Evaluation of Road Restraint Systems by an Accredited Test House in the Context of European Standardisation

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Building Tomorrow’s Transport Infrastructure in South-East Europe

Belgrade
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Crash Testing of Roadside Barriers

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Evaluation of Road Restraint Systems by an Accredited Test House in the Context of European Standardisation

**Standardisation**

**Road Restraint Systems**

- **European Directive on Construction Products**
  - (CE marking)

- **CEN M/111 Mandat**
  - Fixed Road Equipments

- **CEN/TC226/WG1**
  - Crash barriers, safety fences, guard rails and bridge parapets

- **EN 1317 standard**

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**EN 1317**

Road restraint systems

- **EN 1317-1**: Terminology and general criteria for test methods
- **EN 1317-2**: Performance classes, impact test acceptance criteria and test methods for safety barriers
- **EN 1317-3**: Performance classes, impact test acceptance criteria and test methods for crash cushions
- **ENV 1317-4**: Performance classes, impact test acceptance criteria and test methods for terminals and transitions of safety barriers
- **prEN 1317-5**: Product requirements, durability and evaluation of conformity
- **prEN 1317-6**: Parapets for pedestrians
Definition (prEN 1317-5):

A competent laboratory which measures, examines, tests, calibrates or otherwise determines the characteristics or performance of materials or products within the scope of this standard.

A laboratory accredited by a signatory of EA (European co-operation for Accreditation) or the appropriate statutory instrument, within the scope of this standard, in the territory where the test was executed may be presumed to be competent.

ISO/CEI 17025
General requirements for the competence of testing and calibration laboratories

EN1317 – 1

EN 1317- 1 : Terminology and general criteria for test methods

Road Restraint Systems

Vehicle Restraint Systems

Safety Barriers

Terminals and Transitions

Crash Cushions

Pedestrian Parapets

Pedestrian Guardrails

Vehicle Parapets
Test Vehicles

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>Mass (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>passenger vehicle</td>
<td>900</td>
</tr>
<tr>
<td>passenger vehicle</td>
<td>1300</td>
</tr>
<tr>
<td>passenger vehicle</td>
<td>1300</td>
</tr>
<tr>
<td>passenger vehicle</td>
<td>1500</td>
</tr>
<tr>
<td>passenger vehicle</td>
<td>1500</td>
</tr>
<tr>
<td>rigid truck</td>
<td>10000</td>
</tr>
<tr>
<td>rigid truck</td>
<td>13000</td>
</tr>
<tr>
<td>bus</td>
<td>16000</td>
</tr>
<tr>
<td>rigid truck</td>
<td>30000</td>
</tr>
<tr>
<td>articulated truck</td>
<td>38000</td>
</tr>
</tbody>
</table>

No specific vehicle model nor vehicle age is defined. Test houses are free to use the vehicles they want.

Severity Indices

ASI : Acceleration Severity Index

Maximum value of ASI (t) plot obtained from vehicle Centre of Gravity accelerations (x, y, z)

\[ASI(t) = [(a_x/12)^2 + (a_y/9)^2 + (a_z/10)^2]^{1/2}\]
EN1317 – 1

Severity Indices

THIV : Theoretical Head Impact Velocity (m/s)
Speed of a theoretical head when contact with a theoretical box

PHD : Post-impact Head Deceleration (g)
Maximum deceleration of this theoretical head after impact (informative criteria)

EN1317 – 2 safety barriers

EN 1317-2 : Performance classes, impact test acceptance criteria and test methods for safety barriers

Barriers installed on stabilised soil, asphalt or concrete (bridge barriers)
Evaluation of:

1- the impact severity
2- the containment level and the deformation
### Containment levels

<table>
<thead>
<tr>
<th>CONTAINMENT</th>
<th>LEVEL</th>
<th>TEST</th>
</tr>
</thead>
<tbody>
<tr>
<td>low angle</td>
<td>T1</td>
<td>TB 21</td>
</tr>
<tr>
<td></td>
<td>T2</td>
<td>TB 22</td>
</tr>
<tr>
<td></td>
<td>T3</td>
<td>TB 41 + TB 21</td>
</tr>
<tr>
<td>normal</td>
<td>N1</td>
<td>TB 31</td>
</tr>
<tr>
<td></td>
<td>N2</td>
<td>TB 32 + TB 11</td>
</tr>
<tr>
<td>high</td>
<td>H1</td>
<td>TB 42 + TB 11</td>
</tr>
<tr>
<td></td>
<td>H2</td>
<td>TB 51 + TB 11</td>
</tr>
<tr>
<td></td>
<td>H3</td>
<td>TB 61 + TB 11</td>
</tr>
<tr>
<td>very high</td>
<td>H4a</td>
<td>TB 71 + TB 11</td>
</tr>
<tr>
<td></td>
<td>H4b</td>
<td>TB 81 + TB 11</td>
</tr>
</tbody>
</table>

### Test types

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>Mass (kg)</th>
<th>Speed (km/h)</th>
<th>Angle (°)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TB 11 Car</td>
<td>900</td>
<td>100</td>
<td>20</td>
</tr>
<tr>
<td>TB 21 Car</td>
<td>1300</td>
<td>80</td>
<td>8</td>
</tr>
<tr>
<td>TB 22 Car</td>
<td>1300</td>
<td>80</td>
<td>15</td>
</tr>
<tr>
<td>TB 31 Car</td>
<td>1500</td>
<td>80</td>
<td>20</td>
</tr>
<tr>
<td>TB 32 Car</td>
<td>1500</td>
<td>110</td>
<td>20</td>
</tr>
<tr>
<td>TB 41 Rigid Truck</td>
<td>10000</td>
<td>70</td>
<td>8</td>
</tr>
<tr>
<td>TB 42 Rigid Truck</td>
<td>10000</td>
<td>70</td>
<td>15</td>
</tr>
<tr>
<td>TB 51 Bus</td>
<td>13000</td>
<td>70</td>
<td>20</td>
</tr>
<tr>
<td>TB 61 Rigid Truck</td>
<td>16000</td>
<td>80</td>
<td>20</td>
</tr>
<tr>
<td>TB 71 Rigid Truck</td>
<td>30000</td>
<td>65</td>
<td>20</td>
</tr>
<tr>
<td>TB 81 Articulated Truck</td>
<td>38000</td>
<td>65</td>
<td>20</td>
</tr>
</tbody>
</table>
Example of Test types

Qualitative criteria:
- no ejection of parts
- no vehicle rollover, containment of the vehicle
- VCDI (Vehicle Cockpit Deformation Index)
- exit trajectory must comply with the « CEN box »

Quantitative analysis:
- computed criteria:
  - ASI: Acceleration Severity Index
  - THIV: Theoretical Head Impact Velocity (m/s)
  - PHD: Post-impact Head Deceleration (g)
- working width of the barrier
### EN1317 – 2 Safety Barriers

#### Test Analysis

<table>
<thead>
<tr>
<th>Severity class</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>ASI = 1.0, THIV = 33 km/h (PHD = 20 g)</td>
</tr>
<tr>
<td>B</td>
<td>ASI = 1.4</td>
</tr>
<tr>
<td>C</td>
<td>ASI = 1.9</td>
</tr>
</tbody>
</table>

Class C is under discussion

#### Working Width - $W$

Maximum dynamic deflection of the barrier

<table>
<thead>
<tr>
<th>$W$ classes</th>
<th>Valeur (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>W1</td>
<td>W = 0.6</td>
</tr>
<tr>
<td>W2</td>
<td>W = 0.8</td>
</tr>
<tr>
<td>W3</td>
<td>W = 1.0</td>
</tr>
<tr>
<td>W4</td>
<td>W = 1.3</td>
</tr>
<tr>
<td>W5</td>
<td>W = 1.7</td>
</tr>
<tr>
<td>W6</td>
<td>W = 2.1</td>
</tr>
<tr>
<td>W7</td>
<td>W = 2.5</td>
</tr>
<tr>
<td>W8</td>
<td>W = 3.5</td>
</tr>
</tbody>
</table>
EN1317 – 3 crash cushions

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EN 1317-3: Performance classes, impact test acceptance criteria and test methods for crash cushions

Evaluation of:

1- the impact severity
2- the containment level and the deformation

Test definition

<table>
<thead>
<tr>
<th>vehicles</th>
<th>900 kg, 1300 kg, 1500 kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>angle</td>
<td>frontal: centred, 15°, offset ¼ vehicle, lateral: 15°, 165°</td>
</tr>
<tr>
<td>speeds</td>
<td>50 km/h, 80 km/h, 100 km/h, 110 km/h</td>
</tr>
</tbody>
</table>
EN1317 – 3 crash cushions

Ex: Test TC 1.2.100 - R25 (1300 kg) / 100 km/h

Test analysis

Qualitative analysis:
- control of ejections
- control of vehicle trajectory

Quantitative analysis:
- computed criteria:
  - ASI: Acceleration Severity Index
  - THIV: Theoretical Head Impact Velocity (m/s)
  - PHD: Post-impact Head Deceleration (g)
- deflexion of crash cushion
**Terminals and transitions**

**ENV 1317-4**: Performance classes, impact test acceptance criteria and test methods for terminals and transitions of safety barriers

- Terminals: 4 tests
  - Evaluation of:
    - 1- the impact severity
    - 2- the extremity deformation
    - 3- the vehicle trajectory
EN1317 – 4 terminals and transitions

Terminals

the impact severity

<table>
<thead>
<tr>
<th>Severity class</th>
<th>criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>ASI = 1.0 and THIV = 33 km/h pour essais 4 et 5 THIV = 44 km/h pour essais 1 et 2 + (PHD = 20 g)</td>
</tr>
<tr>
<td>B</td>
<td>ASI = 1.4</td>
</tr>
</tbody>
</table>

Test conditions:

Equivalent with EN1317-2 test conditions

(impact point depends on the length of the removable barrier)

Evaluation of:

1- the impact severity

2- the containment and the deformation level

Following EN1317-2 criteria
Over and Above EN1317

EN1317 defines severity and containment tests in typical conditions

BUT

What about the barrier performance in real use conditions:
- Different soil conditions
- Barriers in curves
- Different vehicle types
- Different vehicle speeds and angles
- Different barrier lengths and extremity conditions

Proposal for a study on a rating test procedure
(cf EuroNCAP vs. vehicle passive safety standards)

LIER test procedure

Hybrid II dummy with a Hybrid III head and neck
Speed: 60 km/h - Angle: 30°

2 tests configurations:
- Dummy parallel to the barrier
- 30° angled dummy position (direct impact with the head)

Motorcyclist Protection
Motorcyclist Protection

UNE-135900
Performance assessment of the roadside motorcyclist protective devices

- Localised protection vs. Continuous systems
- Hybrid III dummy
- One launching position:
  - Impact speed: 60 km/h

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Trajectory 1: post centered
Trajectory 2: post offset
Trajectory 3: bay centered

UNE-135900

localised systems
continuous systems

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Motorcyclist Protection

2 severity classes depending on biomechanical criteria:

<table>
<thead>
<tr>
<th>Level</th>
<th>HIC36</th>
<th>Fx (N)</th>
<th>Fz traction (N)</th>
<th>Fz compression (N)</th>
<th>Mx (Nm)</th>
<th>My extension (Nm)</th>
<th>My flexion (Nm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>650</td>
<td>Diagram</td>
<td>Diagram</td>
<td>134</td>
<td>42</td>
<td>190</td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>1000</td>
<td>Diagram</td>
<td>Diagram</td>
<td>134</td>
<td>57</td>
<td>190</td>
<td></td>
</tr>
</tbody>
</table>

Research activities

ROBUST european project
(Road Barrier Upgrade of Standards)

WP1 – Barrier performance from real life accidents
WP2 – Collection of test data From EU laboratories
WP3 – Instrumentation & measurement
WP4 – Full scale tests
WP5 – Computational mechanics
WP6 – Comparison & selection of severity criterion
WP7 – Dissemination
WP8 – Project Management
Simulation

Typical use of computational mechanics:

- Original product
- Experimental crash test
- Validated model
- Simulations of different conditions of use
- Simulations of modified product
- Certification of the product
- Certification of the modification
- To answer users questions

CM-E working group
(sub-group of CEN TC226/WG1/TG1)

- To investigate and develop the application of computational tools for use in the standardisation of road equipments (for modified products)
- To define model requirements for test vehicles and road equipment
- To define an objective validation procedure for simulations
- To define reporting procedures for simulations (data output, variables, etc)