

Technical Report

Testing of Rear Seat Strength in Cars

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Prepared by Ronald Vroman (Consumentenbond),

Peter Gloyns (VSC), James Roberts (VSC)

on behalf of ANEC

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Testing of Rear Seat Strength in Cars

Introduction

The ANEC Traffic Working Group tries to influence car safety standards from the consumer point of view. Over the years, the group has successfully pushed standards (often lowest common denominators to avoid trade barriers) to a higher level, generating higher levels of protection. Examples are the Frontal and Side Impact Regulations for passenger cars, the 03 revision of ECE 44 (Child Restraints)

More than once test experiences of consumer organisations were used to support the consumer position in standardisation discussions.

This test tries to highlight shortcomings in current legislation concerning rear seat strength in cars. By testing different designs of current production models we hope to demonstrate that in the existing car fleet there are differences in performance and that more demanding requirements are needed and achievable.

Summary

Accident studies indicate that a number of fatalities and serious injuries are caused by serious weaknesses of the rear seat back in cars. In October 2002, ANEC launched a research project whose findings confirm the danger that luggage can present to car occupants in the event of an accident. In one of the ANEC crash tests, the luggage actually broke the rear seats and was projected towards the front thus injuring the car occupants sitting in the back of car and possibly those sitting in the front too. The ANEC research project shows that there is an urgent need for more stringent regulations for rear seats.

The International Regulation on rear seat strength testing (UN ECE-R17) is not very demanding in terms of test criteria. In the ANEC crash test, we tested two cars (representing a robust and a less robust design) and carried out the test according to the international regulation as well as according to a more realistic test. In the realistic test, the crash pulse was higher (the same as in the EuroNCAP test on the car concerned) and there was more luggage in the boot of the car compared with the minimum luggage simulation in the regulation test. ANEC also placed (child and small female) dummies in the back of the car, in order to obtain some information about the danger for car occupants. High-speed films and digital pictures of the crash tests clearly demonstrate the danger that the luggage in the car boot presents to the car occupants in real life accidents.

ANEC will use the test results to lobby the European Commission, EuroNCAP and UN-ECE GRSP and WP29, the international committee dealing with car safety, in order to achieve more severe test specifications for rear seat strength.

State of Affairs

Current Legislative Situation

The only requirements for the strength of rear seat backs can be found in ECE Regulation17¹, '*Approval of seats, anchorages and head restraints*'.

This regulation includes a test to evaluate the strength of the seat back together with that of the hinges and latches of the backrest. This test was a compromise after lengthy debates in the responsible ECE bodies GRSP and WP29. Already at that time consumer organisations argued for more stringent rules, as accident statistics indicated injury risks.

The agreed test itself consists of a dynamic test on a test bench, with two 17kg blocks in the boot. The pulse is the same as in ECE 44 (child restraints): with a peak deceleration of 20 to 28g

Note that the legislative test does not include passengers (dummies) on the rear seat, does not take into account the luggage capacity of the car (same test for micro cars and large estates – (station wagons) small and big booted cars). Moreover the pass fail criteria for this test are mild: there are ONLY geometric requirements (relating to the backrest forward movement). Consumer groups always have been arguing that the requirements are not compatible with the space required by young children seated in the back.

A popular statement in car manufacturers circles in favour of this mild legislation is to declare that most of the time the boot of a car is empty and / or no rear passengers are sitting in the car, although they are quite happy to market the luggage carrying capacity from one vehicle over another. Consumer groups have the opinion that the car should be safe in any mode of operation it is designed for. It makes no sense to sell family cars that are not suitable for family use. As long as accident statistics clearly indicate shortcomings, and as long as we buy sacks of garden soil, flat-packed furniture or go camping with our family with a camping kit in the boot, appropriate safety measures must be there.

This part of ECE Regulation17 was introduced in 1998 and is applicable on new car models from August 2000, and on all new cars from August 2002

TRL Study

A study presented by the Transport Research Laboratory (TRL, UK)² reports fatalities and seriously injured children due to failing backrests. Occupants are squeezed between their seat belt that prevents them from moving forward and the backrest that is pushed forward by the luggage in the boot.

This mechanism was mimicked in an R17 test procedure as described above, but additionally belted rear occupants were put on the back seats. This R17 testing with occupants showed considerable belt loads during the impact, which indicates increased injury risk. The study recommends stronger vehicle back seats, tougher criteria and the use of child seats (only CRS held in with the seat belts – which are not very good!) as long as possible as these reduce the risk of crushing from luggage loading.

¹ Discussions on car safety regulations take place at the Economic Commission for Europe of the United Nations (UN-ECE), where the safety expert group (GRSP) advises the parental committee WP29 on the decisions to take. ECE regulations generally are copied into EU Directives.

² Paper 332, M Le Claire, The influence of rear loading on the protection of child car occupants in child restraints; Conference for the Enhanced Safety of Vehicles (ESV), Amsterdam, June 2001.

EuroNCAP

The European New Car Assessment Program generates comparative test results on the crash safety of cars. Since it started in 1997, this program has had a big influence on the safety design of passenger cars. As the program carries out more severe (and more realistic) frontal impacts than the EU Directive requires, car manufacturers had to improve the design of their cars in order to improve their ratings. And they did: Under the influence of EuroNCAP passenger compartments of cars became stronger. But these stronger car bodies can generate higher pulses in frontal impacts, leading to increased forces on seat belts and occupants. Moreover, other energy absorbing parts, like the backrest that is loaded by luggage in the boot, will have to withstand higher forces due to the bigger amount of energy of the luggage.

For the problem area we are dealing with here, EuroNCAP does not deliver any benefits. The program does not take into account luggage in its crash specifications and ratings, and consequently manufacturers are not encouraged to improve.

Summing up

Summarising the actual situation we see that:

- There are worrying data from accident studies due to luggage loading of rear occupants
- Only a mild legislative test is carried out for type approval
- EuroNCAP influences car design, but not in the luggage area.

ANEC Tests

Description

Based on the findings summarised above, ANEC decided to perform some tests that would highlight the differences between the mild legislative requirements and more realistic accident situations, as well as differences in rear seat design in current production cars.

Therefore two car bodies were selected with an estimated robust and less robust design. Both cars were equipped with split folding backrests. The cars were ex-frontal impact Euro NCAP, but the relevant parts for this test were intact. Each car had to undergo two tests, first using the R17 prescribed pulse and luggage, and secondly using the EuroNCAP pulse for the particular vehicle and an amount of luggage that is more in line with capacity of the cars. The luggage in the realistic test consisted of sacks of garden soil, wrapped in little suitcases to protect the sacks from tearing during the impact. This is an amount of luggage that is well below the maximum weight allowed by the vehicle manufacturer, and not unrealistic when we observe a Saturday afternoon parking place of a garden centre. And comparable masses are loaded at DIY shops, furniture shops or airports etc.

In all tests child and small adult dummies were seated in the back of the car and dummy and belt loads were measured.

Comparison of the two test set ups

ECE 17 pulse and luggage	Realistic pulse and luggage
Luggage: 2 blocks, 17 kg each	Luggage: 90kg, in suitcases (4 cases)
Q3 child and 5th %ile female on outboard seats in restraint	Q3 child and 5th %ile female on outboard seats in restraint
Pulse peak 20-28g	Euroncap pulse peak (35 and 53g)



fig. 1: R17 blocks (left) and realistic luggage (right)

Comparison of the two car bodies:

Car A	Car B
Robust design	Not so robust design
peak EuroNCAP pulse (35g) - Average	peak EuroNCAP pulse (53g) - High
Boot volume 424 l	Boot volume 415 l
Max load 529 kg	Max load 570 kg
Calculated manufacturers max boot load 303 kg	Calculated manufacturers max boot load 344 kg



fig. 2: Car A (left) and Car B (right)

The max weight that is allowed in the boot is the remaining weight, assuming that a 4-person family (two P50 hybrid III dummies, one P5 female dummy, and one Q3 child dummy in a child restraint) is sitting in the car.



fig. 3: rear seat occupants

Tests

The actual tests were carried out at CTAG – IDIADA (Pontevedra, Spain) on a reverse acceleration sled, that allows very accurate duplication of the required pulses. This makes it possible to imitate the EuroNCAP frontal impact test. Rear seats, backrests, belts and carpeting were replaced for each test.



fig. 4: inverse acceleration sled

Main Findings

'R17' tests

The test on Car A using the Regulation 17 pulse and luggage blocks, illustrated a vehicle that could keep loading from luggage off all three rear seat occupants at this severity.

The equivalent test on Car B illustrated a situation in which the outboard occupants were again protected from additional loading from luggage. The centre rear seat position experienced the greatest seat back deflection induced by the luggage loading, but still it is probable that the deflection would not load either the AF5 or Q3 dummies in the centre position. The excursions of the dummies were still greater than that of the seat back. Even in this mild test the centre hinge was distorted

Analysis of the deflections of these seat backs at this severity, together with dummy excursions at pelvis and shoulder level, would allow comment on the excursion planes specified in R17. This information is not available at the moment, but will be included in the follow up of this project.

Realistic tests

The EuroNCAP pulse test, with realistic luggage, in Car A illustrated a situation in which a strong seat back section kept luggage loading off the AF5 dummy. Note this seat benefited from additional support provided by the stowed pre-tensioned centre rear belt. This could be used as a general example of how such loads can be controlled within current car design.

For Car A, the peak vehicle deceleration in the EuroNCAP test was 36% higher than that used in the R 17 test. The mass of the luggage load was 160% higher in the "realistic" test. The



fig. 5: Car A post impact

spacing between the luggage and the seat back was the same in both the realistic and R 17 tests. Even at this load, the car was well below its fully rated load.

The Q3 dummy in Car A with realistic luggage and a EuroNCAP pulse did experience additional loading. The seat back hinges both released. Again the result should be used as a general

example of the undesirability of additional loading. It is important to acknowledge that the outboard hinge mounting that failed had been subjected of two previous impact loads.



fig. 6: Car B post impact

The peak of Car B EuroNCAP pulse was 116% higher than that used in Regulation 17. This illustrates that a single low pulse applied to all vehicles has little relationship to the pulse likely to



fig.7: Car B post impact

be experienced in a severe injury impact for a given vehicle. (Please see table of EuroNCAP peak vehicle pulses at end of this report)

In Car B with realistic luggage and the EuroNCAP pulse, both the AF5 and the Q3 dummy were subjected to major additional loading.

The central seat back hinges released and allowed the luggage to enter the passenger compartment where it could threaten the front seat occupants, as well as those in the rear.

The seat back central hinges released under the realistic luggage loading. It is notable that these hinges distorted even in the R 17 test, and were replaced prior to the realistic test.

Measurement of dummy excursions in the realistic Car B test would give measurements for a deflection plane beyond the "safe" plane, as both the dummies were subjected to additional loading. Once again: this information will become available at a later stage.

Further conclusions may be possible, once the correct seat back and dummy excursion measurements have been obtained from film analysis. It is recommended that this will be done before any discussions are held with legislative bodies.

Conclusions

These tests illustrate big differences between the ECE R17 test procedure on the strength of seat back rests and real accident situations. The tests illustrate that with foreseeable luggage loads and crash pulses relevant to serious injury accidents, current seat back designs allow occupants in the rear to experience undesirable additional loading from luggage in the boot.

Any test of luggage retention should include:

- Some reflection of the luggage capacity of the vehicle
- A test pulse that is relevant to serious injury accidents in that vehicle model

The consumer has a right to expect the strength of the barrier between the luggage compartment and the passenger compartment to be sufficient to keep such additional loading from luggage away from the occupants.

Recommendations

- The findings of this work carried out by ANEC should be brought to the consumer's attention.
- The UN and EC committees responsible for this legislation should be informed of this consumer concern. (This approach should only be made when the deflection data have been supplied by the laboratory and been analysed.)
- The EuroNCAP Assembly and Technical Working Group should be informed of the ANEC work and asked to consider how EuroNCAP influence could be brought to bear to improve this area of design. Again, this approach should await the provision of the seat back deflection and dummy excursion data .

How to transport luggage safely

As long as car manufacturers do not improve the strength of their rear seat backrests consumers have to cope with the situation as it is. In case you have to transport heavy luggage you can try to limit the danger as follows:

- Put heavy luggage on the boot floor, as close as possible against the backrest, this avoids dynamic impacting.
- Try to tie down luggage with strong ropes, using the fixing lugs in your car. This might keep the luggage in place during an impact.
- When there are no rear passengers: close the seat belts, they may help to keep the backrest in place.