EUROPEAN ENHANCED VEHICLE-SAFETY COMMITTEE

EEVC SIDE IMPACT HEAD PROTECTION TEST PROCEDURE

WG13 report March 2005

EEVC SIDE IMPACT HEAD PROTECTION TEST PROCEDURE

Encompassing both front and rear seating positions

DRAFT 3r

March 2005

EEVC INTERIOR SIDE IMPACT HEAD PROTECTION

TEST PROCEDURE

DRAFT 3r

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1. INTRODUCTION

The EEVC side impact working group WG13 has been tasked by the EEVC Steering Committee to propose appropriate test procedure(s) that could be used to evaluate interior surfaces of the vehicle that could case head injury in a side impact. EEVC WG13 has focussed most of its research on a subsystems test procedure. With the advent of active head protection systems WG13 has also examined the need for exemptions for certain areas covered by the un-deployed system, the assessment of areas covered by a deployed system and a complementary full-scale impact test based on a pole impact.

The proposed EEVC interior side impact head protection test procedures are designed to evaluate interior surfaces that have been identified as areas that can cause injury to an occupant's head in a lateral impact. The procedures comprise two elements; firstly the evaluation of static (fixed) surfaces, with the exception of glazing, single skin roof panels and secondly active elements, such as air bags that deploy during the early phases of a side impact. Injurious head contacts have been observed in accident data on both front and rear door waistlines, this test procedure does not make any recommendations for the evaluation of this area.

It was the intention that the test procedure would be appropriate for all passenger cars. It has only been validated against vehicle with a fixed/hard roof. It's application to other vehicles such as vehicles with detachable and collapsible roofs will need further research and validation. It is considered that the application to the roof areas of vehicles with detachable and collapsible roofs would be excessively problematic, although it would be appropriate for any fixed A-pillar within the defined zone.

2. BACKGROUND

In three phases of research EEVC WG13 established several details pertaining to a possible EEVC interior headform test procedure. Firstly regarding the choice of headform for the test procedure; of the three headforms available and evaluated by WG13, in the mid 1990s, the US Free Motion Headform (FMH) was the preferred impactor. Secondly a free flight launch system should be adopted, excluding any possibility of using a linear guidance system, and finally a range of issues pertaining to the definition of the test procedure were studied. The third phase included a detailed accident study to assist in the definition of the contact zones.

In recent years vehicle manufactures have introduced a range of new 'active safety systems' ('head area' side air bags) to enhance the protection given to an occupant in a side impact. The provision of such protective devices is seen as potentially very beneficial as they could not only provide protection for head contact internally within the vehicle, but also in the event of head contact with external objects, through the window aperture. However, in the areas where these systems are installed, it may prove difficult, due to space limitations, to provide the full energy absorption requirements. In the equivalent US Standard, FMVSS201, exemption from testing at the full headform test speed is provided for the areas in which these undeployed systems are stored, provided it is demonstrated that the systems do, indeed, provide the protection claimed. This is achieved by subjecting these vehicles to a pole impact test and measuring the dummy head response. [1].

WG13 wishes to include similar exemptions. It now includes relevant features of a pole impact test procedure, based on the pole test defined in FMVSS 201, but using the ES-2 dummy, based on the specification gleaned from the Euro NCAP consortium, which itself uses this FMVSS201u test but with ES-2.

The incorporation of these active systems and their efficacy should be monitored.

The EEVC procedure attempts to encourage head protection of all areas of the side of a vehicle that a human head could impact.

3. IHRA - SIDE IMPACT WORKING GROUP

The proposed procedure was initially designed to address head protection for the front seating positions only, since Regulation 95 only encourages protection for this seating location. The IHRA Side Impact Working Group decided to adopt new research of EEVC WG13 as the foundation for an interior surface test procedure for their suite of advanced side impact test procedures. The work of EEVC WG13 can easily be expanded to cover the extended area of concern, namely protection for the rear seat occupant. To address this need the zones that should be evaluated have been extended in this procedure and are currently undergoing evaluation and validation (Section 1.4.2).

4. PROPOSED TEST PROCEDURES

Two test procedures are described. Firstly the main subsystem headform test to evaluate appropriate internal surfaces that would be impacted by an occupant's head, (Section 4.1.9.2) and secondly the subsidiary pole test that would be used if a deploying head protection system is used in the vehicle under test (Section 4.2). The pole test is based on a full vehicle test involving a pole impact and would assess systems that are designed to protect an occupant's head from external contacts as well as assess the firing mechanism of active head protection systems.

Note: For application within Europe and to be aligned with the scope of protection required in ECE Regualation 95, all references to rear seating zones and targets should be disregarded. For application into IHRA test procedures both front and rear seating positions should be included in the assessment. Further studies will be needed in order to apply the procedure to large occupants in rear seating positions, in particular for smaller vehicles.

4.1 Free Motion Headform (FMH)

EEVC WG13 carried out a dynamic test programme on the three 'most promising' head-forms, available at the time :-

- the EEVC (WG10) adult pedestrian head-form
- the AAMA headform and

- the FMVSS 201[3] Free Motion Head-form (FMH).

The EEVC head-form was being used within the evolving EEVC pedestrian test procedure for exterior surface testing. The FMH, based on the Hybrid III head, was already in use in the US for interior surface testing (FMVSS201). The AAMA headform was one that had been developed by the US auto industry as an improvement on the FMH. The WG13 tests were carried out under closely controlled conditions into a range of impact surfaces, examining padding stiffness, the presence of hard spots within the padding, impact angle and responses to deforming sub structures. For the purposes of this Phase 1 evaluation, a free flight impact was used. The report of the WG 13 'Phase 1' test programme [4] concluded that the Free Motion Head-form (FMH) was the preferred impactor, partially based on harmonisation issues and any further studies should be based on this impactor.

4.1.1 **Headform orientation**

The Free Motion Head-form can be orientated for impact in a number of different ways. EEVC WG13 have tested it in two orientations with respect to the designated forehead contact patch and the FMH's centre of gravity. The FMVSS201 orientation is such that the mid-sagittal plane of the head-form is vertical and perpendicular to the contact surface and the headform skullcap plate plane is perpendicular to the impact direction Figure 1. Thus the contact patch is not coincidental with the axis parallel to the direction of impact, passing through the FMH centre of gravity (C of G). In such an orientation, impacts tend to be offset to the edge of the certified area. The second orientation evaluated was with the FMH centre of gravity directly behind the forehead contact patch in the direction of impact Figure 2.

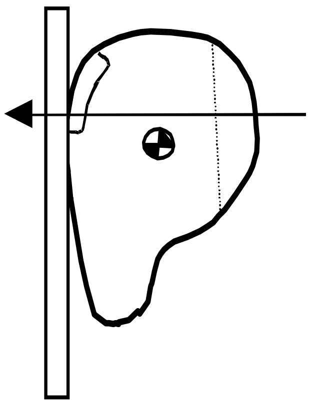

Figure 1 FMVSS 201 alignment

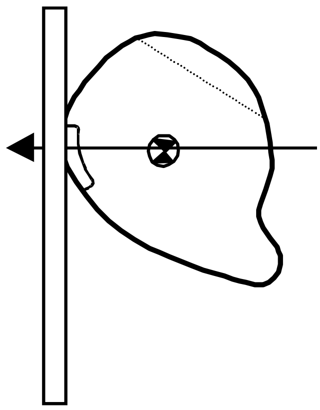

Figure 2 C of G alignment

Tests have shown that, in the 'centre of gravity aligned' mode, the tendency for the head-form to rotate and spin off the struck object is minimised (Figure 2). The severity of this Centre of Gravity aligned test is slightly higher due to the fact that more energy is being absorbed by the struck surface with less being converted to rotational motion of the headform. It was also seen to penetrate deeper into the impacted structure. Thus the FMVSS 201 orientation tends to induce more head-form rotation and a less severe impact.

The coefficient of variation was found to be less for the centre of gravity aligned impacts but the correlation with tests with the EuroSID-1 dummy was better for the FMVSS201 alignment. For this reason and in the interests of harmonisation, WG13 recommended that the FMH be used in the FMVSS201 orientation.

4.1.2 **Launch system**

As noted above, WG13 based its selection of the preferred head-form in a free flight test environment. In order to determine whether it was necessary or advisable to specify the launch system in any proposed test procedure, EEVC WG13 carried out a comparative test programme with the FMH being used in free flight and fully guided modes. This second phase of the EEVC WG13 research programme found significant practical problems with a test procedure based on a guided impact. The tests clearly demonstrated that a 'free flight' launch system should be recommended excluding any possibility of allowing tests to be performed with a fully guided launcher. The phase 1 and 2 programmes also identified a need to specify the distance of free flight between the head-form release and contact to minimise gravitational influences. In addition, a close specification of the period when the impact velocity should be measured was noted as well as a need to specify a clean head-form release from the launch system.

4.1.3 **Impact zones from accident studies**

To guide the specification of the impact zones for the EEVC test procedure positions contacted by the population involved in real world accidents were studied. An analysis of several in-depth accident databases from France, Germany and the UK identified a range of interior and exterior surfaces contacted by occupants' heads in side impact accidents, for both front and rear seating positions in side impacts. These data were also compared to similar US data. The accident data were not collected according to the same strategy in all databases but they yielded similar results. From each accident study, struck surfaces were ranked in order of contact frequency.

Table 1 presents the ranked results for restrained struck side occupants and Table 2 for restrained non-struck side occupants. Impacts to other external objects were noted in the study.

Table 1 – Key Contact Regions, Restrained Struck Side Front Seat 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)

From these results, the B-Pillar and Side Roof Rail are priority areas for evaluation when considering only the struck side occupants. Side other and the A-Pillar are second order priority areas and are also important areas for the non-struck side occupants.

Table 2 – Key Contact Regions, Restrained Non-Struck Side Front Seat 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)

In a 'Type Approval' regime it is not practical to test all conceivable impact points within the identified areas, thus it will be necessary to specify how the impact locations and impact directions should be selected and defined, preferably taking into account the 'worst case' condition. EEVC WG13 has undertaken such an evaluation and has developed a set of guiding principles.

4.1.4 Test zones

One FMH test should be performed to any structure within each 'defined' target area. The precise location of the impact point is initially specified, based on FMVSS201 target points. These are then restricted to points that lie within a cone based on potential head trajectories in side impacts. To ensure that due care is taken of areas between the individual specified target points, the option is given to test at points between the specified target points if these are deemed to be 'worst case', within the guidance given in Section 4.1.3. In addition, certain defined structures are specified as focal points for the FMH test, as they are in FMVSS201.

The Defined structures are:

- Upper seat belt anchorage
- Seat belt adjustment device, if located above the anchorage point
- Grab handle (located within the defined header rail distance)
- Lighting control unit, coat hook or other such 'fixed' vehicle furniture.

Some parts of the defined structures may be obscured from head contact by other vehicle trim, e.g. Fascia or fixed seats. Areas so obscured will not be tested with the head-form.

In the interests of keeping the burden of the cost of testing to a minimum, it would be desirable for a number of the tests, if not all, to be performed in the same vehicle. In such an environment collateral damage must be avoided. The test at one position must not compromise a test at an adjacent position due to any 'pre-damage'. Guidance must therefore be given concerning the spacing of adjacent impact points and the monitoring of damage. Information to support such guidance will be obtained from the 'in-vehicle' tests.

4.1.5 **Door Impacts**

The accident data have indicated that injurious contacts with the door can occur to non-struck side occupants. They have been noted to occur even to restrained struck-side occupants. This proposal does not include tests to these locations unless they lie within certain restricted boundaries, but they could be considered in any future amendment.

4.1.6 **Impact velocity**

The severity of the head-form test should be matched to that in the full-scale test. BASt and TRL carried out an analysis of head velocities observed in side impact tests for EEVC Working Group 9 (WG13, WD2). This study indicated that the maximum 'mean head velocity' in the lateral direction was 7.9 m/s. From high speed film analysis it was deduced that this velocity fell to approximately 6.7 m/s by the time the head contacted an interior surface or passed through 'the side window aperture'. It was therefore proposed by EEVC WG 9 and accepted by WG13 that the head-form test should be based on a head impact velocity of 6.7m/s.

4.1.7 **Impact angles and head-form orientation**

Due to the complex motion that occurs in side impact accidents, potential impact angles onto the vehicles interior struck surfaces can be wide ranging and be influenced by impact type and direction, occupant stature and occupant seating position. It is perceived that the most severe injury would be sustained in an impact perpendicular to the struck surface. Unfortunately accident data are not able to give guidance as to actual impact vectors and head orientations at the point of impact. It is realised that impacts perpendicular to the surface may not always be physically possible to achieve or in some cases realistic.

One method of defining impact vectors would be to use the 'H point' manikin and assume a linear path between the normal head position and the contact point. However, the motion of the head of a restrained occupant in a real side impact accident is far from linear. The motion of the vehicle body is complex and it is likely that an occupant would be in a position that differed from this 'standard' position, prior to an impact, particularly if the vehicle rolls or yaws in the impact. Thus a vector definition based on the angle of impact onto the surface, taking into account the worst case consideration, would be more appropriate.

Clearly, only contact locations and impact velocity vectors that can be achieved within the vehicle should be specified. As the FMH is a non-symmetrical impactor with a defined contact patch in the forehead region, it will be necessary to adjust the headforms orientation to permit an impact to the selected target point, with this contact patch. It is proposed that the head-form be preferentially used with the mid-sagittal plane in a vertical mode. It is important that the main contact should be within the certified FMH contact zone.

Two methods for achieving a clean contact have been discussed. The first method (1) permits pre-defined rotation steps (of 90 degrees) of the mid-sagittal plane about the horizontal fore-aft head axis, which is supported by the majority of WG13 members. The alternative method (2), allows the mid-sagittal plane to be pitched forward vertically and perpendicular to the test surface by the required amount to achieve a clean contact.

Method 1
If it is not possible to achieve a clean contact (as defined in Appendix 1, Section 1.1.1) within the specified contact zone of the FMH, with the headform mid-sagittal plane vertical and perpendicular to the surface, without also contacting other (uncertified) parts of the FMH, then the headform and impact vector should be pitched forward by 10° and the contact conditions re-examined. However, it would also be reasonable to permit rotation of the mid-sagittal plane about the horizontal fore-aft head axis to obtain a clean impact and reduce impacts to non-certified areas of the headform. To reduce the number of different impact possibilities, and hence improve reproducibility, it is proposed that the impact vector pitch angle should initially be limited to 0° and 10° only. Rotation about the impact vector is limited to 90° increments only and intermediate values should not be used. If a clean contact cannot be established after rotation the free motion headform should be rotated back to its original vertical position and the impact vector should be pitched from 10° until a clean contact is established, up to a maximum of 18°. If these conditions can not be met the impact point should be moved.

Method 2
If it is not possible to achieve a clean contact (as defined in Appendix 1, Section 1.1.1) within the specified contact zone of the FMH, with the headform mid-sagittal plane vertical and the velocity vector perpendicular to the surface, without also contacting other (uncertified) parts of the FMH then the headform and impact vector should be pitched downward until a clean contact (according to 1.1.1 Appendix 1) is established and the approach angle is within the ad-hoc range as defined in 6.1.7. If these conditions can not be met the impact point should be moved.

4.1.8 **Worst case evaluation**

To achieve the best level of protection for an occupant's head, the vehicle should be evaluated in a 'worst case' or 'most injurious' manner. If surfaces are evaluated in such a mode then the levels of injury saving, when they are struck in a less severe manner or orientation are likely to be maximised. Worst case features are likely to be related to the stiffness of the padding and the underlying structure being impacted – seams, folds, welds and structural components as well as impact direction and head orientation.

4.1.9 **Vehicle preparation and support structures.**

Two types of interior test are possible. One involving the full vehicle, appropriately trimmed and prepared and the other using sections of the vehicle in a sub-component test.

4.1.9.1 Vehicle based test

The test procedure must be repeatable and reproducible. Thus it is important that there are adequate controls in place to minimise test variability and ambiguities in interpretation. To foster improved repeatability and to reduce the variation in ride height caused by operators moving within the vehicle during set-up, the vehicle should be supported on a rigid support off its normal suspension.

The WG13 accident studies have shown that many head injuries are sustained when the intruding or struck object supports the exterior of the vehicle. For the B-pillar and side roof rail, most of the serious injuries occur with support behind the impacted area. Therefore to be effective, the energy absorption should be built into the vehicle structure and trim. External support would prevent any exterior deflection of the vehicle and encourage the provision of energy absorption within the trim and inner structure of the vehicle adjacent to the head impact position.

This could be achieved either by ensuring that the surface is fully and rigidly supported (externally), as was implemented in the 'Composite Test Procedure' [5], or by specifying a maximum movement of an external vehicle reference point, along the axis of the impactor. The definition of any support system that would be reproducible is difficult. Consequently a limit on external motion is preferable. The accident data do not give any guidance on such a deflection criterion. However, test results give an indication of 'normal' motion. Since the purpose of the support is to avoid gross movement., a limit of a point 'P' of 10 mm of external body deflection is proposed, with respect to the vehicle, along the axis of the impact, Figure 3.

If the side window can be opened tests should be performed with the window fully open. However, only points which can be contacted by the FMH with the window(s) closed should be tested.

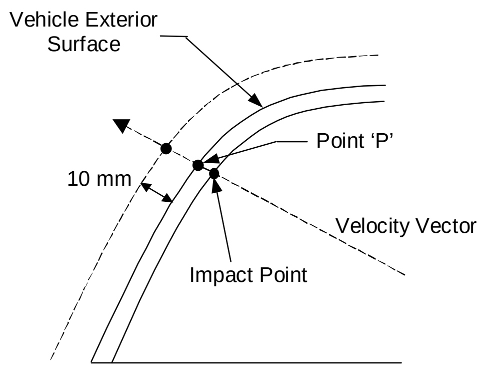

Figure 3 Measurement of external movement

4.1.9.2 Sub-component test

The accident data have shown that many injuries are sustained at positions within the vehicle which are 'externally supported'. Thus a sub-component test of the relevant structure resting on a solid support might provide a good representation of a full-scale vehicle in which the impacted position is externally supported.

However, tests by WG13 with separated B-pillars at the sub-component level demonstrated considerably greater variability than the equivalent car tests. This was considered to be due to the difference in attachment control of the interior trim when only the sub-component was present. On the basis of these results, sub-component tests are not proposed as part of the EEVC test procedure. They may still prove to be of worth in design and development testing if appropriate care is taken regarding trim attachment and stability.

4.1.10 **Deployable or active safety systems**[1]

It is recognised that active head protection systems are being developed and implemented in a number of vehicles and that such systems could afford special or additional protection to the occupant's head. Indeed they may be the only way of protecting the head against external objects. It may prove difficult to achieve adequate performance from the interior headform impact at the standard speed in the area covering the deployment system.

[1] The assessment of deployed systems is a recent WG13 development and will need further validation.

The EEVC Interior Headform Test Procedure should not discourage such advanced safety developments. A pole impact test is added to ensure that the assumption of 'an effective head protection system' is justified. EEVC WG13 proposes to adopt this approach, but using ES-2 in place of the special Hybrid-SID dummy used in FMVSS 201. This makes the assumption that the occupant's head would not contact these zones at the full impact speed (6.7 m/s) since the head protection system will have been deployed in accidents of that severity. However, to ensure that head injury risk is not exacerbated at impact speeds lower than those, that would trigger deployment, the headform test is performed at a lower impact speed for these defined areas (5.3 m/s). A pole impact test is added to ensure that the assumption of 'an effective head protection system' is justified. EEVC WG13 proposes to adopt this approach, but using ES-2 in place of the special Hybrid-SID dummy used in FMVSS 201. Experience with pole impacts using both EuroSID-1 and ES-2 has shown that it reacts normally with a pole and is capable of distinguishing the presence of protective measures in the head area.

4.1.10.1 Active system FMH tests:

Where the requirements of the pole test (defined in Annex 1) are satisfied, additional tests are included to assess further the performance of the active head protection system to check that adequate protection is given over the whole of the deployed area. The areas of an active system, which are capable of providing adequate protection to the head, will be subjected to FMH tests at the full impact speed (6.7m/s). Those areas are to be nominated by the manufacturer and will be their decision whether the tests are performed with the system statically inflated or triggered and deployed.

4.1.10.2 Active system sub-structure FMH tests:

Satisfactory results would indicate that the occupant's head would not contact the vehicle structures underlying the active system at the full impact speed (6.7 m/s) since the head protection system will have been deployed in accidents of that severity. However, to ensure that head injury risk is not exacerbated at impact speeds lower than those, that would trigger deployment, the headform test is performed to the underlying structures of those defined areas at a lower impact speed (5.3 m/s). The underlying structures of the remaining areas, which are not designated as providing adequate protection, will be tested at the full impact speed (6.7 m/s).

4.1.10.3 Risk from deployment

A transition period exists between the active device being undeployed and fully deployed. During this period a time exists when the occupant can have their head close to the deploying system. Such a scenario is often termed 'Out of Position' (OOP). WG13 is of the opinion that consideration should be given to the need for an evaluation of such a situation but a proposal for a test procedure for this is not included in this report.

4.1.10.4 Head protection coverage area

It is observed that an active head protection system can consist of a collection of pockets or zones. Each of the zones may afford differing levels of protection dependant upon where the occupants head contacts the system. WG13 believes it is important to ensure that a minimum level of protection is given to the occupant, independent of contact position. The areas of an active system, which are capable of providing adequate protection to the head, are defined as ensuring a HIC_{dummy} <1000 when impacted at 6.7m/s. The area(s) that offer the least protection will be evaluated, these could include seam connection/kissing points or areas having the least airbag depth, also the shape and stiffness of underlying structures should also be considered. If there is sufficient doubt as to the ability of certain areas to provide adequate protection, then 'worst case' points will be selected (within the defined area(s)) and evaluated with the *active system FMH tests*.

4.1.10.5 Deflation

Consideration is needed to allow for possible second impacts, on how to evaluate devices that are designed to deflate after the initial impact.

4.1.11 **Application of procedure**

This procedure does not currently include any consideration for convertible or coupé-cabriolet vehicles. It is expected that WG13 will make recommendations on how such vehicles can be suitably assessed in the future.

4.2 Pole impact test

The full-scale pole test procedure, being considered by EEVC WG13, mainly duplicates that specified in FMVSS201u and adapted by Euro NCAP. The dummy to be used in the procedure will be adopted based upon the advice of EEVC WG12, which is currently the ES-2 dummy [10].

5. ASSESSMENT CRITERIA

5.1 Headform test

Any test procedure must include tolerances on the test conditions to reduce test variability. Table 3 details a range of appropriate tolerances, based on the experiences of impact testing gained within the WG13 test institutes.

Table 3 FMH Impact tolerances

FMH • Impact velocity *(in the direction of launch.)*	• Measurement to be taken ≤ 100 mm from the impact point along the primary impact vector • Max free flight distance from release to impact 100 mm • Impact velocity accuracy ± 0.2 m/s
Vehicle • Alignment • Exterior surface deflection	• Impact alignment accuracy ≤ 10.0 mm radius of the target point. • Conical alignment ± 5.0° from the intended velocity vector • ≤ 10 mm along the axis of the impact, coincident with the input target

It is generally accepted that HIC, whilst having some deficiencies, is the most appropriate injury criterion for use in an interior head-form test procedure. The FMH is a free-flight test device whose dynamic measurements and injury predictions have been correlated with full-scale test results, which in Europe is currently based on the EuroSID-1 dummy and its ‘side certified head’.

For FMVSS 201, the dynamic performance of the FMH was compared to the Hybrid III dummy, in impacts to the front of each head and a suitable dummy to free motion headform HIC factor was developed. For the EEVC Interior Headform Test Procedure, comparative sled tests with impacts to the certified side of the EuroSID-1/ES-2 dummy head and free flight tests with impacts to the forehead of the FMH, into a range of structures, were carried out by TRL. These tests yielded a linear regression relationship of:

$$\mathbf{Y = 0.6499\ X + 260.32}.$$

This compared well over the important 500 – 1500 HIC range with the correlation trend line given in FMVSS 201 of:

$$\mathbf{Y = 0.75446\ X + 166.4}.$$

To assist in harmonisation and reduce confusion EEVC WG13 agreed to adopt the FMVSS 201 regression relationship, thus:

$$\mathbf{HIC_{dummy} = (0.75446)*HIC_{FMH} + 166.4}$$

In conformity with the full-scale regulatory test [1] the appropriate requirement would be:

$$HIC_{dummy} = \leq 1000 \qquad (\text{or } HIC_{FMH} = \leq 1105)$$

For consistency with ECE Regulation 95, the 36 msec values for HIC would be calculated.

5.2 Pole impact test

The assessment criteria that should be applied to the pole test should be the same as that used for the ES-2 head in the MDB test procedure, defined in ECE Regulation 95.

5.3 Instrumentation and data processing

Instrumentation and data processing must be well defined to ensure reproducibility between test establishments. Factors that must be recorded in the test procedure are:

a) Head-form impact velocity
b) Head-form acceleration (three mutually perpendicular axes through the centre of gravity of the head-form) and
c) Exterior vehicle movement adjacent to the impact point along the impact vector.

Data capture, filtering and data process must conform to the requirements of ISO 6487:1987.[6]

Head Injury Criteria for the head-form (HIC_{FMH}) is calculated according to:

$$\left(\frac{1}{(t_2 - t_1)} \int_{t_1}^{t_2} a d_t \right)^{2.5} (t_2 - t_1)$$

Where 'a' is the resultant head-form acceleration, expressed as a multiple of 'g' *(the acceleration due to gravity)*, and t_1 and t_2 are any two points in time during the impact, which are separated by not more that a thirty-six millisecond time interval.

And then factored to HIC_{dummy} according to:

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

Note: The measurement of impact test velocity is an important parameter within the test procedure. It is important that measurement systems used are appropriate to the level of accuracy required in the test procedure.

6. SUMMARY OF PROPOSED TEST PROCEDURE.

6.1 Free Motion Headform Test method

6.1.1 **Headform – US Free Motion Headform FMH [7]**

The headform used for testing conforms to the specifications of Appendix 1 Section 2

NOTE:
The headform shall be re-certified

- after every [10] tests,
- after each test in which $HIC_{dummy} > 1000$
- after any test in which damage to the head-form flesh is suspected

The headform used for testing must conform to the specifications of Appendix 1. Section 2

6.1.2 **Forehead impact zone**

The forehead impact zone of the headform is determined according to the procedure specified in 6.1.2 paragraphs I to vii below

i. Position the headform so that the baseplate of the skull is horizontal. The midsagittal plane of the headform is designated as Plane S.

ii. From the centre of the threaded hole on top of the headform, draw a line 69 mm forward toward the forehead, coincident with Plane S, along the contour of the outer skin of the headform. The front end of the line is designated as Point P. From Point P, draw a line 100 mm forward toward the forehead, coincident with Plane S, along the contour of the outer skin of the headform. The front end of the line is designated as Point O.

iii. Draw a 125 mm line which is coincident with a horizontal plane along the contour of the outer skin of the forehead from left to right through Point O so that the line is bisected at Point O. The end of the line on the left side of the headform is designated as Point a and the end on the right as Point b.

iv. Draw another line 125 mm which is coincident with a vertical plane along the contour of the outer skin of the forehead through Point P so that the line is bisected at Point P. The end of the line on the left side of the headform is designated as Point c and the end on the right as Point D.

v. Draw a line from Point a to Point c along the contour of the outer skin of the headform using a flexible steel tape. Using the same method, draw a line from Point b to Point d.

vi. The forehead impact zone is the surface area on the FMH forehead bounded by lines a-O-b and c-P-d, and a-c and b-d.

6.1.3 **Free flight trajectory**

The FMH must be accelerated under linear control and released for free flight between 25 and 100mm from the point of first contact.

6.1.4 **Impact Velocity**

Two headform impact velocities are specified, the higher one for the evaluation of all target points not possessing and covered by active Head Protection Systems, Section 4.1.10, and the lower one being used for defined areas of the of vehicle, Appendix 1 Section 1.3, which are covered by approved areas of an active Head Protection System.

- The standard impact speed is 6.7 m/s ± 0.2 m/s measured ≤100 mm from the contact point for 'normal' surfaces.
- For areas covered by 'active head protection systems', which satisfy the requirements of Annex 1 Section 1.4.3, the impact speed is 5.3 m/s ± 0.2 m/s measured ≤ 100 mm from contact point

6.1.5 **Impact location accuracy**

- The impact alignment accuracy shall be within a radius of ≤ 10.0 mm of the selected target point.

6.1.6 **Impact Environment**

- The test temperature range shall be between 19 and 26°C
- The relative humidity shall be between 10 to 70%
- The environment shall be stabilised for a period ≥4 hours prior to test
- Time period between repeated tests using the same headform shall not be less than 3 hours

6.1.7 **Test location and Head-form orientation**

One FMH test should be performed to each test location.

Initially, the Target Points are determined according to the specification in Appendix 1
These are then restricted to those that lie within the 'defined' target area. (Appendix 1, Section 1.4 below) i.e. within an area defined by four planes, two passing through horizontal axes defined by the locations of the heads of large male and small female occupants and two passing through vertical axes also defined by the locations of the heads of large male and small female occupants.

To ensure that due care is taken of areas between the individual specified target points, the option is given to test at points between the specified target points if these are deemed to be 'worst case', within the guidance given in Section 4.1.3 above.

In addition, tests are performed at certain defined structures (taken from FMVSS201u):

- Upper seat belt anchorage
- Seat belt adjustment device, if located above the anchorage point
- Grab handle (located within the defined header rail distance)
- Lighting control unit, coat hook or other such 'fixed' vehicle furniture.

Tests at one position must not compromise a test at an adjacent position due to 'pre-damage'.

Although testing will be performed with adjustable windows in the open position, only those contact points, which can be contacted by the headform with the windows closed, will be tested.

The impact angle, defined as the angle of the impact velocity vector with respect to the plane tangential to the surface at the point of contact, shall be selected to be the “worst case” as close as possible to perpendicular to the impact surface. Both methods are included as previously discussed in Section 4.1.7.

Method 1

Then, for each selected target location, the headform orientation and actual impact location for each test is determined according to the following procedure. For clarity this procedure is illustrated by means of a decision making flow chart in .

- With the mid-sagittal plane vertical, (Section 6.1.2) should coincide with the impact velocity vector through the contact target.
- If a clean contact, as defined in Section 1.1.1, is not possible without contacting other non-certified parts of the FMH, then the headform and impact velocity vector should be pitched forward with respect to the normal by 10° ± 2° and realigned with the target, Figure 5.
- If a clean contact cannot be made with the head mid-sagittal plane, aligned vertically following this adjustment then the FMH and velocity vector should be returned to normal to the surface and the FMH be rolled by 90° ± 2° around the velocity vector, as described in the note.
- If the target location point still cannot be hit cleanly, then the headform should be rotated back to its original vertical position and the headform and impact velocity vector should be pitched forwards, with respect to normal, until a clean contact (as defined in Appendix 1, Section 1.1.1) is established up to a maximum allowable pitch of 18° ± 2° to normal. A pitch of 18° reduces the lateral component of the impact vector by approximately 5%.
- If the selected point still cannot be impacted cleanly then the target point should be moved within the limits defined in Appendix 1, Section 1.3 while still seeking a worst case contactable position.

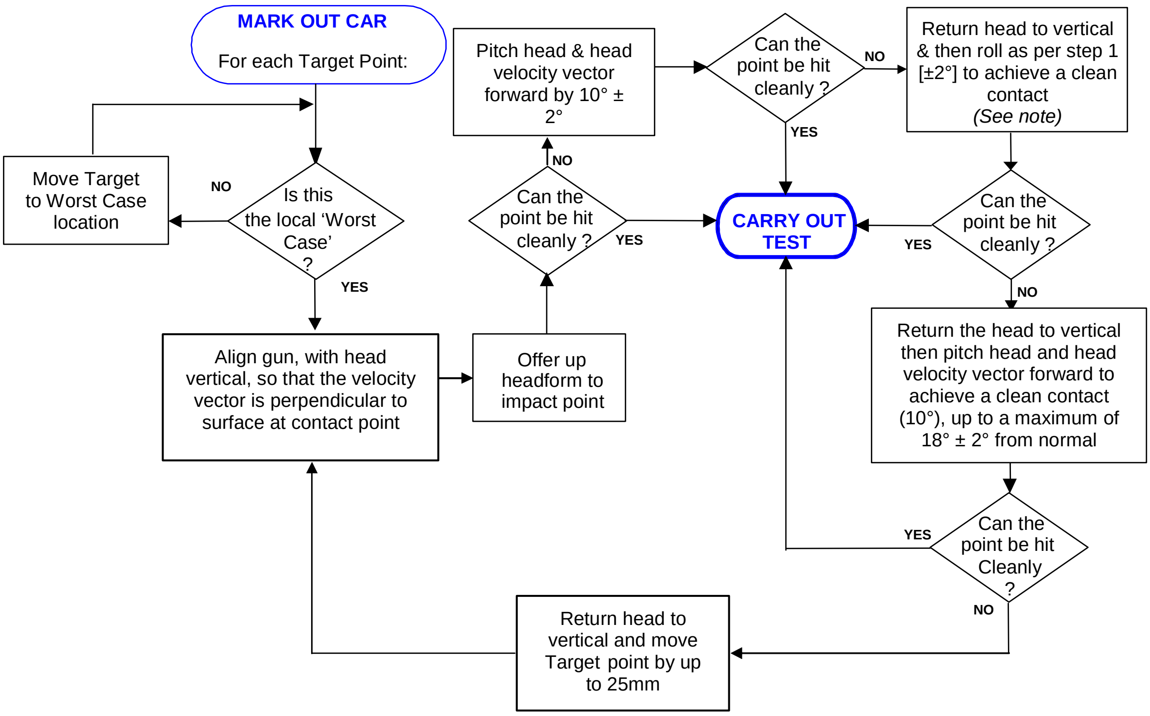

Figure 4 Method 1, Headform alignment flow chart

Note: Clarification note on headform rotation

FMH axial rotation about the impact vector facing towards the target point.

Target area		**Left hand side of the vehicle**	**Right hand side of the vehicle**
Step 1:	**A post target points**	90 degree clockwise	90 degree anticlockwise
	Roof rail target points	90 degree clockwise	90 degree anticlockwise
	B post target points	90 degree anticlockwise	90 degree clockwise

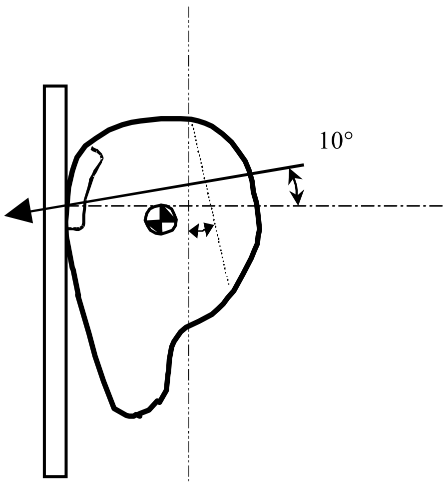

Figure 5 Method 1, orientation 10° forward of perpendicular

Method 2

Then, for each selected target location, the headform orientation and actual impact location for each test is determined according to the following procedure.

- With the mid-sagittal plane vertical, (Section 6.1.2) the impact velocity vector shall be perpendicular to the surface through the contact target.
- If a clean contact, as defined in Section 1.1.1, is not possible without contacting other non-certified parts of the FMH, then the headform and impact velocity vector should be pitched downward with respect to the normal by 10° ± 2° and realigned with the target, Figure 5.
- If the target point still cannot be hit cleanly, again the headform and impact velocity vector should be pitched downwards, with respect to normal, until a clean contact (as defined in Appendix 1, Section 1.1.1) is established.
- If the selected point still cannot be impacted cleanly then the target point should be moved within the limits defined in Appendix 1, Section 1.3 while still seeking a worst case contactable position.

For any method the following exceptions will apply:

(a) Vertical approach angles, as defined in Section 1.1.13, will be limited to no more than [50] degrees (as is used in FMVSS 201) for all impacts. (Recent computer simulations has suggested that Vertical approach angles of [-10 to +20] degrees may be more appropriate).

(b) When testing the A-pillar, as defined in Appendix 1 Section 1.1.9, the horizontal approach angle will be limited to between [195] and [255] degrees for the left hand side, and [105] to [165] degrees for the right hand side. Figure 6. For impacts on the A-pillar only, the longitudinal vertical plane passing through the forehead impact zone points O and P, as defined in Section 6.1.2, shall be perpendicular to the primary axis of the A-pillar at the impact point. Figure 7.

(c) When testing side roof structures, B-pillars and other pillars (where applicable), as defined in Appendix 1 Section 1.1.9, the horizontal approach angle will be limited to between [230] and [295] degrees for the left hand side, and between [65] and [130] degrees for the right hand side. Figure 8.

(d) For point BP2, as defined in Appendix 1 Section 1.3.2.2, the horizontal approach angle will be limited to [270] degrees for the left hand side and [90] degrees for the right hand side.

(e) When testing the rearmost pillar, as defined in Appendix 1 Section 1.1.9, the horizontal approach angle will be limited to between [270] and [345] degrees for the left hand side, and [15] to [90] degrees for the right hand side. Figure 6.

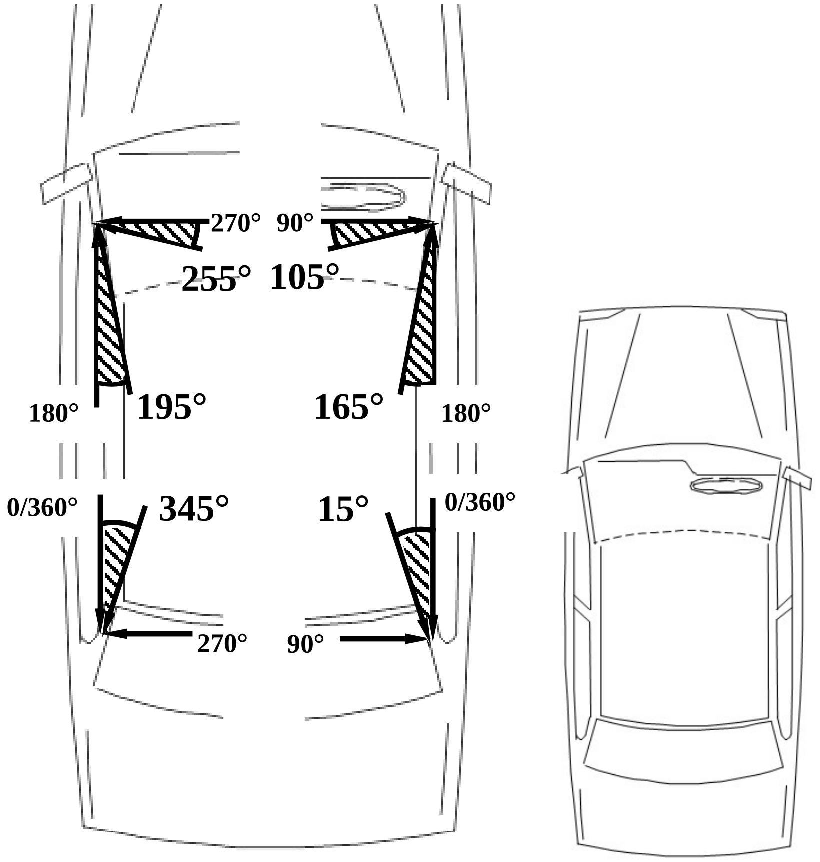

Figure 6 A-pillar and rearmost pillar horizontal approach angle limitations

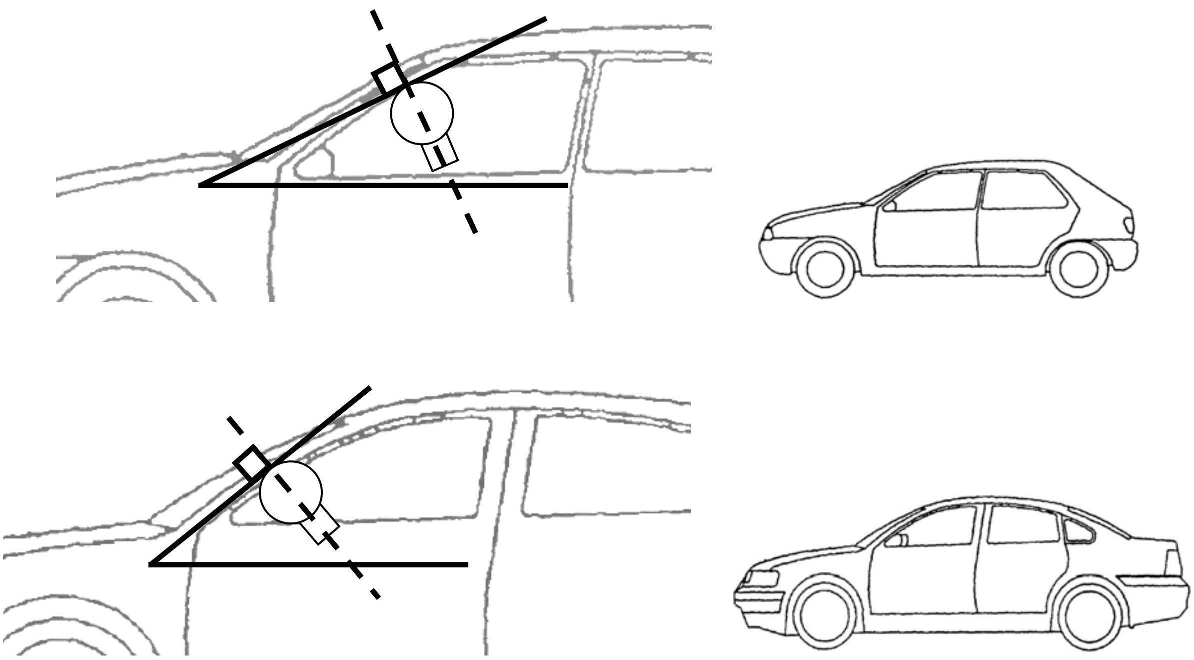

Figure 7 Perpendicular impacts to the A-pillar

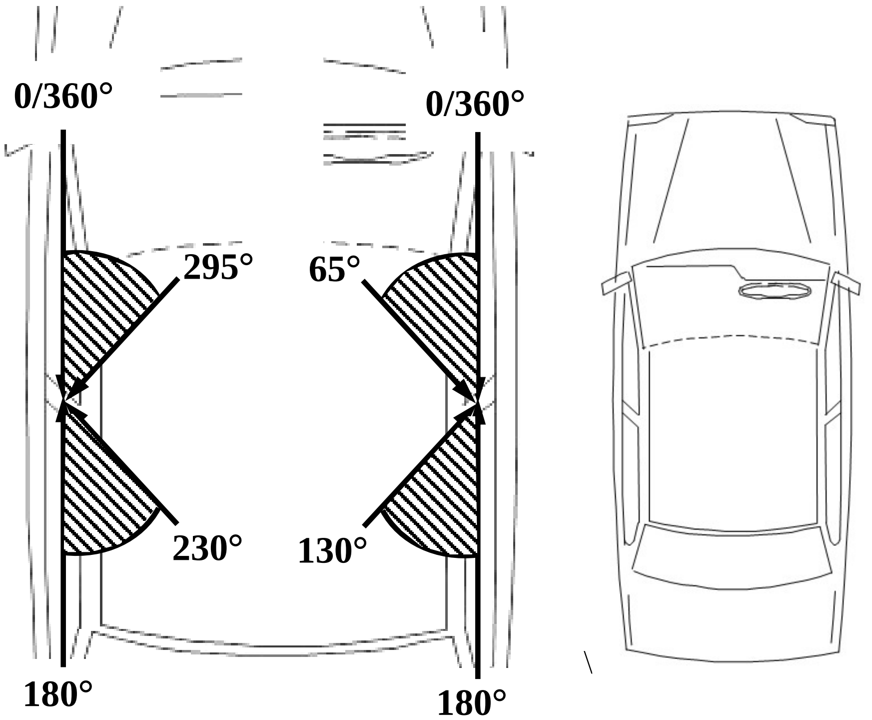

Figure 8 B-pillar and other pillar horizontal approach angle limitations

Note:
During the first phase of the WG13 research the US FMH was selected as the preferred impactor, thus all of the reported WG13 research has focussed on the use of this test device. Much of the intervening WG13 research effort has been directed towards minimising test variability and potential miss-interpretation of the test procedure to create a test procedure that would evaluate worst case conditions and encourage enhanced safety. Both of these issues have been made difficult to achieve due to the non-symmetrical shape of the selected impactor and the alignment of the headform, with the centre of gravity of the headform not being coincidental with the contact point on the headform. As was noted earlier one of the prime reasons for selecting the FMH was based on harmonisation with FMVSS 201. Within Europe the EEVC headforms used in the Pedestrian test procedures have been further developed and is now incorporated within European Directives [8][9]. WG13 believes that many of the more complex issues described in this report, that are designed to achieve clean contacts without ambiguities in interpretation would not be needed if a symmetrical headform were to be adopted. WG13 is of the opinion that the procedure could be much simpler, not needing to include headform pitching and rotation, if an alternative headform were to be used but it would have to be rigorously evaluated to ensue that other complications were not introduced. Some of the alternative options expressed with WG13 would cease to be valid using such an impactor (Annex 3). At this time WG13 is not in a position to indicate whether the use of this headform, now suitable for use within regulation, would be appropriate for internal surface testing since it has not undergone such scrutiny in the in-vehicle environment [4].

6.1.7.1 General guidance

- ‘Worst Case’ impacts

It is expected that ‘worst case’ will differ between vehicles, thus each vehicle should be assessed, by examining the drawings or physical inspection, before assuming the padding, fixing or other structure would be a worst case position.

An inspection of the trims and underlying structure should be carried out to look for :-

- Where the crush depth of padding is minimal.
- The location of fixings and bolts.
- The position of welds, joints or internal webs in the chassis.
- The attachment of padding or other components

The presence of such features could be used to guide a test authority regarding focal point for ‘worst case’ impacts.

- Closeness of repeated test

. Multiple impacts

A vehicle being tested may be impacted multiple times, subject to the limitations given below

- Impacts within 300 mm of each other may not occur less than 30 minutes apart.
- No impact may occur within 150 mm of any other impact. The requirement within FMVSS201 has been increased to 200mm between points for what is believed to be technical reasons.

The distance between impacts is the distance between the centres of the target circle for each impact, measured along the vehicle interior.

- Examination of collateral damage

If other impacts are to be carried out within a 200mm radius of a previous impact point then any structural damage around and beneath the target point must be assessed. If damage is noted and full repair is not possible then no further adjacent impacts should be performed within the area of damage extended by 200mm from the target point. Tests at the adjacent points would have to be performed in a different vehicle.

Note – the chin of the headform can contact parts of the vehicle structure 150mm from the contact point.

Damage assessment

- If any trim or padding has been permanently deformed or show signs of elastic distortion, including attachment points within a 100mm radius of the target points then the padding must be replaced for adjacent tests. *The 100 mm radius could be increased if it is considered that the damage might affect the stiffness of the padding structure in any adjacent impact. All padding and trim attachment points should be examined and assessed for possible collateral stiffness.*

- The extent of damage/deformation to structures underlying the padding should be assessed. If any permanent damage is detected the limit of the damage must then be quantified. No adjacent test should be carried out within 200 mm of the edge of the identified structural damage.

6.1.8 **Vehicle preparation, including support**

The vehicle should be rigidly supported off its wheels with the principle axes of the vehicle being aligned with ground reference co-ordinates. The maximum displacement of the exterior surface of the vehicle, along the axis of the impact adjacent to the point of contact, shall not exceed 10 mm. If necessary, the exterior of the vehicle may be 'additionally' supported to limit exterior movement to 10 mm.

If the side window can be opened, tests should be performed with the window fully open.

6.2 Pole impact test Procedure.♣

The vehicle impacts a fixed 254 mm diameter rigid vertical pole at an impact speed of 29 ± 2 km/h. The pole is aligned with the centre of gravity of the head of the ES-2 dummy. In order to achieve this impact, the vehicle is placed on a carrier, which can translate freely in the direction perpendicular to the vehicle's longitudinal vertical plane.

The impact angle should be 90° ± 3°.

The dummy's seating position should be adjusted, if necessary, to ensure that the head presents a target through the side glazing and is not obscured by the B-pillar.

The *active system FMH tests* and *active system sub-structure FMH tests* will only be performed where the requirements of the pole impact test are satisfied. The procedure is described in Annex 2.

6.3 Performance criteria

6.3.1 **FMH Head Injury Criterion**

The Head Injury Criterion for the head-form (HIC_{FMH}) is calculated according to the following formula:-

$$\left(\frac{1}{(t_2 - t_1)} \int_{t_1}^{t_2} a\,dt \right)^{2.5} (t_2 - t_1)$$

where 'a' is the resultant head-form acceleration, expressed as a multiple of 'g' *(the acceleration due to gravity)*, and t_1 and t_2 are any two points in time during the impact, which are separated by not more than a thirty-six millisecond time interval.

$$HIC_{dummy} = 0.75446\ HIC_{FMH} + 166.4 * 1000$$

♣ NOTE: The pole impact test procedure is based on that specified in FMVSS201 with the ES-2 dummy. The specifications for the test procedure defined in Annex 1 have been taken from an edited version of the Euro NCAP protocol, since this also uses ES-2. Elements only used in the derivation of Euro NCAP ratings and items not appropriate for this draft procedure have been removed.

6.3.2 **Pole Test Head Injury Criterion**

In the pole impact test, the Head Injury Criterion (HIC) must not be more than 1000. The HIC is the maximum value of the expression:

$$\left(\frac{1}{(t_2 - t_1)} \int_{t_1}^{t_2} a\,dt \right)^{2.5} (t_2 - t_1)$$

where 'a' is the resultant head-form acceleration, expressed as a multiple of 'g' *(the acceleration due to gravity)*, and t_1 and t_2 are any two points in time during the impact, which are separated by not more than a thirty-six millisecond time interval.

7. REFERENCES

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4. Roberts, A.K. and e. al. *The Evaluation of Sub-Systems Methods for Measuring the Lateral Head Impact Performance of Cars*. in *15th ESV Conference*. 1996. Melbourne, Australia.
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8. European Parliament and Council of the European Union (2003). *Directive 2003/102/EC of the European Parliament and of the Council of 17 November 2003 relating to the protection of pedestrians and other vulnerable road users before and in the event of a collision with a motor vehicle and amending Council Directive 70/156/EEC. Official Journal of the European Union, L 321, 6.12.2003, p15. Brussels: European Commission.*
9. Commission of the European Communities (2004). *Commission Decision of 23 December 2003 on the technical prescriptions for the implementation of Article 3 of Directive 2003/102/EC of the European Parliament and of the Council relating to the protection of pedestrians and other vulnerable road users before and in the event of a collision with a motor vehicle and amending Directive 70/156/EEC. 2004/90/EC. Official Journal of the European Union, L 31, 4.2.2004, p21. Brussels: European Commission.*
10. EEVC Working Group 12 Technical Report. *Dummy Specified in the European Pole Test as Part of the EEVC Interior Headform Test Procedure.* June 2003.

APPENDIX – 1

Free Motion Headform test

1. LOCATION OF IMPACT POINTS

1.1 Definitions

1.1.1 **Clean contact**

Means a minimum of 10 degrees between any part on the face of the free motion headform and any structures that could be contacted by the face at the time of first contact. (
Figure 9)

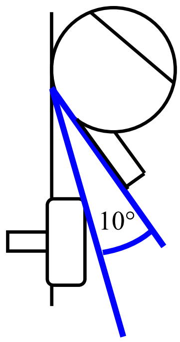


Figure 9 clean contact

1.1.2 **Co-ordinate reference system**

Means the terminology to be used when describing the impact vector for the free motion headform in relation to the vehicle. An orthogonal reference system consisting of a longitudinal X axis and a transverse Y axis in the same horizontal plane and a vertical Z axis through the intersection of X and Y is used to define the horizontal direction of approach of the headform. The X-Z plane is the vertical longitudinal zero plane and is parallel to the longitudinal centreline of the vehicle. The X-Y plane is the horizontal zero plane parallel to the ground. The Y-Z plane is the vertical transverse zero plane that is perpendicular to the X-Y and X-Z planes. The X coordinate is negative forward of the Y-Z plane and positive to the rear. The Y coordinate is negative to the left of the X-Z plane and positive to the right. The Z coordinate is negative below the X-Y plane and positive above it. (Figure 10).

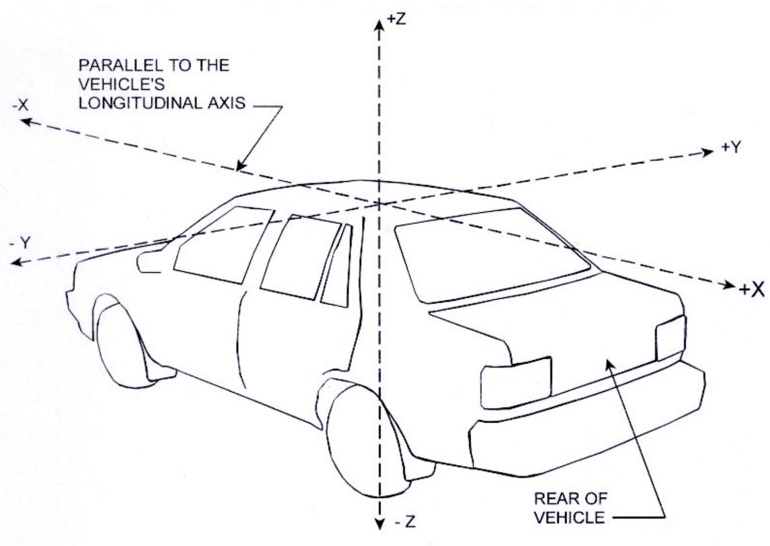


Figure 10 Orthogonal reference system

1.1.3 **Daylight opening**

Means, for openings on the side of the vehicle, other than a door opening, the locus of all points where a horizontal line, perpendicular to the vehicle longitudinal centreline, is tangent to the periphery of the opening. For openings on the front and rear of the vehicle, other than a door opening, daylight opening means the locus of all points where a horizontal line, parallel to the vehicle longitudinal centreline, is tangent to the periphery of the opening. If the horizontal line is tangent to the periphery at more than one point at any location, the most inboard point is used to determine the daylight opening.

1.1.4 **Door opening**

Means, for door openings on the side of the vehicle, the locus of all points where a horizontal line, perpendicular to the vehicle longitudinal centreline, is tangent to the periphery of the side door opening. For door openings on the back end of the vehicle, door opening means the locus of all points where a horizontal line, parallel to the vehicle longitudinal centreline, is tangent to the periphery of the back door opening. If the horizontal line is tangent to the periphery at more than one point at any location, the most inboard point is the door opening.

1.1.5 **Forehead impact zone**

Means, the part of the free motion headform surface area that is determined in accordance with the procedure set forth in Section 6.1.2.

1.1.6 **Horizontal approach angle**

Means, the angle between the X axis and the headform impact velocity vector projected onto the horizontal zero plane, measured in the horizontal zero plane in the counter-clockwise direction. A 0 degree horizontal vector and a 360 degree horizontal vector point in the positive X direction; a 90 degree horizontal vector points in the positive Y direction; a 180 degree horizontal vector points in the negative X direction; and a 270 horizontal degree vector points in the negative Y direction.

1.1.7 **Free motion headform (FMH)**

Means, a test device which conforms to the specifications of Section 2 of this Appendix.

1.1.8 **Midsagittal plane of a dummy**

Means, a longitudinal vertical plane passing through the centre of the dummy such that it divides the dummy into two equal mirror images and, for the purposes of this document, passes through the seating reference point of a designated seating position.

1.1.9 **Pillars**

Means any structure, excluding glazing and the vertical portion of door window frames, but including accompanying mouldings, attached components such as safety belt anchorages and coat hooks, which (1) supports either a roof or any other structure (such as a roll-bar) that is above the driver's head, or (2) is located along the side edge of a window.

(a) A-pillar means any pillar that is entirely forward of a transverse vertical plane passing through the seating reference point of the driver's seat. The top of the A-pillar is defined as being the point adjacent to the windscreen at the most rearward or highest point of the glazing, where there is a connection with the header/side rails and roof panel.
(b) B-pillar means the forward most pillar on each side of the vehicle that is, in whole or part, rearward of a transverse vertical plane passing through the seating reference point of the driver's seat, unless there is only one pillar rearward of that plane and it is also a rearmost pillar.
(c) Other pillar means any pillar which is not an A-pillar, a B-pillar, or a rearmost pillar.
(d) Rearmost pillar means the pillars at the rear of the vehicle which are most rearward from the seating reference point.

1.1.10 **Seat belt anchorage**

Means, any component involved in transferring seat belt loads to the vehicle structure, including, but not limited to, the attachment hardware, but excluding webbing or straps, seat frames, seat pedestals, and the vehicle structure itself, whose failure causes separation of the belt from the vehicle structure.

1.1.11 **Seating reference point**

Means, the unique design H-point which establishes the rearmost normal design driving or riding position of each designated seating position, which includes consideration of all modes of adjustment, horizontal, vertical, and tilt, in a vehicle.

1.1.12 **Sliding door track**

Means, a track structure along the upper edge of a side door opening that secures the door in the closed position and guides the door when moving to and from the open position.

1.1.13 **Vertical approach angle**

Means, the angle between the horizontal plane and the velocity vector, measured in the midsagittal plane of the headform. A 0 degree vertical vector coincides with the horizontal X-Y plane and a vertical vector of greater than 0 degrees makes an upward angle with that plane.

1.1.14 **Windscreen trim**

Means a moulding of any material between the windscreen glazing and the exterior roof surface, including material that covers a part of either the windscreen glazing and the exterior roof surface.

1.1.15 **Active Head Protection system**

Means, an air bag or active padding system that is deployed from a concealed part of the vehicle very early in an impact to protect the head of the occupant from internal or external 'hard' contacts.

1.2 Definition of Targets

1.2.1 Target circle

The area of the vehicle to be impacted by the headform is marked with a solid circle 12.5 mm in diameter, centred on the targets specified in Section 1.3 using any transferable opaque colouring medium.

1.2.2 Location of head centres of gravity (Front outboard designated seating positions)

Suffix 'f' relates to front seat positions e.g. $CG\text{-}R_f$

1.2.2.1 Location of rearmost $CG\text{-}R_f$

For front outboard designated seating positions, the head centre of gravity with the seat in its rearmost normal design driving or riding position ($CG\text{-}R_f$) is located 205 mm rearward and 680 mm upward from the seating reference point. If the seat is adjustable for height, it should be in its lowest normally used position. (Figure 13)

1.2.2.2 Location of forward most $CG\text{-}F_f$

For front outboard designated seating positions, the head centre of gravity is located 70 mm rearward and 580 mm upward from the seating H-point with the seat in its forward most adjustment position. If the seat is adjustable for height, it should be in its highest normally used position. *[NB this is subject to current review based on the seating position of a 5th percentile female driver]* (Figure 13)

1.2.3 Location of head centres of gravity (Rear outboard designated seating positions)

Suffix 'r' relates to ANY rear seating position e.g. $CG\text{-}R_r$

1.2.3.1 Location of rearmost $CG\text{-}R_r$

For rear outboard designated seating positions, the head centre of gravity with the seat in its rearmost normal design position ($CG\text{-}R_f$) is located 205 mm rearward and 680 mm upward from the seating reference point. If the seat is adjustable for height, it should be in its lowest normally used position. (Figure 16)

1.2.3.2 Location of forward most $CG\text{-}F_r$

For rear outboard designated seating positions, the head centre of gravity is located 70 mm rearward and 580 mm upward from the seating H-point with the seat in its forward most adjustment position. If the seat is adjustable for height, it should be in its highest normally used position. *[NB this is subject to current review based on the seating position of a 5th percentile female driver]*(Figure 16)

1.3 Target Locations

Two methods of deriving target points are proposed. The former, Method 1, is to be used if the vehicle manufacture does not supply information on the location of the target points and is extracted from FMVSS201. If the manufacture does supply information on the target points, as defined in FMVSS201 then Method 2 is recommended.

(a) The target locations specified in Sections 1.3.1 to 1.3.7 and are located on both sides of the vehicle and, except as specified in (b), are determined using the procedures specified in those paragraphs.

(b) For each target location – if it is not possible to contact the target point with the forehead impact zone of the free motion headform, with the side glazing closed, for any of the headform orientations within the range specified in Section 4.1.7, then that target is moved to any location within a sphere with a radius of 25 mm, centred on the centre of the original target, which the forehead impact zone can contact. The radius of the sphere may be increased by 25 mm increments until the sphere contains at least one point that can be contacted at one or more combination of angles.

(c) Targets lying outside the zones defined in 1.4 are not included in those to be tested for side impact.

1.3.1 **A-pillar targets (front seat positions)**

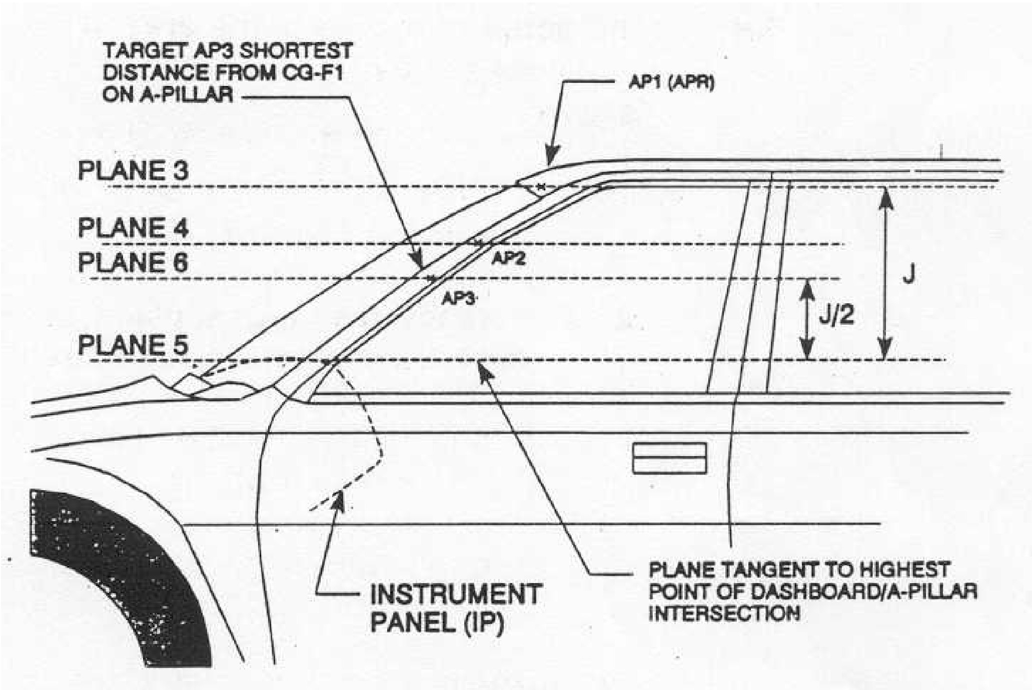


Figure 11 'A Pillar' targets

1.3.1.1 A-pillar reference point and target AP1

On the vehicle exterior, locate a transverse vertical plane (Plane 1) which contacts the rearmost point of the windscreen trim.

Note: if there are two or more pillars each side according to the definition of A-pillar (Appendix 1, section 1.1.1) and the door is attached to or closes onto the rearmost of these pillars, all of the glazing forward of this pillar may be treated as a divided windscreen for the purposes of defining plane 1. The intersection of Plane 1 and the vehicle exterior surface is Line 1. Measuring along the vehicle exterior surface, locate a point (Point 1) on Line 1 that is 125 mm inboard of the intersection of Line 1 and a vertical plane tangent to the vehicle at the outboardmost point on Line 1 with the vehicle side door open. Measuring along the vehicle exterior surface in a longitudinal vertical plane (Plane 2) passing through Point 1, locate a point (Point 2) 50 mm rearward of Point 1. Locate the A-pillar reference point (Point APR) at the intersection of the interior roof surface and a line that is perpendicular to the vehicle exterior surface at Point 2. Target AP1 is located at point APR.

1.3.1.2 Target AP2

Locate the horizontal plane (Plane 3) which intersects point APR. Locate the horizontal plane (Plane 4) which is 88 mm below Plane 3. Target AP2 is the point in Plane 4 and on the A-pillar which is closest to $CG\text{-}R_f$ for the nearest seating position.

1.3.1.3 Target AP3

Locate the horizontal plane (Plane 5) containing the highest point at the intersection of the dashboard and the A-pillar. Locate a horizontal plane (Plane 6) half-way between Plane 3 and Plane 5. Target AP3 is the point on Plane 6 and the A-pillar which is closest to $CG\text{-}F_f$ for the nearest seating position.

1.3.2 B-pillar targets (front seat positions)

1.3.2.1 B-pillar reference point and target BP1

1. Locate the longitudinal vertical plane C at the leftmost point at which a transverse vertical plane, located 300 mm rearward of the A-pillar reference point described in 1.3.1.1, contacts the interior roof (including trim).
2. Locate the longitudinal vertical plane D at the rightmost point at which a transverse vertical plane, located 300 mm rearward of the A-pillar reference point described in 1.3.1.1, contacts the interior roof (including trim)
3. Measure the horizontal distance (D2) between Plane C and Plane D.
4. Longitudinal vertical planes G and H are located at a distance of (0.35*D2) to the left and right respectively of the vehicle longitudinal centreline, measured horizontally.
5. Locate the point (Point 3) on the vehicle interior at the intersection of the horizontal plane passing through the highest point of the forward most door opening and the centreline of the width of the B-pillar, as viewed laterally. Locate a transverse vertical plane (Plane 7) which passes through Point 3. Locate the point (Point 4) at the intersection of the interior roof surface, Plane 7, and plane G or H, as appropriate, defining the nearest edge of the upper roof. The B-pillar reference point (Point BPR) is the point located at the middle of the line from Point 3 to Point 4 in Plane 7, measured along the vehicle interior surface. Target BP1 is located at Point BPR.

1.3.2.2 Target BP2

If a seat belt anchorage is located on the B-pillar, Target BP2 is located at any point on the anchorage. For the test the anchorage will be placed in the position that is most likely to provide additional support to the structure being tested. Where required re-positioning of the anchorage is permissible in order satisfy spacing requirements between impact points.

1.3.2.3 Target BP3

Locate a horizontal plane (Plane 8) which intersects Point BPR. Locate a horizontal plane (Plane 9) which passes through the lowest point of the daylight opening forward of the pillar. Locate a horizontal plane (Plane 10) half-way between Plane 8 and Plane 9. Target BP3 is the point located in Plane 10 and on the interior surface of the B-pillar, which is closest to $CG\text{-}R_f$ for the nearest seating position.

1.3.2.4 Target BP4

Locate a horizontal plane (Plane 11) half-way between Plane 9 and Plane 10. Target BP4 is the point located in Plane 11 and on the interior surface of the B-pillar which is closest to CG-R_f for the nearest seating position.

1.3.3 Side roof targets (front seat positions)

1.3.3.1 Target SR1

Locate a transverse vertical plane (Plane 25) 150 mm rearward of Point APR. Locate the point (Point 11) at the intersection of Plane 25 and the upper edge of the forward most door opening. Locate the point (Point 12) at the intersection of the interior roof surface, Plane 25 and the plane, described in 1.3.6.1 7, defining the nearest edge of the upper roof. Target SR1 is located at the middle of the line between Point 11 and Point 12 in Plane 25, measured along the vehicle interior.

1.3.3.2 Target SR2

Locate a transverse vertical plane (Plane 26) 300 mm rearward of the APR or 300 mm forward of the BPR (or RPR in vehicles with no B-pillar). Locate the point (Point 13) at the intersection of Plane 26 and the upper edge of the forward most door opening. Locate the point (Point 14) at the intersection of the interior roof surface, Plane 26 and the plane, described in 1.3.6.1 7, defining the nearest edge of the upper roof. Target SR2 is located at the middle of the line between Point 13 and Point 14 in Plane 26, measured along the vehicle interior.

1.3.3.3 Other side rail target (target SR3)

1. Except as provided in 4 below, target SR3 is located in accordance with this paragraph. Locate a transverse vertical plane (Plane 27) 150 mm rearward of either Point BPR or Point OPR. Locate the point (Point 15) as provided in either 2 or 3 below, as appropriate. Locate the point (Point 16) at the intersection of the interior roof surface, Plane 27 and the plane, described in 1.3.6.1 7, defining the nearest edge of the upper roof. Target SR3 is located at the middle of the line between Point 15 and Point 16 in Plane 27, measured along the vehicle interior surface.

2. If Plane 27 intersects a door or daylight opening, the Point 15 is located at the intersection of Plane 27 and the upper edge of the door opening or daylight opening.

3. If Plane 27 does not intersect a door or daylight opening, the Point 15 is located on the vehicle interior at the intersection of Plane 27 and the horizontal plane through the highest point of the door or daylight opening nearest Plane 27. If the adjacent door(s) or daylight opening(s) are equidistant to Plane 27, Point 15 is located on the vehicle interior at the intersection of Plane 27 and either horizontal plane through the highest point of each door or daylight opening.

4. Except as provided in 5 below, if a grab handle is located on the side rail, target SR3 is located at any point on the anchorage of the grab-handle. Folding grab-handles are in their stowed position for testing.

5. If a seat belt anchorage is located on the side rail, target SR3 is located at any point on the anchorage.

1.3.3.4 Sliding door track target (target SD)

Locate the transverse vertical plane (Plane 29) passing through the middle of the widest opening of the sliding door, measured horizontally and parallel to the vehicle longitudinal centreline. Locate the point (Point 19) at the intersection of the surface of the upper vehicle interior, Plane 29 and the plane, described in 1.3.6.1 7, defining the nearest edge of the upper roof. Locate the point (Point 20) at the intersection of Plane 29 and the upper edge of the sliding door opening. Target SD is located at the middle of the line between Point 19 and Point 20 in Plane 29, measured along the vehicle interior.

1.3.4 **B-pillar targets (rear seat positions)**

1.3.4.1 Target BP5

Locate a horizontal plane (Plane 8) which intersects Point BPR. Locate a horizontal plane (Plane 9) which passes through the lowest point of the daylight opening forward of the pillar. Locate a horizontal plane (Plane 10) half-way between Plane 8 and Plane 9. Target BP5 is the point located in Plane 10 and on the interior surface of the B-pillar, which is closest to $CG\text{-}R_r$ for the nearest seating position.

1.3.4.2 Target BP6

Locate a horizontal plane (Plane 11) half-way between Plane 9 and Plane 10. Target BP4 is the point located in Plane 11 and on the interior surface of the B-pillar which is closest to $CG\text{-}R_r$ for the nearest seating position.

1.3.5 **Other pillar targets (rear seat positions)**

1.3.5.1 Target OP1

1. Except as provided in 2 below, target OP1 is located in accordance with this paragraph. Locate the point (Point 5), on the vehicle interior, at the intersection of the horizontal plane through the highest point of the highest adjacent door opening or daylight opening (if no adjacent door opening) and the centre line of the width of the other pillar, as viewed laterally. Locate a transverse vertical plane (Plane 12) passing through Point 5. Locate the point (Point 6) at the intersection of the interior roof surface, Plane 12 and the plane, described in *1.3.2.1 4*, defining the nearest edge of the upper roof. The other pillar reference point (Point OPR) is the point located at the middle of the line between Point 5 and Point 6 in Plane 12, measured along the vehicle interior surface. Target OP1 is located at Point OPR.

2. If a seat belt anchorage is located on the pillar, Target OP1 is any point on the anchorage.

1.3.5.2 Target OP2

Locate the horizontal plane (Plane 13) intersecting Point OPR. Locate a horizontal plane (Plane 14) passing through the lowest point of the daylight opening forward of the pillar. Locate a horizontal plane (Plane 15) half-way between Plane 13 and Plane 14. Target OP2 is the point located on the interior surface of the pillar at the intersection of Plane 15 and the centre line of the width of the pillar, as viewed laterally.

1.3.6 **Rearmost pillar targets (rear seat positions)**

1.3.6.1 Target RP1

1. Locate the transverse vertical plane A at the forwardmost point where it contacts the interior roof (including trim) at the vehicle centre line.

2. Locate the transverse vertical plane B at the rearmost point where it contacts the interior roof (including trim) at the vehicle centre line. Measure the horizontal distance (D1) between Plane A and Plane B.

3. Locate the vertical longitudinal plane C at the leftmost point at which a vertical transverse plane, located 300 mm rearward of the A-pillar reference point described in 1.3.1.1, contacts the interior roof (including trim).

4. Locate the vertical longitudinal plane D at the rightmost point at which a vertical transverse plane, located 300 mm rearward of the A-pillar reference point described in 1.3.1.1, contacts the interior roof (including trim).

5. Measure the horizontal distance (D2) between Plane C and Plane D.

6. Locate a point (Point M) on the interior roof surface, midway between Plane A and Plane B along the vehicle longitudinal centre line.

7. The upper roof zone is the area of the vehicle upper interior surface bounded by four planes. A transverse vertical plane E located at a distance of (.35 D1) forward of Point M and a transverse vertical plane F located at a distance of (.35 D1) rearward of Point M, measured horizontally. And, a longitudinal vertical plane G located at a distance of (.35 D2) to the left of Point M and a longitudinal vertical plane H located at a distance of (.35 D2) to the right of Point M, measured horizontally.

Locate the point (Point 7) at the corner of the upper roof nearest to the pillar. The distance between Point M, as described in 6 above, and Point 7, as measured along the vehicle interior surface, is D. Extend the line from Point M to Point 7 along the vehicle interior surface in the same vertical plane by (3*D/7) beyond Point 7 or until the edge of a daylight opening, whichever comes first, to locate Point 8. The rearmost pillar reference point (Point RPR) is at the midpoint of the line between Point 7 and Point 8, measured along the vehicle interior. Target RP1 is located at Point RPR.

1.3.6.2 Target RP2

8. Except as provided in 3 below, target RP2 is located in accordance with this paragraph. Locate the horizontal plane (Plane 16) through Point RPR.

9. 2. Locate the horizontal plane (Plane 17) 150 mm below Plane 16, target RP2 is located in Plane 17 and on the pillar at the location closest to $CG\text{-}R_r$ for the nearest designated seating position.

10. If a seat belt anchorage is located on the pillar, Target RP2 is any point on the anchorage.

1.3.7 **Side roof targets (rear seat positions)**

1. Except as provided in 4 below, target SR3 is located in accordance with this paragraph. Locate a transverse vertical plane (Plane 27) 150 mm rearward of either Point BPR or Point OPR. Locate the point (Point 15) as provided in either *(2)* or *(3)* below, as appropriate. Locate the point (Point 16) at the intersection of the interior roof surface, Plane 27 and the plane,

described in *1.3.6.1 7*, defining the nearest edge of the upper roof. Target SR3 is located at the middle of the line between Point 15 and Point 16 in Plane 27, measured along the vehicle interior surface.

2. If Plane 27 intersects a door or daylight opening, the Point 15 is located at the intersection of Plane 27 and the upper edge of the door opening or daylight opening.

3. If Plane 27 does not intersect a door or daylight opening, the Point 15 is located on the vehicle interior at the intersection of Plane 27 and the horizontal plane through the highest point of the door or daylight opening nearest Plane 27. If the adjacent door(s) or daylight opening(s) are equidistant to Plane 27, Point 15 is located on the vehicle interior at the intersection of Plane 27 and either horizontal plane through the highest point of each door or daylight opening.

4. Except as provided in 5 below, if a grab handle is located on the side rail, target SR3 is located at any point on the anchorage of the grab-handle. Folding grab-handles are in their stowed position for testing.

5. If a seat belt anchorage is located on the side rail, target SR3 is located at any point on the anchorage.

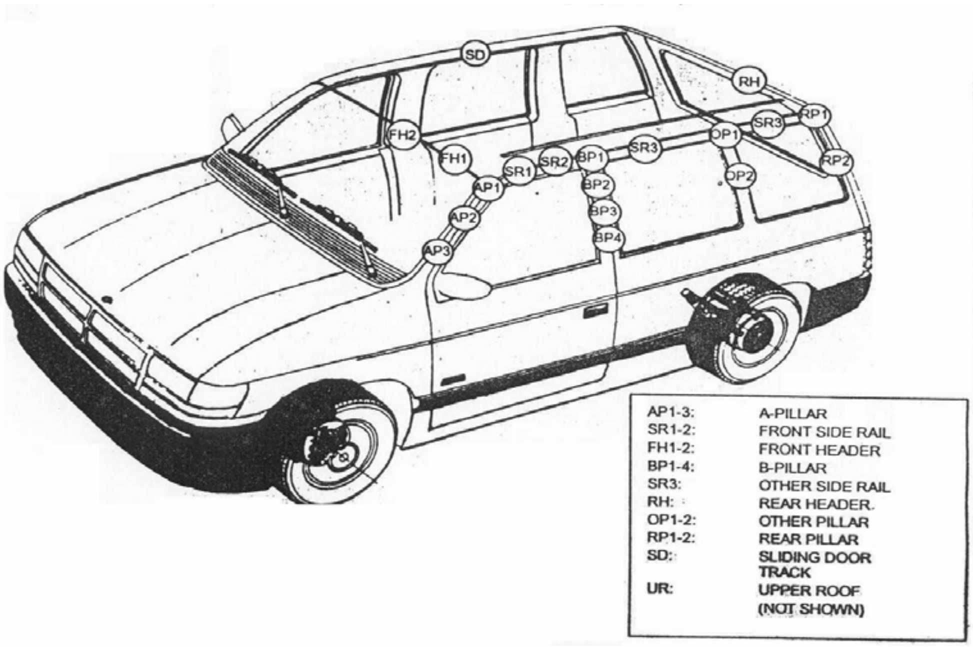


Figure 12 Defined targets, from FMVSS 201.

1.3.8 **Worst Case locations**

If there is a worst case location on the structure containing any of the defined targets and between those targets, with the exception of the seat belt anchorage target, or any other structure other than glazing within the contact zone defined in 1.4, then the test authority may test the "worst case" location instead, provided the FMH can make contact with this location with the side glazing closed.

1.4 TARGET Limitation Zone Definition

1.4.1 **Front Seating Positions**

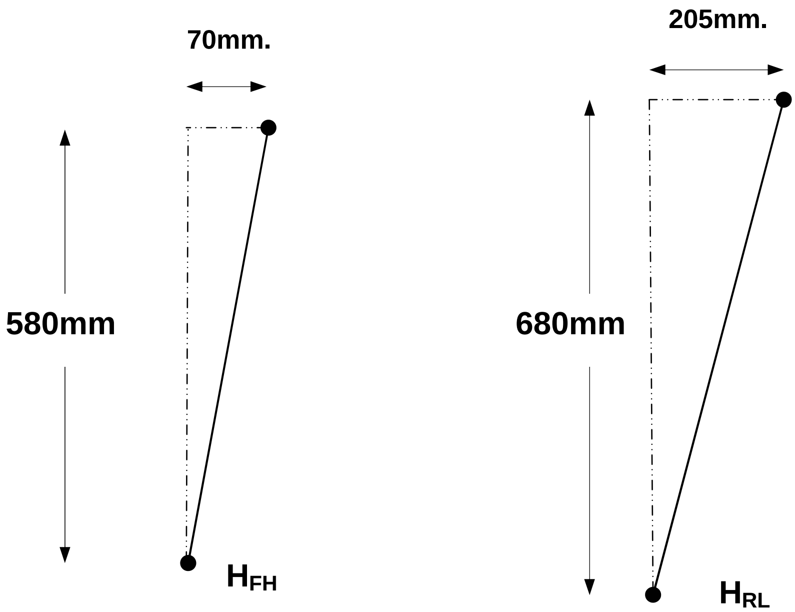
1.4.1.1 For each front outboard designated seating position locate two head centre of gravity positions, CG-F_f and CG-R_f

1.4.1.2 CG-F_f is located 70 mm rearward and 580 mm upward from the seating H-point, as determined by the H-point Manikin procedure as described in ECE Regulation 95, with the seat in its foremost normal design driving or riding position. If the seat is adjustable for height, it should be in its highest normally used position. (Figure 13).

1.4.1.3 CG-R_f is located 205 mm rearward and 680 mm upward from the seating reference point (R-point), with the seat in its rearmost normal design driving or riding position. If the seat is adjustable for height, it should be in its lowest normally used position. (Figure 13).

1.4.1.4 Locate vertical plane P, passing through CG-F_f, which is 45° from the {fore-aft} mid sagittal plane of the dummy. (Figure 14).

1.4.1.5 Locate vertical plane Q, passing through CG-R_f, which is 135° from the {fore-aft} mid sagittal plane of the dummy.



H_{FH} is the H-point at the foremost and highest normal driving or riding position
H_{RL} is the H-point at the rearmost lowest normally used driving or riding position

Figure 13 CG-F_f, CG-R_f and CG-F_r, CG-R_r locations

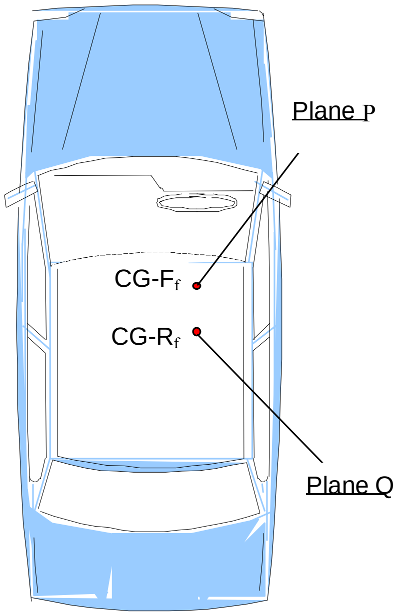


Figure 14 Plan view of planes

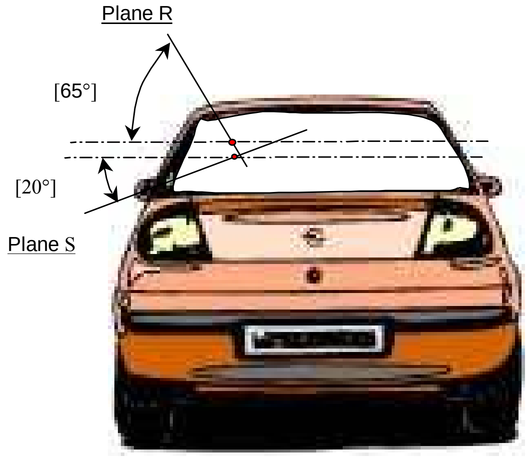


Figure 15 Front view of planes

1.4.1.6 Locate plane R, passing through a horizontal axis through CG-R_f at an angle of 65° from the horizontal plane. (Figure 15)

1.4.1.7 Locate plane S, passing through a horizontal axis through CG-F_f at an angle of -20° from the horizontal plane. (Figure 15)

1.4.1.8 The potential impact locations are located on the inner surfaces of the vehicle within the zone bounded by the line of intersection of these four planes.

1.4.2 Non Front Seating Positions

If the rear seats are adjustable, like front seats (especially the seatback angle) the CoG will be defined as for the front seats.

1.4.2.1 For the rear seat(s), the forward and rearward extent of the potential contact zones are limited by two vertical planes, one set at 45° forward of the lateral axis and passing through CG-R_F (Plane T) and the other set at 45° rearward of lateral passing through CG-R_R (Plane U), where CG-R_F and CG-R_R are the locations of the centres of gravity of the small female and large male sitting in the rear struck side seating position, Figure 16.

1.4.2.2 In order to determine the points CG-R_F and CG-R_R for non-front seating positions the H-point manikin, as defined in ECE R94, should be used. Locations for the CG-R_F and CG-R_R are defined with respect to the torso angle, as measured by the H-point manikin. For the 95th percentile CG-R_R lies 688mm along the torso line, above the H point, and 176mm perpendicularly forward of the torso plane. For the 5th percentile CG-R_F lies 562mm along the torso plane and 68 mm forwards of it, Figure **17** - In small cars the 95th percentile CG-R_R may be located outside the car. In this case the CG-R_R should be lowered so to a position within the vehicle [100mm] below the inside surface of the roof vertically below CG-R_R.

1.4.2.3 If the rear seats are adjustable in two different positions the rearmost normal design driving or riding position will be used for the 95th percentile male and the most forward normal design driving or riding position for the 5th percentile female. If the rear seats are adjustable like the front seat (especially the seatback angle) the CoG will be defined like for front seats.

1.4.2.4 If the rear seat were adjustable for the fore-aft position, CG-RF would be determined with the H-point manikin positioned with the seat in the fully forward position and CG-RF for the fully rearward position, in the normal design riding positions. Where the seat back is adjustable, the H-point manikin will be positioned with the torso angle seat to the design position recommended by the vehicle manufacturer.

1.4.2.5 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) equivalent to that for the front seating positions.

1.4.2.6 In vehicle with low roofs, CG-RR may be theoretically positioned outside of the vehicle. In such cases the location of CG-RR shall be lowered until there is a vertical clearance of [100mm] between CG-RR and the interior surface of the roof.

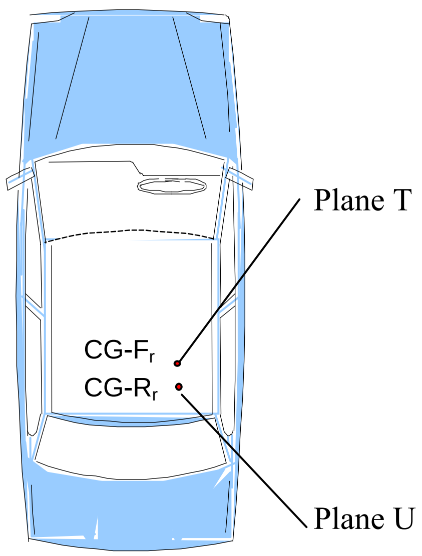


Figure 16 Plan view of planes – Rear seating position

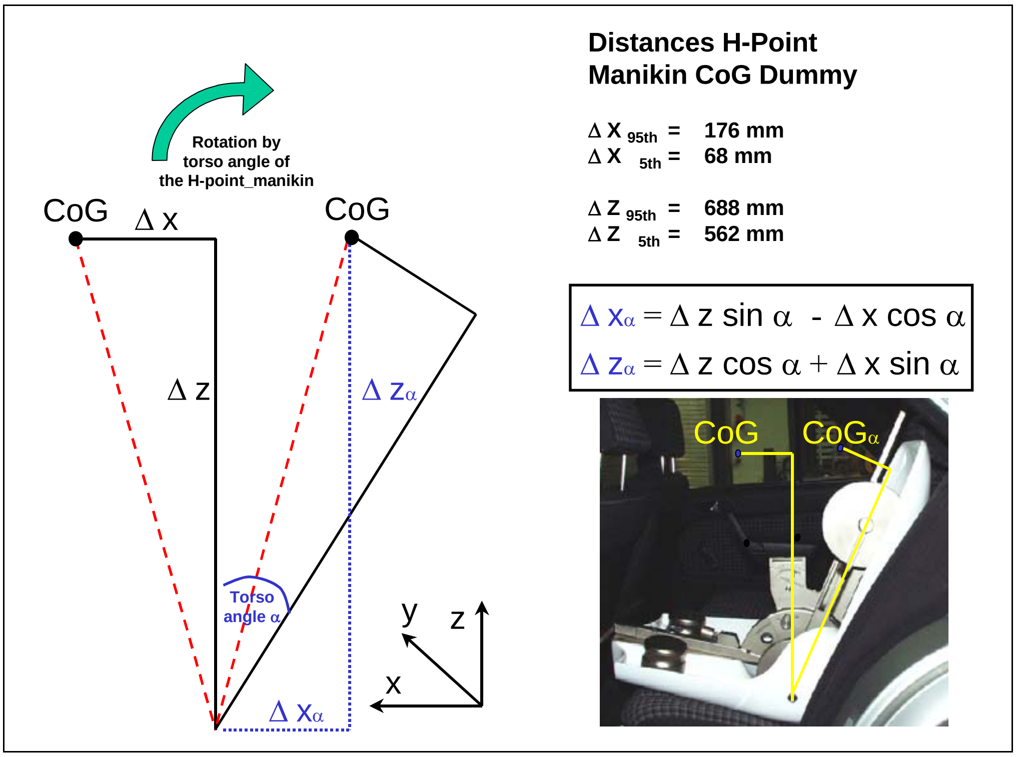


Figure 17 CoG using the H-point manikin, non-front seating positions

1.4.3 **Additional exemption area for low velocity testing for vehicles equipped with a deployable protection system, all struck side seating positions.**

1.4.3.1 Locate the periphery of the stowed system projected perpendicularly onto the vehicle interior surface, including mounting and inflation components but excluding any cover or covers that are not deployed or displaced, when the head protection system is deployed.

1.4.3.2 Define an area in the inside of the vehicle 50 mm from the periphery defined in Section 1.4.1.1.

1.4.3.3 Target points found within this area can be impacted at the lower impact velocity defined in Section 6.1.4.

1.5 TARGET Edge Exclusion Zone Definition, (EEZ)

Specific surfaces, within the area bounded by Planes P, Q, R and S, are defined in which impact targets should not be located. The EEZ areas are defined by the use of a 165 mm spherical ball-and applied to every area defined by planes P, Q, R, S.

1.5.1 Place a 165 mm diameter sphere against the vehicles glazed area and the adjacent interior surface, with the window closed and door shut. The surface which cannot be contacted by the spherical ball shall not be tested (EEZ).

1.5.2 The surfaces between the scribed line and the glazing forms the EEZ in which no targets are located, as shown in Figure 18.

1.5.3 Some parts of the defined structure may be obscured from head contact by other vehicle trim, e.g. Fascia or fixed seats. Areas so obscured will not be tested with the head-form.

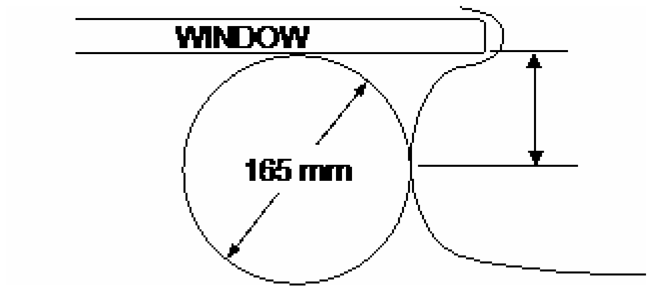


Figure 18 Derivation of Edge Exclusion Zone

2. FMH – TEST DEVICE

2.1 Apparatus

This section describes the anthropomorphic test device (ATD) that is to be used for testing vehicle upper interior components. The device is a modified head component of the Part 572, Subpart E – Hybrid III Test Dummy that is used by the National Highway Traffic Safety Administration (NHTSA), U.S. Department of Transportation, for compliance testing of motor vehicles and motor vehicle equipment with motor vehicle safety standards. The ATD is a free-motion-headform (FMH) that is depicted in the U.S. Code of Federal Regulations – 49 CFR Chapter V (10-1-95 edition); Part 572 – Anthropomorphic Test Devices; Subpart L – Free Motion Headform.

2.2 Apparatus description.

2.2.1 **Drawings**

The drawings and specifications referred to in paragraph 2.3 of this section are incorporated in the FMH by reference. These materials are thereby made part of this regulation. Copies of the materials may be inspected at NHTSA's Docket Section, 400 Seventh Street, S.W., room 5109, Washington, DC, U.S.A. or at the Office of the Federal Register, 800 North Capitol Street, N.W., Suite 700, Washington, DC, U.S.A.

2.2.2 **Incorporated material:**

Drawing number 92041-001, "Head Form Assembly," (November 30, 1992); drawing number 92041-002, "Skull Assembly," (November 30, 1992); drawing number 92041-003, "Skull Cap Plate Assembly," (November 30, 1992); drawing number 92041-004, "Skull Cap Plate," (November 30, 1992); drawing number 92041-005, "Threaded Pin," (November 30, 1992); drawing number 92041-006, "Hex Nut," (November 30, 1992); drawing number 92041-008, "Head Skin without Nose," (November 30, 1992, as amended March 6, 1995); drawing number 92041-009, "Six-Axis Load Cell Simulator Assembly," (November 30, 1992); drawing number 92041-011, "Head Ballast Weight," (November 30, 1992); drawing number 92041-018, "Head Form Bill of Materials," (November 30, 1992); drawing number 78051-148, "Skull-Head (cast) Hybrid III," (May 20, 1978, as amended August 17, 1978); drawing number 78051-228/78051-229, "Skin-Hybrid III," (May 20, 1978, as amended through September 24, 1979); drawing number 78051-339, "Pivot Pin – Neck Transducer," (May 20, 1978, as amended May 14, 1986); drawing number 78051-372, "Vinyl Skin Formulation Hybrid III," (May 20, 1978); and drawing number C-1797, "Neck Blank, (August 1, 1989); drawing number SA572-S4, "Accelerometer Specification," (November 30, 1992), are available from Reprographic Technologies, 9000 Virginia Manor Road, Beltsville, MD 20705.

2.2.3 **Users manual.**

A user's manual entitled "Free-Motion Headform User's Manual," version 2, March 1995, is available from NHTSA's Docket Section at the address in paragraph 2.1. of this section.

2.2.4 **Instrumentation – SAE J211**

The U.S. SAE Recommended Practice J211, OCT 1988, "Instrumentation for Impact Tests," Class 1000, is available from the Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale, PA 15096, U.S.A.

2.2.5 **General descriptions:**

The free motion headform consists of the component assembly which is shown in drawings 92041-001 (incorporated by reference; see § 572.100), 92041-002 (incorporated by reference; see § 572.100), 92041-003 (incorporated by reference; see § 572.100), 92041-004 (incorporated by reference; see § 572.100), 92041-005 (incorporated by reference; see § 572.100), 92041-006 (incorporated by reference; see § 572.100), 92041-008 (incorporated by reference; see § 572.100), 92041-009 (incorporated by reference; see § 572.100), 92041-011 (incorporated by reference; see § 572.100), 78051-148 (incorporated by reference; see § 572.100), 78051-228/78051-229 (incorporated by reference; see § 572.100), 78051-339 (incorporated by reference; see § 572.100), 78051-372 (incorporated by reference; see § 572.100), C-1797 (incorporated by reference; see § 572.100), and SA572-S4 (incorporated by reference; see § 572.100).

Disassembly, inspection, and assembly procedures, and sign convention for the signal outputs of the free motion headform accelerometers, are set forth in the Free-Motion Headform User's Manual (incorporated by reference; see § 572.100).

The structural properties of the headform are such that it conforms to this section in every respect both before and after being used in the test specified in the ECE Regulation No. 21.

The outputs of accelerometers installed in the headform are recorded in individual data channels that conform to the requirements of the U.S. SAE Recommended Practice J211, OCT 1988, "Instrumentation for Impact Tests," Class 1000 (incorporated by reference; see § 572.100).

2.3 Headform drop test – calibration test.

2.3.1 **Performance requirements.**

When the headform is dropped from a height of 376 mm in accordance with paragraph 2.3.2 of this section, the peak resultant accelerations at the location of the accelerometers mounted in the headform as shown in drawing 92041-001 (incorporated by reference; see § 572.100) shall not be less than 225g, and not more than 275g. The acceleration/time curve for the test shall be unimodal to the extent that oscillations occurring after the main acceleration pulse are less than ten percent (zero to peak) of the main pulse. The lateral acceleration vector shall not exceed 15g (zero to peak).

2.3.2 **Test procedure.**

Soak the headform in a test environment at any temperature between 19 degrees C. to 26 degrees C. and at a relative humidity from 10 percent to 70 percent for a period of at least four hours prior to its use in a test.

Clean the headform's skin surface and the surface of the impact plate with 1,1,1 Trichloroethane or equivalent.

Suspend the headform as shown in Figure 50 of the U.S. 49 CFR, Part 752.102. Position the forehead below the chin such that the skull cap plate is at an angle of 28.5 ± 0.5 degrees with the impact surface when the midsagittal plane is vertical.

Drop the headform from the specified height by means that ensure instant release onto a rigidly supported flat horizontal steel plate, which is 51 mm thick and 508 mm square. The plate shall have a clean, dry surface and any microfinish of not less than 0.2 microns and not more than 2.0 microns.

Allow at least 3 hours between successive tests on the same headform.

2.5 Test conditions and instrumentation.

Headform accelerometers shall have dimensions, response characteristics, and sensitive mass locations specified in drawing SA572-S4 (incorporated by reference; see § 572.100) and be mounted in the headform as shown in drawing 92041-001 (incorporated by reference; see § 572.100).

The outputs of accelerometers installed in the headform are recorded in individual data channels that conform to the requirements of SAE Recommended Practice J211, OCT 1988, “Instrumentation for Impact Tests,” Class 1000 (incorporated by reference; see § 572.100).

Co-ordinate signs for instrumentation polarity conform to the sign convention shown in the Free-Motion Headform User’s Manual (incorporated by reference; see § 572.100).

The mountings for accelerometers shall have no resonant frequency within a range of 3 times the frequency range of the applicable channel class.

2.6 Facility certification

It is important that inter test house variability is kept to a minimum. It is suggested that a systems certification test be developed and carried out which would include the evaluation of the launch facility, headform, instrumentation and data processing in a very repeatable and reproducible manner. No proposals are made describing such a test.

Annex – 1

POLE SIDE IMPACT TEST ♣

1. VEHICLE PREPARATION

The vehicle should be prepared as specified in ECE Regulation R95.

1.1 Impact location

The impact reference line is a line on the striking side of the vehicle, on the exterior of the vehicle, where a transverse vertical plane passes through the centre of gravity of the head of the dummy seated in accordance with Section 1.2.1.

1.2 Overview of settings

The seat should be positioned in the mid adjustment position and at the lowest vertical adjustment

1.2.1 **Dummy positioning**

The ES-2 dummy should be set up according to procedures defined in the ECE Regulation R95, with both arms of the dummy placed at the click stops corresponding to 40° angle between the arms and the torso reference line

1.2.1.1 Position of the head

1. Locate the horizontal plane passing through the dummy head centre of gravity. Identify the rearmost point on the dummy head in that plane. Construct a line in the plane that intersects the front door daylight opening at the same horizontal location and is perpendicular to the longitudinal vehicle centreline. Measure the longitudinal distance between the rearmost point on the dummy head and this line (see Appendix 1, section1.1.3). The door daylight opening must be measured when the door is closed.

2. If the distance is less than 50 mm or the point is not forward of the line, then the seat and/or dummy position shall be adjusted as follows. First, the seat back angle is adjusted, a maximum of 5 degrees, until a 50 mm distance is achieved. If this is not sufficient to produce the 50 mm distance, the seat is moved forward until the 50 mm distance is achieved or until the knees of the dummy contact the dashboard or knee bolster whichever comes first. If the required distance cannot be achieved through movement of the seat, the seatback angle shall be adjusted even further forward until the 50 mm distance is obtained or until the seat back is in its full upright locking position.

3. After positioning the dummy measure and record the dummy position and determine the impact location as described in Section 1.1.

1.3 Carrier

♣ *The principles of the pole impact test procedure are based on the EuroNCAP protocol, which is based on FMVSS 201. Whereas FMVSS201 uses an adapted US SID dummy the EuroNCAP procedure used the EuroSID dummy. The EuroNCAP test procedure has been edited and simplified for the purposes of this document by removing the elements specific to EuroNCAP.*

The test vehicle shall be placed on a carrier which has a horizontal flat surface with a sufficiently large area to allow unobstructed longitudinal displacement of the vehicle of about 1000 mm and rotation of the vehicle during the deformation phase of the impact.

To minimise effects of friction between the tyres of the test vehicle and the surface of the carrier this friction is reduced to a minimum by placing the vehicle with each tyre on two sheets of PTFE.

To avoid vehicle movement prior to the impact, the vehicle may be fixed to the carrier until 5 m before the point of impact. The impact speed should be reached 10 m before the point of impact.

Crumple tubes or a comparable device will decelerate the carrier not earlier than 12 ms or 100 mm after the moment / point of impact.

Position the vehicle on the carrier to achieve that the impact reference line is aligned with the centre line of the rigid pole.

The horizontal impact accuracy should be ± 38 mm.

1.4 Pole

The rigid pole is a vertical metal structure beginning no more than 102 mm above the lowest point of the tyres on the striking side of the test vehicle when the vehicle is loaded as specified in Section 1 and extending at least 100 mm above the highest point of the roof of the test vehicle.

The pole is 254 ± 3 mm in diameter and set off from any mounting surface, such as a barrier or other structure, so that the vehicle will not contact such a mount or support at any time within 100 ms of the initiation of the vehicle to pole contact.

Mark a line along the vertical centreline of the pole, which may be used to check the alignment of the test vehicle on the carrier.

1.5 Impact Speed

TARGET SPEED = 29 ± 0.5 km/h – During the acceleration phase of the test, the acceleration of the carrier should not exceed 1.5 m/s^2.

1.6 Impact Angle

The impact angle should be 90°± 3°. Align the vehicle on the carrier so that the angle between the vehicle’s longitudinal and the direction of movement of the carrier is 90°.

2. AFTER TEST

2.1 Calculation of Injury Parameters

The Head Performance Criterion should be derived as specified in ECE Regulation 95 and in 6.3.2 above.

Annex – 2

[ACTIVE SYSTEM TEST PROCEDURE]

2.1 Pre-requisites

Where the requirements of the pole test are satisfied, additional tests are included to assess further the performance of the active head protection system.

The vehicle manufacturer should indicate which areas of the active head protection device provide an adequate level of protection, and are capable of producing a HIC <1000 when impacted by the FMH at 6.7m/s. In addition a recommendation should also be made as to whether the test(s) should be performed with a statically inflated airbag or if the active system is to be fired/deployed during the test(s). The relevant information for either of the aforementioned methods should be provided so as to facilitate the test(s). The testing will be performed as described in the flow chart in Figure **19**.

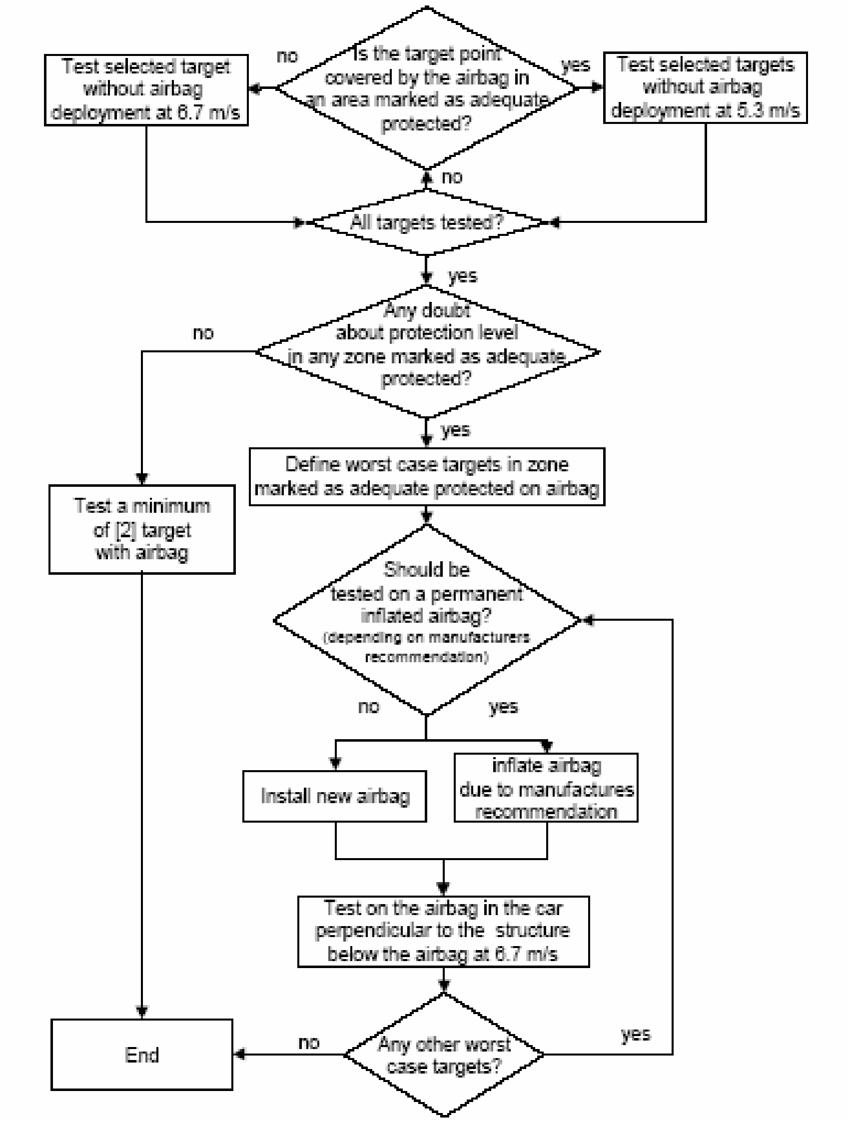


Figure 19 Active system test flow chart

2.2 Active system sub-structure FMH test procedure

2.2.1 **Pre-requisites**

The points as defined in Appendix 1, Section 1.3 will be tested on the vehicle sub-structure(s) with an impact velocity of 5.3m/s if defines as having areas of adequate protection as in Section 2.1. The remaining areas of the vehicle sub–structure, which are not adequately protected by the active device, will be tested with a velocity of 6.7m/s.

2.2.2 **Test conditions**

The criteria defined under Sections 6.1.1, 6.1.2, 6.1.3, 6.1.5, 6.1.6, 6.1.7, 6.1.8 shall also apply to the active system tests.

2.2.3 **Target point locations**

The points defined in Appendix 1, Section 1.3 that are covered by the areas of the active head protection device, as defined in Annex 2, Section 2.1, shall be tested.

2.3 Active system FMH test procedure

2.3.1 **Test conditions**

The criteria defined under Sections 6.1.1, 6.1.2, 6.1.3, 6.1.5, 6.1.6, 6.1.7, 6.1.8 shall also apply to the active system tests.

2.3.2 **Target point locations**

The points defined in Appendix 1, Section 1.3 that are covered by the areas of the active head protection device which have been highlighted by the vehicle manufacturer as providing adequate protection, as defined in Annex 2, Section 2.1, shall be tested. However, if the aforementioned point(s) are not worst case when considering the airbag geometry and construction, then a worst case point will be selected with a deployed airbag.

The test house should test worst case points on the deployed airbag at 6.7m/s until the protection offered by the airbag in the area(s) nominated by the vehicle manufacturer are clearly shown to be adequate. There shall be a minimum of [two] tests to the deployed airbag.

2.4 Performance criteria

The performance criteria as defined in Section 6.3.1 shall also apply to both assessments within the active system test procedure.