteria, etc. have yet not been fully agreed by the members of the subgroup. There are still further data and discussion needed. EuroNCAP wants to have a co-operation with EEVC WG 20.

No final agreements have been reached so far but there is a strong tendency towards:

- Sled test based test procedure using a generic pulse
- More than one test and pulse/speed to avoid sub-optimisation
- 16km/h IIWPG as first choice, seat stability test and OOP under consideration
- No need for a 10km/h low speed test
- Using a BioRID dummy latest build level

The test programme will be based on the existing proposals from ADAC, Thatcham and SRA and the results of the ACEA study. Up to now there has been no decision about how to integrate whiplash testing in the EuroNCAP test program.

A first draft of a test and assessment protocol might be available in spring 2005. Testing might start at the end of 2005. The draft procedure has to be agreed by the EuroNCAP Technical Working Group and approved by the Assembly.

An integration of the whiplash rating into the overall vehicle score is probable.

EEVC WG 20

No regulatory test exists in Europe to assess injury risk in rear impacts, in particular at low severity. To date the EEVC has not been able to develop a viewpoint on rear impact and WAD type injury. In the year 2000 the EEVC Steering Committee asked the EEVC WG 12 to create an ad-hoc working group to investigate the possibility of developing an EEVC view on rear impact and WAD injury. The ad-hoc group found that there was significant amount of research data available and that interesting and promising research projects were ongoing. It recommended the EEVC Steering Committee to start up a new activity with the aim of developing a proposal for a new European regulatory test for whiplash injury (AIS 1 neck injury) protection in rear-end collisions.

The EEVC Steering Committee initiated a new working group, WG 20, and it also gave the WG 12 additional terms of reference regarding the selection of an appropriate crash dummy for the rear impact test procedure.

The terms of reference of the EEVC WG 20 rear impact test procedure(s) and the mitigation of neck injury are as follows:

- Develop test procedure(s) for rear-end collisions, with a prime focus on neck injury reduction (whiplash).
- Draft proposal(s) and report to the Steering Committee within one year of the first meeting.
- Evaluate the proposed test procedure(s) in laboratory conditions and, if needed, make appropriate adjustments to the procedure(s).
- Write final test procedure proposal(s) and report to the Steering Committee within two years of the group's first meeting.

Explanatory comments 1 on the terms of reference:

- The test procedure(s) should include a dynamic sled-based test using generic crash pulses, unless it can be shown to be inappropriate.
- Test conditions should be appropriate with regard to real world accident data.
- Appropriate injury criteria, to be measured in the dummy, will be selected in association with EEVC WG 12.
- In order to ensure that one injury risk (neck) is not reduced with an increase in other injuries (e.g. spine, or soft tissue), due regard should be given to a holistic approach to rear impact injury risk reduction.

The test procedure(s) must address the range of vehicle properties that can influence occupant loading as a function of the vehicle crash pulse, e.g. use of the seat-belt system and the seat system with vehicle body attachment points.

Explanatory comments 2:

- The procedure must include consideration of active safety systems that are triggered by crash sensor information, pre-crash sensor information or occupant interaction(s) and position.
- The test procedure(s) assessment parameters must correlate to injury risk.
- A close relationship should be established with EEVC WG 12, the Biomechanics group, regarding the selection of the most appropriate dummy, injury criteria and injury risk probability relationships. WG 20 will be responsible for co-ordination with WG 12.
- WG 20/WG 12 will select the most appropriate size of dummy for the test procedure(s).
- WG 20 will supply WG 12 with all the necessary input data regarding crash conditions, instrumentation and requirements and the interface between dummy and test set-up.
- Any procedure(s) must have regard to other impact conditions and impacts severities, to avoid sub-optimisation of safety system design, as well as existing standards and regulations.

Current Status of EEVC WG 20 Work

EEVC WG 20 has written a first draft proposal of a dynamic test procedure, based on the IIWPG test procedure. The actual injury, causing the typical WAD symptoms, is however still unknown (though several hypotheses exist), and the injury mechanism has thus not been established. The evaluation of the currently proposed injury criteria (LNL, Nkm, T1-rebound velocity, NIC, NDC, IV-NIC, etc.) and the calculations of the associated risk curves are however not founded in biomechanical research but instead statistically derived from field accident data and reconstructions of real world accident situations. WG 20 had long discussions about the acceptability of an injury criterion that is not based on the biomechanical relationship between loading to the body and injury causation ("black box"). The term "black box approach" denotes the definition of an injury criterion that is based on indirect statistically based evidence. WG 20 has asked the EEVC Steering Committee for guidance on this approach. Provided that the EEVC Steering Committee will approve the validation of injury criteria based on statistical analysis of field accident findings, the WG 20 appears to have a reasonable chance of establishing a test procedure proposal in accordance with its terms of reference.

WG 20 has received new indications that may delay the selection of an injury criterion (or injury assessment value). Earlier indications of good correlation to field accident data of Nkm and NIC appear to be contradicted by recent findings within the EU-Whiplash2 project and indicate better correlation to injury risk with LNL. Therefore further work to investigate the statistical methods behind these studies is needed and this adds some uncertainty about the time frame of the WG 20.

WG 20 has drafted a geometric test procedure and believes that it could be a valuable interim upgrade of the current regulation. If the EEVC Steering Committee approves, the WG 20 is prepared to continue working on the document and present a final draft, Autumn 2004.

Conclusions

The SRA/FOLKSAM test procedure is well established in Sweden. SRA/FOLKSAM will continue testing until EuroNCAP has finalised its test procedure

The ADAC test procedure contains a seat stability test and a high (too) severe whiplash test. ADAC also will adopt the Eur NCAP test procedure.

IIWPG/Thatcham is based on a static assessment (geometry). Dynamic testing (1 pulse) is only carried out with seats with "good" or "acceptable" geometry. IIWPG will continue with their test and assessment protocol (all vehicle models and US activities).

The ACEA test series shows that reproducibility is an issue of major concern. Especially the 25km/h pulse (mean acceleration 8g as used by ADAC) is not suitable for whiplash assessment.

EuroNCAP might present a draft of the test and assessment procedure in spring of 2005.

EEVC WG 20 is working on a static and dynamic test procedure. Further work is depending on the decision of the EEVC Steering Committee.

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