INVESTIGATION OF TEST SEVERITY TO SOLVE COMPATIBILITY PROBLEM OF MODERN CARS

(energetical approach)

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1. AIM OF THE PRESENTATION

2. TEST CONFIGURATIONS INVESTIGATED

3. HYPOTHESIS AND PARAMETERS INVESTIGATED

4. TEST SEVERITY COMPARISON

5. CONCLUSION
Problems

- Accident analysis highlighted problem of compatibility between modern light and heavy cars designed to respect R94 regulation.

What it is needed to solve the problem?

- A change, adapted to light and heavy cars should be introduced as soon as possible in the regulation to switch towards a harmonized fleet
- Improve test severity harmonization between light and heavy cars for the structure and the restraint systems

Application to a test method

- According to previous remarks, the future regulation must integrate a better severity harmonization between light and heavy car (similar EES and delta V)

This presentation investigates the capacity of the two main test candidates to answer this problem and improve the current regulation in a reasonable approach.
TEST CANDIDATES

R94: represents the current regulation and the reference

- R94 amendment (PDB at 60 kph): proposed in Geneva, tentative for solving current problem shown by accident analysis and could be the basis for partner protection introduction.

- MDB Test is shown as a possibility to be introduce in a long term approach as a regulation - two closing speed were investigated:
  - 90 km/h corresponding to a similar severity than R94 amendment for a mass around 1500 kg
  - 112 km/h. This closing speed was proposed by different organizations and probably comes from 2 * 56 km/h.
Test configuration investigated:
- R94 (reference)
- R94 amendment
- MDB@90
- MDB@112

<table>
<thead>
<tr>
<th></th>
<th>R94</th>
<th>R94 Amendment</th>
<th>MDB@90</th>
<th>MDB@112</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trolley mass (kg)</td>
<td>-</td>
<td>-</td>
<td>1500</td>
<td>1500</td>
</tr>
<tr>
<td>Test speed / closing speed (km/h)</td>
<td>56</td>
<td>60</td>
<td>90</td>
<td>112</td>
</tr>
<tr>
<td>Overlap (%)</td>
<td>40</td>
<td>50</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Deformable element face</td>
<td>ODB</td>
<td>PDB</td>
<td>PDB</td>
<td>PDB</td>
</tr>
</tbody>
</table>

Current R94 barrier face was not investigated because results would have been worse in MDB test.
For all test configuration is calculated the order of magnitude:
- EES in kph vs Mass (to evaluate severity for the structure)
- Delta V in kph vs Mass (to evaluate severity for the restraint system)

**Hypothesis:**
Energy absorbed by the ODB barrier: 45 kJ
Energy absorb by the PDB, see figure

Two categories of car mass representing an issue in different part of the world were investigated in more detail:
- Light car: 1000 kg (S)
- Heavy car: 2400 kg (H)
Mass ratio parameter must be take into account to calculate test severity in addition of the energy absorbed by the barrier.
closing speed: 112 km/h - trolley mass: 1500 Kg - Obstacle: PDB

Momentum conservation introduces important and linear differences
trolley mass: 1500 Kg - Deformable element: PDB

Mass ratio = 1

 MDB@112 is severe for light and heavy cars

MDB@90 is severe for light cars
Delta V of the vehicle in MDB Test

trolley mass: 1500 kg

- MDB@90 is less severe for all car mass
- MDB@112 is severe for light cars
<table>
<thead>
<tr>
<th></th>
<th>Delta V</th>
<th>EES</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>R94 (reference)</strong></td>
<td></td>
<td></td>
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<tr>
<td>Delta V</td>
<td>56</td>
<td>56</td>
</tr>
<tr>
<td>EES</td>
<td>45</td>
<td>51</td>
</tr>
<tr>
<td><strong>R94 amendment</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Delta V</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>EES</td>
<td>49</td>
<td>50</td>
</tr>
<tr>
<td><strong>MDB @ 90</strong></td>
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<td></td>
</tr>
<tr>
<td>Delta V</td>
<td>53</td>
<td>35</td>
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<tr>
<td>EES</td>
<td>59</td>
<td>44</td>
</tr>
<tr>
<td><strong>MDB @ 112</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Delta V</td>
<td>67</td>
<td>46</td>
</tr>
<tr>
<td>EES</td>
<td>80</td>
<td>62</td>
</tr>
</tbody>
</table>

According to momentum conservation, important severity differences are observed in MDB test configuration between light and heavy cars.
Above the line 100, the test is severe than current R94
TEST SEVERITY AND HARMONISATION CAPABILITY

**Diagram Description:**

- The diagram plots delta V (energy) against EES (effectiveness) on a 2D graph.
- Key points include:
  - R94 Amendment
  - MDB 90
  - MDB 112

- **Legend:**
  - Red circle: Light car
  - Purple square: Heavy car

- The graph illustrates the severity and harmonisation capability of different reference points, such as R94 reference and R94 Amendment.
Severity Parameter (SP)
SP parameters is the combination of EES and delta V to give an approximation of the global test severity

\[ SP = (EES \times \text{delta V}) \quad \text{km/h} \]

Harmonisation Parameters (HP)
HP parameters is the difference of severity between light and heavy cars (%)
For the same test configuration:

\[ HP = (\text{SP light car} - \text{SP heavy car}) / \text{SP mini} \]
R94 amendment severe for light and heavy cars
MDB@90 less severe for heavy cars / R94
MDB@112 very severe for light cars / R94
TEST SEVERITY HARMONISATION

- Test severity harmonization:
  - close to 0 with R94 amendment
  - important difference in MDB Test
Remark and reminder:

HP of 7% today is responsible for a part of the compatibility problem showed by German and French data.
### TESTS SEVERITY SUMMARY

<table>
<thead>
<tr>
<th>Test Severity / R94</th>
<th>Light car</th>
<th>Heavy car</th>
<th>Test Severity Harmonisation Light / Heavy</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>R94 amendment</strong></td>
<td>Delta V</td>
<td>🔄 🔄 🔄 🔄</td>
<td>🭕</td>
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<tr>
<td></td>
<td>EES</td>
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<tr>
<td><strong>MDB @ 90</strong></td>
<td>Delta V</td>
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<tr>
<td><strong>MDB @ 112</strong></td>
<td>Delta V</td>
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<tr>
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➢ Inhomogeneous severities are observed
CONCLUSIONS: SEVERITY

- MDB test is supposed to reflect car to car accident, however, it is not obvious after considering physics and energetical effects.

- For a large range of mass ratio, MDB is less severe than fixed barrier.

- MDB increases the severity difference between light and heavy cars.

- MDB generates numerous problems, some of them without solution.

- Before finding a solution that could allow us to introduce MDB, fixed barrier remains a simple and reliable solution to answer most of the compatibility problems.
THANK YOU FOR YOUR ATTENTION

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Blog: www.pdb-barrier.com