

Report from the EqOP IWG Workshop No 1 (whiplash/rear-end) at BAST.

September 5-6, 2023.

Participants

Pernilla Bremer, Astrid Linder, Anders Kullgren, Hans Lammers, Ines Levallois, Ansgar Pott, Irina Dausse, Marta Angles, Lotta Jacobsson, Oliver Klöckner, Chokri Ben Fadhel, Mats Svensson, Anna Carlsson, Paul Depinet, Paul Lemmen, Bernd Lorenz, Matthias Schiessler

Goals for the informal working group and the workshop

For the EqOP working group, the strategic goals are:

- equitable and enhanced protection of a diverse population, and
- robust inclusive and effective regulatory solutions.

Passenger car occupants are given priority.

The operational goals in the Terms of Reference that are connected to this workshop are:

Determine how greater diversity should be implemented in the UN crash safety regulations.

- To benefit the female population as soon as possible with available tools, the IWG should first provide a recommendation on the usage of existing ATDs by Dec 2023

Identify any shortcomings of existing regulations and related standards, such as whether the current test protocols can be misapplied to optimize crash performance for the specific test conditions and test dummies in a narrow way that is detrimental to the protection of a diverse population.

The goals for this workshop are:

1. Updated regulation to benefit the female population according to the ToR.
2. Identify any shortcomings of existing regulations and related standards, such as whether the current test protocols can be misapplied to optimize crash performance for the specific test conditions and test dummies in a narrow way that is detrimental to the protection of a diverse population. Also, according to the ToR.
3. To discuss and understand possibilities and challenges with virtual crash testing. Where are the knowledge gaps and how can we develop a robust regulation that leads to higher safety for all in the longer term?

Presentations

Regulation

- **UN R17.10 – anti-whiplash provisions (Hans Lammers, NL)**
The procedure for defining effective height of a HR has been updated recently, for more information see GRSP-65-31.
Possible issues:
 - Cherry picking (optional for manufacturer for dynamic test using 50M BioRID II dummy)
 - Only 50% male

- Maladjustment of head restraint in real life
Sometimes other (not tested) positions may result in worse results.

- Discussion:

- The dynamic performance test is just a year old in regulation and it is optional for the manufacturer.
- The test protocol can be misused today.
- Is it misuse not to adjust the headrest? It is different to e.g., seat belt misuse (behind the back)

Current research knowledge about and practical experience of the topic.

- **Field data analyses Folksam EqOP (Anders Kullgren, Folksam and Anna Carlsson, Chalmers)**

Field data shows that there has been a reduction in risk for both males and females, but the difference in risk between males and females remains.

The study Kullgren et al. (2013) showed that the SAHR1 whiplash system was highly effective for males but increased the risk for females – although the seat fulfilled the requirements and did very well in Euro NCAP’s test. The WIL and the Whips systems protect more effectively and equitably than the standard seat.

- Head restraints are often in the highest position and don’t protect the occupant optimally.
- For the 50th percentile male dummy (BioRID) the Saab 9-3 seat does not push the head forward, whereas the head is pushed forward for the 50th percentile female dummy (EvaRID). This results in a negative acceleration of the head in the “wrong” direction and likely results in higher injury risks.
 - Similar behaviour was not observed with the Saab 9-5 seat.

- Discussion:

- Minimized relative movement between body parts (here. trunk and head) typically result in reduced injury risk.
- During the rebound phase, occupants in frontal crashes can also suffer whiplash injuries.
- Purely geometry-based assessment may not be sufficient.
- Improvements in the design of back rests and head restraints are not exclusively targeted towards optimising BioRID performance, but rather towards improving the injury outcome of both men and women.

- **Rear impact research and program updates (Marcy Edwards, IIHS)**

IIHS implemented whiplash evaluation in 2004 – nearly all modern vehicles earn good ratings. “Good” performing seats have led to a significant reduction in injury claim rates, compared to “poor” performing seats.

The tests that IIHS perform, do not reflect what they see in real world. Insurance injury claim rates show that there is a significant difference between “Good# rated seats in the field. There is a need to continue to reduce whiplash injury in low-severity rear impacts. IIHS is doing research on rear impact protection and plans to update test protocols in the future. Nothing decided yet.

- Addition of a second pulse
- Introduction of virtual testing methods for robustness assessment.
- Discussion:
 - IIHS will focus on the BioRID (50th percentile male), since no other rear impact dummy is available.
 - Delta-v is in 25% of all crashes below 10 km/h and in 25% of all crashes above 25 km/h
 - Requirements for the BioRID virtual model will be defined in the next years.
- **DEOP whiplash improvement proposal (Ines Levallois, FORVIA/CLEPA)**

Actual regulation does not assure that the head of a the 50th female is retained by the stiff parts within the head restraint even when the head restraint is correctly adjusted by the occupant to its lowest position.

The effective height of 830 mm and Euro NCAP whiplash protocol are aggravating the problem. Improvements are possible in geometry by geometric checks on the seat/head restraint.
- **Designing for Equity (Lotta Jacobsson, Volvo Cars)**

Volvo developed rear impact protection in the 1990s based on biomechanical guidelines and without a suitable dummy. The 1st WHIPS seat resulted in significant reduction in whiplash injury risk, benefiting both men and women.

Biomechanical guidelines for equitable protection against whiplash:
Reduce occupant acceleration, minimize relative spine movements, minimize forward rebound. Important to ensure evenness of the seatback and headrest – to minimize relative spine movements.

 - Sub-system drop tests were used to assess the evenness of the seatback.
 - Sub-system energy absorption test used to assess energy absorption and minimizing forward rebound.
- Discussion:
 - Instead of drop tests as used by Volvo, quasi-static loading could be used to promote uniform load distribution throughout the back rest and head restraint.

Technical workshop with two different seats and various ATDs

For the workshop we used the two seats below. They were cut in half to expose the underlying structure. Photos by BAST.

Seat A



Seat B



Seat A received “good” rating in the 2011 Euro NCAP rear impact test.

- Integrated head restraint with soft foam (compared to Seat A), underlying head rest structure optimised towards the centre of gravity of the dummy's head (“BioRID Catcher”)
- Without the possibility to adjust the height of the head restraint and the underlying structure, the injury risk potential increases to all occupants, both shorter and taller than the BioRID.



Seat B (received “marginal” rating in the 2022 Euro NCAP test)

- Height-adjustable head rest with stiffer foam (compared to Seat A), underlying head rest structure consisting of metal bracket.
- The height adjustable head restraint can be seen as an improvement compared to the design of Seat A and should potentially reduce the risk of injury (if the head restraint is set to the correct height). However, especially for smaller occupants, the head restraint cannot be optimally adjusted.



Conclusion technical workshop:

Even though both seats fulfil the legal requirements (and receive “good” and margin” in Euro NCAP rear impact test) they fail to identify the protection of the 50-percentile female. Supporting the spine/minimize movement of the spine for different occupants is important to reduce the risk for WAD for everyone, and the CLEPA proposal addresses the issues with the headrest.

Executive summary of the workshop:

- Improvements in vehicle safety have led to a significant reduction in injuries and fatalities for the latest vehicle generation, benefiting both men and women. But the difference in risk remains, with in the order of 50 % higher risk for females.
- Women still have a higher risk of PMI, of these neck injuries in end collisions are the most common.
- Recent improvements to the seat design are possibly under-represented in the current accident statistics.

- The injury risk increases with an incorrect height adjustment of the head restraint or an excessive distance between the head and the head restraint. A forgiving design of the back rest and head restraint should be targeted.
- The head restraint adjustment mechanism as well as the height adjustment possibilities are restricted through other regulations or assessment programs (e.g., Euro NCAP).
- The dynamic performance test (optional) described in UN-ECE R17 is considerably more complex and potentially poses robustness problems throughout the vehicle's life cycle (CoP). The dynamic test is consequently rarely used, or not used at all.
- The priority of the IWG regarding rear impact protection should be to eliminate poor design of back rests and head restraints:
 - o Extended geometric requirements for the head restraint (e.g., as proposed by CLEPA) could reduce the possibility of head restraints optimised for a specific ATD.
 - o The addition of quasi-static or drop tests to the test procedure could promote uniform load distribution throughout the back rest and head restraint and result in more robust seat design.
- Dynamic assessment with ATDs of various sizes offers the highest potential for improvement, but poses other risks, such as a lengthy development process and robustness of the dummy/test procedure itself and needs further research.
- The component-based assessment of seats for type-approval or in consumer protection (e.g., Euro NCAP) does not encourage the development of vehicle structures more suitable to rear impact protection.
- Non-uniform backrest structures (e.g. due to top tether mount on the back seats) are also potentially problematic, but cannot be assessed with current test protocols.
- Industry partners favour harmonisation of regulations within the framework of the 1998 agreement and UN GTR No. 7.
- Vehicle seats are influenced by other design aspects (e.g., comfort).

Further action with the results from this workshop:

It is important to give everyone that is participating in the EqOP work information about the workshop – so the result from this workshop will be presented at a the EqOP meeting the 21st of September and the further plan is to:

- present the CLEPA proposal to address the issues with the headrest. GTR7 or R17?
- further explore the quasi-static test in GTR7 and discuss the past way forward – GTR7 or R17?
- if needed start working with the justification for and how to include the whole seatback and requirements to make sure the seat is even so people with a smaller stature don't sink into the seat back. A suggestion on how to get started with finding a test method is to begin testing in line with the "drop test" principles – do tests and analyses to discuss, test different methods/setups.
- further explore and discuss if and how to address the need for a forgiving design of the headrest.

- o **Dynamic assessment of the injury protection of seats: Physical and virtual dummy models for low severity tests. Astrid Linder, VTI**

Within the ADSEAT project a prototype of 50th percentile female rear impact dummy (BioRID P50F, Carlsson et al. 2022) was developed as counterpart to the 50th percentile male dummy (BioRID). In addition, a virtual dummy model of an average

female (EvaRID), based on the same design principles of the BioRID was developed, <https://www.humaneticsgroup.com/products/virtual-models/rear-impact-atd-virtual-models/evavid-fe>

In the VIRTUAL project two Set Evaluation Tools has been developed – SET 50F and 50M – a average male and female. When developing the SETs, the risk for whiplash in frontal impact was also taken into account.

- SETs can be used to validate and assess seats.
- Spine allows 3-dimensional movement.
- Further research into the SETs is needed.

Upcoming EqOP Meetings in 2023

- September 15th after IRCOBI (expert meeting / workshop in Cambridge)
- September 21st (3rd session, web meeting)
- October 23rd – 25th (2nd workshop @ European Commission in Brussels)
- November 14th (3rd workshop @ BMW in Munich)
- November 22nd (4th session, web meeting)