EURO NCAP

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Assessment Modifiers

Crash Protection

Technical Bulletin CP 007

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PREFACE

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

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

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

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

CONTENTS

1 INTRODUCTION

The Crash Protection score may be modified where the protection offered by the vehicle can be expected to be worse than that indicated in the crash test. The tests, occupants and body regions to which the modifiers are applicable and the limits used are detailed in the relevant Crash Protection Protocols.

The application of a modifier is based on a number of factors such as the dummy readings, kinematic performance, vehicle deformation data or restraint system performance. Consideration is given to different sized occupants and occupants in different seating positions as well as accidents of slightly different severity and impact conditions. There is no limit to the number of modifiers that can be applied to either the dummy or test. After modifier application, the lowest possible score for a body region or test is zero points, scores will not be negative.

2 APPLICABLE TO ALL TEST TYPES

Modifier – Restraint system failure

Where any occupant restraint suffers damage, breakage or fails to deploy, the test score in which the failure occurred will be penalised. This is applicable to any airbag, seatbelt webbing, seatbelt anchorages, pretensioners, seat structures including mountings and adjustment mechanisms.

This modifier includes but is not limited to:

Non deployment of an or airbag or pretensioner - not to be confused with incorrect deployment.

Ripping or tearing of an inflatable airbag.

Breakage, partial breakage or cuts to seatbelt webbing, a seatbelt anchorage or vehicle seat attachment. Movement/slippage of seat track adjustment mechanism during the test.

Full or partial detachment of seat runners. Breakage or detachment of seat adjustment mechanism.

Modifier – Door opening

When a door opens in the test, the modifier will be applied to the score for that test. The intention is to ensure that the structural integrity is maintained with the underlying principle being to minimise the risks of occupant ejection.

The modifier will be applied for every door including tailgates and moveable roofs. The number of door opening modifiers that can be applied to the test score is not limited.

Modifier – Door structural detachment

Where any door becomes structurally detached at the hinges, latches or runners, 100% of the test score will be penalised. Detachment is applied when the door is no longer structurally attached to vehicle by those structures (not to be confused with door opening).

3 FRONT IMPACT

3.1 Head and neck

HIC15 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, full points are awarded to the head. If there is hard contact, a sliding scale is applied to HIC and Ares 3ms using the limits detailed in Section 3.3.1 of the Frontal impact Protocol.

The driver's head should be predictably restrained by the airbag and remain protected by the airbag during the dummy's forward movement. There should be no bottoming out of the airbag.

Modifier - Airbag contact - head bottoming-out is defined as 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 5g 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.

Modifier - Airbag contact - unstable airbag contact

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. 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. 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 applied.

Modifier - Hazardous airbag deployment

The deployment mode of the airbag should not pose a risk of facial injury to occupants of any size. 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 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 90m/s, the modifier will be applied to the head score.

The head zone is defined in order to cover occupants of various sizes, in a variety of seating positions. It describes an area rearward of a plane, perpendicular to the car's "x" axis, positioned 150mm forward of the face of the Hybrid III 50th percentile dummy, in the normal Euro NCAP frontal impact seating position.

It should be possible to obtain an approximate measurement of airbag deployment velocity from the high speed films taken in the frontal crash test. In marginal cases, or where the view is

obscured, it may be necessary for the manufacturer to provide information from a static deployment of the airbag. Similarly, where the airbag contacts the head of the 50th percentile Hybrid III dummy in the frontal impact test, such that a disturbance can be observed on the dummy instrumentation traces, it may be necessary for the manufacturer to provide information from a static deployment of the airbag.

Modifier - Brain Injury - DAMAGE

Where the DAMAGE criterion exceeds the values detailed below, a modifier will be applied.

DAMAGE ≥ 0.42 and <0.47

DAMAGE ≥ 0.47

Modifier – Adult rear occupant head excursion

The score is reduced for excessive forward excursion. Where the head of the rear passenger exceeds the 450mm or 550mm forward excursion line as defined in Technical Bulletin CP 004, a modifier is applied.

The modifier may be removed when it is shown by means of numerical simulation or a sled test, that the Hybrid III 50th percentile does not contact the front passenger seat when in the 50th male seating position, or when the HIC_{15} value is below 700 in case of contact with the front passenger seat. The rear seat shall be set to the Hybrid III 50th percentile design position.

3.2 Chest and abdomen

Modifier - Steering wheel contact

Where there is obvious direct loading of the chest from the steering wheel the modifier is applied.

Modifier - Shoulder belt load

Where the shoulder belt load filtered at CFC60 exceeds 6.00kN the modifier is applied.

3.3 Knee, femur and pelvis

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.

Modifier - Submarining

The modifier is applied when a sudden drop in any of the two iliac forces measured is seen within 1ms and when the submarining is confirmed on the high speed film or post test stills.

Modifier - Knee loading, variable contact

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 50th percentile dummy in this test. This takes into account the protection of different sized occupants or occupants in different seating positions.

The position of the dummy's knees is specified by the test protocol. Consequently, the contact location 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 contact at other locations, 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. 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, the penalty is applied to the relevant leg.

Modifier - Knee loading, concentrated loads

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 penalty is applied to the relevant leg. 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.

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

If the Concentrated load modifier is not applied to either 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 60mm 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 penalty for Variable Contact will be divided into two with one half of the penalty being applied to the column area and the other half to the remainder of the facia for each knee.

3.4 Lower leg, foot and ankle

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. If a mechanism is present to move the pedal forwards in an impact, the resulting position of the pedal is used in the assessment.

Modifier - Rearward displacement of the worst performing pedal

Pedal displacement is measured for all pedals with no load applied to them. The score is reduced for excessive rearward static displacement of the pedals.

Modifier - Upward displacement of the worst performing pedal

Pedal displacement is measured for all pedals with no load applied to them. The score is reduced for excessive upward static displacement of the pedals.

Modifier - 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.

Where the rearward displacement of a ‘blocked’ pedal exceeds 50mm relative to the pre-test measurement, a modifier 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.

3.5 All dummy body regions

Modifier – 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.

Any airbag(s) which does not deploy fully in the designed manner will attract a 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. 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.

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 or pelvis deploys incorrectly, the penalty will be applied to two body regions, the head and 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 to the side and pole impact scores if a side protection airbag deploys incorrectly

during the frontal crash. Or, if a knee airbag deploys incorrectly in the full width impact, the modifier will be applied to the pelvic region of both the MPDB and full width tests. Where any frontal protection airbag deploys incorrectly, Euro NCAP will not accept knee mapping data for that occupant.

3.6 Test score

Modifier – Displacement of the A-Pillar

There is a relationship between chest loading, as measured by the dummy criteria, and intrusion. To ensure a balance is struck, a geometric criterion on waist level intrusion, as measured by door pillar movement at waist level, is used.

Modifier - 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. The modifier used in the assessment is based on the worst of the rearward, lateral and upward penalties.

Modifier – Integrity of the passenger compartment

When the passenger compartment becomes unstable, any additional load can result in unpredictable excessive further collapse of the passenger compartment. Furthermore, an unstable passenger compartment means the repeatability of the car's response in the test becomes poor and confidence in the car's performance is reduced.

Where the structural integrity of the passenger compartment is deemed to have been compromised, the penalty 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 trans-facia beam to A-pillar joint.

Severe loss of strength of the door aperture.

When this modifier is applied, Euro NCAP will not accept knee mapping data.

Modifier – Footwell rupture

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.

The score is reduced if there is significant rupture of the footwell area. This is usually due to separation of spot-welded seams. A 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, Euro NCAP will not accept knee mapping data.

Modifier - Compatibility

This assessment is based upon three parameters that are determined using the results of the Mobile Progressive Deformable Barrier (MPDB) to car impact. These parameters are:

Standard deviation (SD) – Based upon the standard deviation assessment of the post-test barrier face deformation measurement and ranges from 50mm – 150mm.

Occupant Load Criterion (OLC) - Based upon the trolley deceleration and ranges from 25g - 40g. Details of the OLC calculation are in Technical Bulletin CP 005.

MPDB face bottoming out - The bottoming out criterion is based upon a barrier face penetration depth of 630mm that has been caused by a load bearing structure in an area that is larger than 40mm x 40mm. Where bottoming out occurs, a further 25% of the penalty will be added to the barrier deformation and OLC penalty.

4 SIDE IMPACT

4.1 Head and neck

CAPPING – Direct head contact with the pole

Where the head contacts the pole, the test score will be capped.

Modifier - Brain Injury – DAMAGE

Monitoring.

4.2 Chest

Modifier – Shoulder force

Where the shoulder lateral force (Y direction) component is 3.0kN or above.

Modifier – Chest V*C

Where the viscous criterion (V*C) is 1.0m/s or above.

4.3 Abdomen

Modifier - Abdomen

Where the viscous criterion (V*C) is 1.0m/s or above.

4.4 Pelvis

Modifier - Far side occupant sled tests

Where any of the individual parameters exceed the limits detailed below, the modifier will be applied:

F_{pubic} symphysis 2.8kN

F_y lumbar 2.0kN

F_z lumbar 3.5kN

M_y lumbar 120Nm

4.5 All body regions

Incorrect airbag deployment

Any airbag(s) which does not deploy fully in the designed manner will attract a 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 head. 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 fails to deploy correctly that is intended to provide protection to the head as well as the thorax, abdomen and pelvis, the penalty will be applied to all body regions, the head, chest, abdomen and pelvis. The penalties are applicable to both the side and pole impacts, which are scaled down in the final vehicle rating.

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 or pole impact. In this case the modifier will be applied to both 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.

4.6 Test score

Modifier – Side head protection device (near-side occupant in pole impact only)

Vehicles equipped with head protection side airbags, curtain, seat mounted or any other, will have the inflated energy absorbing areas evaluated by means of a geometric assessment. The airbags must provide protection for a range of occupant sizes in both the front and the rear on both sides of the vehicle. Where a vehicle does not offer sufficient protection, a separate penalty is applied for front and for rear seats the overall pole impact score. Any vehicle that does not provide a head protection device covering the front and rear seat positions on both sides of the vehicle will also attract this modifier.

Coverage areas

To ensure adequate head protection is offered, the head protection device coverage is assessed in the geometric area, or the Head Protection Device (HPD) assessment zone, where the occupant head would most likely impact side structures. If the vehicle is equipped with movable rear seats the seat shall be set to the most rearward position. If there is a third row of fixed seats, these will be included in the assessment unless they are per manufacturers' recommendation not suitable for adult occupation (handbook).

Application

Where the airbags differ between the left and right hand sides of the vehicle, the airbags on both sides of the vehicle will be evaluated and the assessment will be based upon worst performing side. All areas of the airbag, both front and rear, will be evaluated and the assessment will be based upon the worst performing part of any of the airbags.

Exclusions

The head protecting airbags should cover all glazed areas within the defined zone up to the edge of door daylight opening (FMVSS201) where it meets the roofline, B-pillar, C-pillar and door waistline. Seams in the airbag will not be penalised provided that the un-inflated area is no wider than 15mm. Any other areas where the airbag layers are connected will not be penalised provided that the surrounding areas are inflated and any un-inflated areas are no larger than 50mm in diameter or equivalent area or the sum of the major and minor axes of individual areas does not

exceed 100mm. In the case that the un-inflated area would be larger than described above, the OEM shall provide data to demonstrate sufficient energy absorption is guaranteed.

4.7 Rollover

Where a vehicle offers rollover protection, the pole impact score will not be penalised. There will be no partial rewards for rollover protection and both of the following requirements must be met:

The vehicle is equipped with rollover sensing

The curtain airbag mitigates occupant ejection with a long duration of inflation

The pressure in the airbag will be checked by the test laboratory after the full scale tests and/or HPD zone measurements. In all cases, the HPD must be ‘stiff and stable’. If there is doubt regarding the residual pressure, the OEM may then provide an accurate validation test where the pressure is measured. The following tests will be considered as proof of long inflation:

FMVSS 226 test data

CNCAP Curtain airbag pressure tests

Vehicles with movable roofs will not be rewarded by default. The OEM may provide evidence to show that the vehicle does offer a solution to the risks from ejection.

5 CHILD OCCUPANTS

Modifier – Shoulder belt slippage

Shoulder belt slippage will be evaluated during the dummy's forward movement in the MPDB test only.

Partial belt slippage is defined as the diagonal belt moving into the gap between the clavicle and upper arm with folding of the belt webbing, the penalty will be applied to the overall dummy score of the impact in which it occurs.

Full belt slippage is defined as the diagonal belt slipping off the shoulder and moving below the shoulder joint down the upper arm.

Modifier – Restraint

Restraint will be evaluated at any time throughout both the front and side impacts. A lack of restraint includes, but is not limited to, the following:

The lap section does not prevent the dummy from moving upwards during rebound and is no longer restraining the pelvis.

The dummy head contacts the other dummy.

The seatbelt does not correctly restrain the child and CRS.

Modifier – Submarining

Submarining will be evaluated at any time throughout both the front and side impacts. Submarining is applied when the pelvis of the dummy submarines beneath the lap section of the belt.

Modifier – Ejection

Dummy ejection will be evaluated at any time throughout both the front and side impacts. Ejection includes the following:

The dummy pelvis does not remain in the booster seat or on the booster cushion and is not correctly restrained by the lap section of the seatbelt.

The CRS does not remain within the same seating position or is no longer correctly restrained by the adult belt. The CRS must not be displaced onto the floor or any other part of the rear seat/occupant compartment.

Modifier – CRS attachment

Failure of restraint system components Failure of the restraint system components will be evaluated at any time throughout both the front and side impacts.

There is any breakage or fracturing of load-bearing parts of the belt system including buckles, webbing and anchorage locations.

There is any breakage or fracturing of any seat belt lock-offs, tethers, straps, ISOFIX anchorages, backrest to booster cushion connections or any other attachments which are specifically used to anchor the CRS to the vehicle fail.

6 REAR IMPACT

Geometry assessment

This is used to encourage front seats to have optimal geometry in terms of both height and backset.

Worst Case Geometry

The head restraint should be ideally placed for optimal dynamic performance without occupants of different size taking any action other than simply adjusting the seat to suit their leg length. This implies that the head restraint should either be fixed, automatically adjust to the optimal position or should be an adjustable restraint that provides optimum position even in its fully down (worst case) position.

Modifier – Seatback dynamic deflection

The high severity pulse will be subject to an additional seatback deflection assessment where a modifier is applied where seats have a rotation of 32.0° or greater. The seat deformation should be controlled so that a front occupant is not subject to ejection from behind the seat belt in a rear impact and the risk of interaction between the front and rear occupants is minimised.

Modifier – Dummy artefact loading

A modifier is applied as a means of penalising any seat that, by design, places unfavourable loading on other body areas (e.g. preventing realistic ramping up) or exploits a dummy artefact. The modifier will be applied to any seat that, by design, places unfavourable loading on other parts of the body as a result of the head restraint mechanism. This modifier shall also penalise any design feature aimed at exploiting any dummy artefact. This is seen as a clear incentive to avoid such design, and an essential feature to safeguard Euro NCAP's position for future designs.

APPENDIX A

1. Barrier Deformation Standard Deviation

The homogeneity of the vehicle is based on the standard deviation of the intrusion depth within the prescribed measurement area of the MPDB face.

The standard deviation is defined as the spread around the mean intrusion that covers 68.2% of all measured intrusion points. The bigger the standard deviation, the bigger the spread of the measured intrusion points.

The assessment of SD is based on a linear scale from 50mm to 150mm where 50mm is the higher performance limit and 150mm is the lower performance limit.

1.1. Evaluation area

The height of the evaluation area is independent of vehicle size. The lower border is at 250mm above ground level (100mm from the lower edge of the barrier face). The upper border is at 650mm above the ground of the MPDB face.

For a left-hand drive vehicle, the right border of the area is located at 200mm from the right-hand edge of the MPDB face. The left border is dependent on the width of the test vehicle, it is located at 45% of the overall width from the right-hand edge of the MPDB face. See Figure 1.

The evaluation area for right hand drive vehicles will be mirrored accordingly around the vertical axis.

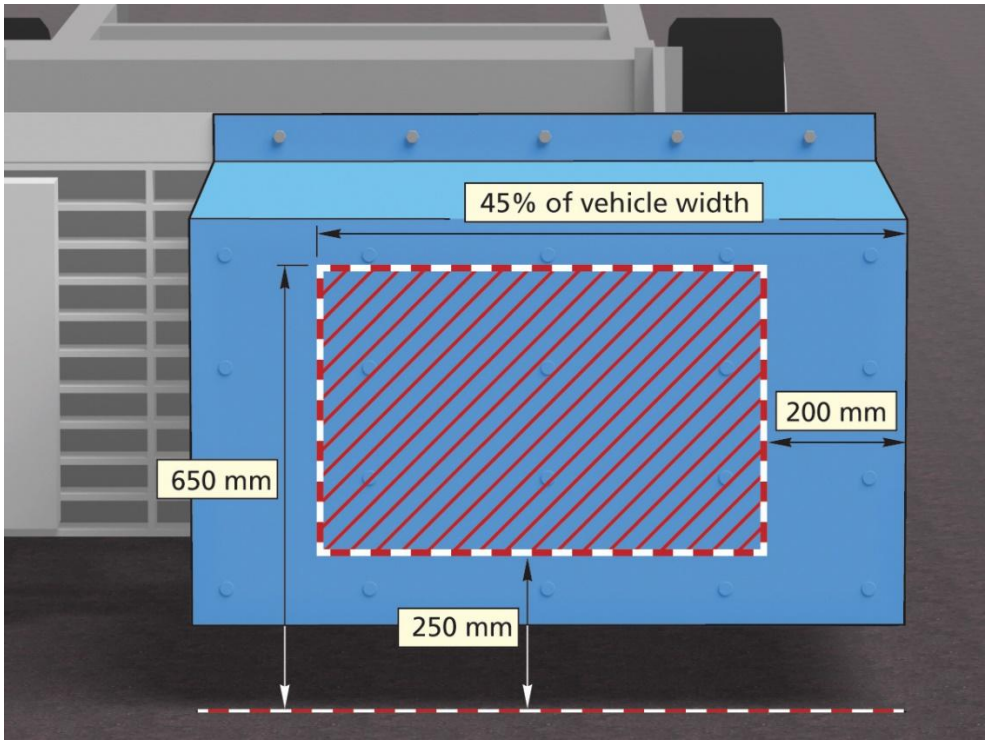


Figure 1: Evaluation area

1.2. Barrier scan data

Scanning of the barrier face shall be conducted in accordance with the procedure detailed in Section 1.3.

The scanning data shall be inserted into the Euro NCAP Compatibility assessment spreadsheet in accordance with the following.

All required data shall be filled in the green cells within the sheet “input scan”.

The intrusion depths of the 1400 measuring points that came out of the scanning process are entered in column F (x-coordinates).

The data shall be entered row by row and top down.

The first measuring point (located top left on the front view of the barrier) shall be entered in line 7.

The last measuring point (located down right on the front view of the barrier) shall be entered in line 1406.

Within cell F2 the minimum measured intrusion depth is displayed.

Within cell F3 the maximum measured intrusion depth is displayed.

Within the sheet “pattern” the position of the single measuring points are displayed

Within the cell J2 the make and model of the tested vehicle and within the cell K2 the test number should be entered (both types of information are only required to relate the evaluation with a certain test they are not relevant for the SD calculation)

Within the cell L2 the location of the steering wheel (left, or right) must be entered. This information will be used by the spreadsheet to determine the location of the evaluation area on the surface of the barrier face.

Within the cell M2 the overall width of the test vehicle must be entered. This information is required to determine the size of the evaluation area on the surface of the barrier face.

Within the cell N2 the occurrence of bottoming out (yes or no) must be entered.

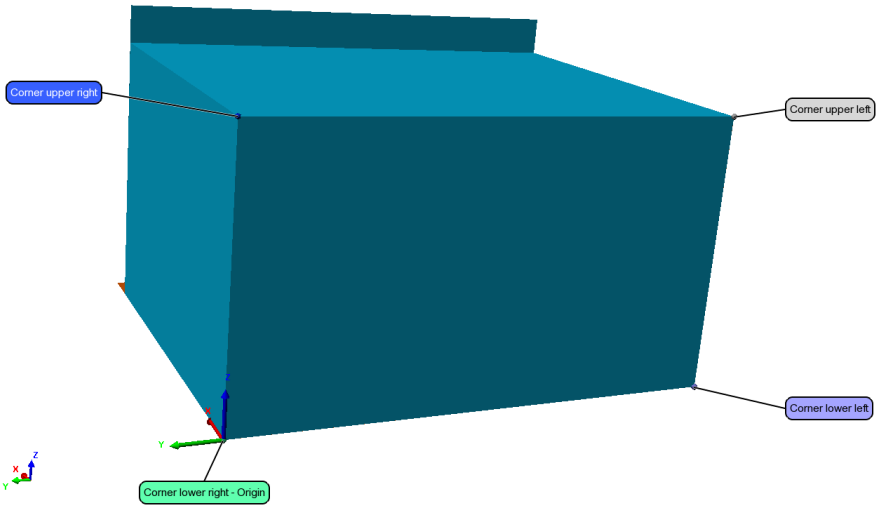
1.3. PDB face measurement

For measuring the deformation of the PDB barrier a 3D measuring system shall be used (e.g. 3D measurement arm with attachable scan module). This system must be capable of recording three dimensional co-ordinates of single points, as well as clouds of points (scanner). A tolerance of **+/- 1mm** is applicable to such a system.

1.3.1. Pre test

Measure the four corner points of the undeformed barrier front face.

Set up an axis system using the following elements:
- Point (point of origin): Lower right corner (seen from direction of motion)
- Vector (Y): from the left lower corner point to the right lower corner point
- Plane (YZ): best-fit plane from all four corner points



Mark and measure at least four reference points each on the left and right side of the barrier back plate where the sheet metal is folded up to build a stiff border. The points shall be spread over the whole length of the border and placed in different height levels to allow a proper realignment of the measurement system after crash.

Mark and measure at least four reference points on the non-struck side rear honeycomb layer.

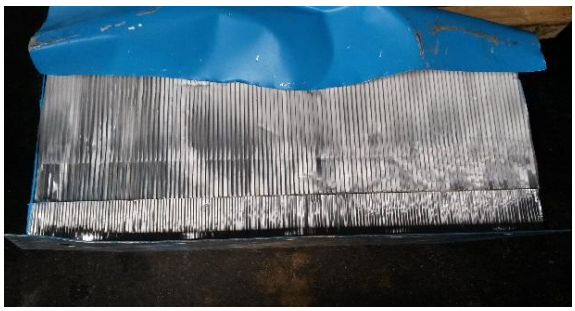
1.3.2. Post test

If the vehicle and barrier face are still connected, care must be taken to separate the two with minimal deformation of the honeycomb. If the two cannot be separated without deforming the honeycomb, remove the barrier from the trolley and try to manoeuvre the barrier face to make separation easier. If this is not successful, vehicle structures should be removed, such as the longitudinals and bumper cross beam. It may be necessary to remove the front wheels and side wing to gain better access to the vehicle structures.

Clean the surface of the barrier from fluids, rough dirt, glass, plastic pieces, loose tape, etc.

Eliminate mechanical artefacts:
In some cases it might be that deformation has occurred that was not caused by the impact but would influence the results in an undesired way. These artefacts should be corrected and documented before the final scan of the barrier surface.

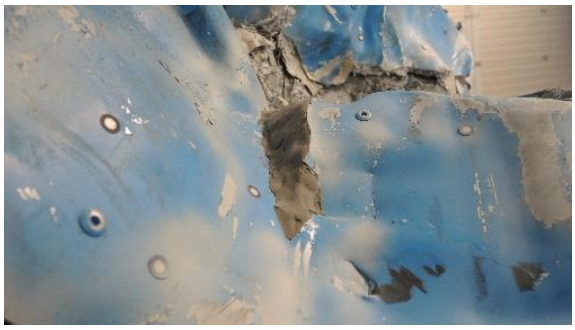
In case of different honeycomb layers separating at the adhesive joints, try to bring them back in contact without further deformation of the honeycomb structure (e.g. with the help of a ratchet strap). To make this easier, remove the cover sheet metal from top and bottom of the barrier.



It may be that the cover sheet metal is bent outward due to car parts getting hooked during rebound (this usually happens at borders of holes punched in by longitudinal beams). In this case, reform the cover sheet metal to match to the contour of the honeycomb.

Sometimes parts of the longitudinal beams may get stuck in the barrier. In this case the barrier scan may be split up in two or more segments. First scan the barrier surface as far as possible without needing to remove the part of the car. Then carefully remove the part with as little influence on the original barrier surface as possible. After that scan the bottom of the hole that is now accessible.

Cracks that are obviously not caused by intrusion shall be filled with clay before scanning (from edge to edge of the cover sheet metal).



Where necessary paint any areas of bare metal on the surface (e.g. with bright priming coat) to enhance scanning quality in these areas.

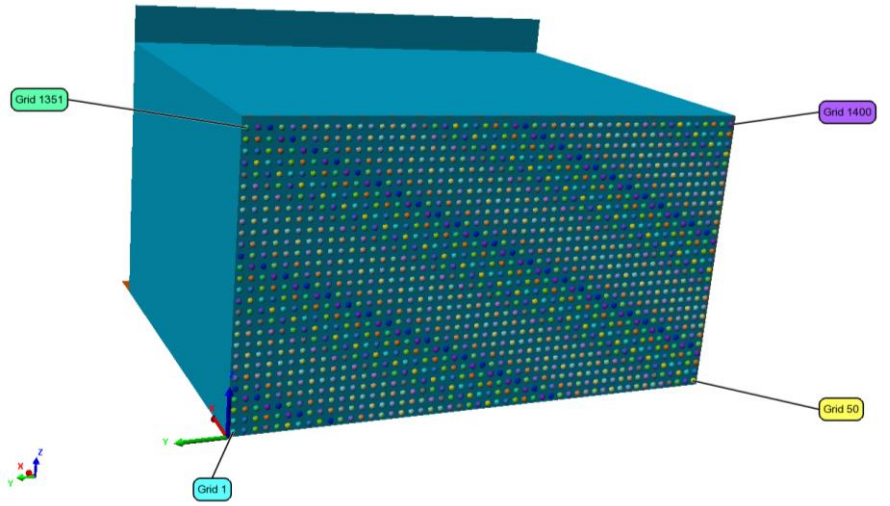
Align the barrier to the measurement system with the help of the eight reference points (left and right side of the flange plate) measured before crash. If the honeycomb has separated from the backplate, the reference points on the unstruck side of the rear honeycomb layer shall be used.

Scan the barrier surface to get a point cloud of the deformed surface. An area of the size of the undeformed barrier surface (projected to the deformed barrier surface in X direction) is sufficient.

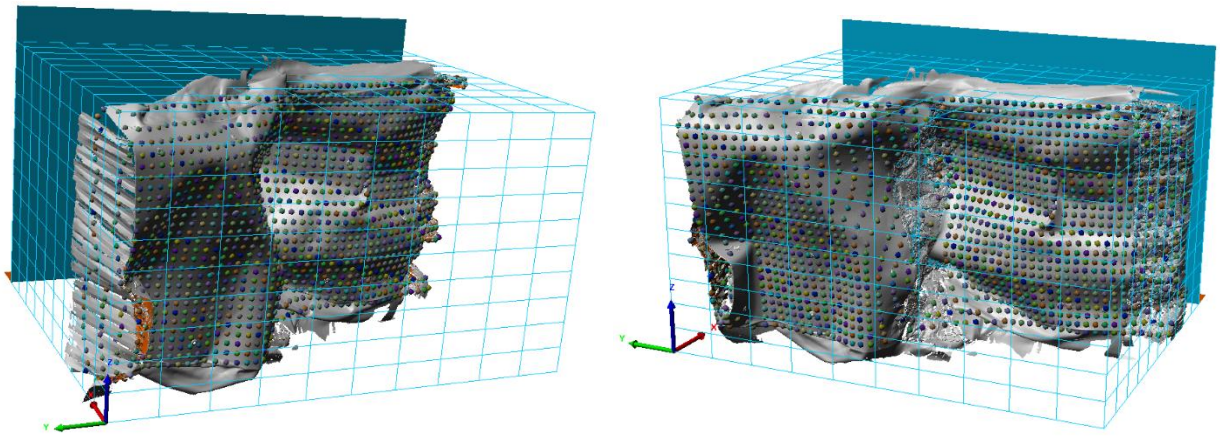
Create a mesh from this point cloud. As parameter a maximum edge length of 10mm shall be used. If available, medium smoothing and data reduction can be applied.

Create a grid of points with an equal distance of 20mm centred on the undeformed barrier surface. This will be a number of 1400 points in total.

Grid1 X=0 Y=10 Z=10	Grid2 X=0 Y=30 Z=10	……..	Grid50 X=0 Y=990 Z=10
Grid51 X=0 Y=10 Z=30	Grid52 X=0 Y=30 Z=30	……..	Grid100 X=0 Y=990 Z=30
……..	……..	……..	……..
……..	……..	……..	……..
Grid1351 X=0 Y=10 Z=550	Grid1352 X=0 Y=30 Z=550	……..	Grid1400 X=0 Y=990 Z=550



The grid points shall be projected on the mesh of the scanned barrier surface along the X axis.



It may be that some points do not hit the mesh (e.g. because of holes in the mesh). This can be ignored if the points are not in the assessment area. Points in the assessment area should be placed as close as possible to the desired position by considering the X value of the neighbouring grid points or the surrounding mesh surface.

Finally, the co-ordinates of the grid points shall be exported to the assessment file.

2. Bottoming out

Bottoming out is defined as an area of the barrier that has been penetrated by 630mm or more that is 40mm x 40mm in height and width.

Bottoming out will be determined from a physical examination of the barrier face and vehicle. This will be evaluated by the Inspectors during the vehicle inspection and be based upon the barrier scanning results.

Where bottoming out occurs within the evaluation zone, a -7% of the MPDB score penalty will be added to the barrier deformation and OLC penalty.

3. Calculation

The assessment of standard deviation and OLC are both calculated on sliding scales between their respective limits detailed in Section 3.6, the bottoming out penalty is then added to produce the final compatibility assessment.

For SD<50mm, OLC<25g and no bottoming out there will be no penalty.

For SD<50mm, OLC<25g with bottoming out the penalty will be -6.25% of MPDB score.

For SD>150, OLC>40g and no bottoming out the penalty will be -25% of MPDB score.

For SD>150, OLC>40g with bottoming out the penalty will be -25% of MPDB score.

Where the SD and OLC are between the respective limits, the calculation is based upon the following percentages:

Performance limits	0%	20%	40%	60%	80%	100%
Standard deviation	50mm	70mm	90mm	110mm	130mm	150mm
OLC MPDB trolley	25g	28g	31g	34g	37g	40g

Figure 2 below shows the sliding scales and resulting scoring rationale.

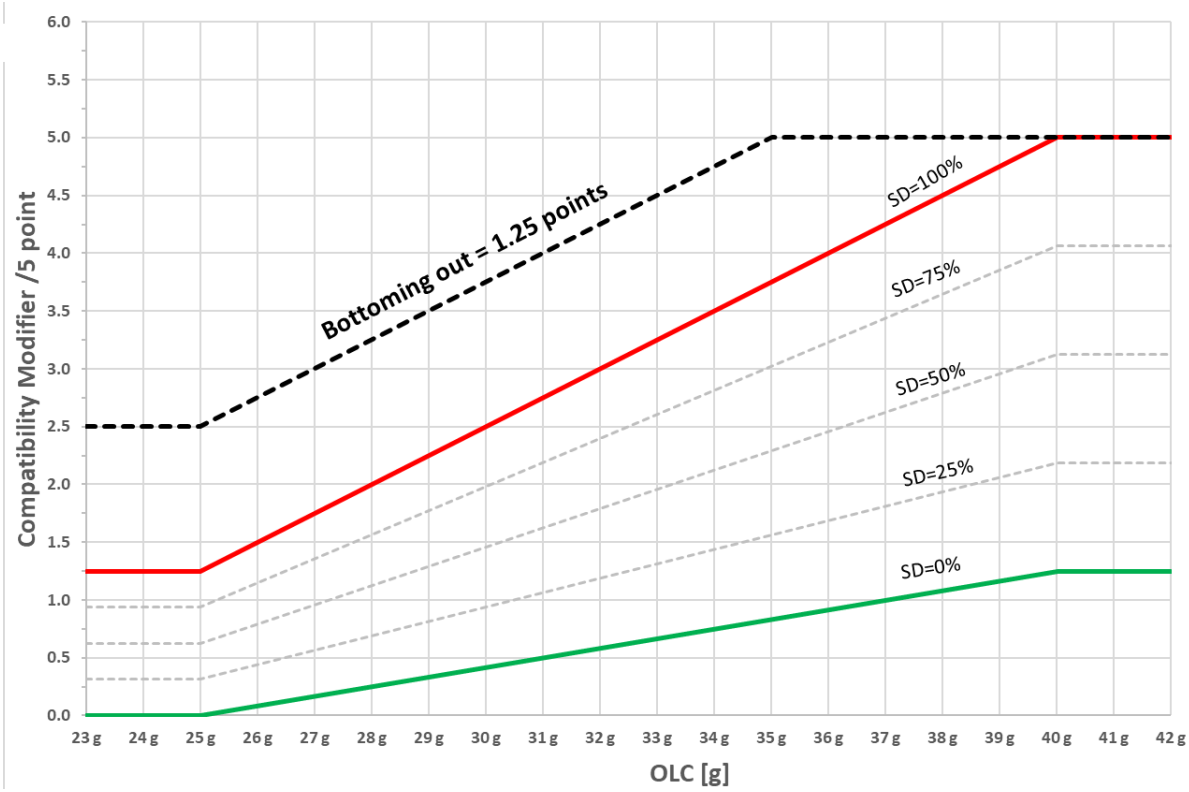


Figure 2: General scoring rationale

4. Examples

Example 1:

Standard deviation (homogeneity) = 119mm = 69%	-2.0
OLC = 34.9g	-0.825
Bottoming out = NO	-0
Modifier	**-2.826**

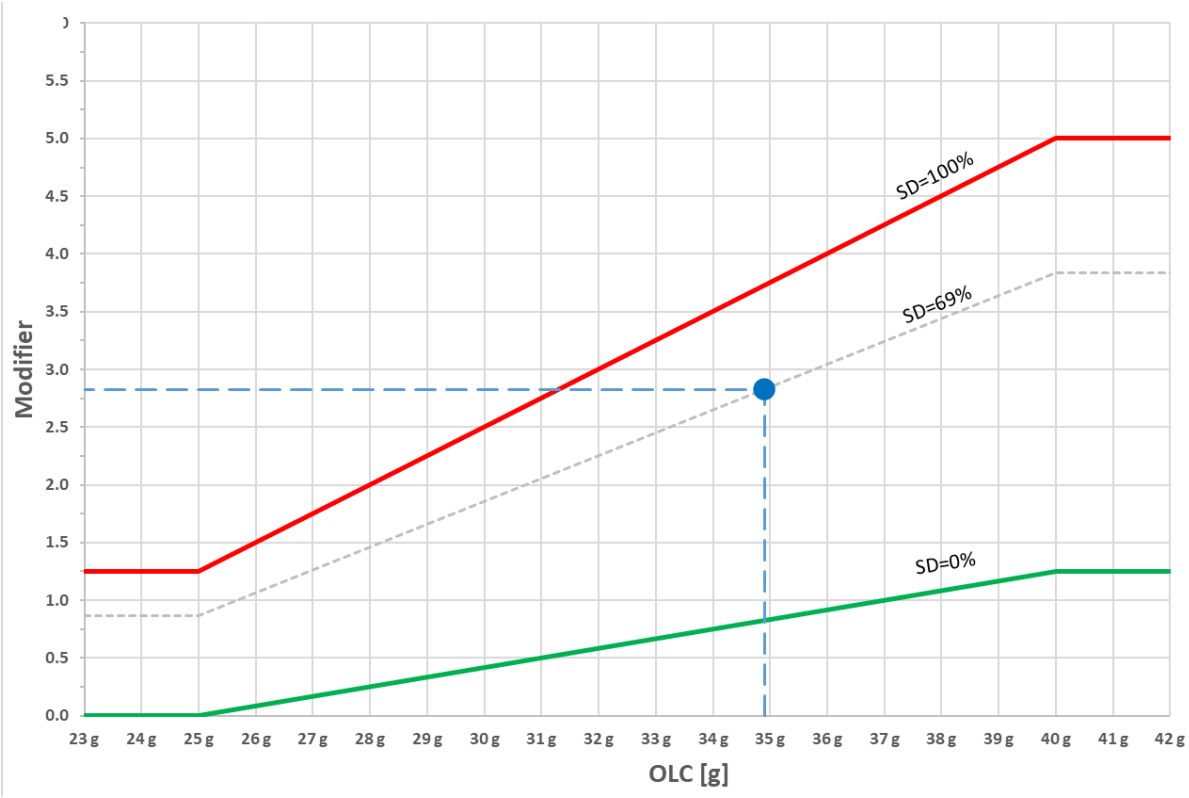


Figure 3: Example 1

Example 2:

Standard deviation (homogeneity) = 140mm = 90%	-3.030
OLC = 37.7g	-1.058
Bottoming out = YES	-1.25
Modifier	**-5.0**

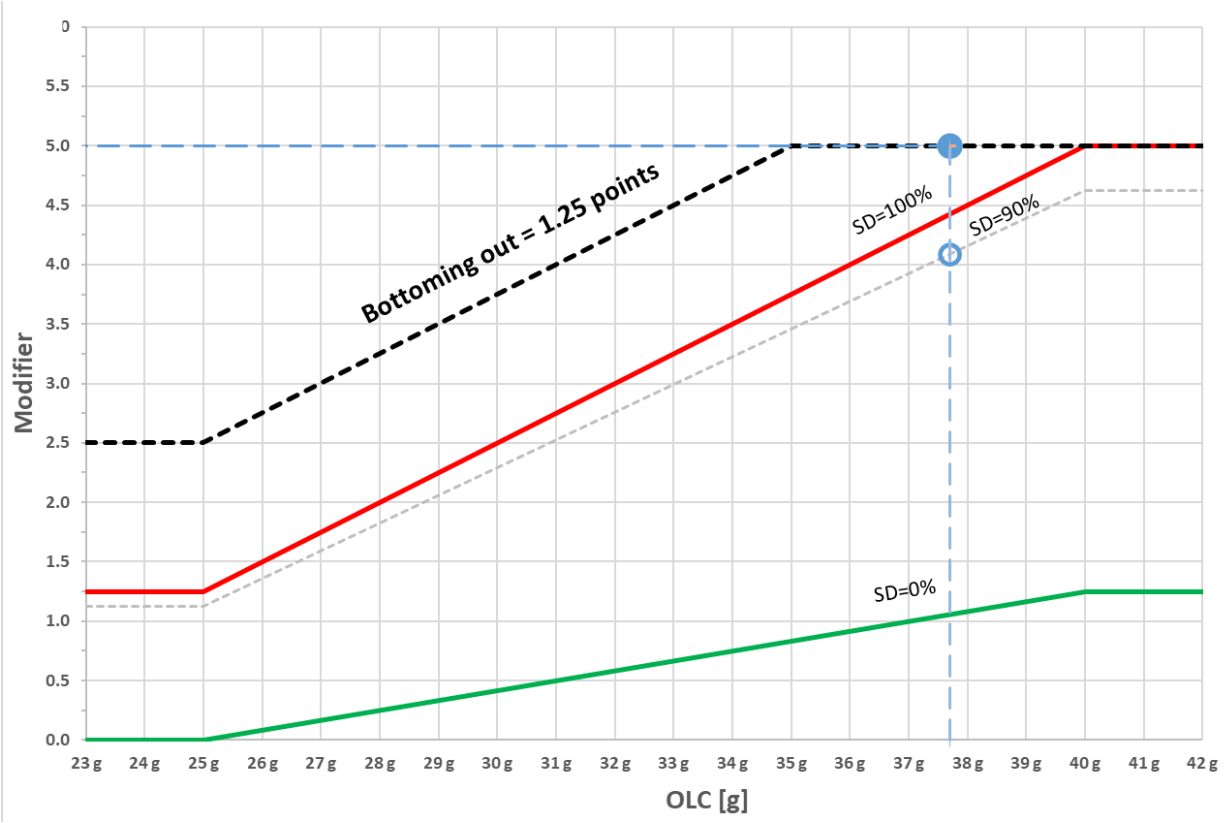


Figure 4: Example 2

Example 3:

Standard deviation (homogeneity) = 100mm = 50%	-0.808
OLC = 27.2g	-0.1.83
Bottoming out = YES	-1.25
Modifier	**-2.242**

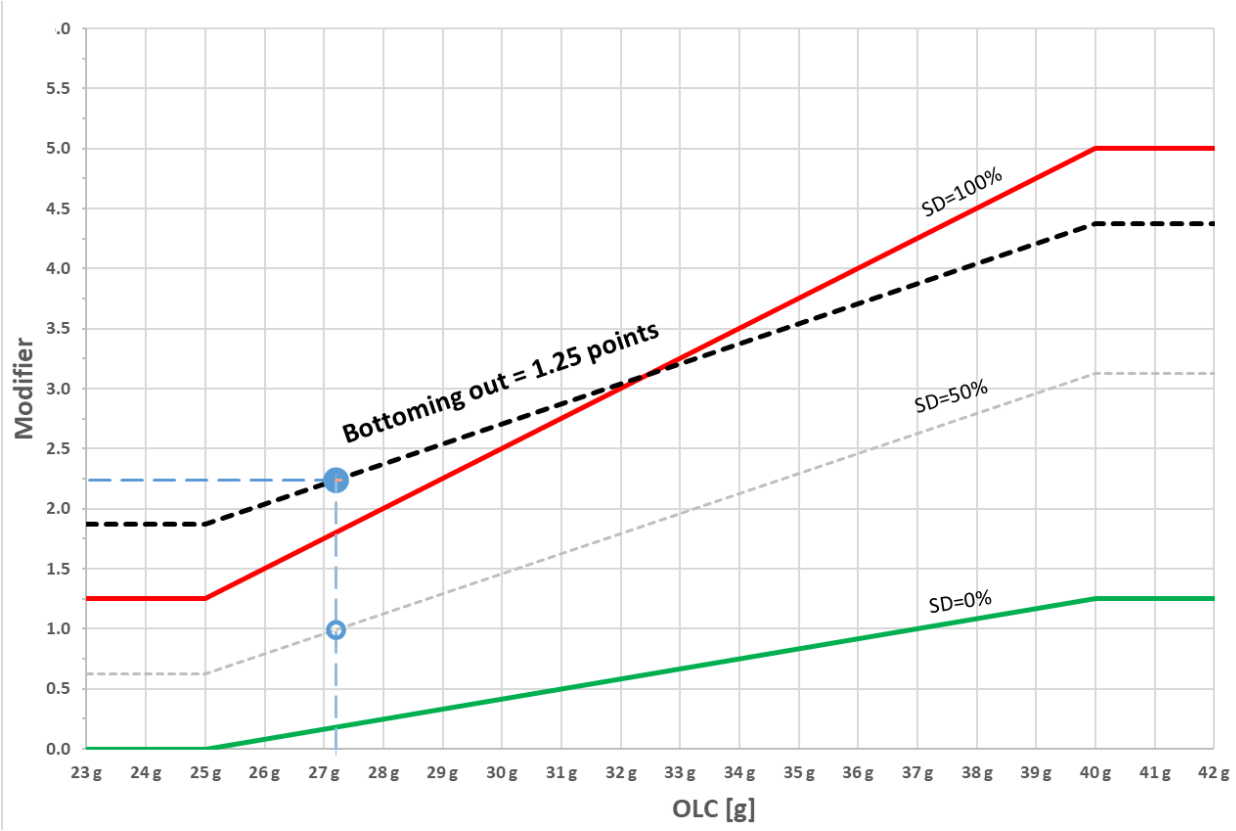


Figure 5: Example 3