INTERNATIONAL HARMONISED RESEARCH ACTIVITIES SIDE IMPACT WORKING GROUP STATUS REPORT

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ABSTRACT

This paper reports on the status of work of the International Harmonised Research Activities (IHRA) Side Impact Working Group (SIWG) as at its 17th meeting prior to the 18th ESV conference in Nagoya in May 2003. This includes decisions made and the reasons for them. A final report to the IHRA Steering Committee will be presented just before ESV including the test procedures to be evaluated between 2003 and 2005.

INTRODUCTION

A steering committee was set up at the 15th Enhanced Safety of Vehicles (ESV) conference in Melbourne in 1996 to work towards a harmonised vehicle safety research agenda to avoid duplication of research. This is the International Harmonised Research Activities (IHRA) Steering Committee comprising government representatives including vehicle safety regulators from around the world. It was agreed that IHRA be responsible for overseeing research activities in six key areas.

One of the original key areas, functional equivalence, was replaced by side impact following the 16th ESV conference in Windsor, Canada in 1998. The six working groups under IHRA after the 16th ESV are shown below with each group chaired by the country in parenthesis:

- Side impact (Australia)
- Advanced frontal crash protection (Italy)
- Vehicle compatibility (United Kingdom)
- Biomechanics (USA)
- Pedestrian safety (Japan)
- Intelligent Transport Systems (Canada)

At the 17th ESV in Amsterdam, progress was again reviewed and it was decided to amalgamate the Advanced Frontal and Vehicle Compatibility Working Groups with the resulting five groups tasked for a further 4 years with a review at each ESV. The Steering Committee also agreed to a revised set of Terms of Reference for the Side Impact Working Group (SIWG).

The various IHRA working groups generally consist of about 10 members to ensure that progress is as speedy as possible. Although IHRA is essentially a government group, industry has been invited with a total of three representatives in each working group, one each from North America, Europe and Asia-Pacific regions. This maximises outcomes by engaging vehicle manufacturers in the research process so that countermeasures can be designed into vehicles as soon as possible.

SIWG MEMBERSHIP

The current members of the IHRA Side Impact Working Group are:

Keith Seyer	Department of Transport and Regional Services, Australia (Chair)
Craig Newland	Department of Transport and Regional Services, Australia (Secretary)
Dainius Dalmotas	Transport Canada
Suzanne Tylko	Transport Canada
Richard Lowne	EC/EEVC
Michiel van Ratingen	EC/EEVC
Joseph Kanianthra	National Highway Traffic Safety Administration, USA
Hideki Yonezawa	National Traffic Safety and Environment Laboratory, JMLIT
Minoru Sakurai	JARI
Akihisa Maruyama	OICA Asia-Pacific/JAMA
Michael Leigh / Stuart Southgate	OICA North America/AAM
Christoph Mueller	OICA Europe/ACEA

Past members:

Robert Hultman	OICA North America/AAM
Haruo Ohmae	JARI
Takahiko Uchimura	OICA Asia-Pacific/JAMA
Rainer Justen	OICA Europe/ACEA

List of Meetings

The IHRA SIWG was created in September 1998 and a list of the meetings held since the 17th ESV is provided below:

Meeting	Date	Place
12th	14-15 June 2001	Lyon, France
13th	7-8 December 2001	Geneva, Switzerland
14th	21-22 February 2002	Melbourne, Australia
15th	21-22 May 2002	Paris, France
16th	16-17 September 2002	Munich, Germany
17th	9-10 December 2002	Geneva, Switzerland
18th	24-28 March 2003	Los Angeles, USA

Location of Minutes

The Minutes of these meetings are located on the IHRA website – http://www-ihra.nhtsa.dot.gov

TERMS OF REFERENCE

At its 12th meeting, the SIWG finalised the revised Terms of Reference which states the objectives of the group, the outcomes of its first 2-year term, the activities to be undertaken in the future and a timeframe for these. These are summarised below.

Objective

Co-ordinate research worldwide to support the development of future side impact test procedure(s) to maximise harmonisation with the objective of enhancing safety in real world side crashes.

Scope

In its first 2-year term, the Side Impact Working Group (SIWG) concluded that new test procedures to address the side impact problem should include:

- A mobile deformable barrier to vehicle test
- A vehicle to pole test
- Out of position airbag evaluation
- Sub-systems head impact test

In its next term, the SIWG will also coordinate research to examine the feasibility of improving side impact protection for occupants on the non-struck side and develop a test procedure to evaluate such protection.

Activities

The SIWG is working towards achieving these goals by:

1. Reviewing any new real world crash data to prioritise injury mechanisms and identify associated crash conditions taking into account likely future trends.
2. Taking into account the need to protect both front seat and rear seat(s) adult and child occupants.
3. Interaction with the IHRA Biomechanics Working Group to monitor the development of harmonised injury criteria.
4. Interaction with the IHRA vehicle compatibility working group to ensure solutions in one area do not degrade safety in another.
5. Monitoring and, as appropriate, providing input to the development of WorldSID and any other side impact dummy.
6. Determining the greatest degree of harmonisation feasible and the design and vehicle safety performance implications of adopting different levels of test severity or the worst case condition.
7. Coordinating the evaluation of proposed test procedures subject to availability of test dummies and injury criteria.

Timeframe

While the progress of the group will be reviewed every 2 years, it is expected that:

- The target date for draft final proposal of test procedure(s) is 2003 ESV

- The target date for final proposal of test procedure(s) is 2005 ESV with validation in the intervening 2 years.

The test procedure(s) would include the best available dummies as recommended by the IHRA Biomechanics Working Group (BWG) (for example, the harmonised test dummy being developed by the ISO WorldSID Task Group (www.worldsid.org)). The BWG will also advise on availability of any other suitable test dummies and the injury criteria to be used.

Members noted that there are differences in fleet compositions around the world but were hopeful that research could be focused on these differences to determine whether they had a quantifiable effect on the injury risk in side impacts.

SUMMARY OF RESEARCH

Methodology

To determine the side impact trauma problem that needed to be addressed, the group began by examining real world crashes in the 3 major geographical regions, North America, Europe and Asia-Pacific, to identify the:

- types of side impact crashes occurring
- injuries being sustained by body region
- causes of these injuries, where possible
- characteristics of the drivers and passengers most at risk (gender, size, seating position, etc)

For vehicle to vehicle crashes, members were asked to report on any research that examined the effects on injury risk of mass, stiffness and geometry of striking vehicles together with any other parameters that were considered important for side impact protection.

There has been close cooperation and communication between the SIWG and other IHRA WGs on advanced frontal, vehicle compatibility and biomechanics, and with the WorldSID Task Group.

Real World Crash Studies

As part of the IHRA BWG task to define the real world side impact safety problem, Transport Canada analysed the real world crash data submitted by the various regions. This study, which is reported in full in the IHRA BWG report, indicated that:

- Collectively, side impacts involving vehicle to vehicle crashes and vehicle to narrow object crashes constitute about 90% of the side impact trauma. However, the frequency of involvement of specific vehicle types and narrow objects varied from region to region.
- Most of the trauma in side impacts occurs to struck side occupants.
- Up to 40% of the trauma to occupants of the struck car in side crashes occurs to non-struck side occupants depending on the geographical region.
- The head and chest were consistently the most frequently injured body regions.
- The frequencies of abdominal, pelvic and lower extremity injuries were also significant, but varied with geographical region.
- The main contact points causing injury to struck side occupants were door structure, exterior object and B-pillar.
- Depending on the region, the proportion of male and female severely or fatally injured occupants in vehicle-to-vehicle crashes were either similar or slightly predominated by females (up to 60%).
- Young males predominated in vehicle to narrow object crashes.
- Elderly occupant casualties were over-represented in vehicle to vehicle crashes.
- Rear occupants account for less than 15% of road trauma in side impacts.

The above research, combined with the need to ensure enhanced side impact protection for all adult occupants, would indicate the importance of using a small adult female test device in the front driver position in an MDB to vehicle test and using a mid sized adult male test device in a vehicle to pole test. Regulators may wish to specify requirements for other dummy sizes, if crash statistics indicate such a need for a particular region.

Parametric Studies on Effect of Mass, Stiffness and Geometry on Dummy Response

In the real world, vehicles of different type size and mass crash into each other. A number of parametric studies have been conducted to examine the effect on injury risk of the mass, stiffness and geometry of the striking vehicle in side impacts. The data presented to the SIWG included results from:

- A computer simulation by the UK Transport Research Laboratory

- A cooperative project of full-scale tests by the Australian Department of Transport and Regional Services and Transport Canada.
- A full-scale test series by the US Insurance Institute for Highway Safety (IIHS).
- Full scale tests by Transport Canada.
- A computer simulation by the NHTSA.
- Full-scale tests and FEM simulations of front-end structures of impacting vehicles for the comparison with current European MDB face by JAMA.
- Full scale tests by JMLIT.

Based mainly on single parameter variations, these data supported the following conclusions on the factors that increased dummy response:

- Raising the vehicle/trolley ground clearance had the greatest effect.
- Increasing the mass and stiffness of the vehicle/trolley has a lesser effect.
- A perpendicular impact maximises the loadings to the driver when compared to crabbing the trolley.
- Non-homogeneous barriers generate more "punch-through" than homogeneous ones.

This is because:

- In high frontal profile vehicles such as 4WDs/Light Trucks and Vans (LTVs) there is typically less engagement of the sill and floorpan of the struck vehicle and these striking vehicles are more likely to load the head (from contact with the high hood/bonnet) and chest (from the higher intrusion profile).
- Typically, injuries occur (40-50 msec after impact) before momentum transfer to the struck vehicle occurs (around 70 msec).
- The stiffness ratio between the front and side structure of vehicles is so high that, for the same geometry, variation in front structure stiffness has little effect on dummy response.

Some of these studies also included increasing impact speed which was found to have an effect similar to increasing ground clearance. For example one of the studies showed that increasing the speed from 50 to 60 km/h had the same or similar effect on dummy responses as increasing the ground clearance from 300 mm to 400 mm.

Compound variations of mass, stiffness, geometric and velocity parameters were not investigated.

Non-struck side test research

Members agreed that there should be a test to evaluate injuries to non-struck side occupants because real world crash data attributed up to 40% of road trauma to this group depending on the geographic region. In the US, FMVSS201 addresses this problem to some extent.

Very little other work is being done in this area except for a collaborative program between General-Motors Holden's, Monash University, Wayne State University, DOTARS and Autoliv. This work showed that current dummies are unlikely to provide correct kinematics but that WorldSID's design showed promise. This work is reported elsewhere in this ESV. However, there is much more to be done in this area and should be given a higher priority in the SIWG's considerations in the future.

CONCLUSIONS

After reviewing further research data, members confirmed that the IHRA Side Impact Test Procedure should comprise:

1. Mobile deformable barrier to vehicle test(s) involving up to 2 mobile deformable barrier types reflecting regional fleet differences.
2. An oblique vehicle to pole test.
3. Out-of-position side airbag evaluation test(s).
4. Sub-systems head impact test.

The following sections will discuss the recommendations made by the group on each of these tests.

MOBILE DEFORMABLE BARRIER (MDB) TEST

Defining the parameters of the Mobile Deformable Barrier (MDB) test has proven to be the most challenging task for the group. While the group was hopeful of recommending only one MDB test, it became clear that this would be difficult because of the fleet differences between regions around the world.

In North America, LTVs currently account for approximately 50% of all new light vehicle sales (cars, light trucks and vans). In other regions there has been an increase in the popularity of "soft-roaders"/small 4WDs, although not to the same extent as North America. While smaller and lighter than traditional 4WDs, their high geometry front structures present similar problems to vehicles they strike.

Therefore, the group is recommending that two MDB test procedures be taken into the validation phase which may result in further refinements:

1. An MDB test using a barrier based on a passenger car/small 4WD-type bullet vehicle. This will initially be the Advanced European (AE)-MDB test procedure currently being developed by the EEVC.

2. An MDB test using a barrier based on a LTV type vehicle. This will initially be the Insurance Institute for Highway Safety (IIHS) MDB test procedure currently being used by the IIHS.

The group noted that:

- A single "worst case" test would be the ideal for harmonisation. However, this could only be achieved if the proposed more severe test could be guaranteed to provide at least the same degree of protection for all significant body regions as generated by the less severe test. Even then, it would be difficult for countries without a large fleet of LTVs to justify a worst case test at the stringency of the proposed IIHS test.
- By taking at least 2 draft test procedures (eg the new draft AE-MDB and the IIHS MDB) into the validation phase, there would be some latitude to develop and select appropriate tests for the different fleet mixes and to examine whether the worse case test option is feasible.
- The accident data indicated that, at a minimum, a small female dummy should be used in the MDB tests and a mid-sized dummy be used in the pole test.

A summary of these two draft test procedures follows:

Advanced European (AE)-MDB Test Procedure

The AE-MDB is designed to provide an impact environment similar to that seen in car-to-car and small 4WD-to-car side impacts. The objective has been to

(i) provide a sufficiently stringent test condition for the rear seat dummy while maintaining the same level of severity for the front seat dummy

(ii) provide a perpendicular test

(iii) provide a severity of test appropriate for a predominantly car-based fleet mix.

(iv) develop test conditions that would require protection measures that would be effective in real car-to-car impacts (ie. that could not be overcome by vehicle design changes optimised for that MDB but that would not work in many car-to-car accidents).

The plan view of the new MDB face design was derived taking into account a number of considerations and the objectives

- The MDB is intended to reproduce, in a purely perpendicular impact with a stationary target vehicle, the loading pattern to front and rear occupants seen in a moving-car-to-moving-car impact configuration. Consequently it must be wider than the normal width of the striking vehicle which translates along the passenger compartment of the moving struck car.
- The relatively high stiffness associated with the striking vehicle longitudinals should be represented but the zone in between and also outside this area should be less stiff.
- The MDB face should not be so wide and stiff as to load simultaneously the A and C pillars in an unrealistic manner such that correct loading to the passenger compartment would not occur.

To achieve these aims, a plan view design which is wider than the existing ECE R95 MDB (1500mm) overall, but narrower at the front face, has been used. Sections 2 and 4 of the MDB face shown in Figure 1 should be stiffer than sections 1, 3 and 5. Chamfering sections 1 and 5 means that the relative stiffness differences between 1 and 2 and between 4 and 5 can be achieved while constructing sections 1, 2, 4 and 5 from the same material. This simplifies the design, and also achieves the aim of avoiding too much contact with A and C pillars.

A review of the vehicle structural survey undertaken by EEVC Working Group 15 has provided data on the range of locations of the longitudinals. Analysis of some dimensional characteristics of car passenger compartments for EEVC Working Group 13 has provided data on the range of separation of front to rear seat H-points. These data are shown diagrammatically in Figure 1.

Comparison of these data has resulted in a design of MDB face with a front face which is 1100mm wide, has an overall width of 1700mm, a centre section

500mm wide, corresponding to the width of the standard load cell wall, and edges chamfered at 45°.

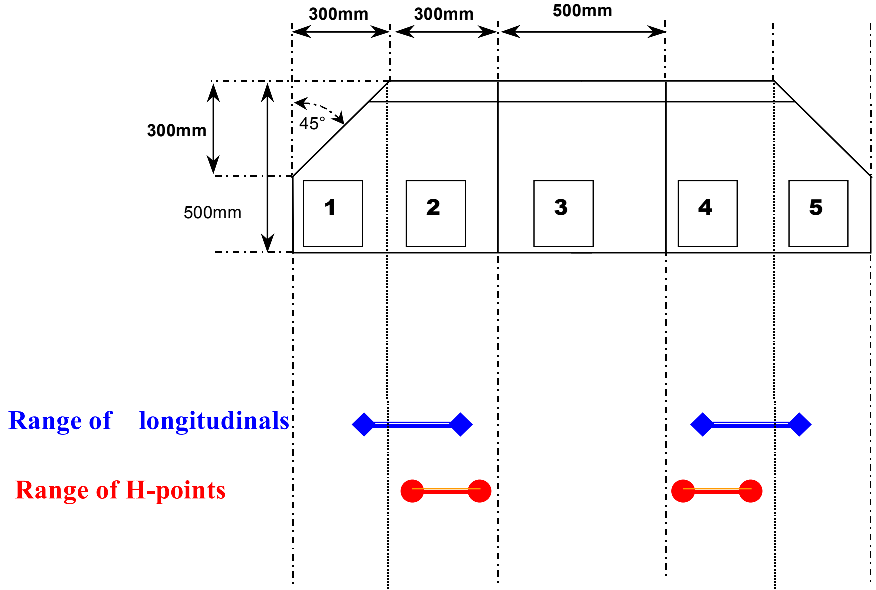

Figure 1.
Plan View of New MDB Face and H-point and Longitudinal Locations

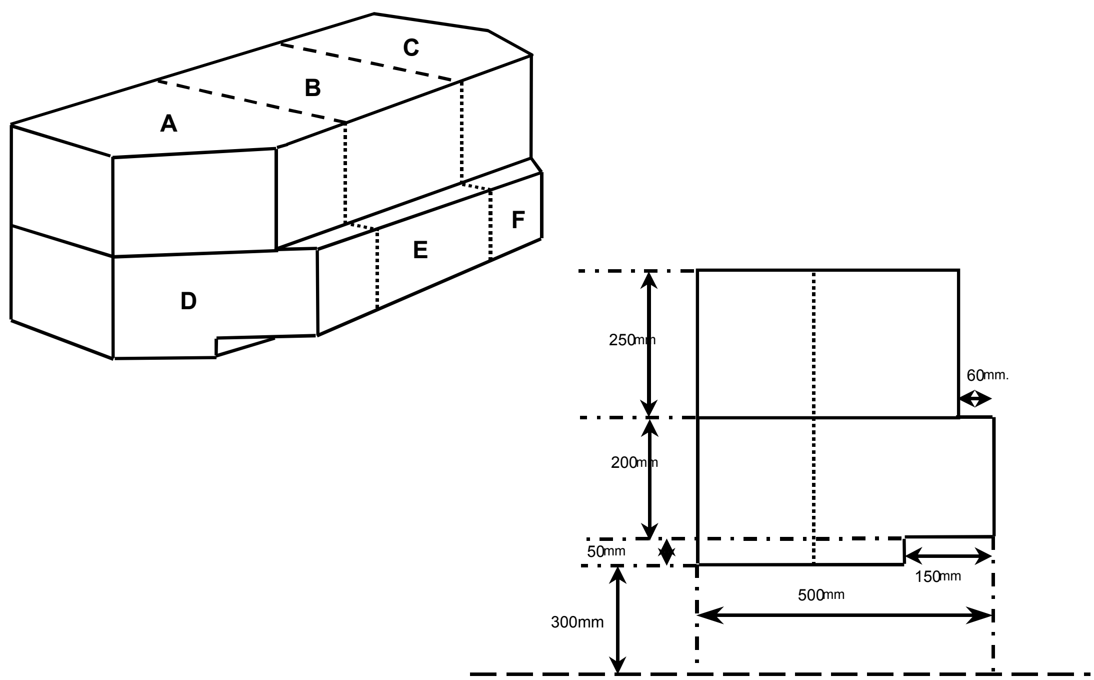

Figure 2:
Schematic and Side View of New MDB Face

Figure 2 shows the overall shape and design of the AE-MDB face. The overall height and depth is the same as the current Regulation 95 MDB face, so that the height of the top of the face is unchanged. The ground clearance at the rear of the MDB face is unchanged but the ground clearance at contact has been raised by 50mm.

Sections 1 and 2 in Figure 1 have been combined to form block A on the top row and D on the lower row. Similarly for sections 4 and 5 which are combined to form blocks C and F.

The characteristics of the material for Blocks A to F are currently given by dynamic force- deformation corridors, derived from load cell wall tests on modern Japanese cars by JARI and some limited modern European car test data. The dimensions of the load cell wall plates are given in Figure 3, labelled to match the AE-MDB block labels.

All of the MDB face blocks in the top row (A – C) are made from the same material. In the lower row, blocks F and D are identical and are made from stiffer material than block E, which is stiffer than the top row material. The force deformation corridors for the load cell plates when impacted by this MDB (Mass 1500kg, impact speed 35km/h) are given in Figure 4.

The proposed test using this MDB is a perpendicular impact. The mass of the MDB is 1500kg and the impact speed is 50km/h. The MDB is aligned such that the centreline of the MDB face is 250mm behind the front seat R-point of the target vehicle.

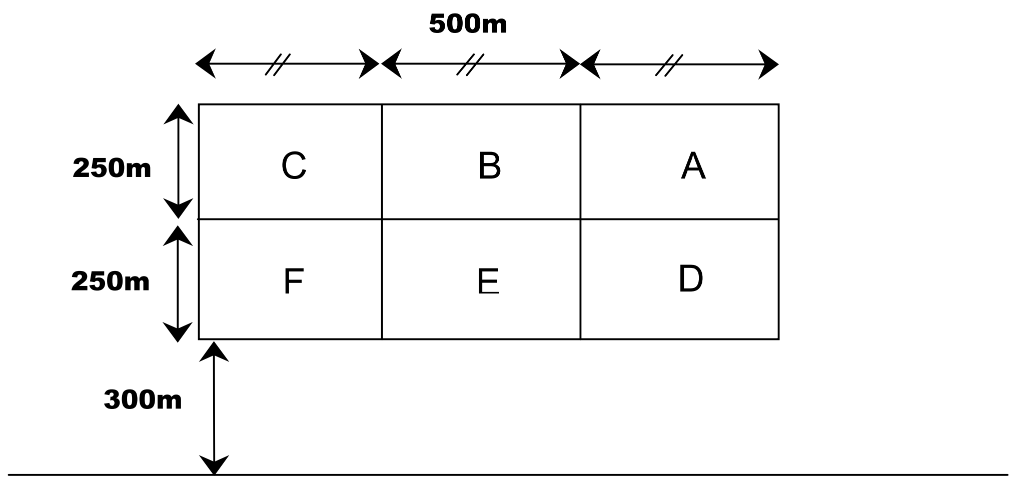

Figure 3.
Load Cell Wall plate configuration and dimensions

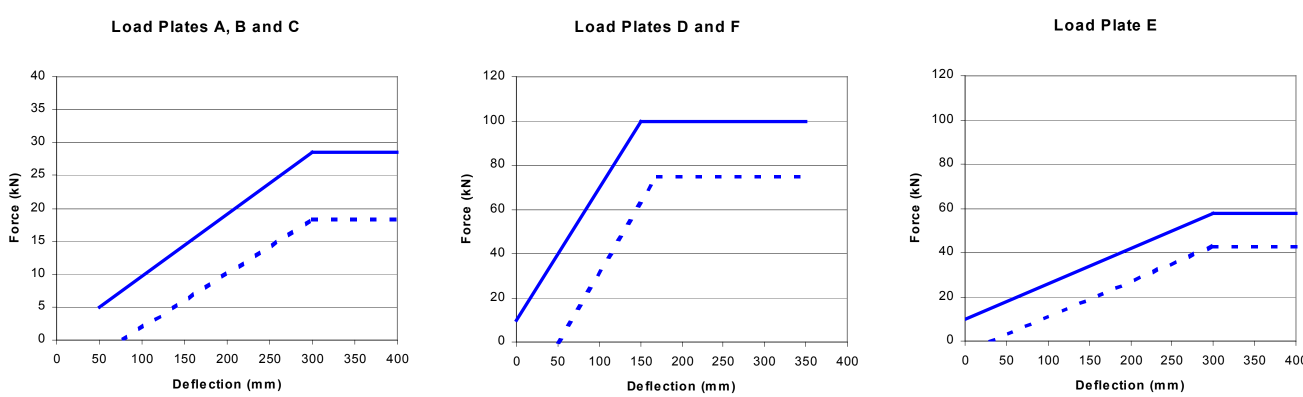

Figure 4.
Force-deformation corridors for AE-MDB

IIHS MDB Test Procedure

The IIHS MDB test consists of a stationary test vehicle struck on the driver's side by a moving barrier fitted with an IIHS side impact deformable face (version 4) ballasted to 1500 kg. The barrier has an impact velocity of 50 km/h (31.1 mph) and strikes the test vehicle on the driver's side at a 90-degree angle. The impact point of the barrier is dependent on the wheelbase of the test vehicle. For a vehicle struck on the left side, the impact point is defined as the distance rearward from the struck vehicle front axle to the left edge of the deformable barrier face when the deformable barrier face makes first contact with the struck vehicle.
The impact point is calculated as follows:

- If wheelbase < 250 cm, then impact reference distance (IRD) = 61 cm
- If 250 cm ≤ wheelbase ≤ 290 cm, then impact reference distance = (wheelbase ÷ 2) – 64 cm
- If wheelbase > 290 cm, then impact reference distance = 81 cm

The horizontal and vertical impact tolerances at the point of contact between the MDB and the vehicle shall be less than ± 25 mm.

The moving deformable barrier (MDB) is accelerated by the propulsion system until it reaches the test speed (50 km/h) and then is released from the propulsion system 25 cm before the point of impact with the target vehicle. The impact speed is clocked over a 1 m length of vehicle travel ending 0.5 m before the vehicle's release from the propulsion system.

The MDB braking system, which applies the test cart's service brakes on all four wheels, is activated 1.5 seconds after it is released from the propulsion system. The brakes on the struck vehicle are not activated during the crash test.

IIHS Moving Deformable Barrier Properties

The moving deformable barrier consists of an IIHS deformable aluminium barrier (version 4) and the cart to which it is attached. The test cart is similar to the one used in FMVSS 214 side impact testing, but has several modifications (Figure 5). The wheels on the cart are aligned with the longitudinal axis of the cart (0 degrees) to allow for the perpendicular impact mode. The front aluminium mounting plate has been raised 100 mm higher off the ground and has been extended 200 mm taller than a standard FMVSS 214 cart to accommodate the IIHS deformable barrier element. Steel plates were added as necessary to increase mass of the cart. The MDB test weight is 1500 ± 5 kg with the deformable element, test instrumentation, camera, and camera mount. The MDB centre of gravity in the fully equipped test condition is 990 ± 25 mm rear of the front axle, 0 ± 25 mm from the lateral centreline, and 715 ± 25 mm from the ground.

The deformable element is 1676 mm wide, has a height of 759 mm, and a ground clearance of 379 mm when mounted on the test cart (Figure 6). Detailed information on the IIHS barrier development and evaluation testing has been previously documented (Arbelaez et al., 2002).

Test Vehicle Mass and Distribution

The test weight of the vehicle, which includes the vehicle instrumentation, four cameras, and two SID-IIs dummies, is 200–240 kg greater than the measured curb weight of the vehicle (as delivered from the dealer with full fluid levels). If the vehicle test weight needs to be increased to fall within the range, steel plates are added to the instrumentation rack. If the vehicle test weight needs to be decreased, non-essential, non-structural items are removed from the rear of the vehicle. The front and rear axle weights are used to determine the longitudinal position of the centre of gravity for the test vehicle.

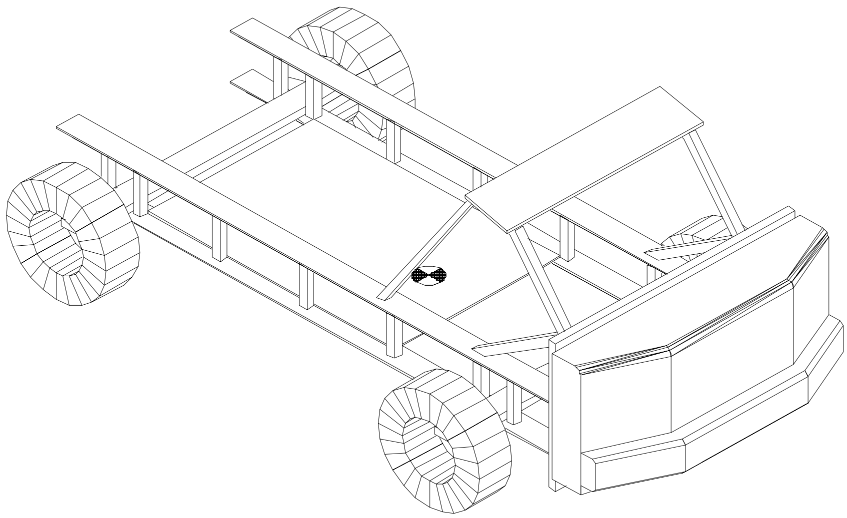

Figure 5.
IIHS Test Cart With Deformable Barrier Element Attached

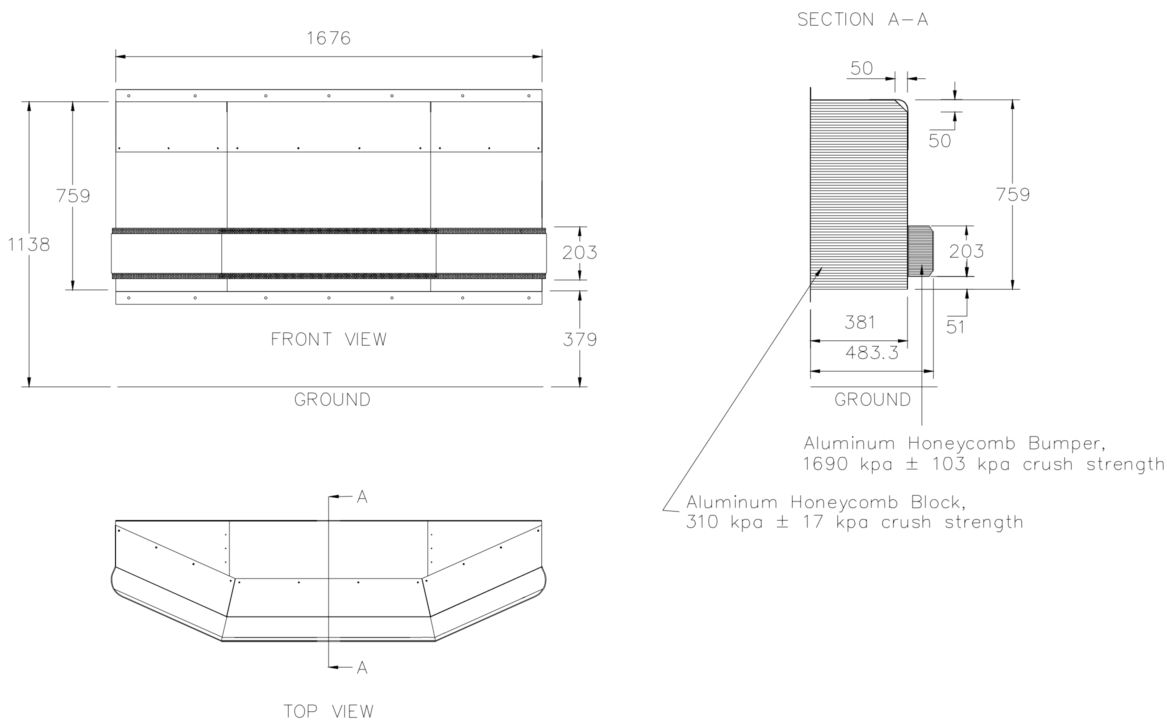

Figure 6
Version 4 of the IIHS Deformable Barrier Element
(All measurements in millimetres)

Driver Seat and Driving Control Placement

The driver seat and adjustable steering controls are adjusted according to the *Guidelines for Using the UMTRI ATD Positioning Procedure for Dummy and Seat Positioning* (Insurance Institute for Highway Safety, 2002). The outboard upper seatbelt anchorage point (if adjustable) is set in the full down position, unless otherwise specified by the test vehicle's manufacturer. After the driver seat has been adjusted, the latching mechanism is examined to note whether all of its components are interlocked. If partial interlocking is observed and normal readjustment of the seat does not correct the problematic misalignment, the condition is noted and the test is conducted without repairing the mechanism. The right front passenger seat is set to match the position of the driver seat.

The driver's head restraint (if manually adjustable) is set in the fully down position. The head restraint height adjustment locking mechanism (if equipped) is examined to ensure the mechanism has engaged. All manually adjustable head restraint tilting mechanisms are adjusted to their full-rearward position during the test.

The driver seat manually adjustable inboard armrest (if equipped) is moved to its lowered position. For vehicles equipped with multiple locking armrest positions, the position that results in the top surface of the armrest being closest to parallel with the ground is chosen. Rear passenger armrests are also placed in the down position. When seats have inboard and outboard armrests, both are placed in the lowered position.

Other General Test Conditions

Fuel is replaced with Stoddard solvent to full capacity within 48 hours of the test. The fuel pump is run for a short period to ensure the Stoddard solvent has filled the fuel lines. The air conditioning system's refrigerant is recovered by methods that comply with applicable environmental regulations.

The non-struck-side doors are fully latched and locked, whereas the struck-side doors are fully latched but not locked. The front and rear driver's side windows are fully raised.

The ignition is turned to its on position, and the transmission is shifted into its neutral position prior to the test. The front left tire is chocked to prevent the vehicle from moving prior to the test.

Crash Dummy Preparation and Setup

A 5th percentile female SID-IIs dummy is positioned in the driver seat according to the *Guidelines for Using the UMTRI ATD Positioning Procedure for Dummy and Seat Positioning*. A second SID-IIs dummy is positioned in the left rear seat according to the *Dummy Seating Procedure for Rear Outboard Positions.* These reflect the current IIHS test protocol but are subject to revision during the IHRA validation phase.

Standard Build Level C SID-IIs (First Technology Safety Systems) dummies will be used for the IIHS side impact program. Both the driver and rear passenger dummies are fitted with the TMJ head skin and its compatible neck shield.

The dummies and vehicle are kept in a climate controlled area in the crash hall where the temperature is maintained at 20.6–22.2 degrees Celsius and the relative humidity at 10–70 percent for at least 16 hours prior to the test. The driver and rear passenger seat belts are fastened around the dummies. For vehicles with continuous-loop lap/shoulder seat belts, the slack from the lap portion of the driver seat belt is removed and the webbing is pulled fully out of the retractor and allowed to retract under tension a total of four times. The lap belt slack is then removed again with a small pulling force. For vehicles with separate lap and shoulder seat belt retractors, the webbing from each is pulled fully out of the retractor and allowed to retract under tension a total of four times.

VEHICLE TO NARROW OBJECT (POLE) TEST

The real world crash data clearly indicated that vehicle impacts into narrow objects was an area that needed to be addressed. There was considerably more consensus on the requirements of a vehicle to pole test procedure than for the MDB test. The following has been proposed:

- Moving vehicle to pole test.
- Oblique impact @ 75 degrees to the longitudinal plane of the test vehicle
- Speed of 32 km/h.
- Pole impact to evaluate at least head and thorax protection.
- Mid-sized adult male test device.
- Rigid pole diameter of 254 mm.

- Pole to span at least below sill height to above roof height.

The main area of discussion has been the diameter of the pole and how this relates to the wish to load the head and thorax simultaneously. These two body regions were identified as being the main causes of trauma in impacts into narrow objects. A larger diameter pole was expected to better achieve head and thoracic loading at the same time as well as resulting in a more repeatable test. All regions except the USA initially supported a 350 mm diameter pole. The current FMVSS 201 dynamic pole test utilises a 254 mm diameter pole as does the consumer crash testing procedures used in various countries.

A recent test program by the USA has shown that an oblique impact using a 254 mm diameter pole was able to simultaneously load the chest and head. Therefore the test procedure proposed by NHTSA will be taken into the validation phase.

This test procedure is intended to simulate real world side crashes with narrow objects such as trees and poles. The goal is to utilize an oblique pole side impact test procedure to evaluate countermeasures for head and chest protection in higher severity side crashes.

In narrow object side crashes, half of the seriously injured occupants are in crashes of delta-Vs 32 km/h or higher. Only 16% are in crashes with a principal direction of force around 90º while 63% are in frontal oblique narrow object crashes. The optional FMVSS No. 201, rigid pole side impact test is at 90º and an impact speed of 18 mph (29 km/h) while the oblique pole test is at 75º and 20 mph (32 km/h).

The impact face of the rigid pole shall be a vertically oriented metal structure with a diameter of 254 mm ±3 mm and beginning no more than 102 mm above the lowest point of the tires (or if the vehicle does not have tires where the tires would have been) on the struck side of the test vehicle and extending at least 150 mm above the highest point of the roof of the test vehicle. The pole face shall be offset from its mounting and support such that the vehicle will not contact the mounting within 100 ms from the initial vehicle-to-pole contact.

The test vehicle's velocity shall be constant (essentially having zero acceleration or deceleration) for a minimum of the last 1.5 m of travel before impact. The final velocity shall be measured (after tow system release) when the test vehicle is within 300 mm of the pole face. A vertical impact reference line shall be established on the test vehicle at the intersection of the vertical transverse plane through the dummy head CG (front outboard designated seating position) and the vehicle exterior. Note that the impact reference line is established after the vehicle is setup with its longitudinal axis 75° (anti-clockwise for LHD and clockwise for RHD) to the line of travel and the dummy is seated. The vertical impact reference line should be aligned with the centreline of the rigid pole (see Figure 7).

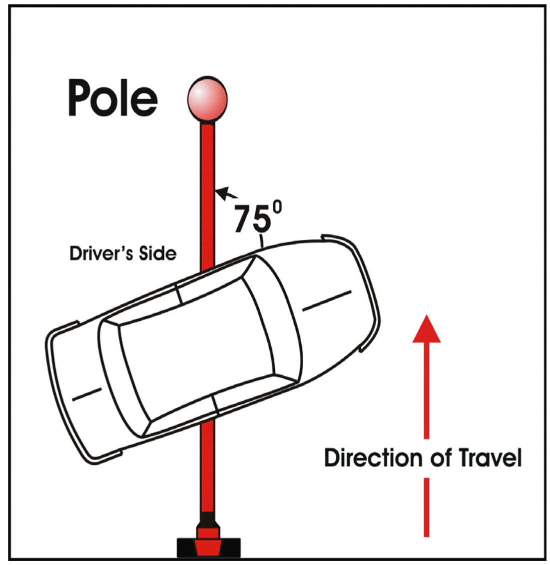

Figure 7.
Vehicle impact alignment

OUT-OF-POSITION SIDE AIRBAG EVALUATION

Initially, it was agreed that NHTSA and Transport Canada would draft the evaluation procedure based on ISO TR 14933 and the NHTSA/Transport Canada research. Later it was agreed that the recent work under the chairmanship of the Insurance Institute for Highway Safety (IIHS) would also be taken into consideration.

In August 2000, the Side Airbag Out-of-Position Injury Technical Working Group (TWG) chaired by the IIHS released the *"Recommended Procedures for Evaluating Occupant Injury Risk from Deploying Side Airbags"*. The procedures were developed in response to a request by the National Highway Traffic Safety Administration (NHTSA) that industry develops public standards which their member companies would adhere to in the design of future side airbags. The TWG procedures recommend Anthropomorphic Test Devices (ATDs), instrumentation, test procedures, and performance guidelines that should be used for assessing the injury risk of interactions between a deploying side airbag and a vehicle occupant. The IHRA SIWG has agreed to take these test procedures into the validation phase which may result in further refinements.

The TWG recommendations are intended to minimise the risk of out-of-position injury for that segment of the population believed to be at greatest risk, namely small women, adolescents and children. As such the ATDs deemed most appropriate by the TWG for the evaluation of risk include the SID-IIs, the Hybrid III 5^{th} percentile female and the Hybrid III 6 and 3-year old child ATDs. A series of test procedures has been developed for each of the following inflatable system types: seat mounted airbags, door or quarter panel mounted airbags and roof-rail mounted inflatable systems. Each test is intended to quantify the level of risk to a designated body region and/or to evaluate the risk of a specific injury mechanism.

The fundamental premise of the TWG recommendations requires that the full complement of tests for a given system be carried out to ensure that a thorough evaluation of the system has been completed. The use of sound engineering judgment is strongly recommended to guide additional tests perhaps with slight variations, for systems demonstrating elevated risks.

Appendix 1 provides an overview of the testing required as a function of airbag system.

INTERIOR HEADFORM IMPACT TEST

The real world crash data indicated that head injuries were a significant part of side impact trauma even though the results of current regulatory MDB tests do not show a head injury risk. Consequently it is proposed that the IHRA harmonised side impact test procedures include a supplementary interior headform test to ensure that the potential contact points for head impact are evaluated.

The test is based on a development by EEVC of FMVSS 201 using the Free Motion Headform in free flight. The test procedure uses the same headform as FMVSS201 and identifies the same interior surface targets except that they are restricted to those liable to be contacted by an occupant's head in side impact accidents. This is achieved by creating four planes which restrict the area for which the targets can be selected. These planes are based on the location of the centres of gravity of the heads of the small female (CG-F) and large male (CG-R). The forward and rearward extent of the potential contact zone are limited by two vertical planes, one set at 45° forward of the lateral axis and passing through CG-F and the other set at 45° rearward of lateral passing through CG-R. The upper and lower limits for the contact zone are created by planes passing through fore-aft horizontal axes through CG-F and CG-R (See figures 8 and 9).

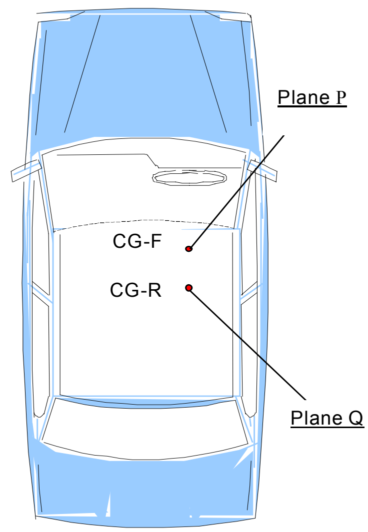

Figure 8
Plan view of planes

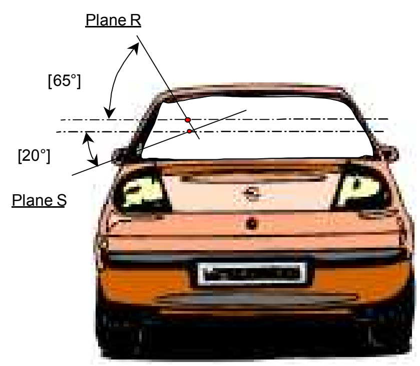

Figure 9
Front view of planes

Those Target Points, as defined in FMVSS201, that lie within the volume created by these four planes are then determined. These points are subject to the headform impact at 6.7m/s. Unlike FMVSS201, it is proposed to permit the option of also testing between the determined Target Points if there is deemed to be a 'worse case' position. As the kinematics in lateral impacts can be complex, especially if the struck car rotates significantly in the accident, the impact direction of the occupant's head to the interior surface is difficult to predict. Therefore, the proposed test procedure will usually be a perpendicular impact with the target point surface, as this is likely to be the worst case situation. Provision is made within the proposal to account for those target positions where this is not possible. It should be noted that these planes, as currently defined, restrict the potential contact points to those relevant only to the front seat occupants.

For rear seat occupants, a further set of four planes can be established for the rear (or any other row of forward facing seats). For instance, for the rear seats, the forward and rearward extent of the potential contact zone are limited by two vertical planes, one set at 45° forward of the lateral axis and passing through CG-RF (plane T) and the other set at 45° rearward of lateral passing through CG-RR (plane U), where CG-RF and CG-RR are the locations of the centres of gravity of the small female and large male sitting in the rear struck side seating position (see Figure 10).

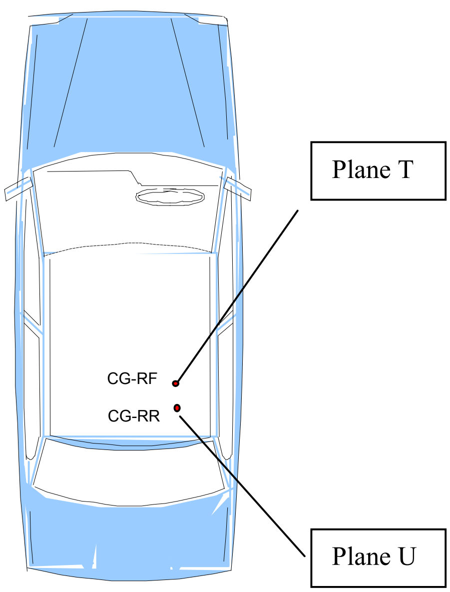

Figure 10
Plan view of planes – Rear seating position

If the rear seat were adjustable for the fore-aft position, CG-RF would be determined for the fully forward position and CG-RR for the fully rearward position. Similarly the upper and lower limits for the contact zone are created by planes passing through fore-aft horizontal axes through CG-RF and CG-RR (not shown).

The proposed Performance Criterion is HIC, calculated from accelerometers within the FMH and transformed into the equivalent HIC for the dummy to be used in the full scale barrier test and/or pole test. For the SID-H3 and the EuroSID, this transform function is:

$$HIC_{dummy} = 0.75446\ HIC_{FMH} + 166.4$$

However, this may differ according to the selected dummy to be used in the IHRA test procedure.

In view of the anticipated benefits from crash-deployed head protection systems in preventing contact both with internal structures and external objects, it is important not to discourage the provision of these systems. Therefore it is proposed to adopt the same exceptions from the full headform test for those areas which cover stored deployable systems that is provided for in FMVSS201. Those locations would be tested at a reduced impact speed (5.3 m/s), subject to the demonstration that the deployable device is effective in the proposed IHRA oblique pole test.

The EEVC work confines impact zones to those that are contactable by restrained occupants in side impacts. With front seatbelt wearing rates approaching 80% in the USA, NHTSA has agreed to look at the EEVC's "restrained-only zones" in the validation phase.

DEVELOPMENT OF HARMONISED TEST DEVICE

The WorldSID Task Group initially had funding and development resources for the mid-sized adult male test device only. ISO Working Group 5 has now given a mandate for the development of a small adult female test device. However, funding and development resources have not yet been allocated for this task, although this is currently being sought. In the meantime, it has been suggested that SID-IIs could be used, but advice will be sought from the IHRA Biomechanics group on its suitability. The design freeze for the mid-sized adult male WorldSID production prototype occurred before the end of 2002 and it is expected that the final regulation-ready dummy will be available by the 2nd quarter of 2004.

RECOMMENDATIONS FOR FUTURE WORKING GROUP ACTIVITIES

In its 4-year term, the group has made recommendations on a set of test procedures that might form the basis of a harmonised side impact regulation. The members believe that there needs to be:

- Continued coordination with the WorldSID Task Group and the IHRA BWG to evaluate the harmonised test device.
- Continued coordination with the IHRA Biomechanics group to develop a set of injury criteria and for advice on suitable test devices.
- Continued coordination with the IHRA Vehicle Compatibility group to ensure that solutions in one area do not result in disbenefits in another.
- Evaluation of the recommended test procedures between 2003 and 2005 to make sure that all injury risks identified in accident studies are addressed and any test redundancies are identified and eliminated.
- Examination of the feasibility of improving side impact protection for occupants on the non-struck side and develop a test procedure to evaluate such protection.

As before, the success of this work is contingent upon the commitment of resources from IHRA members.

Following the validation phase, the finalised test procedures will be submitted to the UN ECE regulatory process to develop a new harmonised side impact regulation.

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APPENDIX 1
Summary of Test Conditions for Different Side Airbag Designs

ATD	TEST POSITION	BODY REGION	AIRBAG DESIGNS				
		Monitored & of interest	Seat back	Door/ quarter-panel	Roof-rail	Roof-rail & seat back	Roof-rail & door/ quarter-panel
Hybrid III 3-year-old	Forward facing on booster seat	Head, neck	✓			✓	
	Rearward facing	Head, neck, thorax	✓			✓	
	Lying on seat, head on armrest/ SM	Head, neck	✓			✓	
	Lying on seat/ SM	Head, neck	✓			✓	
	Outboard facing	Head, neck, thorax		✓			✓
	Inboard facing	Head, neck		✓			✓
	Lying on seat, head on armrest/ QP	Head, neck		✓			✓
	Lying on seat/ QP	Head, neck		✓			✓
Hybrid III 6-year-old	Forward facing on booster seat	Head, neck	✓			✓	
	Inboard facing on booster seat	Head, neck			✓	✓	✓
SID-IIs	Inboard facing /SM	Head, neck, thorax, abdomen, pelvis	✓			✓	
	Arm on armrest with instrumented arm	Arm, forearm	✓	✓		✓	✓
	Forward facing	Head, neck, thorax, abdomen, pelvis		✓			✓
SID-IIs or Hybrid III 5^{th}	Forward facing with raised seat	Head, neck			✓	✓	✓
	Inboard facing with raised seat	Head, neck			✓	✓	✓

✓= test required