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Rational behind the Shoulder Assessment Criteria for WorldSID

Proposal for the GTR PSI Group

ISO Document TR 12350 defines the IRC for the WorldSID 50% male dummy. In this document injury curves for the shoulder region are defined only up to AIS2 severity. More severe injuries could not be found in any data of PMHS testing used in the construction of the injury risk curves. The IRC´s for shoulder relate to the maximum shoulder rib deflection and the maximum shoulder force.

In a severe pole crash, loading of the occupant is inevitable. In order to protect the occupants well in a PSI event the goal is to direct the loads towards the body regions with greater ability to withstand these loads while limiting forces on sensitive body areas such as the thorax.

The use of any shoulder injury criteria based on an AIS2 IRC is not advisable as it prevents an optimal loading of the shoulder. This in turn would lead to designs which load more vulnerable body regions. The aim is a balanced loading according to the biomechanical properties of each body region and therefore a proper protection of the occupant in a PSI event.

However we believe that is important to prevent excessive (i.e. non-biofidelic) shoulder loadings.

In order to develop a shoulder assessment criterion the following research has been consulted: PSI-07-13, WS-06-05e, PSI-07-05e, …)

Behavior of the WS50M was analyzed under various loading conditions and environments, as well as in Simulation as in Testing. The force-deflection curve of the shoulder rib seems to have a similar shape in each analyzed data set. No linear dependency between force and deflection could be found for the shoulder rib. The force - deflection curve has a degressive slope and builds up a force plateau between 40 -70 mm deflection.

This indicates that as long the shoulder does not experience severe loading leading to deformations greater than its design specifications, the WorldSID shoulder can be seen as a biomechanical valid load path.

Two options based on the mentioned research can be proposed:

Option 1: using a shoulder deflection stop to limit the deflection of the shoulder rib to a defined deflection (eg. 70mm). Reaching the maximum deflection will cause a sharp increase in shoulder force (bottoming out). This can be detected by a force increase over 3000 N.

Option 2: setting a force limit of [3000 N] (20% higher than the biofidelic limit known from research) to assess a loading leading to a non-biofidelic shoulder behavior.