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**EUROPEAN NEW CAR ASSESSMENT PROGRAMME
(Euro NCAP)**

**SLED TEST PROCEDURE FOR ASSESSING KNEE IMPACT
AREAS**

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Sled Test Procedure for Assessing Knee Impact Areas (V1.0a)

Introduction

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 pre-tensioners 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.

In order to be able to deal with knee airbags, Euro NCAP have agreed to the use of sled tests to demonstrate how well the knee contact zone provides protection. Having accepted this approach for use with knee airbags, it has to be accepted for other similar situations, where the femur force measured in the Euro NCAP test is less than 3.8 kN, to determine whether or not the variable knee load modifier should be applied. It should be noted that under normal circumstances, where the variable load modifier is not applied, the concentrated load modifier is also not applied.

To clarify what is required, the procedure described below has been developed by the "Knee Mapping Subgroup." The subgroup was comprised of representatives from Euro NCAP, ACEA and JAMA.

There are a number of phases to the procedure. The first phase involves a validation test to demonstrate that the sled test set up and severity can adequately simulate the full scale crash test. The second phase explores the robustness of the knee contact area, using a 95th percentile dummy. For airbags, there is a third phase which aims to ensure that the airbag does not, in itself, pose a hazard to the occupant.

Manufacturers may wish to use this procedure during vehicle development. For cars fitted with knee airbags, Euro NCAP will require information from such tests in order to rate the knee impact area. The Euro NCAP inspection will be used to identify any hazardous regions, for which tests would be required.

Pre-Requisites

Before Euro NCAP will be prepared to consider data from a sled test programme there are certain requirements that need to have been met in the Euro NCAP frontal impact test. It will be necessary for the extent of passenger compartment deformation to be sufficiently small that it would not influence the assessment. This requires that there would need to be no significant deformation of the driver's door aperture and a stable link would need to remain between the knee contact area, with its supporting structure, and the side frame of the car. There should also be no significant deformation of the seat, its mountings or the car's floor, to the extent that they might be considered to invalidate the sled test results.

Hardware Set Up

An acceleration or deceleration based sled rig may be used. Mounted on the sled should be a “body in white” of the car model being assessed. All features which may influence knee impact protection must be installed in the body in white.

The bodyshell should be mounted on the sled such that there will be no permanent deformation of the body or its mounts, in the test programme. This is necessary to help ensure good repeatability. The pitch angle of the bodyshell should be set to 0 degrees, according to the manufacturer’s specification. The yaw angle of the bodyshell is undefined. In most cases, it will be set to 0 degrees. However, there may be situations where the potential knee impact hazards require the yaw angle to be set differently, to maximise their threat. This might be where a supporting structure is strongest at a particular yaw angle. In no cases, would Euro NCAP require 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 should be fully simulated. Included in this would be the support given by the steering column or 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 should be to the same specification as those used in the Euro NCAP frontal impact test. The restraint system and any active devices should 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 should be identified in the Euro NCAP inspection. For the sled tests, it may be acceptable for this type of intrusion to be simulated statically.

Validation Test

For the validation test, the steering column should be adjusted to the settings used in the Euro NCAP frontal impact test.

Main Test Programme

For the main test programme, the column angle and reach should be adjusted to whatever position would maximise femur load. If there is concern about loads passing through the knee joint, the column should be adjusted to maximise knee slider displacement. If there is concern about airbag bottoming out, the column should be adjusted to maximise the chances of the airbag bottoming out. If more than one of these aspects cause concern, multiple configurations would need to be assessed.

Active Restraints

Any active components of restraint systems should 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. 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.

Sled Acceleration

The sled acceleration should be measured and compared with that measured, at the base of the impact side B pillar, in the Euro NCAP frontal impact test. The pulse shapes should be similar and the test severity at least as great. This should be evident from the acceleration and velocity against time traces. The velocity change of the sled (Δv) should also be at least as great as that in the Euro NCAP frontal impact test.

Anthropometric Test Device

Validation Test

For the validation test, a Hybrid III dummy shall be used. It should be equipped, and set up as in the Euro NCAP frontal impact test.

Main Test Programme

For the main test programme, a 95th percentile male Hybrid III dummy will be used. It should initially be positioned as normal but then its position can be adjusted, to the least extent necessary, to ensure a stable knee contact on the location being assessed. In order to ensure a stable knee contact, it may be necessary to prevent the relevant foot from moving forwards in the footwell.

In order to ensure a worst case situation for the knee being tested, the other knee should be so positioned that it would receive the minimum loading. Frequently, this would be achieved by positioning it laterally where it has the greatest spacing from the fascia or where it impacts the least well supported part of the fascia.

Dummy Painting

Paint should be applied to the dummy's knees and lower legs, as specified for the Euro NCAP frontal impact test.

Instrumentation

Validation Test

For the validation test, the 50th percentile dummy should have the full instrumentation specified for the Euro NCAP frontal impact test. This should include the measurement of shoulder belt forces and pelvis acceleration. Although the principal comparisons will be made using knee and femur responses, this data can aid understanding and explain any anomalies.

Main Test Programme

For the main test programme, the 95th percentile dummy should be equipped with instrumentation to record femur axial force and knee slider displacement for both

legs. Shoulder belt loads should also be recorded. These can help 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.

Data Processing

The test data should be sampled and filtered as specified for the Euro NCAP frontal impact test.

Photographic Record

Sled mounted high speed cameras should 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. More detailed, close up shots should record the knee impact location and provide verification that the knee was not deflected from the chosen location. The high speed camera frame rate should be of the order of 1000 frames per second.

Still photographs should show the overall test set up, the fixings of the body in white to the sled, both before and after the series of tests and any structure added to simulate intrusion which could support the knee impact area. The position of the dummy and particularly its knees should be clearly shown, along with a photographic record of the paint applied to the knees. After each test, a record should be made of the knee contact area, any paint transfer marks, and any damage to any of the knee impact area components.

Performance Criteria

The performance criteria used for the assessment will be a subset of those specified in the Euro NCAP Assessment Protocol (Femur force below 3.8 kN and Knee Slider response of less than 6 mm). No adjustment to the performance criteria is made for the change in dummy size. The accuracy with which the validation test simulates the Euro NCAP frontal impact test will be used to judge the safety margin required for the outcome of the tests in the Main Test Programme to be considered satisfactory.

Validation Test

In order to validate the sled test set up and parameters, a validation test shall be performed using a 50th percentile dummy. The knee impact locations should closely match those occurring in the Euro NCAP frontal impact test. For the test set up to be considered as valid, it will be necessary to show that the impact energy dissipated in the knee impacts closely match those in the Euro NCAP test. To determine that this is so, the femur loads, the knee slider displacements, and the damage to the facia will all need to be compared. Overall, the severity should be at least as severe as that in the Euro NCAP test.

Main Test Programme

The first step is to identify the potential hazards in the knee impact area and the knee for which they present a hazard. In the Euro NCAP inspection, the potential hazards will be identified and it will be necessary for all of them to be fully explored in the test programme.

For each potential hazard, it will be necessary to arrange for the knee in question to accurately impact that location. Tests will only be considered acceptable if the knee maintains stable contact with the selected location. If the knee is deflected, the test will not be accepted as a valid measure of the potential hazard. It is acceptable to adjust the seat position, move the dummy sideways and reposition the foot, in order to perform an acceptable test setup.

The spacing between the knee and the potential hazard should be such that it gives the worst performance. This will have to be demonstrated. It could be demonstrated that the worst case knee spacing has been used by supplying comparative tests, with slightly greater and slightly less knee spacing. For the driver's knees, the minimum spacing that would need to be considered would be that where it is still possible to drive the car. This can be determined and demonstrated by a sample of drivers, of around 95th percentile size. For the passenger, feasible seating positions include those with the knees just in contact with the fascia.

As stated earlier, in order to ensure a worst case situation for the knee being tested, the other knee should be so positioned that it would receive the minimum loading. Frequently, this would be achieved by positioning it laterally where it has the greatest spacing from the fascia or where it impacts the least well supported part of the fascia.

Reporting

Full information about the test set up should be supplied to Euro NCAP. This should 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. In principle, anything which could influence the assessment should be fully reported.

For the validation test, a comparison should be provided to satisfy Euro NCAP that the test set up and pulse is suitable for the assessment work. For the main test programme, the points being investigated should be detailed and the outcome from each test should be given. In both cases, full data should be supplied, including graphical plots. A full explanation and comparative analysis should be supplied.

Supplementary Requirements for Knee Airbags

Where the measured femur force is less than 3.8 kN, the concentrated load modifier will not be applied provided that, there is no bottoming out of the knee airbag or, if the airbag does bottom out, the supporting structures comply with the normal Euro NCAP requirements for avoiding the concentrated load modifier. It must be clear that

there is no risk associated with the presence of the airbag module or its support structures.

In order to ensure that the airbag creates no hazard from deployment against a knee or leg positioned close to the fascia, it is necessary to carry out static deployment tests. The major concern is that a deploying airbag may load the leg just below the knee causing excessive forces to be transmitted through the knee joint. To demonstrate that there is no hazard, a 50th percentile dummy with fully instrumented legs should be positioned as close to the fascia as is feasible, using the definitions given earlier for the driver and passenger. The knee height should be located at the worst case position for any occupant size between 5th and 95th percentile. To achieve this, it is acceptable for the body and foot of the dummy to be re-positioned. With the dummy so positioned, the airbag should be deployed. The full set of data from the legs should be supplied, to confirm that there is no “out of position” hazard. If and when ball race knee sliders become available for the 5th and 95th percentile dummies, their use may be required.

Although currently, Euro NCAP does not currently assess the stiffness of structures situated behind an effective knee airbag, any structures which might be considered hazardous will be reported. In future, their presence may become part of the assessment. The concern is that such structures could become a hazard, in more severe impacts, where more extensive passenger compartment intrusion occurs.

Interaction With Euro NCAP

Any manufacturer who intends to present knee mapping test results to Euro NCAP is required to advise the Secretariat before the 121 meeting arrangements are made. Where 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.