17th ESV Conference 2001

EURONCAP - Views and Suggestions for Improvements

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Abstract

Since its creation in 1996, Euroncap evaluated more than 80 cars, ranging from small and city cars, to larger vehicles such as executive cars and people carriers (MPVs). The testing protocol comprises 3 types of tests: a frontal offset test against a deformable barrier, a 90° lateral impact with a moving deformable barrier , and -since March 2000- a pole side impact. In addition a set of subsystem tests with impactors on the bonnet and the front face of the car are conducted to assess the pedestrian protection.
The aim of this paper is to review the testing and assessment protocols and to compare them with those used in other NCAP systems in the USA, Australia, Japan and Europe. In particular, important Euroncap issues such as the stiffness of heavier vehicles that could be increased in the future, and the nature and weight of the modifiers are discussed. Ways to improve the system are suggested in relation with real world accident data. Improvements are suggested in the areas of knee assessment, and chest assessment in frontal impact. For side impact issues such as the type of barrier and the dummy back plate load are dealt with.

Introduction

EuroNCAP was created in 1996 (1)in UK by a group of experts, with the aim to provide consumers with information on the performance of vehicles in passive safety (2). Another aim of the system is to propose incentive to encourage car makers to provide higher standards, i.e. above the legislative level. Vehicles considered have to meet 4 criteria : 1) to be sold in EU, 2) the tested version is the best selling version and 3) the safety equipment has to be standard in all the 15 member states. The first phase of tests was performed in 1996 and published in February 1997. Since then EuroNCAP conducted 8 phases, including nearly all types of popular cars sold in EU. In terms of membership EuroNCAP includes national administrations from UK, France, Germany and The Netherlands as well as automobile clubs, the Fédération Internationale de l'Automobile FIA and consumers' organisations.

EuroNCAP rating principles were to a certain extend inspired from the NCAP tests conducted in USA since 1978 and Australia since 1992 (3). Basically it consists of establishing performance criteria and rank the vehicles according to the results achieved. The rating is then published in a manner that is readable by the consumer.
EuroNCAP tests are not conducted in the same test house. Since phase 3 where small family cars were tested (4), other laboratories joined the Transport Research Laboratory, TRL. These are : TNO in the Netherlands, ADAC and BAST in Germany, and UTAC in France.

EuroNCAP & The European Safety Environment

For frontal and side impact EuroNCAP considered the European Regulations ECE94 and ECE95 as their basis. For the pedestrian assessment the EEVC WG10 requirements were considered. Since March 2000, EuroNCAP added a side impact pole test as an optional test.
Today EuroNCAP is a recognised institution and its demanding criteria lead to a significant change of the passive safety of the cars sold in Europe. Within few years, an improvement of car design can be observed, which can be illustrated by the reduction of compartment intrusion of the small and city cars. For instance in Phase 7b published in September 2000, the maximum displacement of the A pillar - which reflects the intrusion - was below 150 mm for the 4 stars cars. Another achievement of EuroNCAP in stimulating the

market is the increasing number of cars that reached 4 stars. In Phase 1, the maximum score obtained was 3 stars, while in Phase 7b among the 20 cars tested, 7 obtained 4 stars (5).

Test Procedures

EuroNCAP test procedures comprise 3 crash tests and 3 sets of component tests for pedestrian. Detail description is available in EuroNCAP test protocol (6), therefore only main features of each test will be reported here.

Frontal Test - Based on the European test procedure, it consists of an 40% offset deformable barrier test with the vehicle impacting the EEVC barrier at 64 km/h. In front seats 2 Hybrid III 50° percentile dummies are used. In rear seats child protection is evaluated with an 18-month old dummy and a 3-year old dummy. Figure 1 illustrates this test configuration.

Figure 1: Frontal test according to EuroNCAP

Side Impact Test - Based on the European test procedure it is a 90° impact of a moving deformable barrier (Cellbond version 15) against a stationary car at 50 km/h, as illustrated in Figure 2. In the driver seat the Eurosid 1 dummy is used. For rear seats the same child dummies are utilised as in the frontal test. The barrier centreline is aligned with the vehicle R point.

Figure 2 : Side Impact test according to EuroNCAP.

Pole Impact Test - This test is an optional test. It consists of a side impact where the moving vehicle hits a cylindrical pole at a speed of 29 km/h. The pole has a 254 mm diameter and its vertical axis is aligned with the front seat dummy's head. The test procedure, as shown in Figure 3, is very similar to that in use in USA, the FMVSS 201 except for the test dummy (7). EuroNCAP uses the Eurosid 1 dummy while in the USA the SID is utilised.

Figure 3 : Pole test according to EuroNCAP

Pedestrian Tests - The test procedure is based on the EEVC 10 recommendations. There are 3 sets of tests with specific impactors which involve the bumper for the leg impact, the bonnet leading edge for the upper leg impact and the bonnet for the head impact. For the 3 vehicle parts the impact locations have to be within specified areas.

Assessment Protocol

The assessment protocol of Euroncap, described in reference (8), is based on 3 types of performances :

- Dummy measurements (A) such as HIC for the head, chest deflection, etc...,
- Vehicles static deformation - applicable to frontal impact -, (B)
- Vehicle post crash inspection, (C)

For frontal and side impacts, each body region has a score of 4 points. With 4 body regions for each impact, the maximum score achievable is 16 points. The pole test, with one body region, i.e. the head, weighs 2 points. The total score that is theoretically available in the present protocol is therefore 34 points.

In the frontal impact test, the score of each body region is a function of the dummy measurements A, the vehicle deformation data B and the findings of the inspection C, i.e. modifiers. For instance the score of the thorax and the upper leg can be reduced by 50% due to the modifiers C issued by the inspection. The score of the head and lower leg or foot can be reduced by 25%.

In the side impact and pole tests no modifiers, nor structural data are used for the assessment.

EuroNCAP and World-Wide NCAPs

The NCAP systems world-wide differ either in terms of test procedures, or in terms of performance criteria or both. Table 1 summarises the present situation. For the frontal impact, the offset test against the EEVC barrier is used in 4 countries, while the full front test is used in 2. The side impact 90° barrier test is utilised in 3 countries and the crabbed configuration in 1. Two countries included pedestrian tests in their vehicle assessment and the pole test is applied in one country.

Table 1 : Test configurations in world-wide NCAPs

Country	USA*	USA**	Japan	Australia	EU
Frontal	Full	Offset	Full & Offset	Offset	Offset
Lateral	27°	-	90° barrier ***	90° barrier ***	90° barrier****
Other	-	Rear		Pedes-trian	Side pole & Pedes-trian

*National Highway Traffic Safety Administration
**Insurance Institute for Highway Safety
***European Experimental Vehicle Committee

A review of the assessment protocols shows that EuroNCAP is the most demanding system. This is true especially as regards the frontal impact, where EuroNCAP utilises 16 dummy responses, 5 structural measurements and 6 modifiers resulting from the inspection. Japan NCAP in this case has 8 dummy criteria and 4 vehicle deformation measurements, and no modifiers (9). In the USA, the NHTSA frontal NCAP is based on dummy measurements ; the IIHS rating contains both dummy and vehicle deformation responses.

The differences between NCAP systems in the world combined with specific regulatory demands lead to complicated developments of vehicles (different designs) and generate additional costs. It is important that the harmonisation process includes also the NCAP systems.

Main Technical Issues

There are issues that need to be discussed in order to improve the situation. For the frontal impact these are : the modifiers that are used for the knee contact zone, the head stability when contacting the airbag and the lower leg assessment. In addition, structural enhancements of larger vehicles will contribute to worsen the compatibility situation. For the side impact, there is an intention to adopt a modifier relative to the load transmitted to the dummy back plate of Eurosid 1. For the pedestrian, the fact that the present testing protocol is not applied in the same manner in different laboratories and the contradictory requirements between the insurance test i.e. the low speed collision - and the pedestrian leg test add complications to the development process.

Knee Contact Zone - In the present Euroncap assessment protocol for frontal test, the assessment of the upper leg is first measured by the femur force and knee slider displacement peak values. The score corresponding to these values is then reviewed with two switch modifiers, which may generate a maximum penalty of 2 points. That is 50% of the upper leg score. The assessment is made as follows, on the basis of visual inspection of the dashboard :

1. An area , constructed from the highest knee contact point on the dashboard, is defined as an inspection zone. It is a rectangular section with a length equal to the distance from the centre of the steering column to the edge of the left or right knee impact areas. The height of this section is 100 mm. The depth of the inspection zone is 20 mm (See figure 4).
2. Any rigid structure found in this zone, and which may generate concentrated loading on the knee, will lead to a 1 point penalty.
3. If within this area there are structures that would generate higher femur loads than those measured in the full scale test, then a 1 point penalty is given.

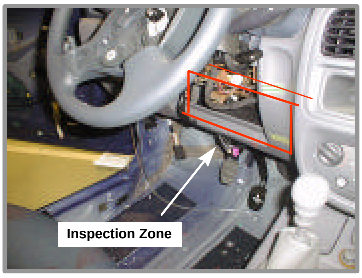

Figure 4 : Illustration of the knee contact zone as defined by the inspection in EuroNCAP

Under the present protocol and according to the results of phase 1 through 7b, there is a high frequency that at least one modifier is applied to the upper leg score. For instance, in phase 7b, all 20 cars involved had 2 modifiers

in the knee area except for one which had one modifier.
The need to improve the situation of the upper leg assessment lead the industry and EuroNCAP Technical Working Group to investigate better ways. A subsystem test, similar to the one shown in Figure 5, could be one the objective methods that might be considered in future phases (10). In terms of vehicle designs, car manufacturers are having troubles with the present situation, as it is difficult to predict the suitability of a given design with EuroNCAP inspection requirements.

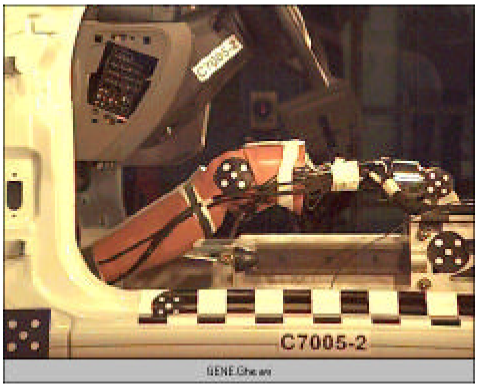

Figure 5 : An example of a subsystem test procedure developed to address the issue of knee assessment in frontal impact.

Head Stability Assessment - This criterion aims at controlling head kinematics with respect to the airbag and steering wheel system. A new requirement was added to the present one in order to identify an airbag bottoming out. A variation of 5G during 3ms in the unloading phase of the head acceleration is used as a criterion for the modifier. There are concerns in the industry as regards this modifier as it may lead to design changes in future driver airbags, resulting in more powerful modules and with possible negative consequences in OOP situations.

Lower Leg Assessment - The lower leg assessment is based on the dummy measures or criteria, i.e. tibia index, tibia axial force, and on vertical and horizontal displacements of pedals. The main issue here is the demanding level of performance that is required for the tibia index parameter, i.e. 0.4 for the green rating. Such a value can be reached with no footwell intrusion in a frontal impact by a translation of the tibia-foot system. One possible consequence of this level of performance is to have countermeasures -padding and or deformable elements - that will be designed to match the rating target, and which may prove inadequate in severe accidents.

Back Plate Load in Side impact - The Eurosid 1 dummy has a back plate that is flat and which can interfere with the seat structure during a side impact. When such event occurs the back plate becomes a load path and may sustain lateral force up to or above 4 kN (11). EuroNCAP is considering to implement a modifier with the intention to differentiate between different designs.

An analysis of the problem was carried out at Renault. Among the concepts tested were seats with 3-point integrated safety belt, which are to be soon introduced in the market. It is expected that such an innovation will contribute - in combination with belt pretensioners and airbag - to real world safety as the belt path over the torso is optimised regardless of occupant size.
This system was evaluated in vehicle side impact tests, including the side impact barrier test at 50 km/h with respect to Euroncap protocol. The only item that differs from Euro NCAP is that the Eurosid 1 dummy was equipped with a specific back plate that has 2 features (see Figure 6) :

- Rounded form so as to diminish possible friction between the seat and the back plate of the dummy
- Force measurement load cell which includes Fy

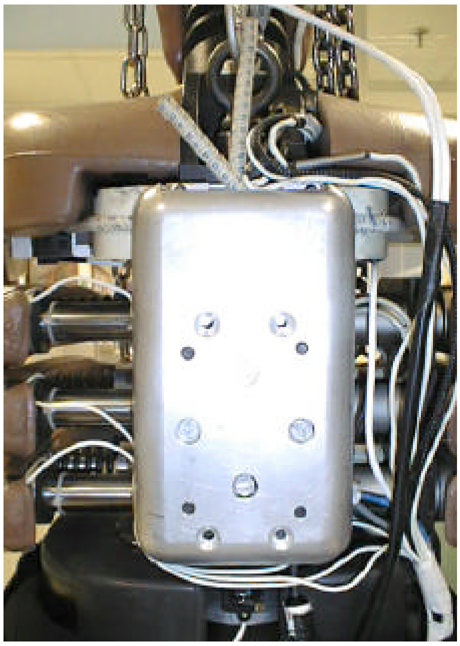

Figure 6 : Illustration of the rounded back plate used in Renault side impact tests.

The data obtained from this test showed that that all peak rib deflections were reached before or at 50 ms ; at this instant the back plate Fy magnitude is only 0.4 kN. The maximum of the back plate load , 1.23 kN, is obtained latter, at 70 ms. If the 1 kN threshold is maintained, then this safety design can be depreciated by the assessment. Detailed description of the corresponding data can be found in reference (12). Therefore it is suggested to reconsider this issue in the present protocol.

Side Impact Barrier - The Cellbond Barrier Version 15 is the barrier that is used in EuroNCAP side impact tests, as shown in Figure 7. An updated version, i.e. version 20, or the Progress Barrier developed by AFL, show much better behaviour with respect to EEVC Force-Crush corridors. While the Progress Barrier is being evaluated by EEVC, the Cellbond Version 20 is at present utilised in vehicle certification tests ; which results in 2 barriers, one used in NCAP and the other for regulation purpose. As EuroNCAP fundamentals are based on European regulation, it is suggested to have only one barrier, regardless of the test purpose.

Figure 7 : The type of barrier used in the present EuroNCAP side impact test.

Pedestrian - Experiences with the previous EuroNCAP testing phases showed that differences in the application of the testing protocol occurred. As a consequence, the reproducibility of tests in different laboratories can be questionable. Because of this the testing protocol is under review.

Other Issues

There are other issues, as important as those discussed here, which needs to be addressed. These are the car to car compatibility, the chest assessment in frontal impact, child protection, seat belt reminders... For the car compatibility, the present EuroNCAP frontal requirements will lead to stiffer cars, if nothing is done to control this problem (13). For the chest assessment, present EuroNCAP requirements are based -among other criteria - on chest deflection of the Hybrid III dummy. The design of this dummy was shown to be not sensitive to restraint improvements such as belt load limiters. As the present trend of car design is oriented towards stiffening the structure, belt load limiters are a key factor, with airbags, to control and manage forces acting on occupants in case of impact. It is essential that the assessment protocol recognises such safety features. Figure 8 presents an injury risk curve to the thorax in relation to shoulder belt load. This characteristic was established from 256 real-world accidents where belt load was estimated from the behaviour of belt load limiters (14, 15).

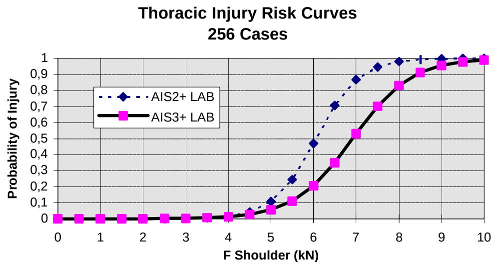

Figure 8 : Probabilities of AIS2+ and AIS3+ risk functions with respect to shoulder belt tension for 256 accident cases.

Summary

After 7 phases of testing, EuroNCAP evaluated all car types that are considered popular or best selling in Europe. The tests showed over the years a tremendous increase of the safety of vehicles, in terms of equipment - i.e. side impact airbag as a standard safety device in some vehicles- as well as in terms of reduction of compartment intrusion. Experiences with the tests and EuroNCAP assessment criteria suggest that important issues related to real world safety or to the test procedures should be addressed. These are :

- The upper leg assessment procedure and performance criteria in frontal impact
- The level of performance criteria for the lower leg in frontal impact
- The need to consider belt load as a performance criterion in the frontal impact
- A concern with the increasing stiffness of vehicles as a consequence of the frontal impact demands
- The back plate load of Eurosid 1 dummy and a the possibility of a modifier in side impact
- The fact that different versions of the side impact barrier are used in NCAP and in certification tests.
- The need to improve the pedestrian testing protocol.

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