Testing Deployable Bonnet Systems within the European New Car Assessment Programme (Euro NCAP)

1st Meeting of Task Force Deployable Bonnet Systems (TF-DBS)
Paris, February 7th & 8th, 2017
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Introduction

- Due to steadily increasing number of vehicles equipped with active bonnets, Euro NCAP developed test procedures for active pedestrian protection systems of passive vehicle safety („pop up bonnets“ etc.)
- 2008-2010: Euro NCAP ad hoc Working Group „Active Pedestrian Protection Systems“
- Main content re. testing of deployable bonnets:
  - Requirements for sensor systems and actuating elements / pedestrian detection
  - Requirements for total response time (TRT) of the system
  - Requirements below the deployment threshold („low speed tests“)
  - Requirements at higher impact speeds (initiation of deployment)
  - Maximum permissible bonnet pre-deflection due to upper body contact
  - Markup of test areas always in closed position
  - State of bonnet for testing dependant on system compliance with prerequisites: undeployed / deployed / dynamically
- Requirements for active systems in Euro NCAP have been implemented from version 5.2 of the testing protocol (dated Nov 2010). Current version 8.3.
Prerequisites - General

- OEM of a vehicle equipped with a deployable system to liaise with the Euro NCAP Secretariat and the test laboratory

- OEM to provide all required information related to the system that is aimed to be tested in deployed position or dynamically to the Euro NCAP Secretariat

- Based on the evidence, Euro NCAP Secretariat to decide if vehicle will be tested with the bonnet or parts of it deployed / undeployed / dynamically

- In case of insufficient information the system will be tested in the undeployed state
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Pedestrian Detection

- Default test tool for giving evidence for the system to detect the hardest to detect pedestrian (HTD): PDI2

- In case of using the PDI2, no CAE data for justifying the HTD needed

- In case of abstaining from the use of PDI2 as representative for the HDT, OEM to demonstrate with an alternative tool the sensor system’s ability to detect a range of pedestrian statures (from 6YO, 5th, 50th, 95th) resulting in head contacts with the vehicle. However, a combination of physical testing and simulations is still needed for demonstration of suitability of sensor system for the range of pedestrian sizes
  
  - Simulations (minimum two per stature) at vehicle centreline and end of bumper test zone to identify the HTD pedestrian and to support the use of an alternative test tool

  - Acceptable models specified in Euro NCAP Technical Bulletin TB013. Pedestrian stances and H-point heights specified in chapters 2.2.2.5 and 2.2.2.6 of the protocol.

  - Minimum output parameters: bumper force, effective mass, energy, bumper intrusion, acceleration (if used as trigger)
Pedestrian Detection (cont’d)

- Physical testing to be used for assessing the capability of the sensing system
- Besides HTD, a surrogate for the “upper limit“ pedestrian will be used
- At least the PDI2 test farthest from sensor to be witnessed by Euro NCAP
- Minimum output parameters: HS film, documentation of test location and test speed, actuator trigger time, evidence of initiation of system deployment

Test matrix:

<table>
<thead>
<tr>
<th>Test</th>
<th>Impactor</th>
<th>Impact point</th>
<th>Speed</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>PDI2/HTD</td>
<td>Directly on localised sensor e.g. accelerometer +/-50mm. If the sensing system uses a combination of contact strip switches and localised accelerometers, the positions of the accelerometers should be used to define the impact locations. For non-localised sensor systems, such as contact switches, test the vehicle centreline.</td>
<td>LT&lt;sup&gt;2&lt;/sup&gt; +/-25km/h</td>
<td>• High speed film • Actuator trigger time • Initiation of deployment</td>
</tr>
<tr>
<td>2</td>
<td>PDI2/HTD</td>
<td>Bumper test zone end, left or right hand side, +/-50mm.</td>
<td>LT +/-25km/h</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>PDI2/HTD</td>
<td>Farthest from sensor(s) if not tested already, +/-50mm.</td>
<td>LT +/-25km/h</td>
<td>• High speed film • Actuator trigger time • Initiation of deployment</td>
</tr>
<tr>
<td>4&lt;sup&gt;3&lt;/sup&gt;</td>
<td>Euro NCAP detailed in Section 9.1 or WG17 impactor to account for larger pedestrians</td>
<td>Directly on localised sensor e.g. accelerometer, +/-50mm. For non-localised sensor systems test directly in line with the front longitudinal member to produce the highest acceleration levels on the impactor. This test may be performed using a representative surrogate with equivalent mass and stiffness to prevent damage to instrumentation.</td>
<td>40km/h +/-25km/h</td>
<td></td>
</tr>
</tbody>
</table>

Notes:
1. HTD = Other appropriate hardest to detect (as defined by section 2.2.1);
2. LT = Lower deployment Threshold.
3. The impacter for test 4 may be chosen by the vehicle manufacturer.

Source: GTR9, Otubushin & Pauer, 2012

Source: Euro NCAP

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Timing of System Deployment

- Impact points that are not affected by active system to be tested statically
- Simulations to be performed, with pedestrian models and codes listed in TB013, representing 6YO, 5th, 50th and 95th, at vehicle centreline
- Simulations to be performed with all pedestrian statures resulting in head to bonnet contact at vehicle speeds of 45 km/h with the bonnet in undeployed state
- Pedestrian stances specified in chapter 2.2.2.5
- In case of a system (other than airbag system) fully deployed and remaining in the intended position prior to HIT of the smallest appropriate pedestrian stature, all headform tests are to be performed with the bonnet in fully deployed position
- Where the system is not fully deployed prior to HIT of any appropriate pedestrian stature, all impact points forwards of the corresponding WAD to be tested dynamically
- Systems not remaining in a permanently deployed position are to be tested dynamically for all impact points
Timing of System Deployment (cont’d)

- For each pedestrian impact location the corresponding WAD and HIT are to be determined from simulation
- Best fit line between all WAD vs HIT plots as well as TRT of the system (provided by OEM) to be depicted in one graph
- From the graph: determination of test method for impact points (deployed position or dynamically):

![Graph showing WAD vs HIT with test method determination]

Source: Euro NCAP Pedestrian Testing Protocol
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Protection below deployment threshold

- Assumption: passive systems providing certain protection also at lower impact speeds. Thus, active systems are also required to have a certain level of protection at speeds below the deployment threshold of the deployable system.

- Applicable to those vehicle parts that are affected by the deployable systems.

- OEM to provide data, giving evidence that no impact point in an area predicted HIC 1350 or less at 40 km/h shall produce HIC values above 1350 at the lower deployment threshold

- Requirement for the prescribed area:
  2/3 HIC 1000

- A maximum of three randomly selected verification tests to be performed

- In case of one or more of the requirements not met: all tests with the system in undeployed state!

Source: Euro NCAP Pedestrian Testing Protocol

Figure 2: Area to meet low speed requirements

Source: Euro NCAP Pedestrian Testing Protocol
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Protection at higher impact speeds

- Requirement: all deployable systems to at least initiate deployment at speeds of $\geq 50$ km/h

- A physical test using the [PDI2/HTD] to be performed at 50 km/h to demonstrate the initiation of the deployment

- Test to be performed at vehicle centreline or as far as possible away from localized sensor, but within the bumper test zone
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Bonnet deflection due to body loading

- Deployable bonnets may have reduced support from their peripheral structures compared to passive systems. Euro NCAP requires that head protection is not compromised by bonnet collapse.

- This is done by measuring and comparing the Z displacement at the position of head contact for both a deployed and undeployed bonnet at the time of first head contact. At the position of head impact the difference between deployed and undeployed bonnet can be no more than 75% of the generated deployment height at that point.

- The evaluation shall be calculated with the use of CAE without the ‘package’ being present.

- At the point of head impact the bonnet deflection in the deployed state may not exceed the total available clearance between deployed bonnet and under bonnet hard point, i.e. \((h2 + h3) - z2 > 0\).

- This would be established using numerical simulations at 40km/h with the appropriate sized pedestrian that loads the least supported part of the bonnet top for that particular size of vehicle. 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.
Bonnet deflection due to body loading

Requirement #1 (w/o package):
1. Undeployed simulation: 40 km/h, centreline, walking posture, 50th % (if no bonnet contact 51st %)
   
   All measures are taken vertically at head impact point at first time of head contact.

   Example:
   
   Deployment height \( h_2 = 100 \text{ mm} \)
   Deflection of active / deployed bonnet \( z_2 = 75 \text{ mm} \)
   Deflection of passive / undeployed bonnet \( z_1 = 50 \text{ mm} \)

   Requirement:
   
   \[ z_2 - z_1 < 0.75 \times h_2 \]
   
   25 mm < 75 mm \( \Rightarrow \) ok

Source: Euro NCAP Pedestrian Testing Protocol

Example (from the protocol):

Deployment height \( h_2 = 100 \text{ mm} \)
Deflection of active / deployed bonnet \( z_2 = 75 \text{ mm} \)
Deflection of passive / undeployed bonnet \( z_1 = 50 \text{ mm} \)

Requirement:

\[ z_2 - z_1 < 0.75 \times h_2 \]

25 mm < 75 mm \( \Rightarrow \) ok

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Bonnet deflection due to body loading

Requirement #2 (w/ package):

Example (from the protocol):

Deployment height $h_2 = 100$ mm
Deflection of active / deployed bonnet $z_2 = 75$ mm
Clearance of passive / undeployed bonnet $h_3 = 30$ mm

Requirement:

$$(h_2 + h_3) - z_2 > 0$$

$130 \text{ mm} - 75 \text{ mm} > 0 \Rightarrow \text{ ok}$$
Pedestrian detection

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Summary
Due to the steadily increasing number of vehicles equipped with active bonnets, test procedures for active pedestrian protection systems of passive vehicle safety („pop up bonnets“ etc.) have been developed.

Main requirements for deployable bonnets are:

- Requirements for sensor systems and actuating elements / pedestrian detection
- Requirements for total response time (TRT) of the system
- Requirements below the deployment threshold („low speed tests“)
- Requirements at higher impact speeds (initiation of deployment)
- Maximum permissible bonnet pre-deflection due to upper body contact

Depending on the compliance with these requirements, deployable bonnet systems are to be tested with the bonnet in the undeployed, deployed or deploying state.

The compliance with these requirements is seen as important not only related to consumer testing but also to corresponding procedures within legislation.
Thank you!