SIDE IMPACTS AND IMPROVED OCCUPANT PROTECTION

Chris Coxon

Department of Transport & Urban Planning, South Australia

Michael Paine

Vehicle Design & Research

Jack Haley

NRMA Motoring and Services,

Australia

Abstract ID 05-0228

ABSTRACT

New Car Assessment Programs (NCAP) in Australia, Europe, Japan and the USA are giving increasing attention to the protection of vehicle occupants in side impact crashes. We review the range of crash tests that are available or are under development for assessing side impact protection, together with the types of vehicle that exists in each market. Real world crashes in the region are reviewed to determine the suitability or influence of existing occupant protection features in reducing injury. The potential benefits of the Australian NCAP consumer crash test program are presented to publicly demonstrate improved side impact protection in reducing injury.

The results of recent pole crash tests conducted by the ANCAP are described in terms of a new strategy for improving side occupant protection.

INTRODUCTION

Real world data shows that many occupant injuries could be avoided with improved side impact protection measures. Recent NCAP test results show that, in most modern vehicles, occupants are protected reasonably well when struck from the side by a small car. However when the striking vehicle has a higher frontal structure, such as many SUVs (four-wheel-drives) there is higher risk of serious head and chest injuries to occupants in the struck vehicle unless head-protecting side airbags are fitted. The Insurance Institute for Highway Safety (IIHS) in the USA has developed a side impact barrier that replicates these higher striking vehicles and test results are now available to assess vehicles for occupant injury in these side crashes. In this paper we compare recent IIHS results with the results of ANCAP/Euro NCAP pole test and mobile barrier side impact tests..

Sources of data

Euro NCAP / ANCAP MDB Side Impact Test at 50km/h (from 1997) JNCAP at 55km/h (from 2000)	
Euro NCAP / ANCAP 90^{o} Pole Test at 29km/h (from 1999)	
IIHS MDB (SUV) Side Impact Test at 50km/h (from 2003)	
NHTSA Crabbed MDB Side Impact Test at 62 km/h (from 1997)	
NHTSA / IHRA Oblique Pole Test at 30km/h (no consumer data)	

The International Harmonisation Research Activity (IHRA) program proposes two new side impact tests - one with a small female dummy in a side test and the other an oblique pole test using a 50 percentile

male dummy. In addition IHRA proposes interior head-form impact tests. More details should be available at the 19th ESV.

NHTSA is developing the oblique pole test. The intention is to better replicate real world pole-type crashes but only experimental test results were available the time of preparation of this paper.

VEHICLE MIX AND REAL WORLD CRASHES

The mix of vehicle types varies considerably between global markets. Each NCAP organisation has tended to tailor its test programs to suit the local mix and best represent real world crashes.

Europe	mostly small cars	mass =< 1400kg
USA/Canada	large vehicles	mass => 2200kg
Japan	mostly small cars	mass =< 1300kg
Australia	larger vehicles	mass => 1600kg

The Australian vehicle mix

Changes in Australian market over last 5 years are characterised by consumer demand falling slightly for larger passenger vehicles and growing for SUVs and light trucks (Figure 1).

This is not expected to change significantly in coming years, unless there is a large increase in fuel costs.

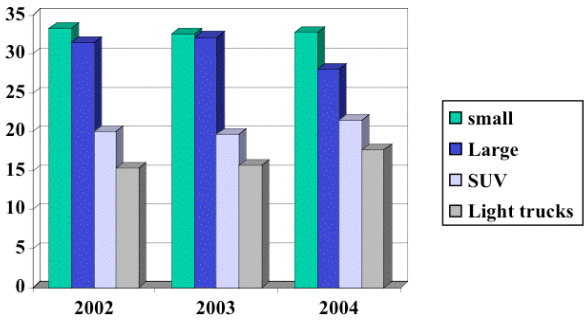

Figure 1. Change in Australian Vehicle Market 2002-4

(% of New Light Vehicle Registrations)

A Monash University Accident Research Centre study on the Australian vehicle market in mid 2004 suggests that SUVs will continue to gain market share to the detriment of small car safety due to incompatibility of ride height, structural mismatch and mass - factors favouring the heavier high-seat SUVs (Newstead and others 2004).

Australian real world crash types

Collisions between vehicles travelling in opposite directions are the most common fatality crashes in Australia. Next are single vehicle crashes where the vehicle leaves the road followed by intersection crashes and then pedestrian impacts. When a vehicle leaves the road the most commonly struck object is a tree or a pole. These are more likely to be fatal in a side impact. Road safety strategies in Australia should therefore give emphasis to reducing the risk of loss of control (so that vehicles stay on the roadway) and providing better occupant protection in intrusive side impact crashes.

Safety features that may reduce serious side impact crashes

There is scope for NCAP organisations to promote the following safety features, which are often optional or unavailable on some models. Avoiding a crash or reducing the energy of impact by using better technology can reduce occupant injuries.

Primary crash avoidance

- Electronic Stability Control
- Antilock brakes
- Tyre pressure warning system
- Good rollover star rating from NHTSA test
- Daytime running lights

Secondary crash protection

- Frontal airbags
- Side airbags
- Side head or curtain airbags
- Structural integrity of occupant space
- Pre-tensioner seatbelts
- Load limiting seatbelts
- Active head restraints
- Pedals that release during severe intrusion
- Automatic crash notification
- Doors that do not open in the crash

NCAP crash tests are designed to assess the performance of the complete vehicle rather than individual components. However some features stand out as providing exceptional protection. An example

is head-protecting side airbags. Pole crash tests conducted by ANCAP (detailed below) show that these devices usually turn a likely fatality, due to severe head injury, into an easily survivable crash.

COMPARISON OF IIHS AND EURO NCAP POLE TEST RESULTS

The following table contains a comparison of published data on IIHS SUV barrier crash tests and Euro NCAP pole tests. It is provided subject to the cautions that:

- Vehicle specifications may vary between countries
- Smaller dummies (5% female) are used in the IIHS test
- IIHS reports HIC15 whereas Euro NCAP/ANCAP report HIC 36

Table 1 Comparison of Head Protection in IIHS and Euro NCAP/ANCAP Crash Tests

High Seat Vehicles (H-Point 700mm or above ground)

Vehicle Model	Head Protecting Side Airbag	IIHS SUV Barrier Result	Euro/ANCAP Pole Test Result
Ford Escape/Mazda Tribute	Side airbag with head bag	Good	Poor*
Ford Escape	None	Marginal	Poor
Honda CR-V	Curtain	Good	No head airbag option in Australia
Honda CR-V	None	Good	Poor
Toyota RAV4	Curtain	Good	Good
Toyota RAV4	None	Good	Poor
Landrover Freelander	None	Good	Not tested
Hyundai Santa Fe	Side airbag with head bag	Good	No head airbag option in Australia
Suzuki Grand Vitara	None	Poor	Not tested

* Head bag failed to deploy correctly in ANCAP test

Low Seat Vehicles (H-Point less than 700mm above ground)

Vehicle Model valid 2004/5	Head Protecting Side Airbag	IIHS SUV Barrier Result	Euro/ANCAP Pole Test Result
Honda Accord	Curtain	Good	Good#
Honda Accord	None	Poor	-
Jaguar X-Type	Curtain	Good	Good
Mercedes C-Class	Curtain	Good	Good@
Saab 9-3	Curtain	Good	Good
Subaru Legacy/Outback	Curtain	Good	Good
Toyota Camry	Curtain	Good	No head airbag option in Australia
Toyota Camry	None	Poor	Not tested
Volvo S40	Curtain	Good	Good
Saab 9-5	Side airbag with head bag	Good	Good
Subaru Forester	Side airbag with head bag	Good	Good

Honda Accord Euro tested by Euro NCAP is a different model to the US one

@ Euro NCAP applied a modifier to the C-Class pole test result due to incorrect deployment of the curtain.

Discussion of Table 1 results

Subject to the small sample sizes, these results suggest that the IIHS SUV barrier test and the Euro NCAP pole test produce similar outcomes for cars. In this class of vehicles, the IIHS test does tend to show a substantial difference between vehicles with and without head protecting side airbags . This suggests that the IIHS test will encourage head-protecting side airbags in cars and other low seat vehicles.

Several SUVs have obtained good/acceptable head injury results in the IIHS test, despite lacking head-protecting side airbags (Ford Escape, Honda CR-V, and Toyota RAV4). The Ford Escape with head-protection obtained good results in the IIHS test but the equivalent Mazda Tribute obtained a poor result in the ANCAP pole test because the side head airbag did not deploy correctly. The Escape, RAV4 and CR-V without side head protection airbags obtained poor head results in pole tests by ANCAP

This suggests that the IIHS test would not necessarily encourage head-protecting side airbags on these compact SUVs or other high-seat vehicles.

Large SUVs such as the Toyota Landcruiser Prado and the Nissan Patrol could also be expected do well without head protection in the IIHS test since the higher seats and heavier mass would benefit the occupants in this particular test.

In the case of high-seat vehicles ANCAP intends to be cautious about accepting the IIHS result as alternative evidence of head protection in side impacts. ANCAP pole test results for these large 4WD vehicles without head-protecting side airbags are expected to be poor.

Comparison of Pole and MDB Side Impact Scores

ANCAP reviewed available test data on Euro NCAP side impact and pole tests and scored pole test using the same scoring system as that outlined in the Euro NCAP Assessment Protocol for side impact tests. This included scoring the chest, abdomen and pelvis (note that usually only the head injury data is assessed for the pole test). Figure 2 shows the results of this comparison. This illustrates that most vehicles have no difficulty with the MDB side impact test and many score the full 16 points. It is apparent that the pole test is much more demanding.

Figure 3 shows the scores for individual body regions for the pole tests (each body region can score up to 4 points). It is evident that with most vehicles there is a high risk of serious chest injury during the pole test, even for vehicles with thorax side airbags. It is understood that there may be a concern with the biofidelity of the EuroSID II dummy under the extreme intrusion that occurs in the pole test. Due to this uncertainty ANCAP does not propose to use this method of scoring pole test results at this stage. However, the test results do suggest that chest injury should be monitored in real-world pole type side

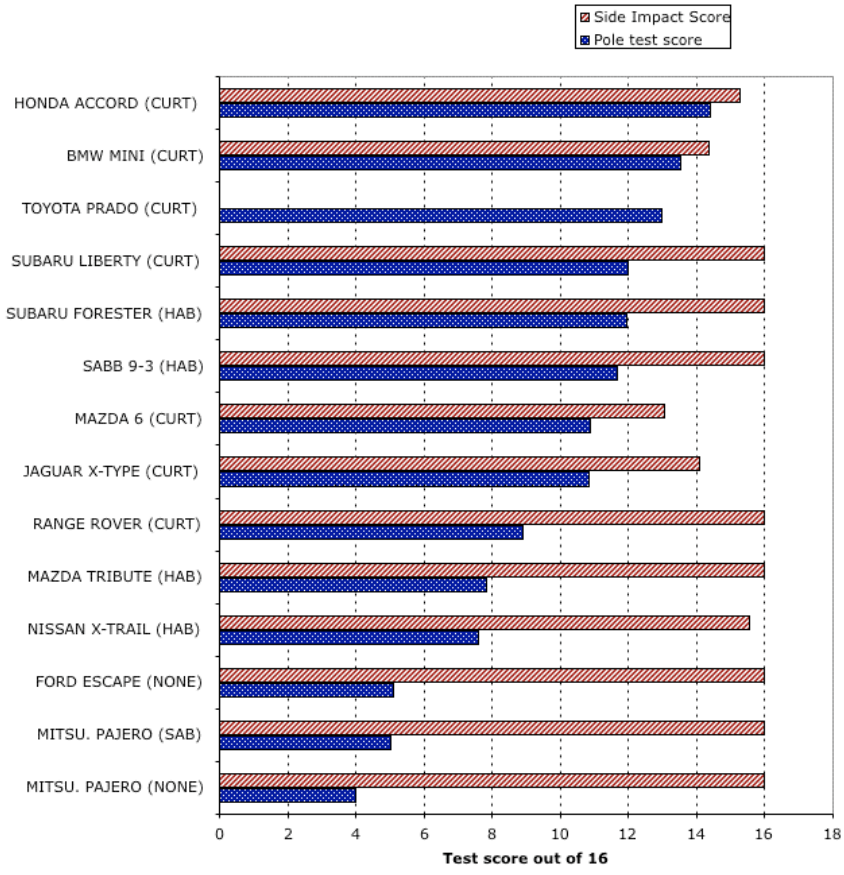

Figure 2. Comparison of Scores for Pole Test and MDB Side Impact Test

Notes: The pole test injury measurements for head, chest, abdomen and pubic symphysis have been scored in the same way as the side impact test. This is not an official ANCAP score.

CURT=curtain, HAB=Head-protecting side airbag, SAB=thorax side airbag.

impact crashes to determine if greater emphasis should be placed on protecting occupants from serious chest injuries.

A high risk of serious abdomen injury has also been observed in some pole tests. A contributing factor may be the crushing of the driver's seat between the intruding door and an unyielding centre console (figure 4). These consoles may also be a source of far-side occupant injuries in side impacts.

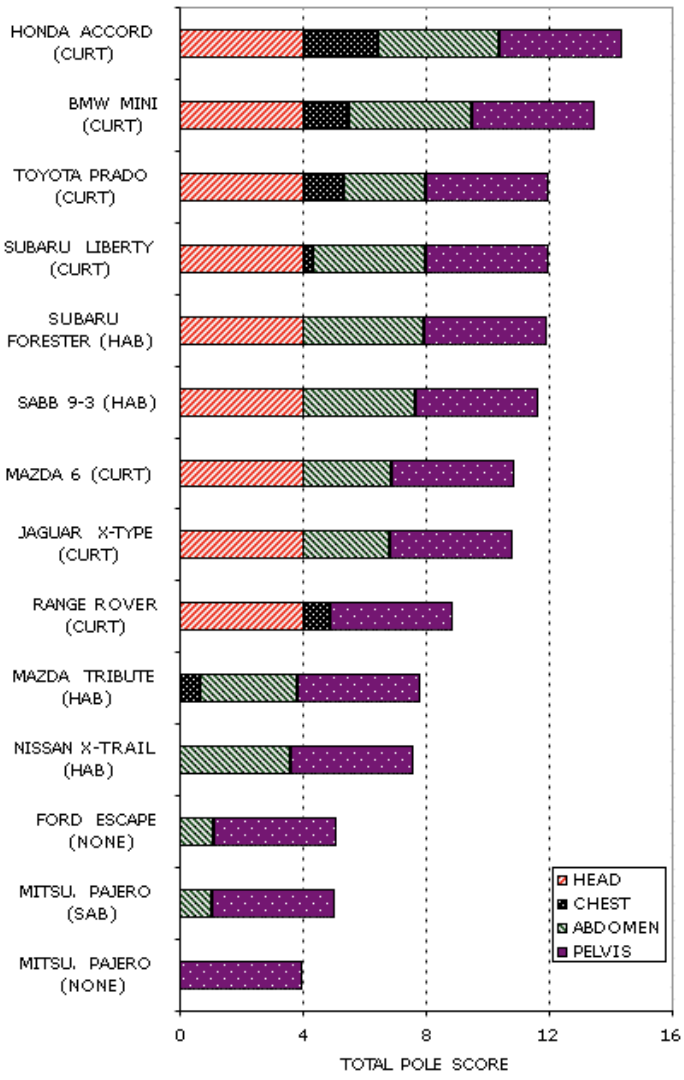

Figure 3. Body Region Scores for Pole Test

Notes: The pole test injury measurements for head, chest, abdomen and pubic symphysis have been scored in the same way as the side impact test. Each body region scores 4 points for a "good" (low) injury measurement. Zero score means a "poor" injury measurement. This is not an official ANCAP score.

CURT=curtain, HAB=Head-protecting side airbag, SAB=thorax side airbag.

Other issues that should be taken into consideration when assessing pole tests are:

- Nature and degree of intrusion into occupant survival space (undertaken by IIHS for the MDB SUV test)
- Fuel leaks (reported by IIHS)
- Extrication of driver dummy (reported by IIHS)
- Head protection provided for rear seat occupants (assessed by IIHS - not directly assessable in pole test)
- Potential for occupant protection in rollover crashes with the curtain remaining inflated long enough to be effective during the rollover.

RESULTS

ANCAP has completed a pole test program on a range of SUVs with and without head protecting side airbags. The results clearly showed the benefits of such equipment when operating properly. The vehicles without such protection produced HIC measurements with an extremely high risk of fatal head injuries. The vehicle with head protecting airbags achieved a low HIC with low head injury risk. One vehicle was fitted with a head protecting side airbag, but it did not deploy properly, resulting in a high risk of fatality.

ANCAP published the results of the pole tests to show that head protecting side airbags provided good protection against collisions with narrow objects such as poles and trees. Side airbags, while providing protection against impacts by conventional vehicles, do not protect the head against higher intruding objects, such as SUVs and pole-type structures.

ANCAP recommends that front, side and head protecting airbags and ESC should be made available by vehicle manufacturers as standard equipment, or at least as a “safety package”, not linked to luxury items such as sunroofs and leather seats. This packaging is common in Australia and increases the cost of the airbag protection, sometimes substantially, which can price it beyond the reach of some vehicle purchasers.

ANCAP also advocated the incorporation of Electronic Stability Control (ESC) into all SUVs, as research by IIHS has shown that such systems drastically reduce the number of run-off-road crashes, thereby reducing the number of pole and tree side impacts (Farmer 2004).

Even with side airbags, chest deflection levels are generally high in most pole crashes with a high risk of injury likely.

CONCLUSIONS

Head protecting side airbags provide clear head injury mitigation benefits in collisions with stiff vertical road-side objects such as trees and poles, and provide protection against impacts by vehicles with high fronts, such as SUVs.

Consumers need to be better educated about the value of head protecting side airbags. This will further encourage vehicle manufacturers to make them available as optional equipment or, even better, install them in all vehicles as standard equipment.

Figure 4. Plan View of Crushed Seat After Pole Test

Figure 5. Peak of Intrusion during Pole Test

Some types of NCAP crash tests are able to assess the head protection provided in vehicles during severe side impacts. The results of these tests need to be strongly promoted amongst new vehicle buyers.

REFERENCES

Berg A and Morris A, 2003, 'Rollover crashes: real world studies, tests and safety systems', Proceedings of 18th ESV, Nagoya.

Chidester A and Roston T, 2003 ';Airbag crash investigations', Proceedings of 17th ESV, Windsor.

Euro NCAP, 2004. Crash Test and Assessment Protocols (www.euroncap.com).

Farmer C, 2004, 'Effect of Electronic Stability Control on Automobile Crash Risk', Traffic Injury Prevention, 5:317-325.

IIHS, 2001, Status Report, Vol 36 No. 1.

IIHS, 2003, Status Report, Vol 38 No.8.

Newstead S, Delaney A, Watson L, Cameron M, 2004, 'A Model For Considering the Total Safety of the light Passenger Vehicle Fleet'. Monash University Accident Research Centre Report 228

Ono Y, Kimura Y, Mizuno K, 2003, 'What we learned from JNCAP and our proposals', Proceedings of 18th ESV, Nagoya.

Samaha R and Elliot D, 2003, 'NHTSA side impact results: motivation for upgraded test procedures', Proceedings of 18th ESV, Nagoya.

Takahashi H, Iyoda M, Aga M, Sekizuka M, Kozura Y and Ishimoto S., 2003, 'Development of rollover curtain shield airbag system', Proceedings of 18th ESV, Nagoya.