EEVC Approach to the Improvement of Crash Compatibility between Passenger Cars

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ABSTRACT

The objective of European Enhanced Vehicle-safety Committee (EEVC) Working Group (WG) 15 *Car Crash Compatibility and Frontal Impact* is to develop a test procedure(s) with associated performance criteria and limits for car frontal impact compatibility. This work should lead to improved car to car frontal compatibility and self protection without decreasing the safety in other impact configuration such as impacts with car sides, trucks, and pedestrians.

The group consists of national government representatives who are supported by industrial advisers. The Working Group serves as a focal point for European research conducted by national and industry sponsored projects. The working group is responsible for collating the results from this research to achieve its objectives. EEVC WG 15 serves as a steering group for the car-to-car activities in the "Improvement of Vehicle Crash Compatibility through the development of Crash Test Procedures" (VC-COMPAT) project partly funded by the European Commission.

This paper presents a review of the current European research status. It also identifies current issues with candidate test procedures and lists the parameters that should be considered in assessing compatibility. The current candidate test procedures are:

- an offset barrier test with the progressive deformable barrier (PDB) face
- a full width wall test with or without a deformable aluminium honeycomb face and a high resolution load cell wall
- an offset barrier test with the EEVC barrier and load cell wall.

These candidate test procedures must allow assessment of structural interaction, frontal force levels and compartment strength.

The Working Group will report its findings to the EEVC Steering Committee and propose a test procedure in November 2006.

INTRODUCTION

Since the 2003 ESV-Conference[1] the *Terms of Reference* of Working Group 15 have been revised. The new *Terms of Reference* are to:

- develop a test procedure to assess car frontal impact compatibility. Work will concentrate on car to car frontal compatibility whilst also considering the effects on other accidents such as impacts with the side of cars, trucks , pedestrians and roadside obstacles;
- establish criteria to rate frontal impact compatibility;
- identify potential benefits from improved frontal impact compatibility;
- through continued research of frontal impact protection, ensure that steps to improve frontal impact compatibility will also lead to improved front impact protection;
- co-ordinate the EEVC contributions to the IHRA working group on Compatibility and Advanced Frontal Impact.

From March 2003 to February 2006, WG 15's research activities are focused on the VC- COMPAT t project [2]. The VC-COMPAT project is partly funded by the European Commission and the contributions of national governments. The main aim of WG 15 and the VC-COMPAT project is to develop a test procedure or a set of test procedures to improve the compatibility of car structures in frontal impacts without decreasing the safety in other impact configuration such as impacts with car sides, trucks, and pedestrians. The VC-COMPAT project consists of two legs: a car to car leg and a car to truck leg. For the car to car leg, EEVC WG 15 serves as a steering group. This means that there is a close co-operation between the VC-COMPAT consortium and WG 15. Research results developed in VC-COMPAT are analysed and discussed in WG 15. Proposals for special test parameters, analysis methods, and the selection of car models to be tested are made by WG 15 and forwarded to the VC-C COMPAT consortium.

OBJECTIVES EEVC WG 15

WG 15 discusses compatibility issues and evaluates its objectives in terms of a route map. The listed objectives represent the current opinions of the group.

General

- Proposed test procedures must address both partner and self protection in frontal impacts without decreasing current (regulatory) self protection levels in other impacts, in particular frontal and side impact.
- The number of additional test procedures should be kept to a minimum.
- Test procedures should be internationally harmonised.

Short Term (aim to report suitable test procedures to EEVC steering Nov 2006)

- Improve structural interaction between vehicles
- Control new requirements for passive safety (regulatory and rating) to ensure that frontal force mismatch does not become greater than current self protection force levels in particular to stop the increase of frontal force level of heavy vehicles.
- Control new requirements for passive safety (regulatory and rating) to ensure that compartment strength does not become less than current levels, especially for light vehicles

Medium Term (Aim to report suitable test procedures to EEVC steering Nov 2010?)

- Improve compartment strength, especially for light vehicles
- First steps to improve frontal force matching
- Further improve structural interaction.

(Status January 31, 2005)

CURRENT ACTIVITIES

As already stated in the previous paper of EEVC WG 15 [1], the ideal behaviour of the car front end (such as in a car to barrier test) can not be seen in all car to car tests. Poor structural interaction is still present in current car to car crashes which results in compartment intrusion in one or both of the cars involved, even at substantially lower test speeds than in regulatory or Euro NCAP testing. The main problem during the crash is that the front-end structures may not stay aligned and do not deform as ideally as designed. This is strongly linked to overriding/ under riding phenomena. It is thus important to ensure the controlled interaction of the vehicle structures involved car during the crash.

As already mentioned the main objective of the VC COMPAT project is the further development of the existing proposals for a potential compatibility test procedure or set of test procedures to be applied in test requirements. To understand the problems highlighted above, the VC-COMPAT project is divided into the following research activities:

- **A structural survey** to create a database of positions and dimensions of the important energy absorbing structures in vehicles. This will be used to determine appropriate structural interaction areas for vehicles.
- **Accident analysis** to estimate the benefit and cost of improved compatibility.
- **A crash testing program** of car-to-car and car-to-barrier crash tests to validate the crash test procedures and develop appropriate performance criteria.
- **Mathematical modelling** to support the development of the test procedures and the cost benefit analysis.

In addition to the co-ordinated activities in VC-COMPAT, EEVC-WG15 is also an exchange point where the results of industry research projects and ongoing national projects are shared. The joint research of the European manufacturers, organised by ACEA has been evaluating the test procedures under review by EEVC WG15. Recent crash test results from ACEA sponsored tests have been shared with EEVC WG15.

COMPARISON OF TEST PROCEDURES

Details of the potential test candidates under consideration by EEVC WG15 have been presented by their developers[3][4]. These test procedures are still under further consideration and consist of:

1. Full width Deformable Barrier (FWDB) test at 56 km/h to assess structural interaction.
2. Progressive Deformable Barrier (PDB) test at 60 km/h to assess structural interaction and frontal force levels.
3. Offset Deformable Barrier (ODB) test at 64 km/h to assess frontal force levels.
4. High speed Offset Deformable Barrier (ODB) test at 80 km/h to assess compartment strength.

For the FWDB test[3] the honeycomb barrier consists of two layers. The front layer has a low stiffness to generate shear forces for the front end structures. The

rear layer with a higher stiffness is segmented (according to the load cell wall array) to separate the main load structures of the car and detect them on the load cells without bridging effects. The assessment of compatibility is based on homogeneity criteria for horizontal rows and vertical columns taking also into consideration the average height of force (AHOF). A recently developed relative homogeneity criterion is under consideration to overcome the mass dependency of the assessment. The ground clearance of the load cell wall and the honeycomb barrier has been adjusted to 80mm from the previous value of 50mm. This adaptation is to center two rows of load cells in the FMVSS Part 581 zone.

For the PDB test[4] the barrier stiffness increases with depth and has upper and lower load levels to represent an actual car structure. This setup is designed to create shear forces on the vertical and lateral connections of the front structures of the test object. The test procedure is aimed at both self and partner protection. The current assessment for compatibility is based on three assessment criteria: the partner protection assessment deformation (PPAD), the average height of deformation (AHOD) and the average depth of deformation (ADOD). All of these criteria are based on the deformation measurements from the barrier face.

The ODB test procedure with an overlap of 40%, the standard ECE R. 94 test, is modified with the addition of a high resolution load cell wall behind the deformable element. The increased test speed of 64 km/h (from the R94 56 km/h) is currently used in Euro NCAP and some of the previous test experience is available in the group.

The high speed ODB (80 km/h) test uses the same test configuration as the 64 km/h ODB. It aims to ensure that a car's compartment strength exceeds a minimum requirement so that it is able to withstand the forces imposed by another car. Note that no instrumented dummy measurements are taken in this test.

To assess the different test procedures envisaged by WG 15, the following parameter list was developed to assist the decision process.

Parameters to be Considered in Assessing Compatibility (status May 2004)

1. Structural interaction
1.1 Reproduction of frontal car to car accident loading
1.2 Show vertical force force/deformation distribution of the car front
1.3 Show horizontal force/deformation distribution of the car front
1.4 Show time history of local forces/deformations
1.5 Potential to show strength of lateral connections between load paths
1.6 Potential to show strength of vertical connections between horizontal load paths

2. Reproduction of Collapse Modes of Load Paths
2.1 Reproduction of frontal car to car accident collapse modes
2.2 Show time history of total forces
2.3 Potential to show optimum energy absorption of car front structures
2.4 Compartment strength to maintain compartment integrity
2.5 Potential to measure compartment strength
2.6 Potential to evaluate compartment integrity

3. Test Procedure
3.1 Simplicity of test procedure
3.2 Repeatability/reproducibility of test procedure

4. Others
4.1 Potential to harmonise with existing legal test procedures for frontal impact
4.2 Applicability to all vehicle types
4.3 Availability of objective assessment criteria.

POSSIBLE SET OF TEST PROCEDURES

The EU-Commission project, APROSYS, has recently started. This project includes an investigation of frontal impacts and potential necessity of a restraint system test in Europe. Therefore a full width test with a high deceleration pulse is under investigation in this project. The applicability of the THOR dummy for this test is also included in the project. The EEVC Working Group 15 is acting as an observer and advisor.

In EEVC WG 15 the opinion is growing that a set of two test procedures may be the best approach to improve self and partner protection in car frontal impacts. EEVC WG 16, which was merged with WG 15 two years ago, had proposed in its final report to introduce a full width test to current legal frontal impact testing. The standard ODB test sets high structural resistance requirements to the tested car while the full width test would complement the ODB test requirements with a high deceleration restraint system test.

WORLDWIDE HARMONISATION PROSPECTIVE

The EEVC WG15 has discussed the request from IHRA to consider the use of a full width test in the US, with or without a deformable face, using a load cell wall to measure the average height of force as a first step for the assessment of car to car compatibility. The working group agrees that the full width test can be used to measure the height of force and that controlling this could be a useful first step for improving SUV/ LTV compatibility with cars. However, the WG15 does not consider the control the average height of force as a sufficient instrument to measure compatibility. Adding a deformable face would provide further development. In addition to improving the measurement of force height, a deformable face would facilitate the future measurement of an interaction "footprint". The use of this interaction footprint would be even more important when the application is extended to conventional cars.

The progress of the IHRA Compatibility and Frontal Impact Group is reported in a separate presentation. From the WG 15 side there is some concern to find a world wide agreed test since there are substantial differences among the U.S., Europe, and Japan car fleets.

CONCLUSIONS

In EEVC WG 15 the opinion is growing that two test procedures could improve car self protection as well as car to car compatibility and could complement each other:

- an offset deformable barrier test procedure with a progressive deformable element seems to have a higher potential for defining compatibility assessment criteria than the current ECE R. 94 element
- a full width barrier test with a full width deformable element and high resolution force measurement behind the deformable element.

In close a co-operation between the VC-COMPAT consortium and EEVC WG 15, the project results will be evaluated carefully and objectively. It seems not too unrealistic to expect that end of 2006 EEVC WG 15 will in the position to propose a test procedure or a set of test procedures to assess the frontal compatibility between cars

Membership of EEVC WG 15

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