

Sled Test Procedure

Knee Impacts

Crash Protection

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PREFACE

During the test preparation, vehicle manufacturers are encouraged to liaise with the laboratory and to check that they are satisfied with the way cars are set up for testing. Where a manufacturer feels that a particular item should be altered, they should ask the laboratory staff to make any necessary changes. Manufacturers are forbidden from making changes to any parameter that will influence the test, such as dummy positioning, vehicle setting, laboratory environment etc.

It is the responsibility of the test laboratory to ensure that any requested changes satisfy the requirements of Euro NCAP. Where a disagreement exists between the laboratory and manufacturer, the Euro NCAP secretariat should be informed immediately to pass final judgment. Where the laboratory staff suspect that a manufacturer has interfered with any of the set up, the manufacturer's representative should be warned that they are not allowed to do so themselves. They should also be informed that if another incident occurs, they will be asked to leave the test site.

Where there is a recurrence of the problem, the manufacturer's representative will be told to leave the test site and the Secretary General should be immediately informed. Any such incident may be reported by the Secretary General to the manufacturer and the person concerned may not be allowed to attend further Euro NCAP tests.

DISCLAIMER: Euro NCAP has taken all reasonable care to ensure that the information published in this protocol is accurate and reflects the technical decisions taken by the organisation. In the unlikely event that this protocol contains a typographical error or any other inaccuracy, Euro NCAP reserves the right to make corrections and determine the assessment and subsequent result of the affected requirement(s).

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1 INTRODUCTION

Any manufacturer intending to present knee mapping test results to Euro NCAP is required to advise the Secretariat when completing the vehicle matrix.

Any additional Euro NCAP inspector or Secretariat time or resources are required to consider knee mapping data or to hold additional meetings, the costs will have to be funded by the manufacturer.

Where knee airbags are fitted to a car, it is not possible to carry out an assessment of the knee contact zone in the normal way. Seat belt systems with devices such as double pretensioners may also make the conventional assessment, used by Euro NCAP, inappropriate. In other cases, the judgement may be marginal and manufacturers may wish to check potentially hazardous areas dynamically.

All sled testing is to be performed using a pulse that is representative of a 50km/h MPDB test.

The manufacturer must demonstrate, for the areas in question, that femur loads are less than 3.8kN and knee slider values are less than 6mm in order to avoid knee modifiers. It should be noted that under normal circumstances, where the variable load modifier is not applied, the concentrated load modifier is also not applied.

The Euro NCAP assessment for knee modifiers considers occupants of larger/smaller stature and weight than the 50th percentile occupant used in the full scale test. The use of the 95th percentile dummy for knee mapping ensures that a penetration deeper than that of the 50th percentile is achieved. Therefore, the full depth of the assessment zone (50th percentile penetration + 20mm) is covered by the test. Additionally, a 5th percentile female dummy may be required to assess those areas where the 95th dummy leg is unable to contact the hazards in the fascia due to space restrictions.

In normal circumstances, the tests can be conducted prior to the full vehicle test based on a Manufacturer's assessment of the knee inspection zone. However, there is the possibility that not all hazards are identified beforehand and additional hazards may be highlighted for assessment in the inspection report.

1.1 Prerequisites

Vehicles that show large structural post test distortion are not eligible for knee mapping. Any of the following post test conditions disqualify the vehicle from knee mapping for any frontal occupants:

- Femur loads >3.8kN in the full vehicle test (driver or passenger)
- Knee Slider >6mm in the full vehicle test (driver or passenger)
- Vehicles that qualify for the application of a structural modifiers i.e. Integrity of the passenger compartment and/or footwell rupture
- Vehicles with A-pillar displacements above 65mm (using the standard Euro NCAP measurement)
- Where any frontal impact restraining devices, such as airbags & pretensioners, deploy incorrectly, knee mapping data may not be accepted for that occupant

1.2 Body in white setup

An acceleration or deceleration sled may be used. A 'body in white' buck of the car model being assessed shall be mounted on the sled. All features which may influence knee impact protection must be installed in the body in white.

The bodyshell must be mounted on the sled such that there will be no permanent deformation of the body or its mounts, during the test programme. This is necessary to help ensure good repeatability. The pitch angle of the bodyshell shall be set to 0 degrees, according to the manufacturer's specification.

The default yaw angle for the sled shall be 0 degrees. If the vehicle manufacturer can identify the need for a yaw angle other than 0 degrees in order to enable a stable contact with an identified hard point, this can be used throughout the main test program. In no cases, would Euro NCAP allow the yaw angle to be greater than 30 degrees.

Parts can be removed from the body in white, provided that there is no question that their removal could influence the performance of the knee impact area. Any structural or inertial support of the knee impact area must be fully simulated. This would include the support given by the steering column or loads transmitted through it.

The doors may be removed and the door aperture reinforced to provide a clear view for the cameras. All components added to the bodyshell shall be to the same specification as those used in the Euro NCAP frontal impact test. The restraint system and any active devices must be replaced for each individual test.

Intrusion may occur which does not directly affect the knee impact area but which might provide additional support to structures supporting the knee impact area. These will be identified in the Euro NCAP inspection. For the sled tests, it may be acceptable for this type of intrusion to be simulated statically e.g. wooden spacers.

Any active components of restraint systems must be identical to those used in the Euro NCAP frontal impact test. However, it is acceptable for them to be triggered remotely to match the Euro NCAP frontal impact test firing times within ± 3 ms. Where remote triggering is used, full details of the firing time, proportion of charge used and any other relevant details should be supplied, along with a comparison with relevant data from the Euro NCAP frontal impact test.

2 TEST PROGRAMME

The pulse performed on the sled facility shall be at least as severe as the representative MPDB test pulse, measured at the struck side B-pillar, and will be assessed according to the method detailed in Section 2.7.

The steering column shall be positioned fully upwards with the axial adjustment in the mid position.

The Euro NCAP inspection report shall detail stature of dummy to be used for the individual tests. Typically, a 95th percentile male Hybrid III dummy is used. However, where it is not possible for the 95th percentile knee to contact the hazard due to its size, the 5th percentile female shall be used.

Whichever stature of dummy is to be used, it shall be equipped with at least instrumentation to record femur axial force and knee slider displacement for both legs. Shoulder belt loads shall also be recorded to demonstrate that the pre-tensioning and load limiting characteristics of the restraint system are similar to those in the Euro NCAP frontal impact test. Additional instrumentation may be necessary in order to establish knee penetration.

For 95th percentile male, adjust the vehicle seat according to the procedure described in the Frontal impact protocol for that stature of dummy. Use the procedure described in the Frontal impact protocol to determine the H-point. Then move the seat rearward by 30mm. If the seat has no locking position 30mm rearward choose the next notch forward.

In the event that the dummy is installed in the vehicle and there is insufficient space between the knee and fascia to position the knee in the desired area, then the H-point should be moved rearward to allow correct position. Should this be insufficient, the seat should be moved rearward until there is sufficient space up to the 95th percentile seating position.

For 5th percentile dummies, adjust the vehicle seat according to the procedure described in the Frontal impact protocol for that stature of dummy. All other seat adjustments are to be set to enable a stable knee contact with the target point.

2.1 Driver dummy positioning

The tolerances below detail the standard dummy position in the test programme. If the point cannot be contacted by the knee after following the steps detailed below, it may be necessary to deviate from one or all of these values. In particular, the foot position must be such that the correct knee impact area will be reached. Care should be taken that deviation from the original position is as small as possible.

H-point X, Z - within a square $\pm 13\text{mm}$ in X and Z of a point 30mm rearward of the manikin H-point. If the target H-point in the horizontal direction cannot be achieved with the given seat position, move the seat one notch in the appropriate direction and try to position the dummy again.

Pelvic angle - $22.5^\circ \pm 2.5^\circ$ from the horizontal.

Head - The transverse instrumentation platform of the head shall be horizontal to within $\pm 2.5^\circ$.

Arms - For driver testing, place hands on the steering wheel in a similar fashion to that of the Euro NCAP test. However, minor adjustments on the arm and hand positions are allowed if this

allows for better camera views of the knee impact area. For passenger testing, place the arms as in the Euro NCAP test setup.

Torso - The torso shall align with the centre of the seat. However, the torso might have to be twisted to one side to allow for the knees to strike the points indicated in the Euro NCAP inspection. During twisting it is acceptable for the H-point location to change to ensure the correct area is impacted in a stable manor.

Legs - the femurs shall initially be in contact with the seat cushion as far as possible. The distance between the knees of the dummy shall be $210\text{mm} \pm 5\text{mm}$ when measured at the outside metals surface of the knees. The femur and tibia for each leg shall be as close as possible to a vertical plane. The leg position shall be modified laterally so that the main load bearing knee will come into contact with the potential hard-point as indicated in the inspection report. The other knee shall be aimed at an area where it would be expected to receive experience little or no loading. Frequently, this would be achieved by positioning it laterally where it has the greatest spacing from the facia. The lateral position of the knees can be achieved with a variation of the knee spread and/or a twist of the torso.

Feet - The feet should be placed as flat as possible on the toe board parallel to the centreline of the vehicle. If either of the feet comes into contact with a footrest or a wheel arch, place the foot fully onto that rest. It is permissible to adjust the foot position to ensure that the correct knee impact location can be obtained. In order to ensure a stable knee contact, it may also be necessary to prevent the relevant foot from moving forwards in the footwell.

2.2 Passenger dummy positioning

The minimum knee penetration required for all of the passenger femur load tests within main test programme is based on the forward limit of the inspection zone. This will be detailed in the inspection report and be based upon the penetration of the passenger knee obtained in the official Euro NCAP test including an additional 20mm.

The passenger dummy positioning procedure will follow the procedure described for the drier above. However, if this seating/dummy position does not achieve a minimum knee penetration equal to that of the limit of the inspection zone, the seat and dummy should be adjusted so that this limit is reached by the knee throughout the main test programme.

The penetration of the passenger knee will be established using high speed video footage and/or pelvic displacement calculations. Alternative measurement methods for establishing pelvic displacement will also be accepted which can be shown to be of equal accuracy as using pelvic acceleration to establish knee penetration. If the position of the dummy is limited by the knees contacting the hazard and/or the amount of available seat travel, that most forward position should be used.

Situations were potential hazards for knee slider are highlighted are treated equivalent to test for potential knee hazards. The dummy positioning procedure will follow the procedure described above. However, if this seating/dummy position does not achieve a minimum knee displacement equal to that of the limit of the inspection zone (20mm), the seat and dummy shall be adjusted so that this limit is reached. If knee slider displacement is a concern it needs to be ensured that there is stable contact between the tibia and potential hazard. It may be necessary to make small adjustments to the angel of the Tibia to ensure contact with the correct location.

2.3 Ensuring a stable knee contact to the potential hard point

In order for a knee mapping sled test to be valid, it needs to be ensured that the main load bearing knee remains in stable contact with the potential hard point during the impact sequence. If the knee is deflected, the test will not be accepted as a valid measure of the potential hazard. It is important that the other knee is loaded as little as possible by either not contacting the facia or impacting the least supported area of the facia.

In order to ensure this it is allowable for the knee spread to be artificially fixed (i.e. by the application of structural foam or similar, between the legs). Furthermore, it might be necessary to prevent the feet from moving forward during crash in order to prevent a dynamic drop of the knee during the impact sequence.

If a stable contact cannot be achieved with artificial knee spreading alone it is allowable to use an appropriate yaw angle of the sled other than 0 degrees to assess an individual hard point.

In any case, it is essential to confirm the stable knee contact with the use of appropriate high speed camera footage.

In the absence of acceptable camera evidence, paint or other suitable alternatives may be used in order to identify that the correct point has been contacted.

The performance criteria used for the assessment will be femur forces below 3.8kN and the knee slider responses shall be less than 6mm. No adjustment to the performance criteria is made for any change in dummy size.

2.4 Static deployment tests

In order to ensure that the airbag creates no hazard from deployment against a knee or leg positioned close to the facia, it may be necessary to carry out static deployment tests. The concern is that a deploying airbag may load the leg just below the knee causing excessive forces to be transmitted through the knee joint.

Where the knee slider displacement in the full width test is below 3mm due to deployment of the airbag, no further testing is required.

Where the knee slider displacement in the full width test is above 3mm, due to deployment of the airbag, and the gap between the tibia and facia of the driver dummy is less than 50mm, no further testing is required.

Where the knee slider displacement in the full width test is above 3mm, due to deployment of the airbag, and the gap between the tibia and facia of the driver dummy is 50mm or greater, a static deployment test is required.

A 5th female dummy shall be positioned in the driver's seating position and moved forward until the gap between the tibia and facia is no more than 50mm. This distance may be established by moving either the seat or the dummy on the seat cushion.

The gap between the tibia, knee and facia is to be measured after positioning the 5th female dummy for the full width test using a sphere of 50mm in diameter.

The dummy shall be instrumented with roller bearing knee sliders in both legs.

The knee airbag should then be deployed and the knee slider data recorded.

Where no static deployment data is provided or the knee slider displacement from the static deployment test is 6mm or above, the variable contact modifier will be applied.

2.5 Knee airbags

The test set-up and the assessment criteria described above are also applicable for vehicles with knee airbags. Knee mapping test data must be provided in order to avoid the variable load modifier. However, it is assumed that a properly deploying knee airbag substitutes the function of foam and load spreader in order to avoid the concentrated load modifier. The presence of a knee airbag will not automatically lead to the removal of the concentrated load modifier; knee mapping data will be required to prove the effectiveness of the system. The presence of a knee airbag will not automatically lead to the removal of the concentrated load modifier; knee mapping data will be required to prove the effectiveness of the system.

Where the measured femur force is less than 3.8kN and the knee slider displacement is below 6mm, the variable contact and concentrated load modifiers will not be applied provided that, there is no bottoming out of the knee airbag.

It must be clear that there is no risk associated with the presence of the airbag module or its support structures.

Where a knee airbag does bottom out in the official MPDB test, an additional sled test with the HIII 50% percentile dummy in the MPDB test seating position is required with an airbag deployment time 10ms later than that observed in the official test. Where the femur loads or/and knee slider displacement exceed the acceptance criteria in Section 0, the variable load modifier will be applied.

Bottoming out of the knee airbag will be identified from the femur traces using sharp increases in femur load of at least 1kN in 5ms, and an accompanying increase in pelvis acceleration. There may also be physical damage to any underlying structures and evidence from high speed film.

If a knee airbag is deemed to have bottomed out in any of the tests and the femur loads and/or knee slider results exceed the 6mm limit, the variable load modifier will be applied.

2.6 Data processing and reporting

Insufficient high speed or still photography could result in the knee mapping not being accepted by the Euro NCAP Secretariat.

Data processing shall be supplied to Euro NCAP in ISO-MME format in accordance with Technical Bulletin CP 005.

The key deliverables will be as follows:

- Summary dossier
- Reference pulse data in ISO MME format
- BIW & test set-up data
- Restraint system time to fire and comparison with full scale test

- All sensor outputs in ISO MME format
- All sensor curves plotted in a single PDF file (sled and ATD)
- High speed film (min. 1000fps)
- Photos
- Folder and file structure as detailed in CP 005.

Full information about the test set up shall be supplied to Euro NCAP. This must include details of any work that has been done to compensate for supportive intrusion, how the steering column lower mass and attachments have been simulated and any special arrangements related to dummy positioning. Anything which could influence the assessment should be fully reported.

For the main test programme, the locations being investigated shall be detailed and the outcome from each test must be given. In both cases, full data shall be supplied, including graphical plots. A full explanation and comparative analysis must be supplied.

High speed film is required for ALL knee mapping testing.

Sled mounted high speed cameras must be used to record the whole of the relevant scene. This would include the seat, seat belt system, facia, steering column, door aperture and dummy trajectory from both left and right sides. It should record the knee impact location and provide verification that the knee was not deflected from the chosen location and that the feet remained stable on the toe board. This should include a camera view showing the knees and a camera view that shows the feet for the complete impact sequence. The high speed camera frame rate must be of the order of 1000 frames per second.

Still photography

In order for any knee mapping results to be accepted by Euro NCAP, it is essential that adequate photographic evidence of the test is provided by the manufacturer.

Pre and post test still photography is required to clearly show the sled set-up and BIW construction. Still photographs must show the fixings of the body in white to the sled, in particular the steering column and facia mounting and the appropriate body reinforcements before and after the series of tests. Additionally, any structures added to simulate intrusion which could support the knee impact area should also be recorded.

The structures present in the facia must be clearly visible to provide evidence that the sled set-up is representative of a production vehicle and that all required components have been included.

It is essential that the position of the dummy and particularly its knees are clearly shown, along with a photographic record of the paint applied to the knees. After each test, a record must be made of the knee contact area, any paint transfer marks, and any damage to any of the knee impact area components.

Any broken, damaged or fatigued components shall also be fully recorded using photographs. In some cases it will be necessary to remove these from the facia after the tests in order to provide the best view.

2.7 Sled Pulse

The pulse used for the knee mapping tests must meet the requirement detailed in Euro NCAP Technical Bulletin CP 500.