GLOBAL NCAP

Assessment Protocol
Adult Occupant Protection

2025 - 2029
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CONTENTS

ACKNOWLEDGMENT

1 INTRODUCTION

The Global NCAP assessment programme is designed to provide a fair, meaningful and objective assessment of the impact performance of vehicles and to provide a mechanism to inform consumers of the results. This protocol is based on that used by the European New Car Assessment Programme (Euro NCAP) for the Adult Occupant Protection (AOP) rating.

DISCLAIMER: Global 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, Global NCAP reserves the right to make corrections and determine the assessment and subsequent result of the affected requirement(s).

2 METHOD OF ASSESSMENT

The starting point for the assessment of AOP is the dummy response data recorded from the frontal or side impact test. Global NCAP decides which test is to be performed first. Initially, each relevant body area is given a score based on the measured dummy parameters. These scores can be adjusted after the test based on supplementary requirements. For example, consideration is given to whether the original score should be adjusted to reflect occupant kinematics or sensitivity to small changes in contact location, which might influence the protection of different sized occupants in different seating positions. The assessment also considers the structural performance of the vehicle by taking into account aspects such as steering wheel displacement, pedal movement, foot well distortion, and displacement of the A pillar. The assessment will also focus on the structural differences, if any, between the driver and passenger sides to assess if both the driver and passenger are equally protected in the case of a crash on either side of the vehicle. The adjustments, or modifiers, are based on both inspection and geometrical considerations applied to the body area assessments to which they are most relevant.

For AOP, the rating is based on the driver and/or passenger data. It is stated that the judgement relates primarily to the driver but it also considers the protection of the front passenger. The adjusted rating for the different body regions is presented, in a visual format of coloured segments within a human body outline for the driver and passenger.

No attempt is made to rate the risk of life-threatening injury any differently from the risk of disabling injury. Similarly, no attempt is made to rate the risk of the more serious but less frequent injury any differently from the risk of less serious but more frequent injury. Care has been taken to try to avoid encouraging manufacturers to concentrate their attention on areas which would provide little benefit in crashes.

2.1 Points calculation

A sliding scale system of points scoring has been adopted for the biomechanical assessments. This involves two limits for each parameter, a more demanding limit (higher performance), beyond which a maximum score is obtained and a less demanding limit (lower performance), below which no points are scored. For the adult rating, the maximum score for each body region is four points. Where a value falls between the two limits, the score is calculated by linear interpolation.

For all parts of the AOP assessment, capping limits are maintained for criteria related to critical body regions: head, neck and chest for the frontal impact test; head, chest, abdomen and pelvis for the side and pole impact tests. Exceeding a capping limit generally indicates an unacceptably high risk of injury. In all cases, this leads to loss of all points related to the tests. Capping limits can be equal to or higher than the lower performance limit, depending on the test. When a vehicle offers “side seating” positions, those that are perpendicular to the travel direction of the vehicle, AOP points will be capped to zero.

2.2 Rating calculation

The AOP rating is based on the score obtained in the tests by comparing the value with limits set for each level of stars. Global NCAP applies additional requirements for the highest performing star levels that need to be met for the stars to be awarded. If these conditions are not fulfilled, the rating result will be reduced to the level where all conditions are met.

3 ADULT FRONTAL IMPACT OCCUPANT PROTECTION ASSESSMENT

3.1 Criteria and limit values

The basic assessment criteria, with the upper and lower performance limits for each parameter, are summarised below. Where multiple criteria exist for an individual body region, the lowest scoring parameter is used to determine the performance of that region. The lowest scoring body region of the driver or passenger is used to determine the score. For frontal impact, capping is applied to the following critical body regions: head, neck and chest and for side impact, capping is applied to: head, chest, abdomen and pelvis. When the vehicle is rated zero stars in either the frontal or side impact test, the remaining test may not be performed. Capping can be reached by biomechanical value reading (in this case the result is capped to zero stars) or when one critical body region scores zero after modifiers are applied (in this case the result is capped to one star).

3.1.1 Head

3.1.1.1 Drivers with steering wheel airbags and passengers

If a steering wheel airbag is fitted, the following criteria are used to assess the protection of the head for the driver. These criteria are also used for the passenger.

***Note**: HIC_{15} levels above 700 have been recorded with airbags, where there is no hard contact and no established risk of internal head injury. A hard contact is assumed, if the peak resultant head acceleration exceeds 80g, or if there is other evidence of hard contact.*

If there is no hard contact, a score of 4 points is awarded. If there is hard contact, the following limits are used:

	Higher Performance Limit	Lower Performance and Capping Limit
HIC_{15}	500	700 (20% risk of injury ≥ AIS3 [1,2])
Resultant Acc. 3 msec exceedance	72g	88g

3.1.1.2 Drivers with no steering wheel airbag

If no steering wheel airbag is fitted, and the following requirements are met in the frontal impact test:

HIC_{15}	<700
Resultant Acc. 3 msec exceedance	<88g

then, 6.8kg spherical headform test specified in United Nations Regulation (UN R) 12 [3] will be carried out on the steering wheel. The tester attempts to choose the most aggressive sites to test and it is expected that two tests will be required, one aimed at the hub and spoke junction and one at the rim and spoke junction. The assessment is then based on the following criteria:

	Higher Performance Limit	Lower Performance and Capping Limit
HIC_{15}		700
Resultant Peak Acc.	80g	120g
Resultant Acc. 3 msec exceedance	65g	80g

From the spherical headform tests, a maximum of 2 points is awarded for performance better than the higher limits. For values worse than the lower performance limit, no points are awarded. For results between the limits, the score is generated by linear interpolation. The results from the worst performing test are used for the assessment. This means that for vehicles, not equipped with a steering wheel airbag, the maximum score obtainable for the driver's head is 2 points.

For vehicles without steering wheel airbags that do not fulfil the *HIC_{15}* and *Resultant Acc. 3 msec exceedance* criteria, to perform a headform test as described in Section 3.1.1.2, performance limits will be applied as per Section 3.1.1.1.

3.1.2 Neck

	Higher Performance Limit	Lower Performance and Capping Limit
Shear	1.9kN @ 0 msec 1.2kN @ 25 - 35msec 1.1kN @ 45msec	3.1kN @ 0msec 1.5kN @ 25 - 35msec 1.1kN @ 45msec*
Tension	2.7kN @ 0 msec 2.3kN @ 35msec 1.1kN @ 60msec	3.3kN @ 0msec 2.9kN @ 35msec 1.1kN @ 60msec*
Extension	42Nm	57Nm* Significant risk of injury [4])

*(*EEVC limits)*

***Note**: Neck Shear and Tension are assessed from cumulative exceedance plots, with the limits being functions of time. By interpolation, a plot of points against time is computed. The minimum point on this plot indicates the score. Plots of the limits and colour rating boundaries are provided in Appendix I.*

3.1.3 Chest

	Higher Performance Limit	Lower Performance and Capping Limit
Compression	22mm (5% risk of injury ≥ AIS3 [5])	42mm*
Viscous Criterion	0.5m/sec (5% risk of injury ≥ AIS4)	1.0m/sec* (25% risk of injury ≥ AIS4)

*(*EEVC limits)*

3.1.4 Knee, Femur and Pelvis

	Higher Performance Limit	Lower Performance Limit
Femur compression	3.8kN (5% risk of pelvis injury [6])	9.07kN @ 0msec 7.56kN @ ≥ 10msec* (femur fracture limit [4])
Knee slider compressive displacement	6mm	15mm* (cruciate ligament failure limit [4,7])

*(*EEVC limit)*

***Note**: Femur compression is assessed from a cumulative exceedance plot, with the limits being functions of time. By interpolation, a plot of points against time is computed. The minimum point on this plot indicates the score. Plots of the limits and colour rating boundaries are provided in Appendix I.*

3.1.5 Lower leg

	Higher Performance Limit	Lower Performance Limit
Tibia index	0.4	1.3*
Tibia compression	2kN	8kN* (10% risk of fracture [4,8])

*(*EEVC limits)*

3.1.6 Foot and ankle

	Higher Performance Limit	Lower Performance Limit
Pedal rearward displacement	100mm	200mm

***Notes**:*
1. Pedal displacement is measured for all pedals with no load applied to them.
2. If any of the pedals are designed to completely release from their mountings during the impact, no account is taken of the pedal displacement if that release occurred during the test and if the pedal retains no significant resistance to movement.
3. If a mechanism is present to move the pedal forwards in an impact, the resulting position of the pedal is used in the assessment.
4. The passenger's foot/ankle protection is not currently assessed.

3.2 Modifiers

3.2.1 Driver

The score generated from driver dummy data may be modified where the protection for different sized occupants or occupants in different seating positions, or crashes of slightly different severity, can be expected to be worse than that indicated by the dummy readings or deformation data alone. **There is no limit to the number of modifiers that can be applied, neither per body region nor in total amount.** The concepts behind the modifiers are explained in Section 7.

3.2.1.1 Head

Unstable contact on the airbag

If during the forward movement of the head its centre of gravity moves further than the outside edge of the airbag, head contact is deemed to be unstable. The score is reduced by one point. If for any other reason head protection by the airbag is compromised, such as by detachment of the steering wheel from the column or bottoming-out of the airbag by the dummy head, the modifier is also applied. In cases where the airbag shows a decrease in internal pressure while the head is still moving forward, increasing the risk of bottoming out, this modifier will be applied.

***Note**: Head bottoming-out is defined as follows:*
There is a definite rapid increase in the slope of one or more of the head acceleration traces, at a time when the dummy head is deep within the airbag. The acceleration spike associated with the bottoming out should last for more than 3ms. The acceleration spike associated with the bottoming out should generate a peak value more than 5 g above the likely level to have been reached if the spike had not occurred. This level will be established by smooth extrapolation of the curve between the start and end of the bottoming out spike. In cases where the modifier is applied due to a low-pressure airbag, there must be clear evidence from the high-speed videos of insufficient airbag pressure during the dummy´s forward movement as well as close proximity to the steering wheel. Bottoming out of passenger airbag will bring a -1 modifier to the passenger head.

Hazardous airbag deployment

If, within the head zone, the airbag unfolds in a manner in which a flap develops, which sweeps across the face of an occupant vertically or horizontally, the -1 point modifier for unstable airbag contact will be applied to the head score. If the airbag material deploys rearward, within the “head zone” at more than 90 m/s, the -1 point modifier will be applied to the head score.

Incorrect airbag deployment

Any airbag(s) which does not deploy fully in the designed manner will attract a -1 point modifier applicable to each of the most relevant body part(s) for the affected occupant. For example, where a steering wheel mounted airbag is deemed to have deployed incorrectly, the penalty will be applied to the frontal impact driver’s head (-1). Where, a passenger knee airbag fails to deploy correctly, the penalty will be applied to the frontal impact passenger’s left and right knee, femur and pelvis (-1). Where the incorrect deployment affects multiple body parts, the modifier will be applied to each individual body part. For example, where a seat or door mounted side airbag deploys incorrectly in the frontal impact that is intended to provide protection to the head as well as the

thorax, abdomen and pelvis, the penalty will be applied to two body regions, -1 to the head and -1 to the chest.

The modifier(s) will be applied to the scores of the impacts for which the airbag was intended to offer protection, regardless of the impact in which it deployed incorrectly. For example, the penalty will be applied if a seat mounted side airbag deploys incorrectly in the frontal impact. Where any frontal protection airbag deploys incorrectly, Global NCAP will not accept knee mapping data for that occupant.

Unstable contact on a steering wheel without an airbag

If, during the forward movement of the head, its centre of gravity moves radially outwards further than the outside edge of the steering wheel rim, head contact is deemed to be unstable. The score is reduced by one point. If for any other reason head contact on the steering wheel is unstable, such as detachment of the steering wheel from the column, the modifier is also applied.

Displacement of the steering column

The score is reduced for excessive rearward, lateral or upward static displacement of the top end of the steering column. Up to 90 percent of the European Enhanced Vehicle-Safety Committee (EEVC) limits, there is no penalty. Beyond 110 percent of the EEVC limits, there is a penalty of one point. Between these limits, the penalty is generated by linear interpolation. The EEVC recommended limits are: 100mm rearwards, 80mm upwards and 100mm lateral movement. The modifier used in the assessment is based on the worst of the rearward, lateral and upward penalties.

3.2.1.2 Chest

Displacement of the A-pillar

The score is reduced for excessive rearward displacement of the driver's front door pillar, at a height of 100mm below the lowest level of the side window aperture. Up to 100mm displacement, there is no penalty. Above 200mm, there is a penalty of two points. Between these limits, the penalty is generated by linear interpolation.

Integrity of the passenger compartment

Where the structural integrity of the passenger compartment is deemed to have been compromised, a penalty of one point is applied. The loss of structural integrity may be indicated by characteristics such as:

- Door latch or hinge failure unless the door is properly retained by the door frame.
- Buckling or other failure of the door resulting in severe loss of fore/aft compressive strength.
- Separation or near to separation of the cross facia rail to A pillar joint.
- Severe loss of strength of the door aperture.

When this modifier is applied, knee mapping data will not be accepted.

Steering wheel contact

Where there is obvious direct loading of the chest from the steering wheel, a one point penalty is applied.

Shoulder belt load

Where the shoulder belt load measured exceeds 6kN, a two point penalty is applied for the chest.

3.2.1.3 Knee, Femur and Pelvis

Variable Contact

The position of the dummy's knees is specified by the test protocol. Consequently, their point of contact on the facia is pre-determined. This is not the case with human drivers, who may have their knees in a variety of positions prior to impact. Different sized occupant and those seated in different positions may also have different knee contact locations on the facia and their knees may penetrate the facia to a greater extent. To take this into account, a larger area of potential knee contact is considered. If contact at other points, within this greater area, would be more aggressive, penalties are applied.

The area considered extends vertically 50mm above and below the maximum height of the actual knee impact location [8]. Vertically upwards, consideration is given to the region up to 50mm above the maximum height of knee contact in the test. If the steering column has risen during the test it may be repositioned to its lowest setting if possible. Horizontally, for the outboard leg, it extends from the centre of the steering column to the end of the facia. For the inboard leg, it extends from the centre of the steering column the same distance inboard, unless knee contact would be prevented by some structure such as a centre console. Over the whole area, an additional penetration depth of 20mm is considered, this is identified as the maximum knee penetration in the test. The region considered for each knee is generated independently. Where, over these areas and this depth, femur loads greater than 3.8kN and/or knee slider displacements greater than 6mm would be expected, a one point penalty is applied to the relevant leg.

Concentrated Loading

The biomechanical tests, which provided the injury tolerance data, were carried out using a padded impactor which spread the load over the knee. Where there are structures in the knee impact area which could concentrate forces on a part of the knee, a one point penalty is applied to the relevant leg.

Where a manufacturer is able to show, by means of acceptable test data, that the Variable Contact and/or Concentrated Loading modifiers should not be applied, the penalties may be removed.

If the Concentrated Loading modifier is not applied to any of the driver's knees, the left and right knee zones (defined above) will both be split into two further areas, a 'column' area and the rest of the facia. The column area for each knee will extend 75mm from the centreline of the steering column and the remainder of the facia will form the other area for each knee. As a result, the one point penalty for Variable Contact will be divided into two, with half a point being applied to the column area and half a point to the remainder of the facia for each knee.

Removal of knee modifiers

Global NCAP allows the vehicle manufacturer to present evidence in the form of knee mapping data in order to remove applied knee modifiers. Tests must be performed according to the Euro NCAP Sled Test Procedure Version 2.7 or later and carried out using original components only. Global NCAP reserves the right to witness the test. Knee mapping data will be accepted under the conditions below:

- The driver and front passenger's head, neck and chest scores are orange, yellow or green.
- Femur loads <3.8kN in the full vehicle test.

- Knee Slider <6mm in the full vehicle test.
- No structural modifiers applied i.e. integrity of the passenger compartment and/or footwell rupture (including modifiers applied due to asymmetrical structures).
- A pillar displacements must be below 65mm (using the Euro NCAP standard measurement).
- All restraint systems must be final production and exactly as the ones fitted in the tested vehicle, with the same characteristics and performance (volume, firing times, loads etc).

Knee mapping data must be presented for review before the 1-2-1 meeting.

3.2.1.4 Lower leg

Upward displacement of the worst performing pedal

The score is reduced for excessive upward static displacement of the pedals. Up to 90 percent of the limit considered by EEVC, there is no penalty. Beyond 110 percent of the limit, there is a penalty of one point. Between these limits, the penalty is generated by linear interpolation. The limit agreed by EEVC was 80mm.

3.2.1.5 Foot and ankle

Footwell rupture

The score is reduced if there is significant rupture or deformation of the footwell area. This is usually due to separation of spot welded seams. A one point penalty is applied for footwell rupture. The footwell rupture may either pose a direct threat to the driver's feet or be sufficiently extensive to threaten the stability of footwell response. When this modifier is applied, knee mapping data will not be accepted.

Pedal blocking

Where the rearward displacement of a 'blocked' pedal exceeds 175mm relative to the pre-test measurement, a one point penalty is applied to the driver's foot and ankle assessment. A pedal is blocked when the forward movement of the intruded pedal under a load of 200N is <25mm. Between 50mm and 175mm of rearward displacement, the penalty is calculated using a sliding scale between 0 to 1 point.

3.2.2 Passenger

The score generated from passenger dummy data may be modified where the protection for different sized occupants or occupants in different seating positions, or crashes of slightly different severity, can be expected to be worse than that indicated by the dummy readings alone. **There is no limit to the number of modifiers that can be applied**. The concepts behind the modifiers are explained in Section 7. The modifiers applicable to the passenger are:

- Unstable Contact on the airbag
- Hazardous airbag deployment
- Incorrect airbag deployment
- Displacement of the A pillar
- Integrity of the passenger compartment
- Shoulder belt load
- Knee, Femur and Pelvis, Variable Contact
- Knee, Femur and Pelvis, Concentrated Loading
- Footwell rupture

The assessments for airbag stability, head bottoming-out (where present) and the knee impact areas are the same as for the driver. For the outboard knee, the lateral range of the knee impact area extends from the centre line of the passenger seat to the outboard end of the facia. For the inboard knee, the area extends the same distance inboard of the seat centre line, unless knee contact is prevented by the presence of some structure such as the centre console. The passenger knee zones and penalties will not be divided into two areas even if the concentrated load modifier is not applied.

Passenger head contact with dashboard (no airbag)
If, during the forward movement of the passenger's head, it contacts the dashboard, the head score is reduced by one point.

The protection offered to the passenger in a frontal passenger-side 40% offset deformable barrier crash test must also be assessed. To do this:

1) Check for the same layers in the A pillar on the driver and passenger sides, door waist level reinforcement, footwell area reinforcements inside the compartment and beneath the floor under the vehicle and compare welding spots density for the passenger and driver side.

2) In cases where there are differences between both the driver and front passenger, or when there is other evidence of sub-optimisation for the driver side only, modifiers for structure, head bottoming out, knees and footwell area will be included for the adult calculation. These modifiers can subsequently be removed completely or in part by assessing a passenger-side frontal offset test.

3) In cases where both sides have the same reinforcements, and there is no obvious evidence of sub-optimisation, the manufacturer will provide a comparison of driver and passenger-side frontal offset results for confirmation.

3.2.3 Door opening during the impact

When a door opens in the test, a -1 modifier will be applied to the score for that test. The modifier will be applied to the frontal impact assessment for every door (including tailgates and moveable roofs) that opens. The number of door opening modifiers that can be applied to the vehicle score is not limited.

3.2.4 Door opening forces after the impact

The force required to unlatch and open each side door to an angle of 45 degrees is measured after the impact. A record is also made of any doors which unlatch or open in the impact. Currently, this information is not used in the assessment but it may be referred to in the text of the published reports.

Door opening forces are categorised as follows:

Opens normally	Normal hand force is sufficient
Limited force	≤ 100N
Moderate force	> 100N to < 500N
Extreme hand force	≥ 500N
Extreme hand force	Tools necessary

3.2.5 Fuel leakage

In the case of fuel leakage after the crash test, a -1 point modifier will be included in the Offset Deformable Barrier (ODB) full score. Fuel leakage assessment may include additional post-crash actions such as ignition of the vehicle. In the case the fuel leakage introduces a fire risk, this will be penalized as such.

3.2.6 Fire risk

In the case that after any of the tests, there is evidence of fire or evidence of risk of fire, the AOP points will be capped to zero.

3.2.7 EV safety

After the test, checks according to EVs post-crash requirements in UN R94, UN R95, UN R135 and UN R137 will be undertaken. Failing to comply with the "protection against electrical shock" chapter as described in the regulation will result in the AOP points being capped to zero.

The relevant items evaluated under the protection against electrical shock are:

- Absence of high voltage
- Low electrical energy
- Physical protection
- Isolation resistance:

  o Electrical power train consisting of separate DC- or AC-buses; OR
  o Electric power train consisting of combined DC- and AC-buses

- Electrolyte leakage
- REESS retention
- REESS fire hazards

Global NCAP reserves the right to penalize or highlight electrical shock risks in addition to the ones described in the UN Regulation, if justified.

3.2.8 Asymmetries and borderline cases

When a modifier is applied and a borderline case is being considered, the vehicle manufacturer may submit evidence of a higher load case test described in Appendix II.

For the ODB test, in case of asymmetry (such as variations in reinforcements, layers, and spot weld density), Global NCAP will apply modifiers for structural instability, footwell area and knees. The manufacturer can request the removal of these modifiers by providing evidence of a passenger side (not right hand drive [RHD] vehicle) ODB test. No CAD data will be accepted as evidence. It is the responsibility of manufacturers to inform the Global NCAP Secretariat in advance of testing when asymmetries are present that could potentially affect the structural or biomechanical performance of the test.

3.3 Scoring and visualisation

The protection provided for adults for each body region in the frontal impact assessment are presented visually, using coloured segments within body outlines. The colour used is based on the points awarded for that body region after application of modifiers but excluding possible capping (rounded to three decimal places), as follows:

Green	4.000 points
Yellow	2.670 - 3.999 points
Orange	1.330 - 2.669 points
Brown	0.001 - 1.329 points
Red	0.000 points

For frontal impact, the body regions are grouped together, with the score for the grouped body region being that of the worst performing region or limb. Results are shown separately for the driver and the passenger. The grouped regions are:

- Head and Neck
- Chest
- Knee, Femur, Pelvis (i.e. left and right femur and knee slider)
- Leg and Foot (i.e. left and right lower leg and foot and ankle)

4 SIDE IMPACT ASSESSMENT

4.1 Criteria and limit values

The basic assessment criteria used for side impact, with the upper and lower performance limits for each parameter, are summarised below. Where multiple criteria exist for an individual body region, the lowest scoring parameter is used to determine the performance of that region. **There is no limit to the number of modifiers that can be applied.** The concepts behind the modifiers are explained in Section 7. For side impact, capping is applied on the head, chest, abdomen and pelvis. To ensure robustness in engineering solutions, Global NCAP decides if testing will be conducted at the passenger or driver side of the vehicle using the same biomechanical and modifiers criteria. Capping can be reached by direct biomechanical value reading (in this case the result is capped to zero stars) or when one critical body region scores zero after modifiers are applied (in this case the result is capped to one star).

4.1.1 Head

4.1.1.1 Side impact

	Higher Performance Limit	Lower Performance and Capping Limit
HIC_{15}	500	700 (20% risk of injury ≥ AIS3 [1,2])
Resultant Acc. 3msec exceedance	72g	88g

4.1.2 Chest

The assessment is based on the worst performing individual rib.

	Higher Performance Limit	Lower Performance and Capping Limit
Compression	22mm (5% risk of injury≥AIS3 [10])	42mm* (30% risk of injury≥AIS3 [10])
Viscous Criterion	0.32 (5% risk of injury≥AIS3 [10])	1.0* (50% risk of injury≥AIS3 [10])

*(*EEVC limits)*

4.1.3 Abdomen

	Higher Performance Limit	Lower Performance and Capping Limit
Total abdominal force	1.0kN	2.5kN*

*(*EEVC limits)*

4.1.4 Pelvis

	Higher Performance Limit	Lower Performance and Capping Limit
Pubic symphysis force	3.0kN	6.0kN* (pelvic fracture in young adults)

*(*EEVC limits)*

4.2 Modifiers

4.2.1 Incorrect airbag deployment

Any airbag(s) which does not deploy fully in the designed manner will attract a -1 point modifier applicable to each of the most relevant body part(s) for the affected occupant. For example, where a head curtain airbag is deemed to have deployed incorrectly, the penalty will be applied to the side impact driver's or passenger's head (-1). Where the incorrect deployment affects multiple body parts, the modifier will be applied to each individual body part. For example, where a seat or door mounted side airbag that is intended to provide protection to the head as well as the thorax, abdomen and pelvis fails to deploy correctly, the penalty will be applied to two body regions, the head (-1) and the chest (-1).

The modifier will be applied even if the airbag was not intended to offer protection in that particular impact. For example, the penalty will be applied if a driver's knee airbag deploys incorrectly in a side impact. In this case, the modifier will be applied to the frontal impact driver knee, femur and pelvis body parts. Where a frontal protection airbag deploys incorrectly, knee-mapping is not permitted for the occupant whom the airbag was designed to protect.

4.2.2 Backplate loading

Where the backplate load Fy exceeds 4.0kN, a two point penalty is applied to the driver's or passenger's chest assessment. Between 1.0kN and 4.0kN the penalty is calculated using a sliding scale from 0 to 2 points. Only loads applied to the backplate, which might unload the chest by accelerating the spine away from the intruding side are counted.

	Higher Performance Limit	Lower Performance Limit
Fy	1.0kN	4.0kN* (pelvic fracture in young adults)

4.2.3 T12 modifier

Where the T12 loads Fy and Mx exceed 2.0kN or 200Nm respectively, a two point penalty is applied to the driver's or passenger's chest assessment. Between 1.5kN – 2.0kN or 150Nm – 200Nm, the penalty is calculated using a sliding scale from 0 to 2 points. The assessment is based upon the worst performing parameter. Only loads which are transmitted up the spine, which might unload the chest during the loading phase of the impact will be considered.

	Higher Performance Limit	Lower Performance Limit
Fy	1.5kN	2.0kN
Mx	150Nm	200Nm

Using Society of Automotive Engineers (SAE) J211 sign convention
Fy > 0 and Mx < 0 for left hand drive (LHD) vehicles
Fy < 0 and Mx > 0 for right hand drive (RHD) vehicles

4.2.4 Door opening during the impact

When a door opens in the test, a -1 point modifier will be applied to the score for that test. The modifier will be applied to the side impact assessment score for every door (including tailgates and moveable roofs) that opens. The number of door opening modifiers that can be applied to the vehicle score is not limited.

4.2.5 Door opening forces after the impact

A check is made to ensure that the doors on the non-struck side can be opened. The doors on the struck side are not opened.

4.2.6 Fuel leakage

In the case of fuel leakage after the crash test, a -1 point modifier will be included in the Mobile Deformable Barrier (MDB) full score. Fuel leakage assessment may include additional post-crash actions such as ignition of the vehicle. In the case the fuel leakage introduces a fire risk, this will be penalized as such.

4.2.7 Fire risk

In the case that after any of the tests, there is evidence of fire or evidence of risk of fire, the AOP points will be capped to zero.

4.2.8 Asymmetries and borderline cases

For the MDB and pole impact tests, no points will be scored for the chest and abdomen if asymmetries are suspected to affect the structural or biomechanical performance of the vehicle.

These include, but not limited to, absence of side impact reinforcements, energy absorption parts, or dummy artifact loading devices. The manufacturer can provide evidence of a MDB and/or pole impact test conducted on the opposite side of the official test to have the modifiers removed.

No CAD data will be accepted as evidence. It is the responsibility of manufacturers to inform the Global NCAP Secretariat in advance of testing when asymmetries are present that could potentially affect the structural or biomechanical performance of the test.

4.3 Scoring and visualisation

The protection provided for adults for each body region are presented visually, using coloured segments within body outlines. The colour used is based on the points awarded for that body region after application of modifiers but excluding possible capping (rounded to three decimal places), as follows:

Green	4.000 points
Yellow	2.670 - 3.999 points
Orange	1.330 - 2.669 points
Brown	0.001 - 1.329 points
Red	0.000 points

For the side impact, all the individual regions are used. The contribution of the side impact tests to the AOP score is calculated by summing the body scores for the relevant body regions. The total score in the side test is limited to 16 points. This is achieved by adding up the individual scores (after modifiers have been applied) for the side impact test (max. 16 points).

5 SEAT BELT REMINDERS (SBRs)

Global NCAP will assess SBRs in the front and rear seating positions according to the Euro NCAP Assessment Protocol – SA Version 5.6 (Chapter 3). In addition, the visual signal of the SBR must be located in a place where the driver can see it without moving their head but only moving their eyes not more than 15 degrees vertically and 15 degrees horizontally (centre console not acceptable). Manufacturers must indicate which positions are fitted with SBR systems as standard prior to the test. Rear seats will only be assessed for the “buckled” and “unbuckled” conditions. **Short or long term deactivation of SBRs is not allowed. Manufacturers must communicate in advance with the Global NCAP Secretariat should this function exist in the vehicle prior to the assessment.**

5.1 Pre-condition

A vehicle is eligible for scoring SBR points if the following conditions are met:

- The driver and front passenger’s head, neck, chest scores are orange, yellow or green.
- SBRs must be standard across all variants of the model.
- If the third or more row of seats is optional, on any variant, the assessment will be based on a vehicle fitted with the optional seats.

1 https://www.latinncap.com/en/our-tests

5.2 Scoring

SBRs will give 0.5 point for the driver seating position and 0.5/N point for each front passenger position that meets the requirements (N is the number of available front passenger positions). For the rear seating positions, the maximum achievable score is 1 point all together (all rear positions must meet the requirements to score). Hence, the maximum number of SBR points achievable is 2. Scoring the 0.5 SBR point for the driver position is a precondition for scoring passenger SBR points. Scoring full SBR points for the front occupants is a precondition for rear SBR point scoring.

6 ADULT OCCUPANT PROTECTION (AOP) RATING

The AOP score is calculated by summing the scores for the front impact (16 points max.), side impact (16 points max.) and SBR assessment (2 points max.). The total achievable score is 34.00 points and the overall scores are then used to generate star ratings by comparing the score to the limits in the table in Section 6.5 below.

6.1 Additional requirements for 5 stars

The 5-star rating is reserved only for vehicles that offer additional safety over that currently assessed by Global NCAP. In addition to meeting the required score, the following conditions must be met:

6.1.1 Electronic Stability Control (ESC)

Electronic Stability Control (ESC) must be fitted as standard across all variants of the tested model. The manufacturer must show evidence of compliance with GTR8, including all test data (videos, traces, setup information) and a test report signed by a type approval authority, UN or Euro NCAP accredited lab. Global NCAP reserves the right to test according to the GTR8 test conditions and pass/fail requirements and inform consumers of any result or findings.

Additionally, Global NCAP will conduct at least 3 runs of a “moose test” in two different scenarios with a professional driver from the accredited crash test facility in order to evaluate the real-life robustness of the ESC system. The test will be performed according to the latest version of the “Latin NCAP Moose Test Testing Protocol”[1]. Global NCAP will inform consumers of the maximum speed achieved on the test.

Global NCAP will introduce the moose test results into the scoring in the near future, continue to monitor the performance of the vehicles and reserves the right to propose further changes to the setup, scenario, criteria or rating, if any.

6.1.2 Pedestrian protection

The test must have Pedestrian Protection fitted as standard according to UN R127 or GTR9. To demonstrate functionality, the vehicle manufacturer must fund a UN R127 or GTR9 validation test, with a pass or fail result. Pedestrian Protection must be fitted as standard across all variants.

6.1.3 Side head protection – five stars

A side head protection system must be fitted on the test model as standard. Where no side head protectipon systems are present, the pole side impact test will not be allowed. Additionally, head protection side airbags, curtain, seat mounted or any other must fulfil the geometric

assessment according to the Euro NCAP Side Airbag Head Protection Evaluation[2] for both front and rear (second row) occupants.

***Note**: The requirement is for the fitment of a side head protection system, meaning that the manufacturer is free to use a solution other than an airbag. However, for technologies other than conventional curtain or side head airbags, the manufacturer is requested to provide evidence that the system is effective, at least in principle, before a test can be allowed.*

To ensure robustness in engineering solutions, Global NCAP decides if testing will be conducted at the passenger or driver side of the vehicle using the same biomechanical and modifiers criteria.

To demonstrate functionality, a side pole test must be sponsored according to the Euro NCAP Side Pole Test Protocol version 5.2, where the following criteria should be met:

HIC_{15}	<700
Peak Resultant Acc	<80g
No direct head contact with the pole	

For thorax, abdomen and pelvis, dummy readings must not exceed the lower performance limits set in Sections 4.1.2, 4.1.3 and 4.1.4, respectively. In the case that this happens, the pole side impact score will be capped to zero.

In the case where hazardous airbags deployment is noticed in the side pole impact test, and the same hazardous deployment is possible in the Side MDB, the modifier of -1 point can be carried over to the Side MDB assessment.

6.1.4 Seat belt reminders (SBRs)

In cases where the vehicle offers fully compliant SBR systems for all front seat positions, a minimum score of 1 point will be awarded.

Vehicles equipped with Federal Motor Vehicle Safety Standard (FMVSS) 208 compliant SBR systems (in relation to sound and duration) will exceptionally qualify for front and rear seat related points for a period of one year following the publication of the protocol, as long as:

- Global NCAP compliant SBRs are offered on 80% of volume sales; AND
- The manufacturer can demonstrate that the FMVSS 208 compliant SBR system hardware and architecture does not technically allow an upgrade to meet Global NCAP specifications.

6.2 Additional requirements for 4 stars

Similar to 5 stars, additional requirements apply to 4 stars vehicles. In addition to meeting the required score, the following conditions must be met:

6.2.1 Electronic Stability Control (ESC)

Identical requirements as set in Section 6.1.1 apply.

6.2.2 Pedestrian Protection

The test model must have Pedestrian Protection fitted as standard according to UN R127 or Global

Technical Regulation (GTR) 9. To demonstrate functionality, the vehicle manufacturer must prove compliance to regulation UN R127 or GTR9. The manufacturer must also agree to fund an audit test at a Global NCAP designated facility upon request. The Pedestrian Protection must be fitted as standard across all variants.

6.2.3 Side head protection – four stars

Identical requirements as set in Section 6.1.3 apply.

6.2.4 Seat belt reminders (SBRs)

Identical requirements as set in Section 6.1.4 apply.

6.3 Additional requirements for 3 stars

6.3.1 Electronic Stability Control (ESC)

Identical requirements as set in Section 6.1.1 apply.

6.3.2 Pedestrian Protection

Identical requirements as set in Section 6.2.2 apply.

6.3.3 Side head protection – three stars

Identical requirements as set in Section 6.1.3 apply.

6.3.4 Seat belt reminders (SBRs)

Identical requirements as set in Section 6.1.4 apply.

6.4 Additional requirements for 2 stars

6.4.1 Electronic Stability Control (ESC)

Identical requirements as set in Section 6.1.1 apply.

6.5 Scoring summary table

	Minimum score: ODB + MDB	Minimum SBR score (front & rear)	Minimum ESC performance	Pole Impact – side head protection	Pedestrian Protection
5 stars	27.00	1 point (Section 6.1.4)	Section 6.1.1	Section 6.1.3	Section 6.1.2
4 stars	22.00	1 point (Section 6.2.4)	Section 6.2.1	Section 6.2.3	Section 6.2.2
3 stars	16.00	1 point (Section 6.3.4)	Section 6.3.1	Section 6.3.3	Section 6.3.2
2 stars	10.00	0	Section 6.4.1	0	0
1 star	4.00	0	0	0	0
0 stars	0.00	0	0	0	0

6.5.1 Star rating limit

In order to avoid the highly undesirable situation of a vehicle gaining a rating of multiple stars when an important and vital body region is poorly protected (colour red), the rating will be limited to no more than 1 star regardless of the total number of points scored.

6.5.2 Relationship between points and stars for frontal and side tests

In order to avoid the undesirable situation of a vehicle performing very poorly in the frontal or side tests, with a difference of scores in front and side above 40%, the vehicle will have its Adult star rating reduced by one star to show that it did not provide good all-around protection.

7 CONCEPTS BEHIND THE ASSESSMENTS

7.1 Frontal impact

7.1.1 Head

***CONCEPT**: The driver's head should be predictably restrained by the airbag and should remain protected by the airbag during the dummy's forward movement. There should be no bottoming out of the airbag. Under slightly different test conditions, for example, speed, dummy size and dummy position, the head should also be predictably restrained by the airbag.*

***CONCEPT**: Hazardous airbag deployment*
The deployment mode of the airbag should not pose a risk of facial injury to occupants of any size.

***CONCEPT**: Incorrect airbag deployment*
All airbags that deploy during an impact should do so fully and in the designed manner so as to provide the maximum amount of protection to occupants available. It is expected that, where required, all airbags should deploy in a robust manner regardless of the impact scenario.

***CONCEPT**: Geometric control of steering wheel movement is needed to ensure that the airbag launch platform remains as close as possible to the design position, to protect a full range of occupant sizes.*

7.1.2 Neck

***CONCEPT**: Neck injuries are frequent, but relatively little is known about appropriate injury criteria. The neck criteria recommended by EEVC are used to identify poorly designed restraint systems. It is not expected that many vehicles will fail these requirements.*

In addition to the EEVC recommended limits, others have been added, at the request of the vehicle manufacturers. It is assumed that good restraint systems will have no problems meeting these criteria.

7.1.3 Chest

***CONCEPT**: Rib compression is used as the main guide to injury risk. It is expected that the Viscous Criterion will only identify vehicles with poorly performing restraint systems.*

The injury risk data is relevant for seat belt only loading rather than combined seat belt and airbag loading. No change is made in the event of a combined seat belt and airbag restraint. This avoids value judgements about the extent of the airbag restraint on the chest and is in line with the EEVC recommendation.

***CONCEPT**: There is an interrelationship between chest loading, as measured by the above dummy criteria, and intrusion. To ensure that a good balance is struck, a geometric criterion on waist level intrusion, as measured by door pillar movement at waist level, is used.*

***CONCEPT**: When the passenger compartment becomes unstable, any additional load can result in unpredictable excessive further collapse of the passenger compartment. When the passenger compartment becomes unstable, the repeatability of the vehicle's response in the test becomes poor and confidence in the vehicle's performance is reduced.*

***CONCEPT**: The chest performance criteria are developed for loads applied by a seat belt. The more concentrated loading from a "stiff" steering wheel exposes the chest to direct loading injury.*

7.1.4 Abdomen

Protection of the abdomen is important, but no criteria or assessment techniques are available at present.

7.1.5 Knee, Femur and Pelvis

***CONCEPT**: Transmitting loads through the knee joint from the upper part of the tibia to the femur can lead to cruciate ligament failure.*

Zero knee slider displacement is both desirable and possible. The higher performance limit allows for some possible movement due to forces transmitted axially up the tibia.

***CONCEPT**: The knee impact area should have uniformly good properties over a wide area of potential impact sites. This is to account for people sitting with their knees in different positions and slight variations in impact angle. The characteristics of the area should not change markedly if knee penetration is slightly greater than that observed with the 50 percentile dummy in this test. This takes into account the protection of different sized occupants or occupants in different seating positions.*

***CONCEPT**: Loading on the knee should be well distributed and avoid concentration that could result in localised damage to the knee.*

The injury tolerance work that supports the legislative femur criterion was conducted with padded impactors that spread the load over the knee.

7.1.6 Lower leg

***CONCEPT**: Loads resulting in fracture of the tibia produce bending moments and forces measurable at the upper and lower ends of the tibia. These measurements on the tibia relate to the risk of tibia fractures.*

At the request of the vehicle manufacturers, further limits were added to those proposed for lower leg protection. These limits can be expected to help protect the ankle joint.

***CONCEPT**: Pedal blocking*
There should be no blocking of any foot operated pedals which have displaced rearward after the impact; blocked pedals represent a greater hazard to the lower limbs of the driver than non-blocked pedals.

7.1.7 Foot and ankle

***CONCEPT**: Expert opinion suggests that a Tibia Index of less than 0.2 would be necessary to prevent ankle joint failure. Until biofidelic ankle and foot become available, the assessment will be based on intrusion. Intrusion is highly correlated with the risk of injury.*

***CONCEPT**: Rupture of the footwell exposes the occupant to additional dangers. Objects outside the passenger compartment may enter, parts of the occupant may contact items outside the passenger compartment, there is a risk from exposed edges and the structure may become unstable.*

7.1.8 Door opening

***CONCEPT**: The intention is to ensure that the structural integrity is maintained. The underlying principle is to minimise the risks of occupant ejection occurring.*

The 'door opening' modifier will be applied if any of the following have occurred:
- *the latch has fully released or shows significant partial release, either by release of its components from one another, or effective separation of one part of the latch from its supporting structure.*
- *the latch has moved away from the fully latched condition.*
- *if any hinge has released either from the door or bodyshell or due to internal hinge failure.*
- *if there is a loss of structure between the hinges and latches.*
- *if door or hinges fail whilst the door opening tests are being conducted post impact, as loading from an occupant could have a similar effect.*
- *if there was any potential risk of occupant ejection and/or partial ejection/entrapment from openings such as sliding doors or moveable roofs. Dynamic opening during the impact of any apertures, such as roofs, will also be considered even if the openings have closed during or post the test.*
- *if both side doors latch together with no B-pillar or other form of restraint, the modifier may apply to both the front and rear doors.*

7.2 Side and pole impact

***CONCEPT**: Incorrect airbag deployment*
All airbags that deploy during an impact should do so fully and in the designed manner so as to provide the maximum amount of protection to occupants available. It is expected that, where required, all airbags should deploy in a robust manner regardless of the impact scenario.

***CONCEPT**: Backplate*
Poor dummy biofidelity should not be exploited in such a way that compromises other outputs from the dummy.

***CONCEPT**: T12*
Poor dummy biofidelity should not be exploited in such a way that compromises other outputs from the dummy.

***CONCEPT**: Seat position in side impact*
Effective side impact protection needs to consider occupants of all sizes. This concept is included in the EU Directive. Currently, side impact tests are conducted with the seat in the design position. In future, consideration may be given to the level of protection in other seating positions.

7.3 Door opening (front, side, pole impact)

***CONCEPT**: The intention is to ensure that the structural integrity is maintained. The underlying principle is to minimise the risks of occupant ejection occurring.*

The 'door opening' modifier will be applied if any of the following have occurred:

- *the latch has fully released or shows significant partial release, either by release of its components from one another, or effective separation of one part of the latch from its supporting structure.*
- *the latch has moved away from the fully latched condition.*
- *if any hinge has released either from the door or bodyshell or due to internal hinge failure.*
- *if there is a loss of structure between the hinges and latches.*
- *if door or hinges fail whilst the door opening tests are being conducted post impact, as loading from an occupant could have a similar effect.*
- *if there was any potential risk of occupant ejection and/or partial ejection/entrapment from openings such as sliding doors or moveable roofs. Dynamic opening during the impact of any apertures, such as roofs, will also be considered even if the openings have closed during or post the test.*
- *if both side doors latch together with no B-pillar or other form of restraint, the modifier may apply to both the front and rear doors.*

8 REFERENCES

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9 Schneider, L.W., Vogel, M. and Bosio, C.A. Locations of driver knees relative to knee bolster design. The University of Michigan Transportation Research Institute, Ann Arbor, Michigan. UMTRI-88-40. September 1988.

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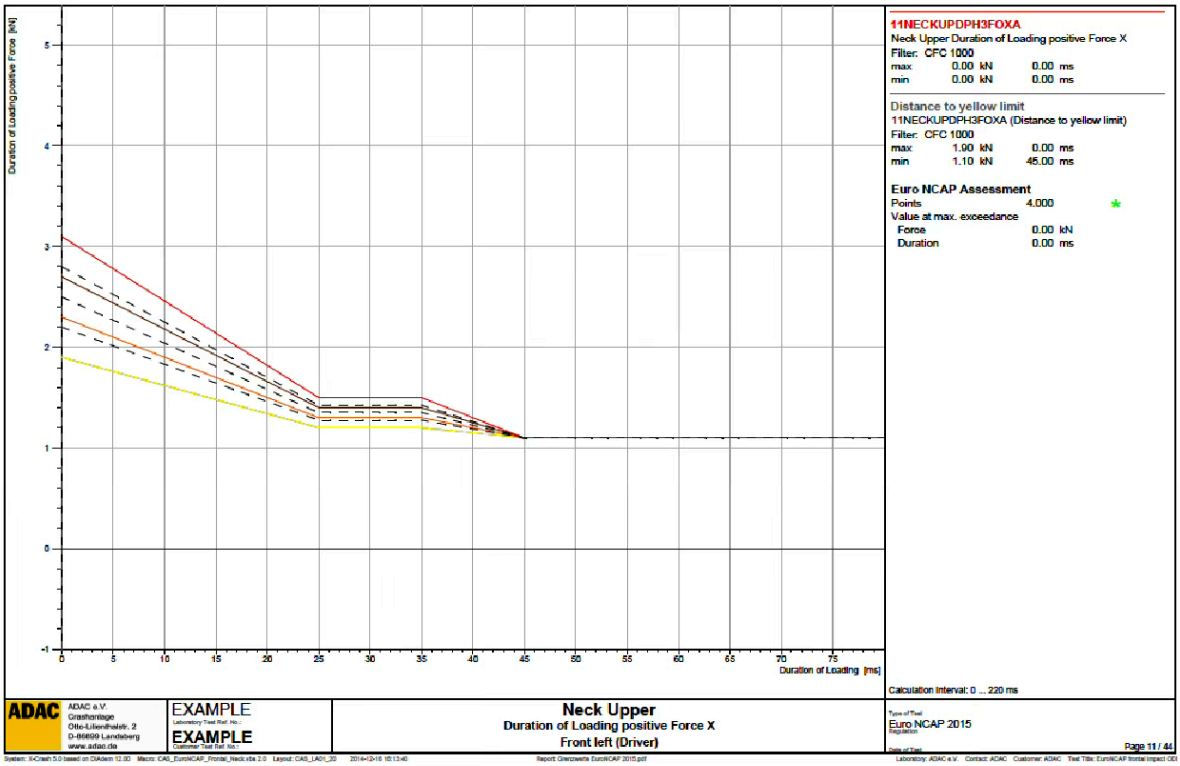
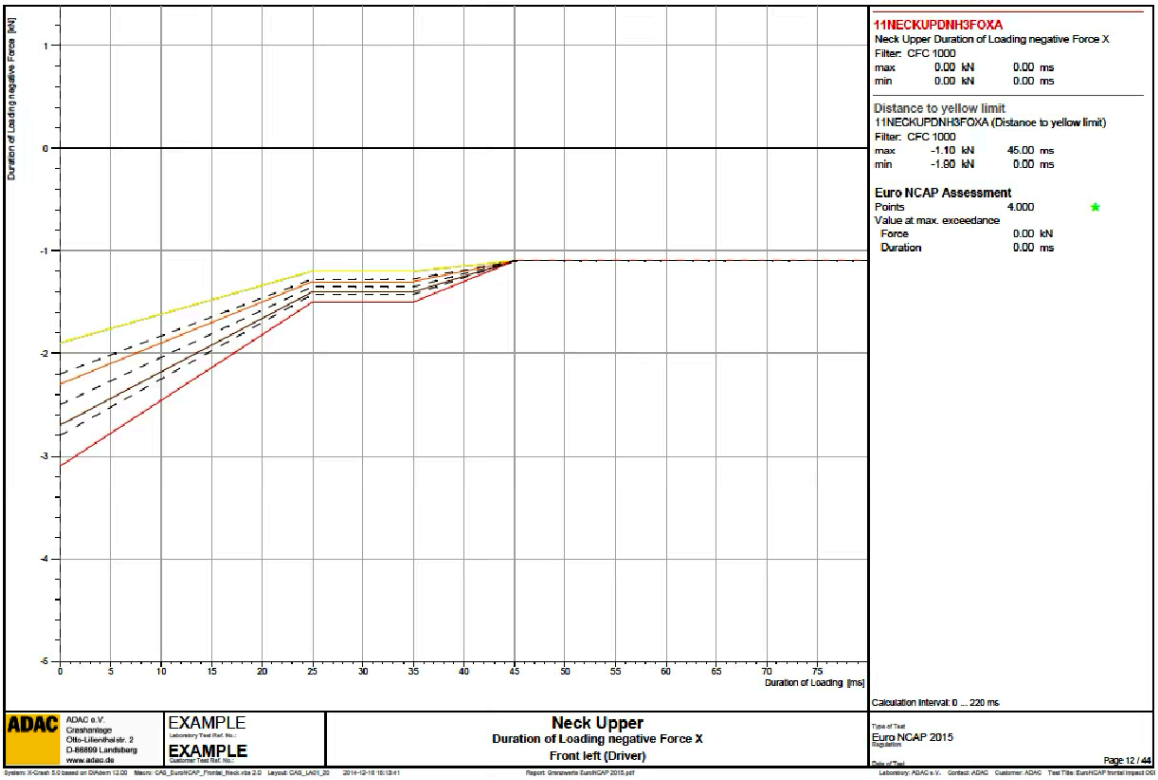
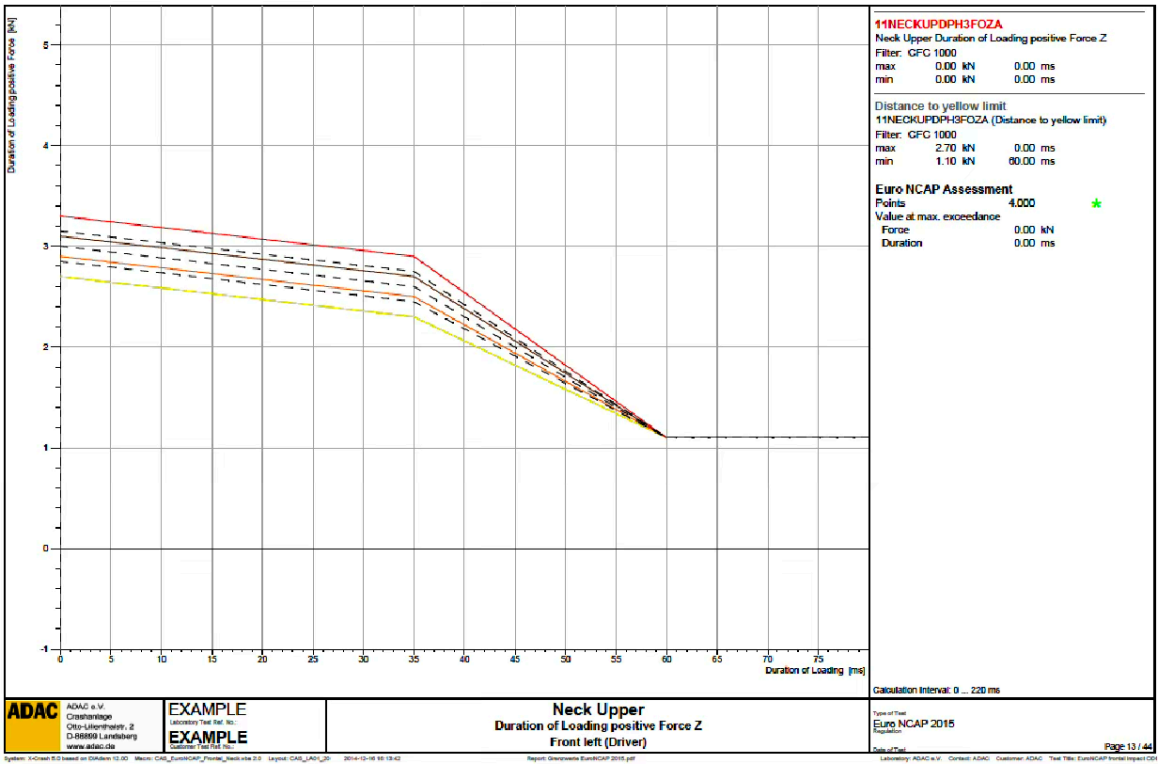
APPENDIX I

GRAPHICAL LIMITS FOR CUMULATIVE EXCEEDANCE PARAMETERS

1 Upper neck shear FX - positive
2 Upper neck shear FX - negative
3 Upper neck tension FZ
4 Femur compression






Duration of Loading positive Force [kN]
Duration of Loading [ms]
11NECKUPDPH3FOZA
Neck Upper Duration of Loading positive Force Z
Filter: CFC 1000
max 0.00 kN 0.00 ms
min 0.00 kN 0.00 ms
Distance to yellow limit
11NECKUPDPH3FOZA (Distance to yellow limit)
Filter: CFC 1000
max 2.70 kN 0.00 ms
min 1.10 kN 60.00 ms
Euro NCAP Assessment
Points 4.000
Value at max. exceedance
Force 0.00 kN
Duration 0.00 ms
Calculation Interval: 0 ... 220 ms
ADAC
ADAC e.V.
Crashanlage
Otto-Lilienthalstr. 2
D-86899 Landsberg
www.adac.de
EXAMPLE
EXAMPLE
Neck Upper
Duration of Loading positive Force Z
Front left (Driver)
Euro NCAP 2015
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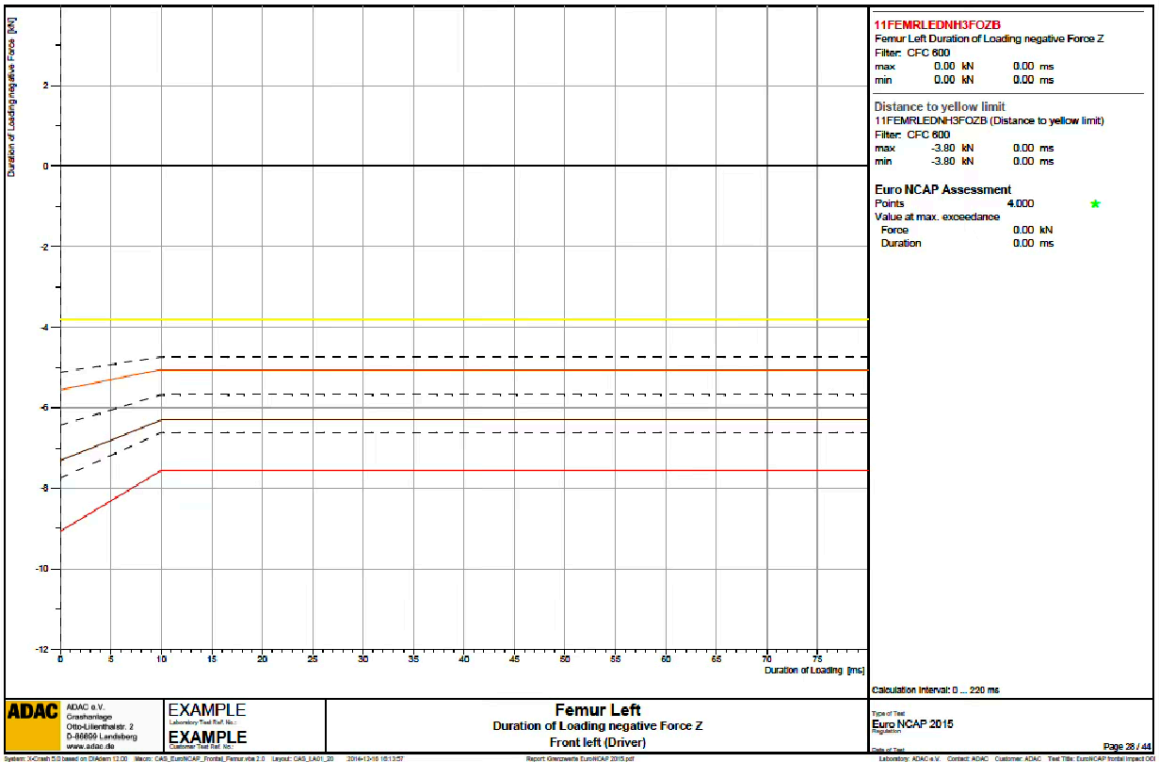
Duration of Loading negative Force [kN]
Duration of Loading [ms]
11FEMRLEDNH3FOZB
Femur Left Duration of Loading negative Force Z
Filter: CFC 600
max 0.00 kN 0.00 ms
min 0.00 kN 0.00 ms
Distance to yellow limit
11FEMRLEDNH3FOZB (Distance to yellow limit)
Filter: CFC 600
max -3.80 kN 0.00 ms
min -3.80 kN 0.00 ms
Euro NCAP Assessment
Points 4.000
Value at max. exceedance
Force 0.00 kN
Duration 0.00 ms
Calculation Interval: 0 ... 220 ms
ADAC
ADAC e.V.
Crashanlage
Otto-Lilienthalstr. 2
D-86899 Landsberg
www.adac.de
EXAMPLE
EXAMPLE
Femur Left
Duration of Loading negative Force Z
Front left (Driver)
Euro NCAP 2015
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APPENDIX II

ADULT OCCUPANT PROTECTION PROTOCOL

Border line case for unstable structural modifier ODB

In the case of structural stability, footwell area or chest contact modifiers are applied in the ODB test, and where a borderline case is in consideration, evidence should be shown to Global NCAP inspectors that in a more stringent test scenario, the reasons for the introduction of the modifiers are the same or close to the evidence recorded during the test.

The modifiers should show close performance in the same vehicle in an ODB test as the tested version but at 68km/h, 30% overlap (ensure the longitudinal is contained in the barrier impact) and 150kg extra load. Under these conditions, the deformation of the structure must be the same as the tested version, within a 10% tolerance in the 3D measurement and no added spot weld full or partial detachment, hinges or transfacia tube failures as well as no chest contact detected in order to remove the modifiers. No CAD data will be accepted, only full scale test with driver and passenger HIII 50%, Q3 and Q1.5 as per the official test. Complete data, videos, pictures, 3D measurement and structure stripping driver side must be shared within 24 hours after the test.

ABBREVIATIONS & ACRONYMS

AIS	Abbreviated Injury Scale
AOP	Adult Occupant Protection
EEVC	European Enhanced Vehicle-Safety Committee
ESC	Electronic Stability Control
EU	European Union
Euro NCAP	European New Car Assessment Programme
FMVSS	Federal Motor Vehicle Safety Standard
GTR	Global Technical Regulation
HIC	Head Injury Criterion
LHD	Left Hand Drive
MDB	Mobile Deformable Barrier
ODB	Offset Deformable Barrier
RHD	Right Hand Drive
SAE	Society of Automotive Engineers
SBR	Seat Belt Reminder
UN	United Nations
UN R	United Nations Regulation

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