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# Deflection of Deployable Bonnets in DB Systems

**1<sup>st</sup> Meeting of Task Force Deployable Bonnet Systems (TF-DBS)  
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# Background



- Since several years, testing and assessment of vehicles with deployable bonnet systems has been implemented within consumer information programmes such as Euro NCAP
- The Euro NCAP protocol allows for the increasing number of car models with deployable (active) bonnets being tested more appropriately
- However, for impact locations being tested with the bonnet in deployed state, various requirements like
  - the appropriate detection of pedestrians
  - protection potential at higher and lower speeds
  - a correct timing of the bonnet deployment
  - a maximum bonnet deflection due to pedestrian body loading

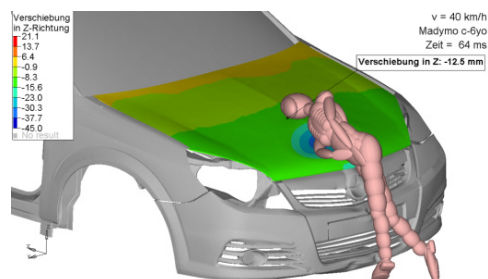
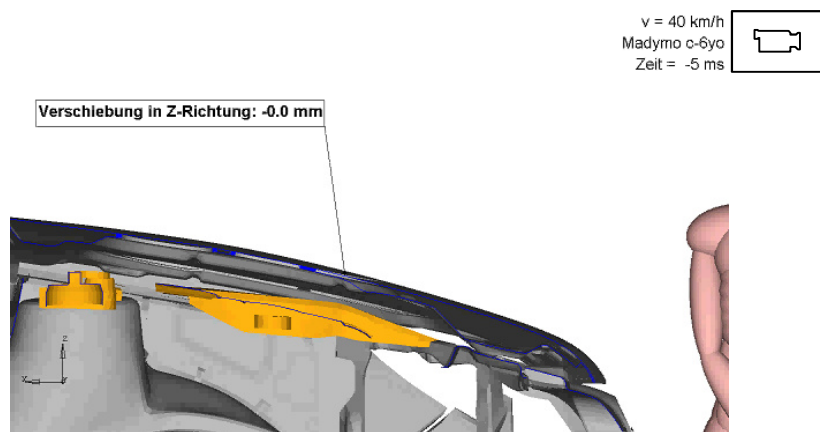
have to be met.

# Bonnet deflection

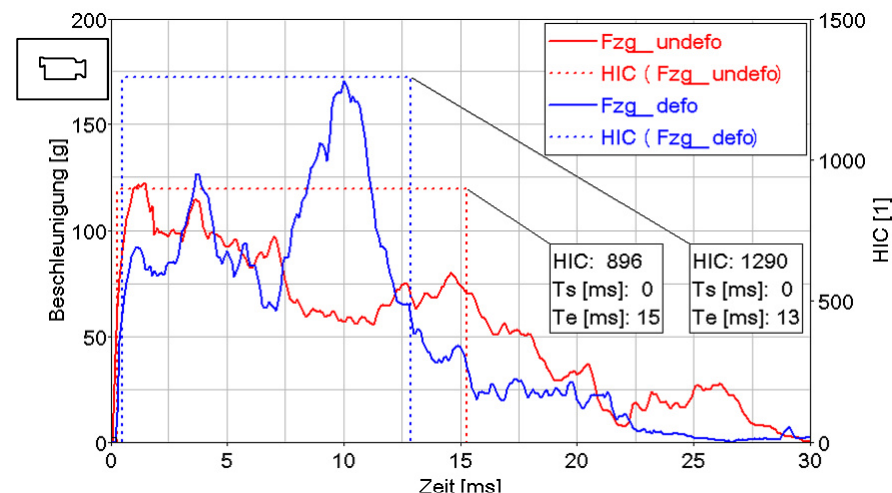


## Influence of upper body on head impact (example: passive bonnet)

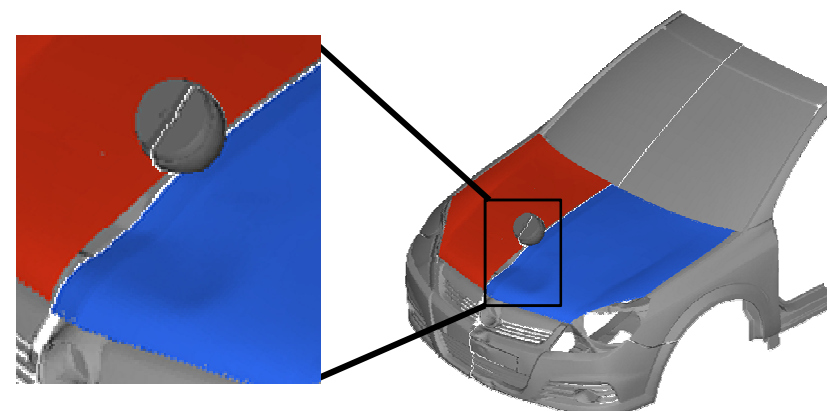
- Bonnet deflection in head impact area caused by upper body
- Pre-deflected bonnet causing higher HIC values



Intrusion in head impact area prior to actual head impact



Time history curves and HIC values



Head impact against pre-deformed and undeformed bonnet

\*Source: Nuss F., Hamacher M., Zander O. (2011)

# Required bonnet clearance



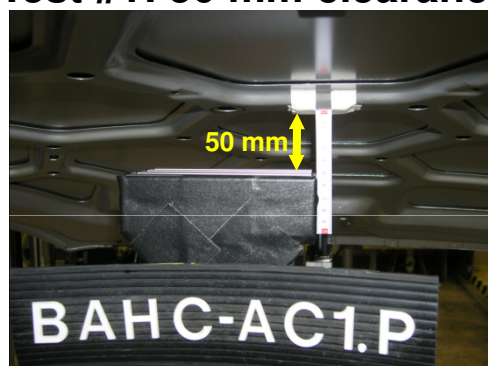
Deployable bonnets need to provide additional deformation space for the pedestrian at head contact position and in the moment of head contact.

Definition of required clearance for bonnet deformation from best practice:

Tests on test rig with 3,5 kg CH impactor

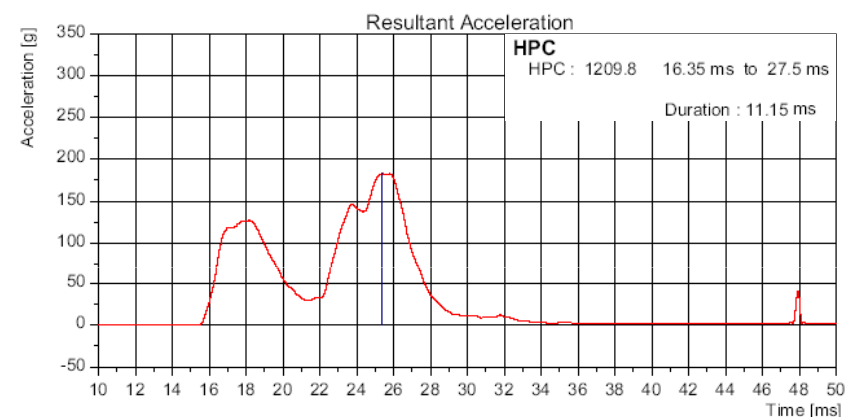
Distance between inner bonnet surface and structure: approx. 50 and 65 mm

Test #1: 50 mm clearance

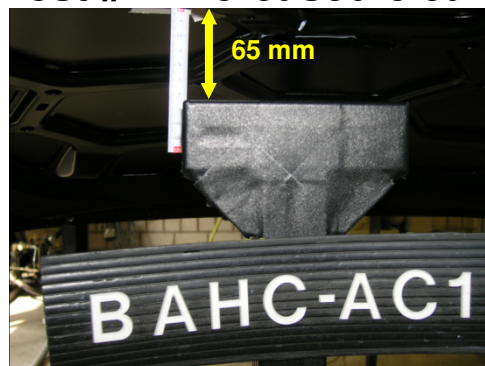


Bottoming out

HPC 1210

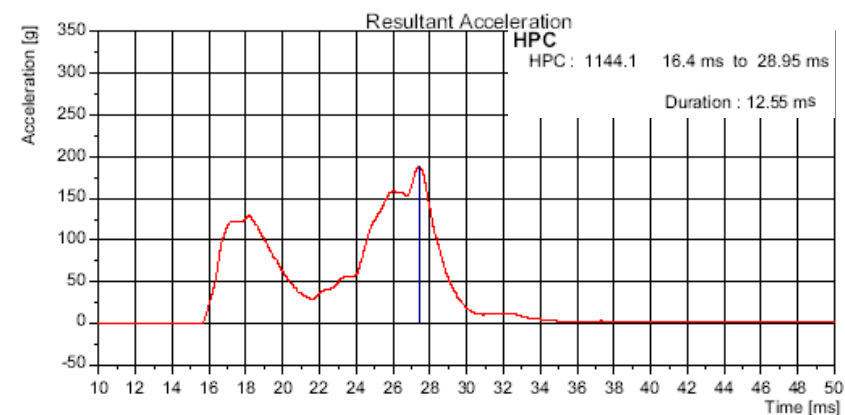


Test #2: increased clearance – 65 mm



Bottoming out

Lower HPC 1144

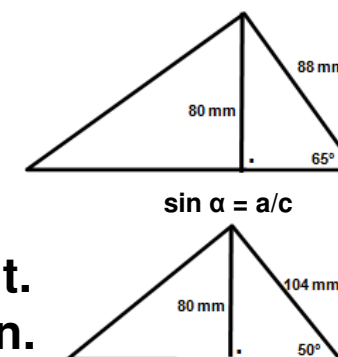


# Proposed new requirement



A clearance of 65 mm between bonnet surface and underlying structure is not sufficient.

Regardless of the deformation space provided by the active / deployable bonnet, in any case a vertically measured clearance of at least 80 mm at head contact position at the moment of head contact is necessary to ensure avoidance of bottoming out. This will be 104 mm for CH and 88 mm for AH in impact direction.



(Annotation: in the windscreen area, Euro NCAP requires a clearance of at least 100 mm in impact direction for defaulting impact points (HPC < 650))

In order to assess the bonnet deflection due to upper body contact at the point and time of head contact, HBM simulations with the appropriate statures are suggested.

HBM simulations should be provided by the OEM.

The vertically measured clearance between bonnet and underlying structure is suggested not to go below 80 mm at the point and time of head impact in all simulated cases.

# Proposal for GTR9



Given that deployable bonnets may have reduced support from their peripheral structures compared to passive systems, it is required that head protection is not compromised by bonnet collapse.

At the point and time of head impact it is therefore essential that the bonnet deflection in the deployed state does not compromise the clearance between deployed bonnet and under bonnet hard point which is necessary to ensure the needed level of head protection. **Therefore, the sum out of vertically measured deployment height and the vertically measured clearance of the undeployed bonnet, both at head impact point, minus the vertically measured deflection of the deployed bonnet must be greater than 80 mm:  $(h2 + h3) - z2 > 80$  mm, see Figure x.**

This can be established using **numerical simulations** at 40km/h with the appropriate sized pedestrians (6YO child, 5<sup>th</sup> female, 50<sup>th</sup> male) that load the least supported parts of the bonnet top for that particular size of vehicle at vehicle centerline and **between WAD 1000 and the bonnet rear reference line**. (For example, on a small vehicle with a short bonnet it may be that the 50th percentile male contacts the vehicle rearward of the bonnet top. Therefore, a smaller pedestrian stature will be required.)

In case of a total clearance less than 80 mm, it has to be proven that the bonnet underneath the head does not reach the underlying structure when impacting the pre-loaded bonnet. If this evidence is not given, the headform tests are to be performed in undeployed state of the bonnet.

Source: Euro NCAP Pedestrian Testing Protocol (modified)

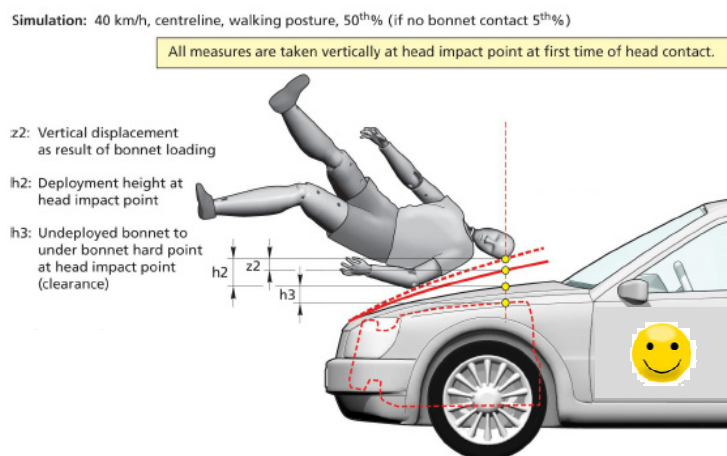


Figure x

## Example

Deployment height  $h2 = 120$  mm

Deflection of active / deployed bonnet  $z2 = 75$  mm

Clearance of passive / undeployed bonnet  $h3 = 50$  mm

Requirement:

$$(h2 + h3) - z2 = > 80$$

$$(120 \text{ mm} + 50 \text{ mm}) - 75 \text{ mm} > 80 \rightarrow \text{ok}$$

# Conclusions

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**Pop up bonnets need to withstand injury risks occurring during real life impact situations.**

**Rigid under bonnet parts within reach are of a high injury risk for VRU and are to be avoided.**

**The bonnet deflection due to upper body loading is expected to have a significant influence on the bonnet clearance at location and time of head impact.**

**Since a value of 30 mm clearance is assumed to be needed to fulfill performance criteria at speeds below the deployment threshold, a fixed value should be also feasible at higher impact speeds.**