GLOBAL NCAP

ASSESSMENT PROTOCOL
ADULT OCCUPANT PROTECTION

VERSION 1.0 - AUGUST 2017

CONTENTS

AKNOWLEDGEMENT

1. INTRODUCTION

The Global New Car Assessment Programme (Global NCAP) is designed to provide a fair, meaningful and objective assessment of the impact performance of cars and provide a mechanism to inform consumers. This protocol is based upon those used by the European New Car Assessment Programme for adult occupant protection and child occupant protection ratings.

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 adult occupant protection is the dummy response data recorded in the frontal impact. 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 car by taking account of such aspects as steering wheel displacement, pedal movement, foot well distortion and displacement of the A pillar. The adjustments, or modifiers, are based on both inspection and geometrical considerations and are applied to the body area assessments to which they are most relevant.

For Adult occupant protection, the overall rating is based on the driver data, unless part of the passenger fared less well. It is stated that the judgement relates primarily to the driver. 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 accidents.

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 also 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 tests that are part of the adult occupant protection assessment, capping limits are maintained for criteria related to critical body regions: head, neck and chest. Exceeding a capping limit generally indicates unacceptable high risk at 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.

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 driver or passenger is used to determine the score. For frontal impact, capping is applied on the critical body regions: head, neck and chest.

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 always used for the passenger.

Note: HIC36 levels above 1000 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		
HIC_{36}	650	(5% risk of injury ≥ AIS3 [1,2])
Resultant Acc. 3 msec exceedence	72g	
Lower performance and capping limit		
HIC_{36}	1000*	(20% risk of injury ≥ AIS3 [1,2])
Resultant Acc. 3 msec exceedence	88g	*(*EEVC limit)*

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_{36}	<1000
Resultant Acc. 3 msec exceedence	<88g

then 6.8kg spherical headform tests specified in ECE Regulation 12 [3] are 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	
Resultant peak Acc.	80g
Resultant Acc. 3 msec exceedence	65g
Lower performance and capping limit	
HIC36	1000
Resultant peak Acc.	120g
Resultant Acc. 3 msec exceedence	80g

From the spherical headform tests, a maximum of 2 points are 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 cars not equipped with a steering wheel airbag, the maximum score obtainable for the driver's head is 2 points.

3.1.2 Neck

Higher performance limit			
Shear	1.9kN @ 0 msec,	1.2kN @ 25 - 35msec,	1.1kN @ 45msec
Tension	2.7kN @ 0 msec,	2.3kN @ 35msec,	1.1kN @ 60msec
Extension	42Nm		

Lower performance and capping limit			
Shear	3.1kN @ 0msec,	1.5kN @ 25 - 35msec,	1.1kN @ 45msec*
Tension	3.3kN @ 0msec,	2.9kN @ 35msec,	1.1kN @ 60msec*
Extension	57Nm*		(Significant risk of injury [4])
			*(*EEVC Limits)*

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

3.1.3 Chest

Higher performance limit		
Compression	22mm	(5% risk of injury ≥ AIS3 [5])
Viscous Criterion	0.5m/sec	(5% risk of injury ≥ AIS4)
Lower performance and capping limit		
Compression	50mm*	(50% risk of injury ≥ AIS3 [5])
Viscous Criterion	1.0m/sec*	(25% risk of injury ≥ AIS4)

3.1.4 Knee, Femur and Pelvis

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

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

3.1.5 Lower Leg

Higher performance limit		
Tibia Index	0.4	
Tibia Compression	2kN	
Lower performance limit		
Tibia Index	1.3*	
Tibia Compression	8kN*	(10% risk of fracture [4,8])
		*(*EEVC Limits)*

3.1.6 Foot/Ankle

Higher performance limit	
Pedal rearward displacement	100mm
Lower performance limit	
Pedal rearward displacement	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 provided that release occurred in the test and that the pedal retains no significant resistance to movement.
is taken of the pedal displacement provided that release occurred in the test and that 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 accidents 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. The concepts behind the modifiers are explained in Section 4.

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 case the head contacts any interior part of the car, excluding the rebound phase, the modifier will also be applied e.g. the dashboard.

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.

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 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 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 adequately retained by the door frame.
- Buckling or other failure of the door resulting in severe loss of fore/aft compressive strength.
- Separation or near 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.

3.2.1.3 Knee, Femur & 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 occupants and those seated in different positions may also have different knee contact locations on the facia and their knees may penetrate into the facia to a greater extent. In order to take some account of this, a larger area of potential knee contact is considered. If there is contact at other points within this greater area, 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, beyond that 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 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.

[1] Reducing to 60mm by 2013.

If the Concentrated load 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[1] 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 one half of a point being applied to the column area and one half of 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, chest score 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.
- A-pillar displacements must be below 65mm (using the standard Euro NCAP measurement).

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 & Ankle

FOOTWELL RUPTURE
The score is reduced if there is significant rupture 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 points.

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 accidents 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 4. The modifiers applicable to the passenger are:

- Unstable Contact on the airbag
- Hazardous airbag deployment
- Incorrect airbag deployment
- Knee, Femur & Pelvis, Variable Contact
- Knee, Femur & Pelvis, Concentrated loading

The assessment's airbag stability, head bottoming-out (where present) and the knee impact areas are the same as for 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.

3.2.3 Door Opening during the Impact

When a door opens in the test, a minus one-point 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
Tools had to be used	Tools necessary

3.2.5 Seat Belt reminders (SBR)

Global NCAP will assess SBR in the front seating positions according to Euro NCAP Assessment Protocol – SA Version 5.6 or later (Chapter 3). 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). Hence the maximum number of SBR points achievable is 1. A car is eligible for scoring SBR points if the following conditions are met:
- The driver and front passenger's head, neck, chest score are orange, yellow or green.

3.3 Scoring & 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 (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 driver and 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).

The contribution of the frontal impact test to the Adult Occupant Protection Score is calculated by summing the body scores for the relevant body regions, taking the lower of the driver and passenger scores. The total achievable score is 17.00 points and the overall scores are then used to generate star ratings as follows:

Frontal Impact:

14.00 – 16.00 points + 1 point SBR + 4ch ABS + ECE95*	5 stars
11.00 – 13.99 points	4 stars
8.00 – 10.99 points	3 stars
5.00 – 7.99 points	2 stars
2.00 – 4.99 points	1 star
0.00 – 1.99 points	0 stars

*To be eligible for 5 stars the car must score over 14 points in the ODB test (after application of modifiers). In addition, it must have the full point on SBR, 4 Channel ABS and offer some side impact performance protection. To demonstrate the latter, a MDB test must be sponsored by the manufacturer on an actual Global NCAP market car of the identical specification as the frontal crash car according to the test specification of ECE R95. The MDB test would need to be performed even in cases where under the regulatory requirements the vehicle would be exempted due to various reasons, for example seating position. In order to qualify for 5 stars, the performance criteria of ECE95 should be met. The test results may be published by Global NCAP. Where the car is equipped with a side protection airbag (curtain or thorax side airbag) the airbags should be standard fitted.

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

This assessment will be applied on the basis of dummy response alone, for any body region where there is an unacceptably high risk of life-threatening injury i.e. if the dummy response has exceeded the lower performance limit. The body regions which could give rise to a 'star cap' are the head, neck and chest.

4 CONCEPTS BEHIND THE ASSESSMENTS

4.1 Frontal Impact

4.1.1 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.

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.

4.1.2 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 cars will fail these requirements.

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

4.1.3 Chest

CONCEPT: Rib compression is used as the main guide to injury risk. It is expected that the Viscous Criterion will only identify cars 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 combined seat belt and airbag restraint. This avoids value judgements about the extent of 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 car's response in the test becomes poor and confidence in the car'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.

4.1.4 Abdomen

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

4.1.5 Knee, Femur & 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.

4.1.6 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 risk of tibia fracture.

At the request of the car 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.

4.1.7 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 a 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 and may contact items outside the passenger compartment. There is a risk from exposed edges and the structure may become unstable.

4.2 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 post 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.

5 REFERENCES

1. Prasad, P. and H. Mertz.
   The position of the US delegation to the ISO Working Group 6 on the use of HIC in the automotive environment.
   SAE Paper 851246. 1985
2. Mertz, H., P. Prasad and G. Nusholtz. Head Injury Risk Assessment for forehead impacts.
   SAE paper 960099 (also ISO WG6 document N447)
3. ECE Regulation 12 Revision 3 - Uniform Provisions Concerning the Approval of Vehicles With Regard To the Protection of the Driver against the Steering Mechanism in the Event of Impact. 1994.
4. Mertz, H. Anthropomorphic test devices. Accidental Injury - Biomechanics and Prevention, Chapter 4. Ed. Alan Nahum and John Melvin. Pub. Springer-Verlag 1993.
5. Mertz, H., J. Horsch, G. Horn and R Lowne. Hybrid III sternal deflection associated with thoracic injury severities on occupants restrained with force-limiting shoulder belts.
   SAE paper 910812. 1991.
6. Wall, J., R. Lowne and J. Harris. The determination of tolerable loadings for car occupants in impacts.
   Proc 6th ESV Conference. 1976
7. Viano, D., C. Culver, R. Haut, J. Melvin, M. Bender, R. Culver and R. Levine. Bolster impacts to the knee and tibia of human cadavers and an anthropomorphic dummy. SAE Paper 780896, Proc 22nd Stapp conference.
8. EEVC WG. The Validation of the EEVC Frontal Impact Test Procedure. Proc 15th ESV Conference, Melbourne, 1996.
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.
10. Lowne, R. and E. Janssen. Thorax injury probability estimation using production prototype
    EUROSID. ISO/TC22/SC12/WG6 document N302.

APPENDIX I

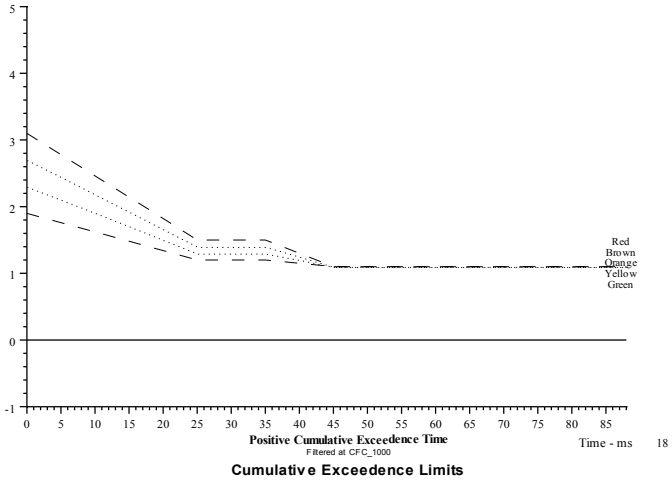
GRAPHICAL LIMITS FOR CUMULATIVE EXCEEDENCE PARAMETERS

1 Upper Neck Shear FX - Positive

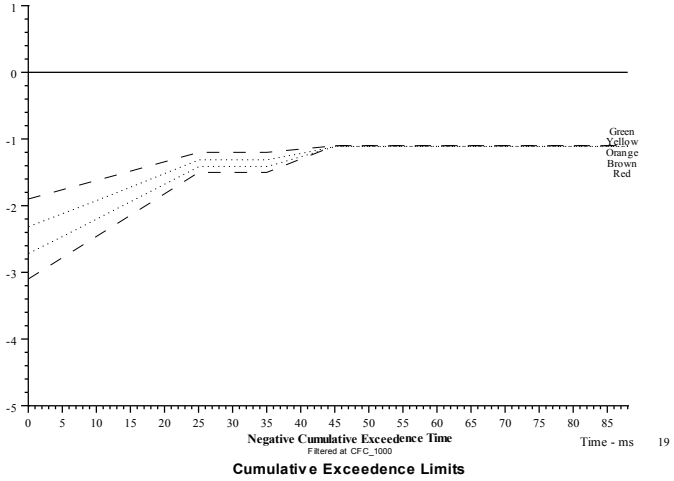
2 Upper Neck Shear FX - Negative

3 Upper Neck Tension FZ

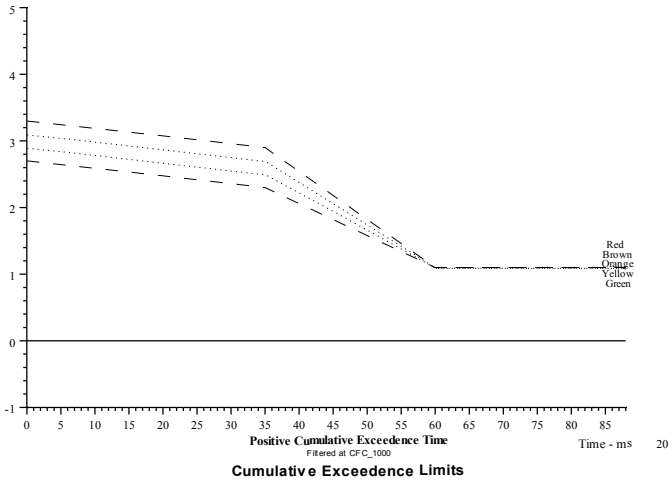
4 Femur Compression



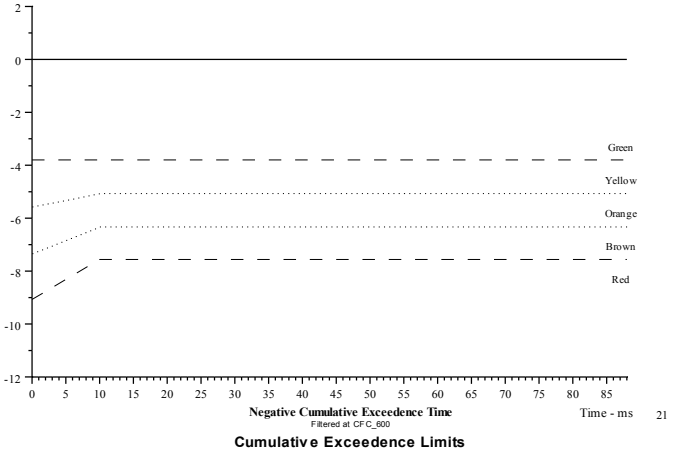
18



19



20



21

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