

Background for validation of reference HBMs for Annex 2 of GTR9-03 proposal

Submitted by the Chair (Republic of Korea) of the Informal Working Group on the Deployable Pedestrian Protection Systems of UN Global Technical Regulation No. 9. *

The text reproduced below was prepared by the experts of the Informal Working Group (IWG) of the Deployable Pedestrian Protection Systems (IWG-DPPS) on UN Global Technical Regulation No. 9 and proposes a background for validation of the reference Human Body Models (HBM) used in Annex 2 of GTR9-03 proposal.

* In accordance with the programme of work of the Inland Transport Committee for 2022 as outlined in proposed programme budget for 2022 (A/76/6 (part V, sect. 20) para. 20.76), the World Forum will develop, harmonize and update UN Regulations in order to enhance the performance of vehicles. The present document is submitted in conformity with that mandate.

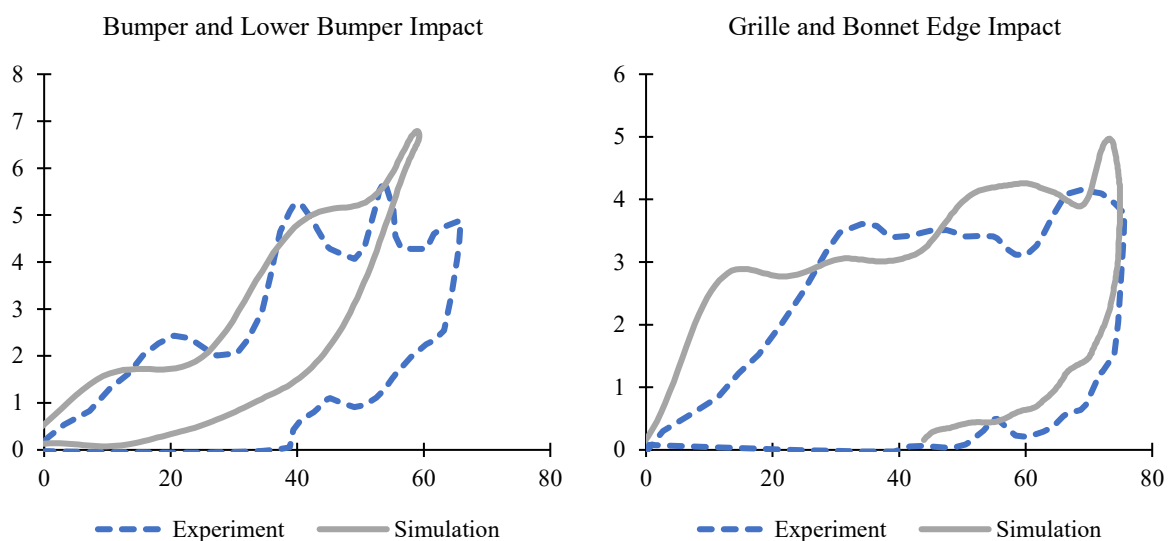
Background - validation of reference Human Body Models

This section contains a description of the validation of the reference AM50 human body models that were used for the definition of the qualification corridors, as depicted in Chapter 2.5 of Annex 2.

The validation procedure, in contrast to the previously described qualification simulations, describes the process towards determination of the degree to which the reference models represent the pedestrian kinematics during real world crashes.

For their individual validations, the different HBMs had to undergo a harmonized procedure. This procedure consisted of simulations of the HBM against a model representing a generic vehicle frontend (SAE buck¹) used in post-mortem-human-subject (PMHS) experiments.² The SAE buck simulation model is part of the THUMS User Community validation repository.³ It has been validated by comparing its responses to previously published impactor tests with a hardware version of the SAE buck¹, shown in Figure A.6.

Figure A.6
Impactor responses of SAE bucks used for Human Body Model validation



The HBM responses were compared to scaled corridors² derived from three tests with PMHS. The procedure used for the validation of those models that were used for the qualification corridors is limited to the purpose of pedestrian Head

¹ Pipkorn, Bengt; Forsberg, Christian; Takahashi, Yukou; Ikeda, Miwako; Fredriksson, Rikard; Svensson, Christian; Thesleff, Alexander (2014): Development and component validation of a generic vehicle front buck for pedestrian impact evaluation. In: 2014 IRCOBI Conference Proceedings.
http://www.ircobi.org/wordpress/downloads/irc14/pdf_files/82.pdf

² Forman, J. L.; Hamed Joodaki; Ali Forghani; Patrick Riley; Varun Bollapragada; David Lessley et al. (Hg.) (2015): Biofidelity Corridors for Whole-Body Pedestrian Impact with a Generic Buck. International Research Council on the Biomechanics of Injury. Lyon, France. Online verfügbar unter
http://www.ircobi.org/wordpress/downloads/irc15/pdf_files/49.pdf

³ <https://tuc-project.org/whole-body-pedestrian-impact/>

Impact Time (HIT) and Wrap Around Distance (WAD) calculation. It is not suited to qualify for injury assessment in this or any other crashworthiness regulation. If HBMs are intended for extended usage, more enhanced validations are needed.

To validate the very same model, which is used for the qualification simulations, the HBM posture was not aligned with the PMHS tests, but corresponded to Table 2-1 of Annex 2 instead. The main difference between the posture from the PMHS tests and Table 2-1 is the arm posture (the PMHS leg position and the proposed HBM position both target the SAE J2782⁴ measures and are therefore comparable). Previous studies have shown that the arm posture effects HIT by roughly ± 3 ms⁵ which is smaller than the range of results observed in the PMHS study.

The HBMs were positioned vertically relative to the SAE buck such that AC (as defined in Fig. A.3) is positioned at a height of 932 mm. (Based on the offset between H-Point and pelvis reference point used for tracking defined in SAE J2782⁴, the provided location of the pelvis reference point² was offset by 73 mm to convert it to the AC location. The minimum value of the pelvis reference point from the corridor was taken to ensure that HC requirements from Table 2-1 are not contradicted.)

For the lateral position, AC was aligned with the vehicle centreline.

No ground floor was modelled. Gravity was applied and the HBM was positioned as close as possible to the vehicle model. The SAE buck model driving towards the HBM with an initial velocity of 40 km/h. The same contact settings as defined in 2.2 were used (i.e. the static and dynamic coefficient of friction between the car and the HBM is set to 0.3.).

All outputs as described in 2.3. were generated and analysed. From the simulations, the HIT was calculated according to 3.3. All reference HBMs fulfilled the criteria defined in Table 2-11, based on the scaled corridors from the PMHS tests² (transformed to the coordinate system defined in Figure A.1) while also fulfilling all quality checks defined in 2.4. For the calculation of ΔHC_x , HC_x was offsetted with its value at the time of first contact with the vehicle to be in line with the PMHS tests.² For the HIT, the mean value from the PMHS tests was taken and a tolerance of +5 percent and -10 percent was added (consistent to the trajectories as specified in SAEJ2868.⁶

[Table 2-11
Validation of AM50 HBMs

<i>HIT [ms]</i>		<i>ΔHC_x [mm]</i>		<i>HCz [mm]</i>	
Min	Max	Min	Max	Min	Max

⁴ Performance Specifications for a Midsize Male Pedestrian Research Dummy SAE J2782_201911 https://doi.org/10.4271/J2782_201911

⁵ Klug, Corina; Feist, Florian; Raffler, Marco; Sinz, Wolfgang; Petit, Philippe; Ellway, James; van Ratingen, Michiel (2017): Development of a Procedure to Compare Kinematics of Human Body Models for Pedestrian Simulations. In: 2017 IRCOBI Conference Proceedings.

⁶ Pedestrian Dummy Full Scale Test Results and Resource Materials SAE J2868_201010

*HIT [ms]**ΔHCx [mm]**HCz [mm]*

For the other statures, no reference PMHS tests were available. The following reference HBMs have been used for developing the corridors in this Annex.

**[Table 2-12
Reference models used for 6yo and AF05**

*05F**6yo*
