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EUROPEAN NEW CAR ASSESSMENT PROGRAMME (Euro NCAP)

ASSESSMENT PROTOCOL – PEDESTRIAN PROTECTION

Version 8.0
June 2014

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1 INTRODUCTION

Important changes have been made to the Euro NCAP ratings resulting in the introduction of the overall rating scheme. Individual documents are released for the four main areas of assessment:

- Assessment Protocol – Adult Occupant Protection.
- Assessment Protocol – Child Occupant Protection.
- Assessment Protocol – Pedestrian Protection.
- Assessment Protocol – Safety Assist.

In addition to these four assessment protocols, a separate document is provided describing the method and criteria by which the overall safety rating is calculated on the basis of the car performance in each of the above areas of assessment.

The following protocol deals with the assessments made in the area of Pedestrian Protection, in particular in the adult and child head, the upper leg form and lower leg form impacts.

2 METHOD OF ASSESSMENT

The assessment of pedestrian protection is made with the use of headform, upper legform and legform data. In the legform areas, the bumper and front of the bonnet of the car will be marked with a grid and are assessed using the two legform impactors. Euro NCAP will test "worst case" grid points and manufacturers may nominate additional tests to be performed and the results will be included in the assessment.

In the headform impact area, a grid will be marked on the outer surface of the vehicle. The vehicle manufacturer is required to provide the Euro NCAP Secretariat with data detailing the protection offered by the vehicle at all grid locations. The data shall be provided to the Euro NCAP Secretariat before any test preparation begins. The predicted level of protection offered by the vehicle is verified by Euro NCAP by means of testing of a sample of randomly selected grid-points and the overall prediction is corrected accordingly.

2.1 Points Calculation

For the legform impact areas, a sliding scale system of points scoring has been used to calculate points for each measured criterion. This involves two limits for each parameter, a more demanding limit (higher performance), below which a maximum score is obtained and a less

demanding limit (lower performance), beyond which no points are scored. Where a value falls between the two limits, the score is calculated by linear interpolation. No capping is applied to any of the measurements. The maximum score for each grid point is one point for bumper and bonnet leading ledge tests. The total score will then be scaled to a maximum of six points for each impactor.

For the headform impact area, the protection predicted by the vehicle manufacturer will be compared to the outcome of the randomly selected test locations. The results at those test locations will be used to generate a correction factor, which will then be applied to the predicted score. Only data that results in a correction factor of between 0.750 and 1.250 are accepted. Where this is not the case, the cause will be investigated and the Secretariat will subsequently take a decision as to how to proceed. Where the data are accepted, the headform score will be based on the predicted data score with correction applied.

3 PEDESTRIAN IMPACT ASSESSMENT

3.1 Criteria and Limit Values

The assessment criteria used for the pedestrian impact tests, with the upper and lower performance limits for each parameter, are summarised below. Where multiple criteria exist for an individual test, the lowest scoring parameter is used to determine the performance of that test, unless indicated otherwise.

3.1.1 Headform

The manufacturer must provide predicted data for all grid points. This data shall be expressed as a colour according to the corresponding colour boundaries for the predicted HIC_{15} performance below. Alternatively, HIC_{15} values may be provided.

Green	$HIC_{15} < 650$
Yellow	$650 \leq HIC_{15} < 1000$
Orange	$1000 \leq HIC_{15} < 1350$
Brown	$1350 \leq HIC_{15} < 1700$
Red	$1700 \leq HIC_{15}$

The manufacturer is allowed to colour a limited number of grid points blue where the performance is unpredictable. These grid points will always be tested. The procedure is detailed in the Pedestrian Protection Test protocol.

3.1.2 Upper Legform

Higher performance limit

Bending Moment	285Nm
Sum of forces	5.0kN

Lower performance limit

Bending Moment	350Nm
Sum of forces	6.0kN

3.1.3 Legform

Higher performance limit

Tibia Bending Moment	282Nm
MCL Elongation	19mm
ACL/PCL Elongation	10mm

Lower performance limit

Tibia Bending Moment	340Nm
MCL Elongation	22mm
ACL/PCL Elongation	10mm

3.2 Modifiers

There are no modifiers applied.

3.3 Scoring & Visualisation

3.3.1 Scoring

A maximum of 24 points is available for the headform test zone. The total score for all grid points is calculated as a percentage of the maximum achievable score, which is then multiplied by 24 points. The bonnet leading edge and bumper test zone will be awarded a maximum of 6 points each. A total of 36 points are available in the pedestrian protection assessment.

3.3.1.1 Headform

Each of the grid points can be awarded up to one point, resulting in a maximum total amount of points equal to the number of grid points. For each predicted colour the following points are awarded to the grid point:

$HIC_{15} < 650$	*1.00 point*
$650 \leq HIC_{15} < 1000$	*0.75 points*
$1000 \leq HIC_{15} < 1350$	*0.50 points*
$1350 \leq HIC_{15} < 1700$	*0.25 points*

$1700 \leq HIC_{15}$	*0.00 points*

3.3.2 Headform Correction factor

The data provided by the manufacturer is scaled using a correction factor, which is calculated based on a number of verification tests performed. The verification points are randomly selected grid points, distributed in line with the predicted colour distribution.

The actual tested total score of the verification test points is divided by the predicted total score of these verification test points. This is called the correction factor, which can be lower or higher than 1.

$$Correction\ Factor = \frac{Actual\ tested\ score}{Predicted\ score}$$

The correction factor is multiplied to all the grid points (excluding defaulted and blue points). The final score for the vehicle can never exceed 100% regardless of the correction factor.

3.3.2.1 HIC tolerance

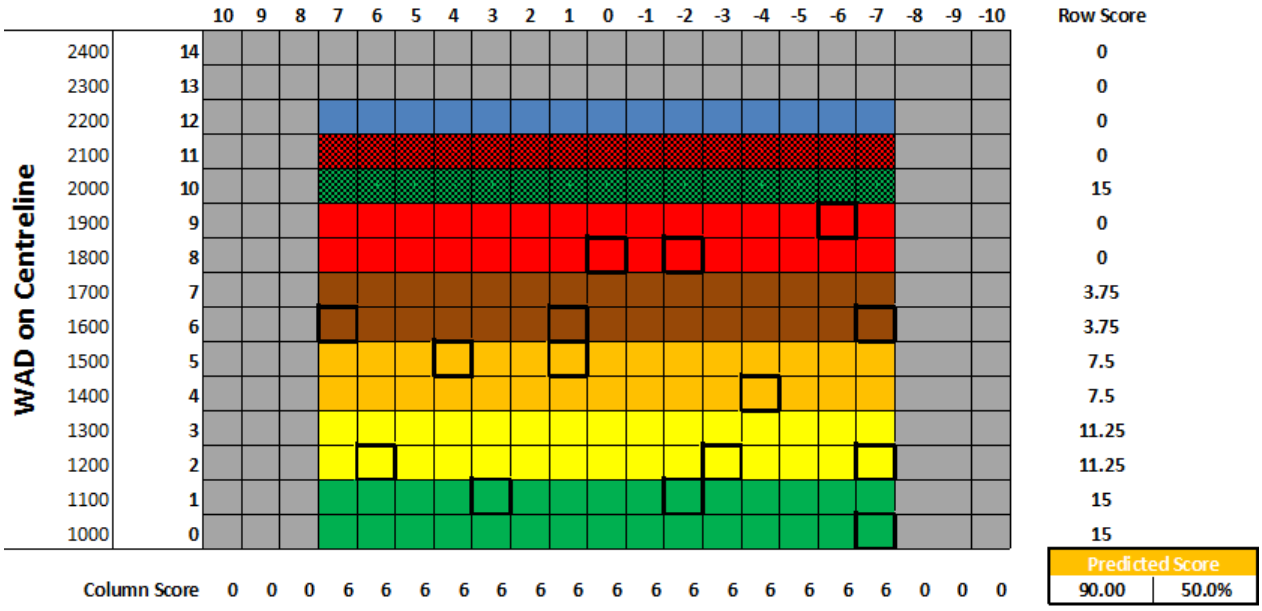
As test results can be variable between labs and in-house tests and/or simulations a 10% tolerance to the HIC value of the verification test is applied. The tolerance is applied in both directions, meaning that when a tested point scores better than predicted, but within tolerance, the predicted result is applied. The tolerance only applies to verify whether the predicted colour of the tested verification point is correct. When, including tolerance, the colour is not in line with the prediction, the true colour of the test point will be determined by comparing the actual measured HIC value with the colour band in section 3.3.1.1 without applying a tolerance to the HIC value.

Prediction	***HIC_{15} range***	***Accepted HIC_{15} range***
Green	$HIC_{15} < 650$	$HIC_{15} < 722.22$
Yellow	$650 \leq HIC_{15} < 1000$	$590.91 \leq HIC_{15} < 1111.11$
Orange	$1000 \leq HIC_{15} < 1350$	$909.09 \leq HIC_{15} < 1500.00$
Brown	$1350 \leq HIC_{15} < 1700$	$1227.27 \leq HIC_{15} < 1888.89$
Red	$1700 \leq HIC_{15}$	$1545.45 \leq HIC_{15}$

3.3.2.2 Example:

Headform testing:

Manufacturer X has provided the following prediction to Euro NCAP with a total score of 90 points (excluding blue) out of the possible 195:



The prediction consists of the following:

15 Default Green	*x 1.00 =*	*15.00*
30 Green	*x 1.00 =*	*30.00*
30 Yellow	*x 0.75 =*	*22.50*
30 Orange	*x 0.50 =*	*15.00*
30 Brown	*x 0.25 =*	*7.50*
30 Red	*x 0.00 =*	*0.00*
15 Default Red	*x 0.00 =*	*0.00*
15 Blue		
195 grid points		***90.00 points***

15 verification points were chosen for testing:

		Verification										Score
1-10	GRID-point	R2|C-7	R2|C-3	R1|C-2	R4|C-4	R5|C1	R5|C4	R8|C-2	R6|C-7	R2|C6	R1|C3	
	Prediction											6
	Test result (HIC)	750	600	500	1200	1492	850	2000	1400	1112	660	
	Test result (pts)	0.75	0.75	1	0.5	0.5	0.75	0	0.25	0.5	1	6
11-20	GRID-point	R8|C0	R6|C7	R0|C-7	R9|C-6	R6|C1						
	Prediction											1.50
	Test result (HIC)	2000	1822	700	1544	1450						
	Test result (pts)	0	0.25	1	0.25	0.25						1.75
											Correction factor	1.033

$$Correction\ Factor = \frac{Actual\ tested\ score}{Predicted\ score} = \frac{6.00 + 1.75}{6.00 + 1.50} = 1.033$$

8 Blue zones were tested containing 15 blue points:

Blue points										Score
Blue	Blue Zone	1	2	3	4	5	6	7	8	
	GRID-point	12,7 / 12,6	12,5 / 12,4	12,3 / 12,2	12,1 / 12,0	12,-1 / 12,-2	12,-3 / 12,-4	12,-5 / 12,-6	12,-7	
	Test result (HIC)	1000	650	1700	1500	1700	1699	1350	1349	
	Test result (pts)	0.5	0.75	0	0.25	0	0.25	0.25	0.5	**4.5**

The final score will be:

150 Predicted	*75.00 x 1.033 = 77.475*
15 Default Green	*15.000*
15 Default Red	*0.000*
15 Blue	*4.500*
195 grid points	***96.975 points***

The score in terms of percentage of the maximum achievable score is 96.975/195 = 49.730%
The final headform score is 49.730% x 24 = **11.935 points**

3.3.2.3 Upper Legform

Each of the grid points can be awarded up to one point resulting in a maximum total of points equal to the number of grid points. A linear sliding scale is applied between the relevant limits of each parameter. The upper legform performance for each grid point is based upon the worst performing parameter.

The total score for the upper legform area will be calculated out of six by scaling the sum of grid points score by the relevant number of grid points.

Example:
For a vehicle that has 9 grid points and tests are performed to points U0, U-2 & U-4 with the following results:

Test result U0	**Score**	**Total**
Femur upper bending moment = 281.40Nm	1.000	
Femur middle bending moment = 342.60Nm	0.114 =>	**0.114**
Femur lower bending moment = 324.10Nm	0.398	
Femur sum of forces = 5.26kN	0.740	

Test result U-2	**Score**	**Total**
Femur upper bending moment = 395.81Nm	0.000	**0.000**

Femur middle bending moment = 467.69Nm	0.000
Femur lower bending moment = 435.69Nm	0.000
Femur sum of forces = 6.80kN	0.000

Test result U-4	**Score**	**Total**
Femur upper bending moment = 152.00Nm	1.000	**1.000**
Femur middle bending moment = 208.00Nm	1.000	
Femur lower bending moment = 245.00Nm	1.000	
Femur sum of forces = 4.89kN	1.000	

Grid points that have not been tested will be awarded the worst result from one of the adjacent points. Given that U-1 and U-3 have not been tested, both will be awarded the result from the adjacent point U-2. Symmetry will also be applied to all grid points on the opposite side of the vehicle (U+1 to U+4).

U+4	U+3	U+2	U+1	U0	U-1	U-2	U-3	U-4
1.000	0.0	0.0	0.0	0.114	0.0	0.0	0.0	1.000

The score for each individual grid point is then summed, this produces a score in terms of the maximum achievable percentage of 2.114/9 = 23.488%
The final upper legform score is 23.488% x 6 = **1.409 points**

3.3.2.4 Legform

Each of the grid points can be awarded up to one point resulting in a maximum total of points equal to the number of grid points. A linear sliding scale is applied between the relevant limits of each parameter. The one point per grid point is divided into two independent assessment areas of equal weight:

1. Tibia injury assessment based on the worst performing of tibia moments T1, T2, T3, T4 (0.500 point).

2. Knee injury assessment based upon MCL elongation, as long as ACL/PCL elongation is smaller than the threshold (0.500 point).

The total score for the legform area will be calculated out of six by scaling down the sum of grid points scores by the relevant number of grid points.

Example:
For a vehicle that has 11 grid points and tests are performed to points L1, L+3 & L+5 with the following results:

Test result L+1	**Score**	**Total**
Tibia bending moment = 280.00Nm	0.500	0.500

ACL or PCL elongation = 10.00mm	Fail	} 0.000
MCL elongation = 15.00mm	0.500	
		= 0.500

Test result L+3	**Score**	**Total**
Tibia bending moment = 320.00Nm	0.172	0.172
ACL or PCL elongation = 9.50mm	Pass	} 0.250
MCL elongation = 20.50mm	0.250	
		= 0.422

Test result L+5	**Score**	**Total**
Tibia bending moment = 340.00Nm	0.000	0.000
ACL or PCL elongation = 10.00mm	Fail	0.000
MCL elongation = 19.00mm	0.000	
		= 0.000

Grid points that have not been tested will be awarded the worst result from one of the adjacent points. Given that L0, L+2 & L+4 have not been tested, L0 will be awarded the score from L+1, L+2 will be awarded the score from L+3 and L+4 will be awarded the score from L+5. Symmetry will also be applied to the other side of the vehicle.

L+5	L+4	L+3	L+2	L+1	L0	L-1	L-2	L-3	L-4	L-5
0.0	0.0	0.422	0.422	0.500	0.500	0.500	0.422	0.422	0.0	0.0

The score for each individual grid point is then summed, this produces a score in terms of the maximum achievable percentage of 3.188/11 = 28.981%
The final upper legform score is 28.981% x 6 = **1.739 points**

3.3.3 Visualisation of results

3.3.3.1 Headform results

The protection provided by each grid location is illustrated by a coloured area, on an outline of the front of the car. Where no grid is used in the assessment and the fallback scenario is adopted, the same 5 colour boundaries and HIC650 – HIC 1700 values will be applied. The headform performance boundaries are detailed below.

Green	$HIC_{15} < 650$
Yellow	$650 \leq HIC_{15} < 1000$
Orange	$1000 \leq HIC_{15} < 1350$
Brown	$1350 \leq HIC_{15} < 1700$
Red	$1700 \leq HIC_{15}$

3.3.3.2 Legform & upper legform results

The protection provided by each grid location is illustrated by a coloured point on an outline of the front of the car. The colour used is based on the points awarded for that test site (rounded to

three decimal places), as follows:

Green	*grid point score = 1.000*
Yellow	*0.750 <= grid point score < 1.000*
Orange	*0.500 <= grid point score < 0.750*
Brown	*0.250 <= grid point score < 0.500*
Red	*0.000 <= grid point score < 0.250*

4 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 EEVC WG17 Report, 'Improved Test Methods to Evaluate Pedestrian Protection Afforded by Passenger Cars', September 2002.