A voluntary safety excellence labelling: A way ahead for Road Restraint Systems (RRS)?

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ABSTRACT

The paper delivers a short state-of-the-art analysis of the current status of Road Restraint System (RRS) certifying practices following the minimum requirements defined by the current version of EN 1317 standard for crash testing and verification of said systems (CEN, 2010). Introduced back in 1998, the CEN standard EN 1317 defines testing and certification procedures for safety barrier, crash cushions, end terminals and transitions. After decades of application, a growing sentiment in the market is that the safety performance of this type of products has decreased (in favour of increasingly cheaper products) following the absence of a sound market surveillance rendering suitable indicators to distinguish those products that provide greater quality and safety.
In this paper, some recent technical work performed by the Technical Sub-Committee on Road Restraint Systems of the Smart Transportation Alliance is laid out, documenting a range of heterogenous crash-test results across European test houses within the framework of a crash-testing campaign. Finally, the paper proposes a voluntary excellence labelling for the manufacturers of barrier systems, to review crash behaviour and highlight those products with better safety features.

1. INTRODUCTION

In Europe today, 19,800 fatalities happen every year, amounting to a monumental 1.287 million lives impacted by road accidents (European Commission, 2022). Furthermore, for every fatality on Europe's roads, it can be calculated that 4 people will become permanently disabled, 10 will suffer brain or spinal cord damage, 10 will be seriously injured and 40 will have sustained minor injuries. EU's road accidents amount to approximately €130 billion annually, representing a major cost for society at large and making up approximately 2% of the GDP of most Member States today (European Commission, 2010).
The EU seeks to reduce road fatalities by 50% in 2030, and back in the day supported CEN introducing the EN1317 standard for improved safety of barriers, guardrails, crash cushions, terminals and transitions. This standard is influential in 30-40% of all road fatalities.
A significant problem today is the proliferation of low-cost products on the market, with hardly any technological improvements but an 'incredible' performance, which seem impossible to reproduce in subsequent tests carried out by independent third parties. The absence of an effective market surveillance, in addition the fact that price seems to be the only selection factor in public procurement for a given performance of this type of products, appear to contribute decisively to the situation.

1.1. EN 1317 STANDARD

The standard introduced a revolutionary detail to crash test requirements for road restraint systems at the time. Nevertheless, an update of the standard seems reasonable to reflect

technical developments within the last 13 years in terms of both new vehicle typology and road barrier efficiency. In other words, the bar for road safety systems should always be ambitious to enforce a high standard across all European roads.
The EN1317 standard was reworked in 2010 for the last time. It defines the crash test and certification conditions and requirements, dealing with 7 containment levels according to the impact severity they withstand. 5 different features are observed within the test to assess the safety levels of any given system and which are explored briefly in the following subsections:

1. Containment level (restraint capability);
2. Impact severity (ASI, THIV);
3. Deformation (W, D);
4. Redirection;
5. Others (VCDI, detached pieces, etc.).

Containment Level

The containment level of any tested system reflects its ability to hold back vehicles. Depending on the vehicle fleet mix of a road, different levels of containment may be adequate: low, normal, higher, very high. The classification is dependent on the total impact energy of vehicles (Brunksi et al., 2019)

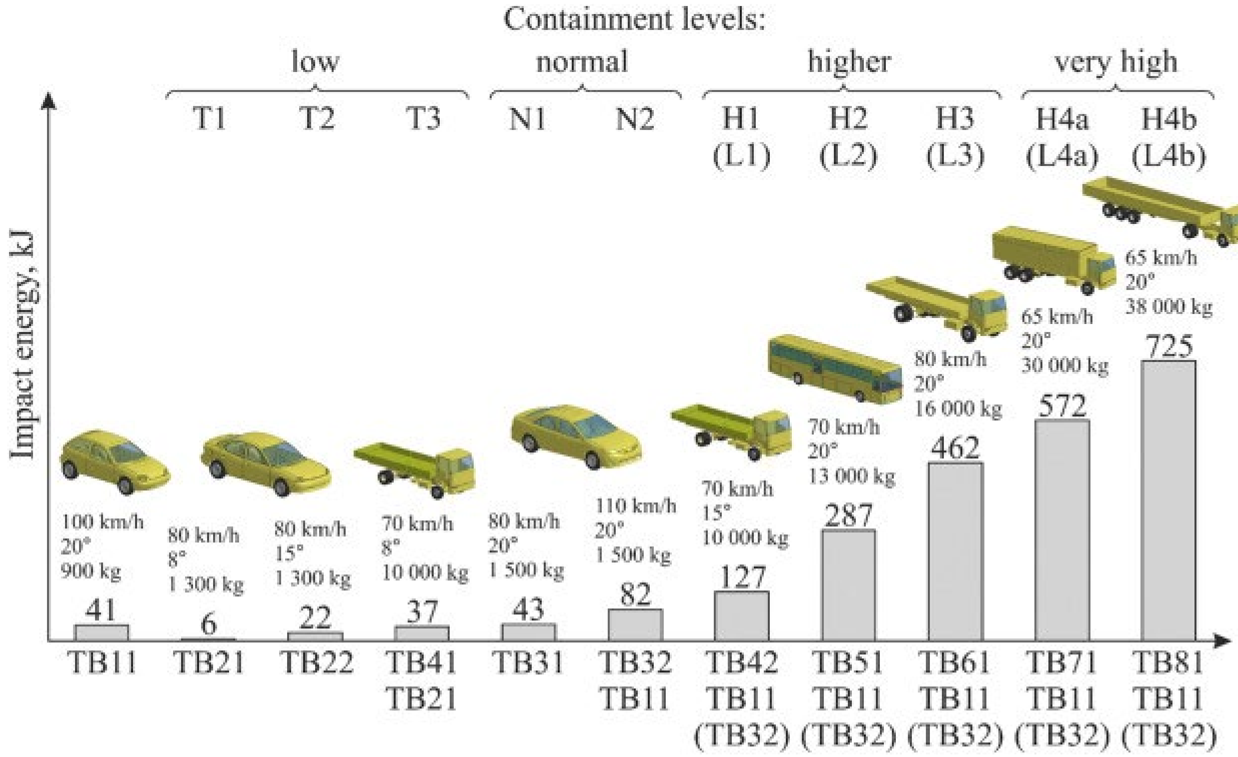


Figure 1 - Containment levels of EN1317 (Source: Brunksi et al., 2019)

Impact Severity

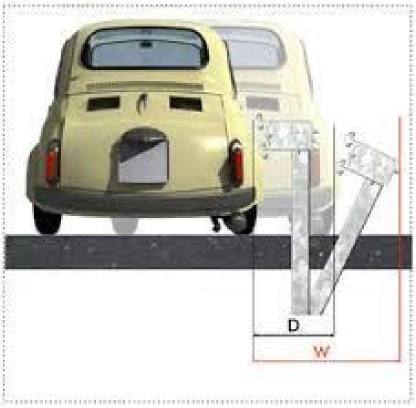
The impact severity level is reflected via the Acceleration Severity Index (ASI), which is measured via accelerometers on-board of the crash test vehicle during the collision with the barrier system. Additionally, a Theoretical Head Impact Velocity (THIV) assesses the damage that would have been inflicted on a passenger on-board the vehicle, wherein the head of the theoretical passenger is considered as a free moving object within the vehicle.

Table 1 - Impact severity levels per ASI and THIV values

Level/Class	Maximum values	
A	ASI ≤ 1,0	THIV ≤ 33 km/h
B	1,0 < ASI ≤ 1,4	
C	1,4 < ASI ≤ 1,9	

Deformation

The deformation of the barrier system is measured by the Dynamic Deflection (D), which describes the maximal lateral displacement of the traffic face produced during the impact and the Working Width Classes (W), which is split into 8 classes.



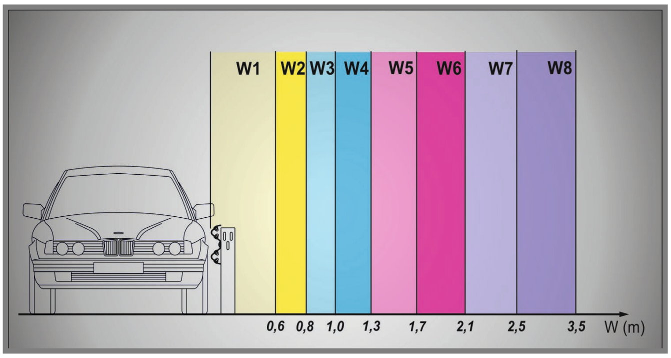


Figure 2 - EN1317 dynamic deflection and working width classes of barrier (l.) & working width classes overview (r.)

Redirection

Road restraint systems should aim at redirecting the vehicle back onto the driving lane and do so in the safest way possible, meaning avoiding that the vehicle leaves the road (run-off collisions and roadway departures) but also avoiding a catapult effect, wherein the driver has no chance of regaining control over the vehicle and/or endangers other oncoming or passing traffic.

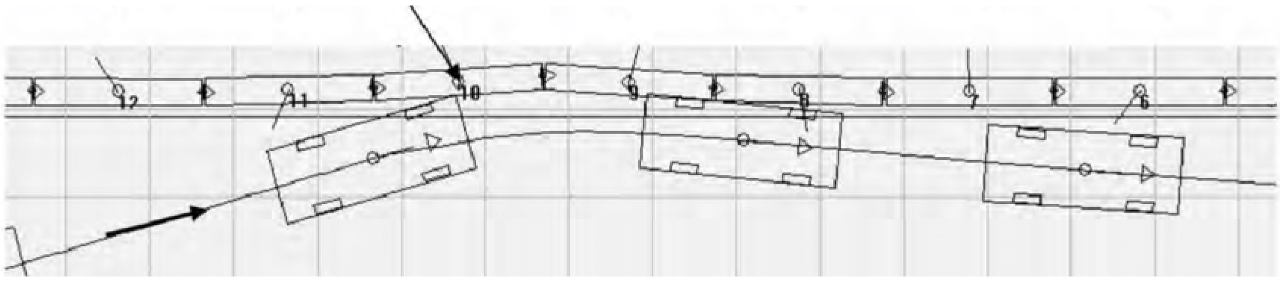


Figure 3 - Vehicle redirection (Source: Prochowski, 2010)

Others

Additionally, some other factors can impact the safety rating of a road barrier system, such as the Vehicle Cockpit Deformation Index (VCDI), which gives an indication on the degree of deformation of the vehicle itself or the number and extend of detached parts of the barrier system upon impact of the vehicle.

1.2. EU REGULATION 305/2011

The administrative process of crash testing and certification of systems is also defined in another 2011 European Regulation (European Parliament and European Council, 2011). It states that apart from a Declaration of Performance (DoP) issued by the manufacturer, a Certificate of Constancy of Performances (CE) is mandatory. A shortcoming of this Regulation by design is that certification bodies and crash test laboratories can be the same entity, which presents a possible conflict of interest of sorts.

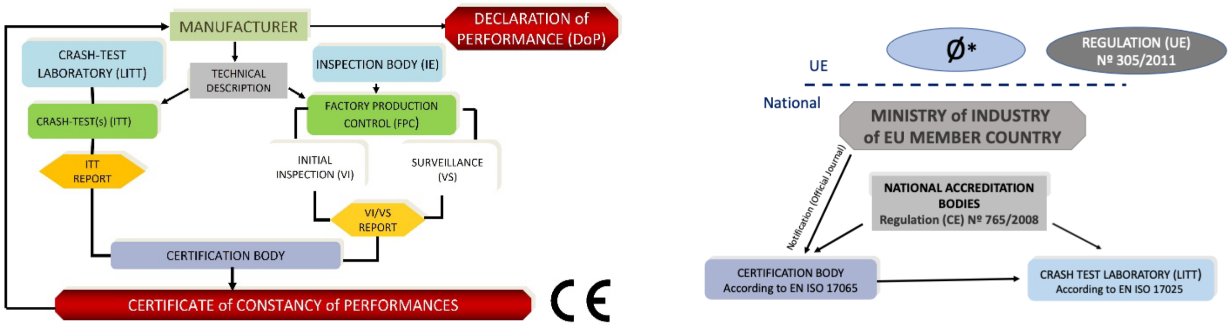


Figure 4 - EU Regulation 305/2011 legal framework

1.3. THE PROBLEM

Certain products with ‘surprising’ performance according to their design should be tested by a centralised European or several national authorities. The absence of such tests has prompted a wave of problematic barrier systems being introduced to the market, which seem to not meet minimum safety requirements and in some cases are not even assembled of the same materials as when they passed the certification process – potentially posing a great danger to Europe’s road safety.

2. TESTS CAMPAIGN

A series of crash tests structured around a round-robin approach were conducted by the Smart Transportation Alliance between 2016 and 2022 across four European countries (Spain, Italy, Austria and France). The tests subjected 3 different RRS to the same standardised testing method and setup. Funded in-house by the Smart Transportation Alliance membership, the tests were also over sought by independent certification bodies to guarantee the neutrality of test results. The purpose of the tests was to verify that the tested barrier systems complied to the EN1317 norm under normal testing conditions. The results are in many cases shocking and reveal serious non-conformities in the assessment and certification processes. All of the systems tested were purchased on the regular market and via commercial channels, which count public authorities and highway concession operators across Europe.

2.1. 1ST ROUND (H2-W4-A)

Subject of the first testing round was a EN1317-certified H2 steel barrier system. A TB51 crash test for containment level H2 and working width W 4 (1.0-1.3 metres) (corresponding to a 13 tons coach, crashing at a 20° angle with 65 km/h). Some inconsistencies were observed when the certification documentation was analysed in detail, which is why the system has been selected for this testing round.

In total, 4 separate crash tests were conducted in laboratories in Spain, Italy, France and Austria. Prof. Vittorio Giavotto of the Polytechnic University of Milan acted as an independent supervisor to certify the validity of the crash tests.
In none of the tests the system achieved the expected performance, resulting in a catastrophic failure in 3 out of the 4 tests:

1. 1st test: System did not contain the vehicle;
2. 2nd test: System did not contain the vehicle;
3. 3rd test: Vehicle exceeded the Working Width in two classes (W4 should be 1.0-1.3 metres, was 1.8 metres instead, indicating a W6 (1.7-2.1 metres));
4. 4th test: System did not contain the vehicle.

i)

ii)

iii)

iv)

Figure 5 - H2-W4-A crash tests (from top to bottom row): i) 1rst test, vehicle not contained, ii) 2nd test, vehicle not contained, iii) 3rd test, system exceeds working width by 2 classes, iv) 4th test, vehicle not contained

In most of these cases, the vehicle did not even bounce off the barrier and instead cut straight through the steel system, indicating a gross failure to adhere to the standards and legislation and presenting a mortal risk in case of single vehicle collisions under real-world conditions by not being able to contain the vehicle on the road at all.

2.2. 2ND ROUND (H4b-W5-B)

The second testing round explored an EN1317-certified pre-cast concrete barrier system of the type H4b. Some inconsistencies were observed when the certification documentation was analysed in detail, which is why the system has been selected for this testing round.

Two tests were conducted on this system:

1. TB11 test: 900 Kg car, crashing at a 20° angle and 100 km/h;
2. TB81 test: 38 tons articulated truck, crashing at a 20° angle and 65 km/h.

Figure 6 – TB81 Tested concrete barrier (l.) & sketch of impact area (r.)

Each of the test, failed and did not pass the minimum requirements set out by the EN1317 standard:

1. TB11: System contained the vehicle, but was wrongly classified, infringing on section 4.7 of the EN1317-2 and section A.5.2 Annex A of the EN1317-5. The ASI value indicates that the barrier should be classified as severity class C (ASI value is 1.53) rather than class B (for ASI values smaller than 1.4) (Stopel, 2021);
2. TB81: During the crash test, the system failed altogether due to complete breakage of the principal element of the barrier. The vehicle did not only break the barrier and stepped over it but also rolled over, resulting in a complete crash. It was also found that the connector between the barrier parts differed substantially from the description of the barrier by the manufacturer (16.5 cm instead of 24 cm).

Both tests present obvious defects in test report and execution and subsequently must have been discarded by the certification bodies as well. It is evident that the barrier is filed under the wrong classifications and even contain different parts than the system which were originally certified. The crash test of the TB81 barrier yielded a dramatic result, as the barrier was designed for median installation and is categorised as “very high containment” to prevent vehicles from entering the road lane heading into the opposite direction of traffic.

Figure 7 - TB11 crash test result ASI value 1.53 (left), TB81 crash test result with rolled over crash vehicle (right)

2.3. 3RD ROUND (H1-W3-A)

In a last testing round, another steel barrier system of the type H1 and working width W of 3 (0.8-1.0 metres) went through a TB42 crash test. This corresponds to a 10 tons rigid truck crashing at a 15° angle with 70 km/h. In total, 2 separate crash tests were organised for this EN1317-certified road restraint system. Bureau Veritas and Asquer acted as independent supervisors to certify the validity of the crash tests and the barrier system materials.

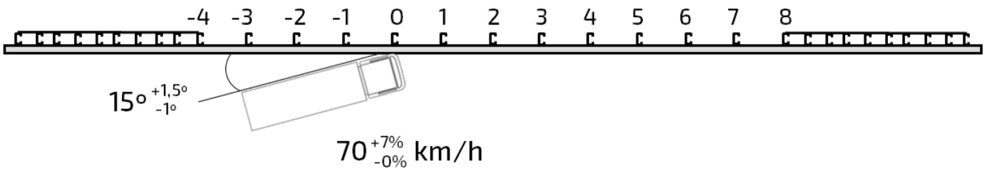


Figure 8 - TB42 sketch of impact area (top), result of crash test with deformed barrier (bottom)

Both tests, conducted in two different laboratories, failed and did not pass the minimum requirements set out by the EN1317 standard:

1. Crash test 1 failure: The barrier did not contain the vehicle, EN1317 not met due to barrier crossing and complete breakage of the principal element of the barrier.

2. Crash test 2 failure: The barrier did not contain the vehicle. EN1317 not met due to barrier crossing of the vehicle.

In this case, both tests failed in a catastrophic way. Both tests were over sought by external certification bodies and in neither case did the barrier contain the vehicle at all. The barriers in question are regularly installed across Europe to contain vehicles on dual carriageways and are labelled officially as “high containment” barriers, suitable explicitly for heavier vehicles and high-risk areas (such as mountain passes). Their purpose as opposed to light vehicle barriers is the retention and redirection of the vehicle, which is not provided.

3. TEST RESULTS

The overall test results are shocking and highlight a huge gap in the assessment and certification of barriers in Europe today: products which actually do not comply with the EN1317 standard are not detected and circulate on the European market. To detect these systems in the future, documentation review will not be sufficient. In order to put effective market surveillance in place, it would make sense that suspicious products with incredible performance (due to mistakes in the documentation but also the design of the product) are tested by an independent body.

4. SAFETY LABELLING

With all the challenges highlighted above and extensive internal testing of the compliance of barrier systems in-house, this paper proposes the introduction of a new voluntary and industry-led Safety Excellence labelling for RRS. Supporting the reduction of road fatalities by 50% in 2030, the labelling would serve in reinforcing and re-establishing a dialogue between road agencies, authorities, standardisation bodies, test houses and the industry to achieve three key objectives:

1. Implementing the instrument of the labelling standards as one further criterion for the participation in public tenders to assure that the documentation and correct technical details of the tested road restraint systems correspond to the documentation of the manufacturer thus supporting the decision possibilities of the road administration.
2. Securing the compliance of EN1317 (assessment of the existing certificate, meaning the quality of the work performed by test houses and certified bodies).
3. Assessing the specific behaviour of RRS products to inform road agencies and consumers of the possible safe applications of a product to specific road sections and/or traffic conditions.

The proposed assessment protocol of the Safety labelling proposed has been applied on several certified RRS to calibrate scoring results across independent experts. The results of this evaluation have demonstrated the added value for all parties. This kind of labelling can help to re-introduce trust and a higher safety standard on the market and could eventually contribute towards an updated EN1317 standard.

5. CONCLUSIONS AND FOOD FOR THOUGHT

After conducting in total 8 crash tests within the tests campaign, all the barrier systems tested failed in achieving the declared performance, and in 7 of the 8 tests, in a catastrophic way. This result illustrates a large underlying systematic problem of the way the European RRS market functions. Citizens should expect increased safety performances after so many years of intensive regulatory, surveillance, industrial and R&D activity.

Several action points can be proposed to improve the quality and reliability of systems across categories and classes:

1. Introduce a voluntary labelling for manufacturers and launch a large-scale outreach campaign targeted at public authorities and operators/owners of road concessions who might be affected by defect RRS on their roads (so as to incorporate the labelling in their procurement processes).
2. Introduce testing by independent existing national or a new EU-wide organisation(s) to verify that the minimum requirements are met and recall faulty products from the market and issue fines for manufacturers whose products do not meeting the minimum EN1317 requirements.
3. Definition (and inclusion in national guidelines) of minimum technical features that deactivate some characteristics of the systems that cause "doubtful" advantages, and these characteristics always related to application conditions (system's height, minimum post length, minimum thicknesses of longitudinal elements, post spacing, debris, etc.).
4. Elaboration and adoption of a new Specification for the evaluation of Vehicle Restraint Systems (going beyond EN 1317, which is mandatory).
5. Revise the EN1317 standard and amend the norm by adapting the minimum requirements to the changes in vehicle fleet compositions (e.g., increasing share of heavier vehicles, introduction of autonomous vehicles and many more) and the technological advancements in the last 12 years (e.g., new steel grades, improved mechanical design of barriers, etc.). It should be expected safety standards to have increased after more than 10 years of intensive R&D activities in almost all manufacturing houses.

All of the action points above require a close-knit cross-national collaboration between national and international institutions and companies, but it seems invaluable to launch such a process to achieve the highest possible standard for reliable Road Restraint Systems of the future and to decrease the share of fatal accidents significantly, saving more human lives on the short and long term.

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