RESEARCH PROGRESS ON IMPROVED SIDE IMPACT PROTECTION: EEVC WG13 PROGRESS REPORT

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ABSTRACT

The tasks of EEVC Working Group 13 are aimed at the improved protection of car occupants in side impacts. Specifically, EEVC WG13 has been concentrating on three main tasks; the development of an interior headform impact test procedure, an improved specification for the Mobile Deformable Barrier used in the EEVC Side Impact Test Procedure and contributions to the IHRA activities on the development of the next generation side impact test procedures. This report describes progress on these three topics.

INTRODUCTION

EEVC Working Group 13 was created in 1992 to coordinate national research, within Europe, on side impact test procedures. The terms of reference, which are reproduced in the appendix, have been updated to ensure that the target issues that the WG addresses are relevant and achievable within a foreseeable time frame.

Since the last ESV Conference, WG13 has been continuing the development of an interior headform impact test procedure, produced an improved specification for the Mobile Deformable Barrier used in the EEVC Side Impact Test Procedure, provided research support for the review of the European Directive on Side Impact Protection and has contributed to the IHRA activities on the development of the next generation side impact test procedures

This paper reports the WG13 progress on these topics.

INTERIOR HEADFORM SIDE IMPACT TEST.

The development of an interior headform side impact test procedure was initiated because European accident data indicated the importance of head injuries in side impacts and a demonstrated that there was a wide range of head contact location possibilities. However, in the regulatory full scale side impact tests the head of the EuroSID rarely made contact with the vehicle interior and, when it did, only one position in the vehicle was evaluated.

The development programme was planned in four phases: The first phase comprised a test programme to enable the selection of the preferred headform from three possibilities. This was reported at the 15th ESV Conference (Roberts et al, 1996). The second phase was designed to determine whether a free flight or a guided headform impact was the better choice for such a test procedure. The difficulty in producing sensible and reliable results with the guided system precluded the reporting of this phase at the 16th ESV Conference. However, these difficulties contributed to the evidence for the decision to select a free flight system. Thus the conclusion from Phases I and II were that the preferred system would be a free flight test using the FMVSS 201 Free Motion Headform. This selection had the further benefit of potential harmonisation with the US Standard (FMVSS201)

The third and current phase of this work included

- the correlation between the FMH response and that of EuroSID,
- the influence of vehicle support on the results,
- the possibility of a sub-systems approach to testing, the capability of predicting a 'worst case' impact configuration,
- the suitability of EuroSID for pole impacts with side head airbags present and
- an accident analysis to identify the zones within the vehicle liable to be impacted by the head in lateral impacts.

Currently, only the accident analysis and the FMH–EuroSID correlation tests have been completed and analysed. These results of topics are discussed below.

Correlation of EuroSID with the FMH

The FMH-EuroSID study was undertaken by TRL for EEVC WG13. The aim of this test work was to establish a regression equation for relating the response of the FMH with the response of the EuroSID-1 dummy head during similar head impact conditions. For FMVSS201, the response of the FMH had been correlated against impacts to the forehead of the Hybrid III head. Although the EuroSID head is basically a Hybrid III head, it is slightly modified and the correlation required was against the side of the head for lateral impacts. A variety of structures were evaluated in order to provide a wide range of headform response, with values of HIC both above and below the criteria prescribed in the EC side impact directive (HIC less than 1000). Ten test structures were used for this work which included B-pillars from current production 'world market' cars and foam structures of various thickness and stiffness.

Two headform orientations were used for the FMH tests (Figure 1.). The first was entirely in accordance with the test procedure specified in FMVSS 201, whereby the headform was orientated with the point of contact offset from the centre of gravity of the headform in the direction of impact. This resulted in rotational motion of the headform during impact. The second was performed with the point of contact aligned with the centre of gravity of the headform in order to minimise the rotational motion ("C of G aligned"). The mass of the headform was 4.54kg and the impact velocity was 6.7m/s.

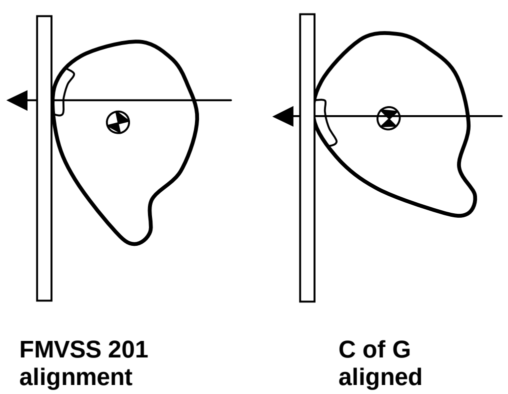

Figure 1. FMH orientation alignments.

A whole dummy impact test method was developed which enabled the dummy's head to impact the interior fitting test piece at a velocity of 6.7m/s. The test procedure was developed by computer simulation using a EuroSID-1 dummy model and was validated by conducting a number of preliminary sled tests. The EuroSID-1 dummy was positioned, unrestrained, on a rigid seat which was mounted side facing on the sled. The sled was accelerated towards a rigid wall to a velocity of 7.0m/s. Immediately before the sled reached the wall it was arrested by crumple tubes, which brought the sled to rest within a short distance, approximately 50mm. The dummy continued to slide across the seat until the pelvis and upper spine impacted a 100mm thick deformable cushion which was mounted on the rigid wall, representing the door structure of a vehicle. As the pelvis and upper body decelerated, the head and neck translated and rotated towards the rigid wall.

The target B-pillar structure was positioned on the rigid wall, such that it was impacted by the head at the prescribed velocity of 6.7 m/s. Each test was performed twice and the mean value obtained.

During the tests, the FMH with C of G aligned did not rotate and therefore, all of the kinetic energy was absorbed by the test structure. However, the FMH in FMVSS201 orientation did rotate during the test, hence less energy was absorbed by the structure.
The results were found to provide a suitable range of response with the HIC results ranging from less than 500 to more than 2500. It was found that the vehicle B-pillar achieved the lowest results with a peak acceleration of 68g and a HIC of 245 (FMH in FMVSS 201 orientation).

The test procedure provided a consistent and repeatable method of evaluating the impact performance of test structures. The FMH with C of G aligned provided the most consistent results with an average coefficient of variation in HIC of 4.5%. The FMH to FMVSS 201 orientation results gave an average coefficient of variation in HIC of 8.7% and the EuroSID-1 results gave an average coefficient of variation in HIC of 9.2%.

The results for the FMH HIC in the FMVSS 201 orientation and the C of G orientation were correlated with the results from the EuroSID-1.(Figures 2 and 3)

The correlation coefficient for HIC in the 201 orientation was 0.64 while it was 0.29 for the C of G aligned orientation.

The equation of the regression line for the 201 tests was

$$Y = 0.6499 X + 260.3$$

(where Y is the HIC measured on the EuroSID-1 head and X that measured on the FMH)

which is not too dissimilar to the regression developed by NHTSA of

$$Y = 0.75446 X + 166.4.$$

The results for the FMH with C of G gave a regression line of

$$Y = 0.2426 X + 504.65$$

which differed notably from the regression developed by NHTSA.

The results showed that the orientation of the free motion headform would greatly effect the measured performance of a test structure. The correlation coefficient of the EuroSID-1 to the FMH - FMVSS 201 orientation was higher than that in the C of G orientation, but the variation was greater for the FMVSS 201 orientation

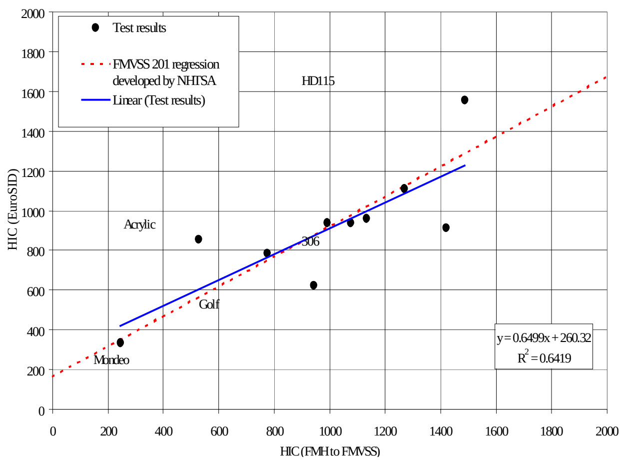

Figure 2. Correlation of EuroSID with FMH (FMVSS 201 orientation)

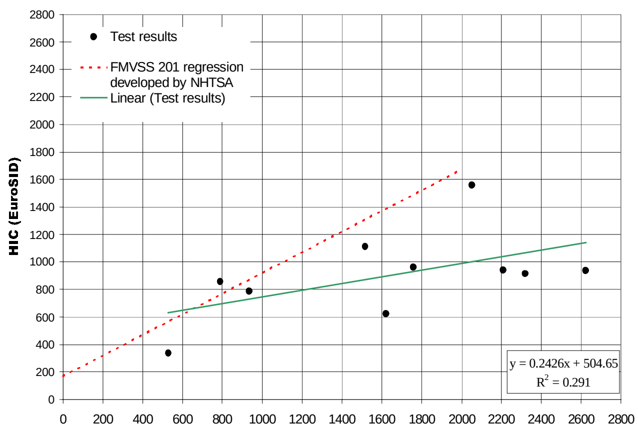

Figure 3. Correlation of EuroSID with FMH (C of G aligned orientation)

Figure 4 shows both the EEVC (201 orientation) and the FMVSS201 regression lines relating the HIC measured on the FMH to that expected on a dummy head. It can be seen that the differences are small, particularly near the critical value of HIC 1000.

As the regression coefficient was greater for the 201 orientation, and in the interests of potential harmonisation, it was agreed that the FMVSS201 orientation would be used for the EEVC test procedure. Also, since the regression equation was very similar to that used in FMVSS201, it was

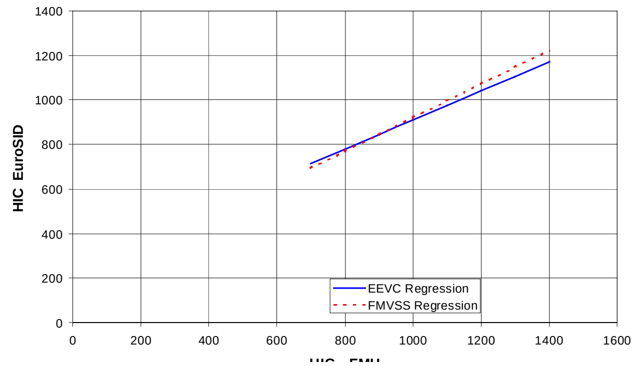

Figure 4. EEVC and FMVSS201 relationships between FMH and Dummy HIC values

decided to use the FMVSS equation for translating the FMH results into dummy HIC values.

Head Impact Locations from Accident Studies

The objective of this study was to determine the range of head impact locations observed in real world crashes to aid the specification for the impact test locations. Four organisations have supplied data for the study:

1. TRL - Data from the Co-operative Crash Injury Study (CCIS) in the UK,
2. BASt - Medical University of Hannover database in Germany,
3. LAB PSA-Renault - A retrospective accident analysis in France.
4. NHTSA - NASS files in the US.

The data have been analysed to determine the most important impact areas in terms of frequency of contact in accidents. The influence of intrusion on the severity of injuries also has been analysed. Different sampling strategies and contact classifications have been used for each database, therefore it is not valid simply to add the data together to make a single large database. However, each sample can be used to give evidence of the head contact sites observed in side impacts according to its own sampling and categorisation methods.

Each database was analysed for all non-rollover, single-impact, side-impact accidents. Side impact was classified as an impact with the principle direction of force between 2 and 4 o'clock, and 8 and 10 o'clock at any point on the side of the vehicle.

In Europe, it is a legal requirement that vehicle occupants wear a seat belt at all times with certain limited exceptions. Consequently, the protection of restrained occupants is considered the priority condition. However, protecting unrestrained occupants can be considered also if it is possible to provide protection in a cost effective manner without diminishing the protection given to those who are restrained.

Similarly, as this test procedure is considered to be an adjunct to the full scale Side Impact Test Procedure, the contacts for the struck side occupants would be relevant. However, it is of interest to consider the situation also for the non-struck-side occupants to provide further guidance regarding priority contact zones.

Tables 1 and 2 show the priority contact areas for the four accident data bases for restrained struck side and restrained non-struck side occupants respectively. For the analysis in these tables, contact areas not to the car side interior have been eliminated. Thus contact with external objects, window glass and steering wheel, for instance, are not included.

From these tables, it can be seen that the priority areas for the struck side occupant are the B-Pillar and the side roof rail. The "side other" and the A-Pillar are second priority areas. These become relatively more important if the non-struck side occupants are considered.

Table 1 –
Key Contact Regions, Restrained
Struck Side Occupants

Contact Site	Priority in terms of no. of AIS1+ injuries recorded			
	BASt	LAB	TRL	NHTSA
A Pillar	=5	No Contacts	3	3
B Pillar	1	1	1	1
Side Roof Rail	=2	2	2	2
Side Other (inc. door)	=2	No Contacts	4	
Roof	4		No Contacts	
Upper Anch' Point	=5		5	
Window Frame		3		

(Shaded cells indicate zones that were not included as separate categories in that database)

Thus initially, the test procedure will specify contact zones for testing which emphasise the B-Pillar and side roof rail.

Table 2 –
Key Contact Regions, Restrained
Non-Struck Side Occupants

Contact Site	Priority in terms of no. of AIS1+ injuries recorded			
	BASt	LAB	TRL	NHTSA
A Pillar	=2	4	No contacts	3
B Pillar	=2	3	2	2
Header	No Contacts		=4	
Side Roof Rail	1	2	3	1
Side Other (inc. door)	=2	1	1	
Roof	5		=4	
Window Frame		5		

(Shaded cells indicate zones that were not included as separate categories in that database)

The accident statistics were analysed for the effect of support behind the structure which was struck by the head. In the TRL data (UK CCIS database), the occurrence of intrusion for recorded contacts is noted, together with an assessment of whether there was some strong external support behind the intruded structure. This is based on UK data and the occurrence of intrusion and associated head contacts may vary between countries but the effects of support would be expected to be the same.

Tables 3 and 4 show the effect on the injury severity distribution of head contact with intruded structures with and without external object support behind the contact point, both for the struck side occupants and for all front seat occupants (restrained and unrestrained combined).

It can be seen that, for both cases, the proportion of casualties suffering AIS 3 or more is greatly increased when the contacted structure is intruded, particularly if this is supported externally. This aspect will be taken into consideration when the test details are specified.

Table 3
Intrusion – Struck Side Occupants

	No Intrusion	**Supported Intrusion**	**Unsupported Intrusion**
	No	No	No
AIS 1+	176	31	17
AIS 3+	27	15	6
% with AIS 3+	13%	33%	26%

Table 4
Intrusion – All Front Seat Occupants

	No Intrusion	Supported Intrusion	Unsupported Intrusion
	No	No	No
AIS 1+	288	50	21
AIS 3+	44	29	8
% with AIS 3+	13%	37%	27%

The next stage of this topic will be to propose an appropriate test procedure based on these studies. It is anticipated that the impact zones will be defined in a manner based on FMVSS201, although the vehicle support, identified contact positions and impact angles may be specified based on a worst case estimation within those zones. Once the draft test procedure has been proposed, this will be validated using a range of modern vehicles to determine the practicality, repeatability and design implications for the draft procedure.

DESIGN SPECIFICATION FOR THE EEVC MDB FACE

The European regulations on side impact protection (ECE Regulation 95 and EU Directive 96/27/EC). include a dynamic full scale impact of a mobile deformable barrier (MDB) into the side of the target vehicle. The MDB comprises a deformable face attached to a trolley. The deformable face is currently defined by overall and element dimensions together with force-deflection and energy dissipation requirements in a certification test against a flat rigid load cell wall. The certification test is performed at 35km/h while the full scale test impact speed is 50km/h. It has been reported that different designs of MDB face, that perform similarly under the certification test, produce significantly different results when used to test cars.

To study this problem, a representative sample of most of the currently available MDB faces were subject to both the normal certification test and some special EEVC tests. These tests were designed to differentiate between both ‘good’ and ‘bad’ MDB faces and to identify differences in construction and design strategies that might affect dynamic crush behaviour.

MDB Face Evaluation Programme

. The test conditions for the special tests were described in the EEVC WG13 paper presented to the 16th ESV Conference (de Coo: 98) and comprised:

1. High speed flat wall test. A flat rigid load cell wall test, similar to the certification test, but at the full test speed of 50km/h. For this test it was necessary to add an additional deformable element behind the existing MDB face to absorb the additional kinetic energy of the mobile barrier. This test was designed to determine whether the deformable face performance changed with impact speed.

2. Pole impacts. Two tests were defined where the MDB face impacted a vertical half cylinder placed against the load cell wall. One test positioned the pole central to the MDB face and in the second configuration the pole was placed at the vertical intersection between the central and outer elements at one side. These tests were intended to evaluate the realism of the load transfer across the MDB face and how well the elements were connected. It partly represented an impact to a strong B-pillar. The structural integrity of the design also was evaluated in these tests.

3. Rigid angled wall tests. These tests generated non-parallel loading to the deformable elements with the angles of the walls selected to represent typical deformation profiles observed in full scale side impact tests. Two tests were defined, separating out the effects of angled loading to the sides of the MDB face and to the lower edge from the car sill.

3.1 *Rigid Edge Loading Wall Test*. This first loaded the edges of the MDB face, producing a final profile in the horizontal plane similar to that of the MDB faces seen in car impact tests.

3.2 *Rigid Sill Loading Wall Test*. This loaded the lower edge of the MDB face in a way which duplicated (in a controlled uniform manner) the non parallel loading generated by the stiff sill member of a car. To avoid the angled wall lifting the whole MDB in this test, the wall and MDB face were both inverted.

4. Yielding Wall Test. In this test the MDB face impacts a surface that is initially flat but which deformed to a 'concave' shape representing a deformed car profile. This was achieved in a repeatable manner by using a central flat panel which could translate rearwards by deforming the supporting crumple tubes, and two hinged side panels whose free edge rested on this central panel.

MDB Face Faces used in the Test Programme All but one of the MDB face were manufactured from aluminium honeycomb. Seven current MDB face designs were included in the programme. An eighth

MDB face, based on a profiled honeycomb design that is known to produce particularly variable results when impacted against vehicles, was also included in order to ensure that the supplementary test procedures could distinguish a 'poor design', although no barrier face to this design was currently available for general use..

The barriers tested in the EEVC Evaluation Programme can be classified into three groups based on their generic design.

A <u>Multi-Layer Barrier Designs.</u> Multi-layer honeycomb barrier faces use a series of aluminium honeycomb blocks of different crush strengths to achieve the progressive force-deflection corridors specified in the current Directive. The weakest blocks are at the front of the barrier face, and the stiffest blocks at the rear. The honeycomb is held together with interface layers. The material used for the interface layers varies between different MDB face manufacturers. The MDB faces in the EEVC evaluation programme conforming to this generic design were:

1. Cellbond Composites Ltd (UK) – Multi-2000 Barrier
2. Showa Aircraft Industry Co Ltd (Japan) – European Deformable Barrier Face
3. Yokohama (Japan) – MDB Barrier Face for Side Impact
4. Plascore (USA) – European Side Impact Barrier

B <u>Progressive MDB Face Designs</u> The MDB faces in this category use single blocks of honeycomb which have their properties modified in order to change the crush characteristics progressively along the block. The MDB faces in the EEVC evaluation programme conforming to this generic design were:

1. AFL (France) – Progress Barrier
2. Darchem (UK) –Side Impact Deformable Barrier

The two MDB faces achieved the progressive performance by different methods. In the AFL MDB face, the honeycomb was differentially etched so that the cell wall thickness of the honeycomb is thinnest for the weakest section of the MDB face (at the front) and thickest at the rear of the MDB face. In the Darchem MDB face, the property of the honeycomb was modified by punched holes in the cell walls.

C <u>Profiled Barrier Designs</u>. An alternative method for producing the progressive force-deflection curves is to profile the energy absorbing material from which the MDB face is constructed. The MDB faces in the EEVC evaluation programme conforming to this generic design were:

1. Fritzmeier (Germany) – EEVC Element
2. Cellbond Composites (UK) –Pyramid Barrier

This Fritzmeier MDB face was manufactured from polyurethane foam and was the only MDB face in the programme not manufactured from Aluminium honeycomb. The Cellbond Pyramid MDB face was a specially produced barrier face included in the programme to ensure that the supplementary test procedures in the test programme could identify the problems already experienced in full-scale vehicle testing with profiled honeycomb MDB face designs.

Since, in a honeycomb barrier, a large volume of air can be trapped during crush, ventilation from the hollow honeycomb sections during impact could affect the dynamic response.. The MDB Faces were tested according to the recommendations of the manufacturer with any ventilation system specified attached directly to the flat unventilated interface on the trolley.

All of the high speed film records and transducer records were reviewed by an expert panel and by EEVC WG13. The report of the analysis of the test is given in an EEVC publication (EEVC WG13, 2000). The summary conclusions are given below.

Many factors have been taken into account but particular observations noted by the expert panel and by WG13 members as being significant were:

1 Most of the barrier faces were close to the required performance corridors. However, there were differences between the different designs of MDB faces, even within one design category, that could result in differences in vehicle performance in the side impact test.

2 Some barrier faces showed less variation between test institutes than others.

3 Review of the *unfiltered* force data demonstrated that multilayer barrier faces showed distinct stepped force-deflection responses while the progressive barrier faces showed smooth responses. The size of the steps was influenced by the interlayer design. Smooth responses are more likely to provide repeatable results in MDB-to-car impact tests.

4 Pre-crushing the rear faces of the multilayer blocks could result in tilting or rotating of the block and possible subsequent shear of the elements. It may also lead to undesirable load spreading or load distribution in the event of a concentrated force, such as was seen in the pole test.

5 Lateral translation of the front plate should be able to occur without transmitting shear forces into the depth of the remote parts of the barrier face, as demonstrated in the pole tests.

6 The direction of expansion and the construction method of the honeycomb could influence the failure mode under non-collinear loading (Angled Edge and Sill loading tests).

As a consequence, WG13 did not feel confident that the variances seen in full scale tests could be eliminated unless the design and construction of the MDB face were specified. All of the EEVC experts and their advisors agreed that the best solution would be to specify a single design and construction together with supplementary tests to ensure performance conformity of the elements of the MDB face. WG13 unanimously preferred the progressive design generic type. Following this recommendation, and with the help of the main aluminium honeycomb barrier face manufacturers, a new design-based specification has been developed (EEVC, 2000a).

The draft revised MDB face specification defines a deformable face based on six blocks, together with a front plate, a back plate and a defined ventilation system. The whole barrier face and ventilation system is intended to be mounted onto a trolley with a flat unventilated front mounting plate of specified size so that both the interface between MDB face and trolley and the ventilation are controlled.

The materials from which the various components of the MDB face are made are carefully specified, using materials that should be widely available where possible. Most of the details of the design, such as material thickness, number of honeycomb cells, block dimensions and adhesive type, can be specified. The principle of the design, that is used to achieve the increase in force as the blocks are deformed, is to make the wall thickness of the aluminium honeycomb material thinner the nearer it is to the front of the block, usually by chemical etching. It is not practical to specify this aspect of the dimensions of the face. To circumvent this, the quasi-static stiffness of each block is defined. It is the intention that a sample from each 'batch' of each block type is tested for this static stiffness. In this way, the performance of each MDB face should be certified.

The dynamic test force-deformation requirements are seen as a final check on the performance of a production design and would be required far less frequently than the batch sampling for the quasi static test. Now that the complete design is specified, it is considered that the corridors for the dynamic test could be narrower than they are in the current regulation, which will help to improve repeatability.

The revised specification is intended to result in a standardised MDB face which performs in a reliable manner when impacting vehicles and which can be manufactured by any competent aluminium honeycomb fabricator with access to the appropriate test equipment. It is intended to ensure that all MDB faces produced by the same manufacturer will perform in the same way (Repeatability) and MDB faces produced by different manufacturers will perform in the same way (Reproducibility). EEVC WG13 are undertaking a validation programme designed to ensure that these aspects of MDB faces, produced to the new specification, can be assessed. This test programme will also enable the improved dynamic performance corridors for this design to be generated.

SUPPORT FOR IHRA ACTIVITIES

EEVC Working Group 13 provides the technical input to the work of the International Harmonised Research Activities Side Impact Working Group (IHRA SIWG) for Europe.

This IHRA WG is coordinating the worldwide research that should form the foundation for future side impact regulations in the expectation that coordinated research will help to produce harmonised regulations in the future (Seyer, 2001). It is recognised that the crash environment varies around the world and EEVC WG13 has been engaged at reviewing the implications of this for Europe.

WG13 has provided multinational accident data from several sources to indicate the main accident circumstances in Europe. Car-to-car and car-to-pole or narrow object (depending on the country) remain the main problem areas for Europe whereas in North America, side impacts by Light Trucks and Vans (LTVs) are seen to be an increasing problem. Thus impacting vehicle mass and geometry are issues that have been addressed. WG13 has provided the results of a simulation study which have demonstrated that geometry, particularly ground clearance, has the major influence on the response of the dummy in the struck vehicle.

Figures 5 and 6 give the thoracic and pelvic responses resulting from changes in impactor mass, velocity, geometry and stiffness. The general conclusions from this study were that raising and lowering the MDB face has the greatest effect on the chest injury criteria.

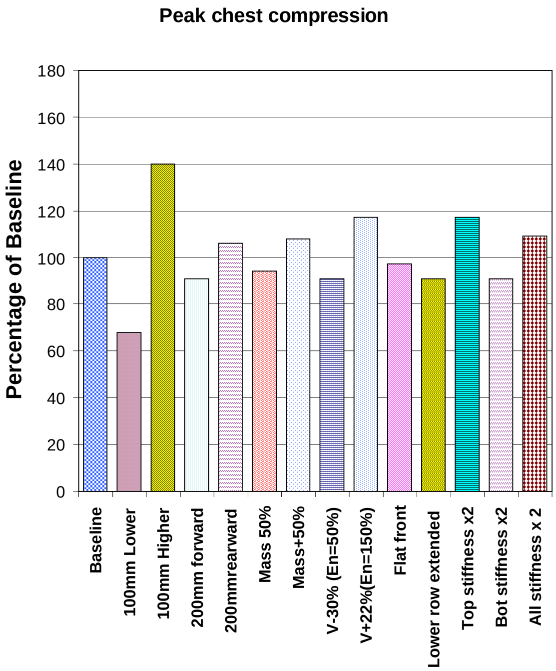

Figure 5. Influence of mass, impact velocity, geometry and stiffness on thorax response.

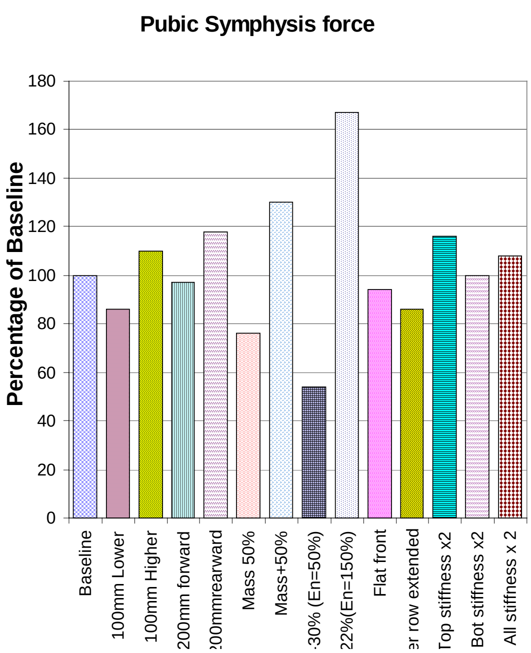

Figure 6. Influence of mass, impact velocity, geometry and stiffness on pelvic response

The pelvic force was affected by the impact energy both from mass and velocity changes. The MDB face impact height and stiffness have less effect on the pelvis. This confirms the results seen from past EEVC full scale tests except that the influence of mass on the pelvic response seems to be more obvious with this simulation exercise (Lowne, 1989).

The other issues, regarding the appropriate MDB design, centre on the relative benefits of perpendicular and crabbed impacts and whether a rear dummy is adequately exercised in the test procedure. EEVC WG13 has commenced studies to explore this through accident analyses and full scale tests with different MDB face and mass configurations.

Accident analyses

The aim of this analysis was to understand more about the influence of the principle direction of force on the injury outcome for a sample of the real world accident population.

Analysis of the UK CCIS database indicated that perpendicular impacts were equally as frequent as angled impacts. However, the proportion of casualties that were seriously or fatally injured was 60 percent for perpendicular impacts compared with 45 per cent for the angled impacts. This concurs with the differences in dummy responses observed between crabbed and perpendicular impacts (Lowne ’89).

Thus the perpendicular impact appears to be the worst case condition as well as representing at least half of the side impact accident configurations in Europe.

MDB Full Scale Tests

The perpendicular impact, as specified in the current European regulation, represents the worst case condition for the front seat occupant. However, it may not provide a sufficiently stringent test for the protection offered to rear seat occupants. Transport Canada has performed tests with a modification of the European MDB, widened and with a raised ground clearance. EEVC has commenced a research study to evaluate this and other concepts for a new barrier face design. One objective was to determine whether the test for the rear seat occupant could be made more stringent while retaining the current test severity for the front seat occupant.

In the first phase of this study, three MDB side impact tests were conducted to examine the effects of barrier ground clearance, width, mass and front face profile on the responses of a front and rear dummy in a small European car. A fourth test (moving car to moving car) was carried out in order to represent more closely the type of loading that might be seen in a real world accident. Data from a EuroNCAP test on the Renault Megane were used as baseline reference values for typical front dummy loads seen in a European ECE Regulation 95 test since the side impact test in EuroNCAP is essentially the same as the current regulatory test. Figure 7 illustrates the modifications made to the standard EEVC MDB face for these tests.

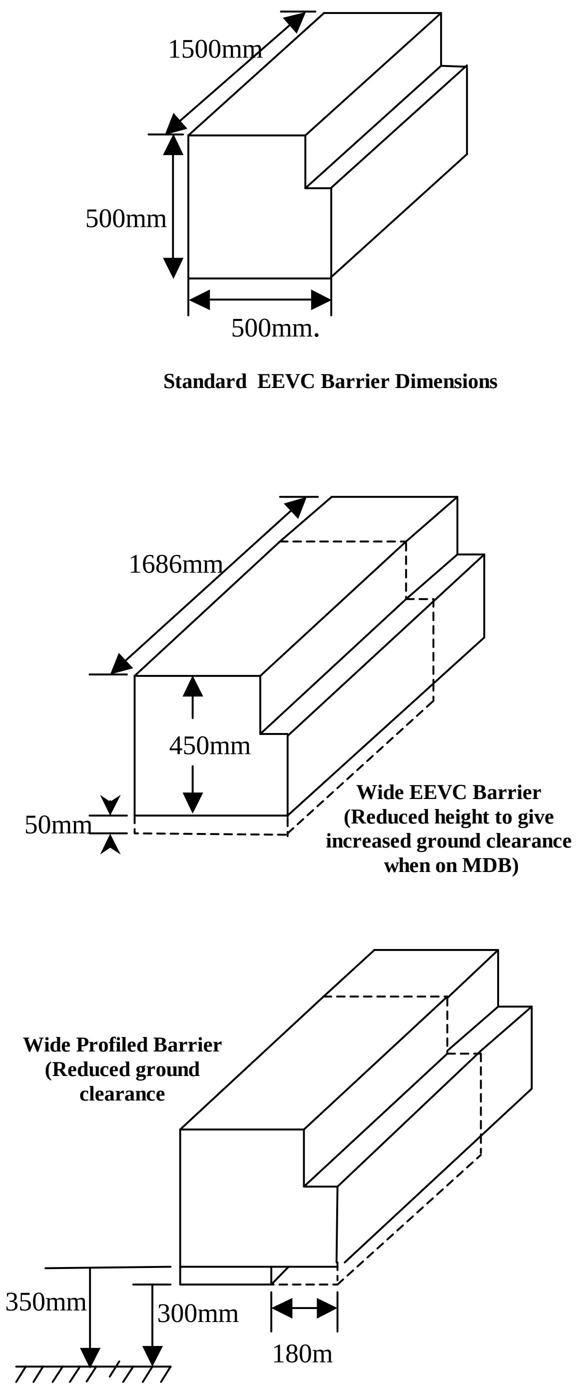

Figure 7. Standard and Modified EEVC MDB Faces

The test matrix is shown in Table 5

These phase 1 side impact tests with wide barriers and increased ground clearance and the car to car test indicated that, in general, the severity of the loading on the driver was maintained in all of the modified barrier tests when compared with the standard barrier design results. In two of the tests (wide barrier 350/300mm ground clearance at 950kg and 1500kg) some of the driver dummy results were more severe, particularly in the lower body regions. Thus these tests were at least as stringent for the driver as the current standard.

Table 5.
Test Matrix – Wide

Impactor Mass (kg)	Impactor	Barrier Height (mm)	Target Vehicle	Speed Km/h
950 +/-20	Standard EEVC MDB	300	Megane	50 +/-1
950 +/-5	Wide EEVC MDB	350	Megane	50 +/-1
950 +/-5	Wide EEVC MDB	300/350 profiled	Megane	50 +/-1
1500 +/-5	Wide EEVC MDB	300/350 profiled	Megane	50 +/-1
1390	Mondeo	N/A	Megane	24.1/ 48.3*

* Megane/Mondeo

The driver dummy upper body responses were higher in all the MDB tests than for the car to car test but the lower body responses were similar, especially with the higher mass MDB. This is due to the front end height of the Mondeo being noticeably lower than that of the MDB face. Changes to the barrier ground clearance (even over a partial depth) appeared to have a larger influence on the dummy results than the alterations to the MDB mass. Increasing the mass of the MDB to be more representative of the current European vehicle fleet would appear to be a logical step. Increasing the mass to 1500kg (as proposed by IHRA for reasons of promoting harmonisation with the US) would not appear to be a cause for concern.

For the barrier face characteristics and geometry used, the rear dummy appeared to be less sensitive to the barrier modifications made in this test series compared to the front dummy. As for the driver, the rear dummy chest responses were higher in the MDB tests than in the car-to-car test. However, for this dummy, the abdomen and pelvis responses were lower in the MDB tests than in the car test. Further work on the MDB face design will be needed to examine this aspect.

Future tests in this series will be expected to provide further guidance on an appropriate MDB face definition for European accident conditions.

REVIEW OF SIDE IMPACT DIRECTIVE

The current EC Side Impact Directive included the need to review certain technical aspects. The technical content of the Directive was based on proposals put forward by the EEVC. These proposals were the culmination of many years of accident investigation, research and testing by a number of European institutions. However, since full scale testing using dummies was new for Europe, the review was included in the first edition of the Directive to allow benefit to be taken of the latest research and experience with the tests when used within a legislative framework.

EEVC WG13 contributed to the following topics for review currently being undertaken

- test speed,
- seating position derogation,
- the barrier height above the ground,
- the necessity of a pole test in addition to the side impact requirements of Directive 96/27/EC.
- Viscous Criterion

To assist with the review, WG13 undertook an accident analysis from existing databases available within Europe. In addition, the review made use of knowledge gained from current research on full scale testing and on the results of EuroNCAP tests which were made available to EEVC.

Test Speed. From the accident analyses, there was an indication that the overall severity of impact in the test procedure should be raised. The total intrusion seen in accidents was normally greater than that seen in the Side Impact test. However, there are a number of parameters that could influence this, including barrier mass, stiffness, height, in addition to the impact speed. The accident data for two countries indicated that the current test speed included about 25 per cent of serious injury cases and 10 – 20 per cent of fatal accidents, suggesting a potential benefit from an increased test speed. However, this should only be considered in association with other changes to impact severity.

Seating Position Derogation. The Directive includes a derogation that the range of front seat positions for which the test could be performed should exclude effectively those where the pelvis is adjacent to the B-Pillar. This was introduced because technical solutions to the problem of impact to the B-pillar were unproven when the Directive was drafted. The accident review indicted that there were clearly cases of injury due to contact with the B-pillar, particularly to the head but also to the chest and abdomen. However, the frequency of those contacts was not certain. The introduction of side airbags demonstrated that this problem could now be solved. WG13 noted that the removal of the derogation might result in an effective mandatory fitment of side airbags. It recommended that it would be advisable to undertake a research programme regarding the effect of side airbags on out-of-position occupants before making this commitment

Barrier Height Above The Ground. An attempt was made to evaluate the appropriateness of the current MDB face ground clearance from the accident review. From the accident analyses, there was no strong evidence to suggest that the current ground clearance of the MDB face was inappropriate.

An associated study of the front and side structures of modern cars suggests that the ground clearance (i.e. the height of the bottom surface of the MDB face) should be raised but not the level of the top of the MDB face. This would not be possible to achieve without a redesign of the whole MDB face. EEVC recommended that note be taken of this indication that the ground clearance may need to be raised in the future but that no action should be taken in the short or medium term.

Pole Test. The accident study indicated that side impacts to poles and narrow objects constitute a significant proportion of MAIS 3+ side impact injury accidents. In the Netherlands, Sweden and the UK, these ranged from 12 percent to 16 percent while in Germany pole or narrow object impacts comprised 53 percent of all such side impacts. If only struck side occupants are considered, these figures were even higher. The accident statistics also showed that these casualties are primarily young males, more than half being aged under 30 years.

EEVC recommended that consideration be given to the development of a suitable pole impact test for the longer term. This forms part of the IHRA proposals for the future side impact test procedures

Injury Criteria (including V*C) An analysis was made of the results for the viscous criterion from the EuroNCAP tests which use a test procedure based on that specified within the Directive. The results indicate that the current value of 1.0 m/s is achieved by most of the cars that have been subject to the

EuroNCAP test since the programme started, and all of the cars except for one ($V*C_{max}$ = 1.01) of the last two phases which primarily includes the more recent vehicle designs. The mean value of $V*C_{max}$ for the last two phases was 0.48m/s. The recommendation of EEVC is that the existing criteria, including the viscous criterion, should be retained at their current values unless future research indicated a need to refine these.

FUTURE WORK

It is anticipated that the problems associated with the current ECE R95 MDB face specification will be resolved in the short term. WG13 will concentrate on the completion of the development of the interior headform test procedure and research in support of the activities of the IHRA WG on Side Impact.

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APPENDIX

TERMS OF REFERENCE

The terms of reference of WG13 for the period covered by this report were:

(a) *the development of a repeatable and meaningful head impact test for the evaluation of head impact protection in side impacts.*

(b) studies to reduce the variation in test results of the full scale side impact test due to differing designs of barrier faces and dummy positioning.

(c) assessment of accident data analyses in support of the EC Side Impact Directive review.

(d) *organise and coordinate the EEVC contributions to the IHRA international working group on Side Impact Test Procedures.*

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