Version 1.0
May 2025

# HIII 50th

# Model Qualification Procedure

## Crash Protection

# Technical Bulletin CP 510

Implementation 1st January 2026

# 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).

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# 1 INTRODUCTION

This document supports the Euro NCAP Crash Protection Frontal Impact protocol by providing details of the data required in qualification of Hybrid III CAE models. From 2026 onwards VTC frontal simulation data will be required for all vehicles assessed by Euro NCAP.

The Hybrid III models qualification process is divided into three stages beginning with normative standard requirements, component test simulations and full scale frontal sled test simulations performed in a simplified environment. Qualification procedure are given for Hybrid III 5$^{th}$ percentile female (HF), Hybrid III 50$^{th}$ percentile male (H3) and Hybrid III 95 percentile male (HM).

Additional reference documents and additional information are available using the following link:

https://openvt.eu/EuroNCAP/hiii-qualification

# 2 STAGE 1 - NORMATIVE DUMMY REQUIREMENTS

## 2.1 Normative references

Mass properties, external dimensions, range of motion, instrumentation and dummy dynamic qualification procedures must be according to following Euro NCAP Crash Protection technical bulletins:

- CP103 - Hybrid III 5th Specification and Certification
- CP104 - Hybrid III 50th Specification and Certification
- CP105 - Hybrid III 95th Specification and Certification

No verification of the dummy model with respect to the following quasi-static qualification procedures is requested:

- Hip flexion test left and right for the H3
- Torso flexion test for the HF

## 2.2 Simulation Setup

All qualification procedures described in the related documents must be simulated with the respective HIII percentile model. All setups must also meet the following simulation-related requirements:

- Dummy-related control cards must be identical in all setups and between stages
- Gravity
- Signals must be outputted and filtered according to the specification of each certification procedure

The last specification requires an output of signals before t0 to perform filtering and offset correction as requested in the norm, this is why the simulation must start in advance of t0.

# 3 STAGE 2 – COMPONENT LEVEL TEST

In stage 2, the performance of the dummy models will be evaluated in terms of value over time for a sub-set of normative certification tests from stage 1 (Table 1). The aim is to ensure a similar behaviour in the loading and unloading phases between the different models (e.g. LS-Dyna, VPS, supplier) of the same percentile. This aspect is currently not covered by the certification requirement of stage 1.

Table 1: Stage 2 configurations per dummy percentile

| Test Type | Abbreviation | HF | H3 | HM |
|---|---|---|---|---|
| Neck Frontal Flexion | NEFX | SAE J2862 | SAE J2856 | SAE J2860 |
| Neck Extension | NEEX | SAE J2862 | SAE J2856 | SAE J2860 |
| Thorax Impact High Speed | THHS | | | SAE J2860 |
| Thorax Impact Low Speed | THLS | SAE J2878 | SAE J2779 | |
| Left Knee Impact* | ULIL | SAE J2862 | SAE J2856 | SAE J2860 |
| Right Knee Impact* | ULIR | SAE J2862 | SAE J2856 | SAE J2860 |
| * in case of symmetric models (materials and modelling) only one side is required | | | | |

## 3.1 Simulation setup

The setups must be modelled and conforming to the specifics described by the related certification requirement. At least 20 ms signal must be added before t0 (starting of the loading) to eliminate any bias and to avoid filtering issues. This can be achieved by additional computation time or by adding a zero amplitude signal. Additional computation time must be simulated (see Table 2). Gravity shall be applied. Control cards must be identical in all tests.

Table 2. Computation time for each stage 2 loadcase

| Test: | NEEX | NEFX | THLS | THHS | ULIL/ULIR |
|---|---|---|---|---|---|
| **Computation time [ms]:** | 200 | 200 | 100 | 100 | 50 |

## 3.2 Reference data

Reference signal data can be found under the link provided in the Introduction.

## 3.3 Output

Table 3 lists all required ISOMME outputs per test setup. Signals must be sampled with a frequency of 10 kHz. Units and directions of each channel must be aligned to the reference data, which is recorded and provided in SAE J211 standard.

Table 3: List of required ISOMME outputs of the load cases for stage 2 validation

| Test Type | Channel | HF | H3 | HM |
|---|---|---|---|---|
| NEFX / NEEX | Impactor acceleration | T0PEND000000ACXD | T0PEND000000ACXD | T0PEND000000ACXD |
| | Angle Low Neck Joint | D0SUBJLO0000AN0P | D0SUBJLO0000AN0P | D0SUBJLO0000AN0P |
| | Angle Upper Neck Joint | D0SUBJUP0000AN0P | D0SUBJUP0000AN0P | D0SUBJUP0000AN0P |
| | Upper Neck Force, X | D0NECKUP00HFFOXA | D0NECKUP00H3FOXA | D0NECKUP00HMFOXA |
| | Upper Neck Moment, Y | D0NECKUP00HFMOYB | D0NECKUP00H3MOYB | D0NECKUP00HMMOYB |
| THHS | Impactor acceleration | | | T0IMPA000000ACXD |
| | Chest compression+ | | | D0CHST0000HMDSXC |
| | Chest acceleration | | | D0CHST0000HMACXC |
| | | | | D0CHST0000HMACYC |
| | | | | D0CHST0000HMACZC |
| THLS | Impactor acceleration | T0IMPA000000ACXD | T0IMPA000000ACXD | |
| | Chest compression* | D0CHST0003HFDSXC | D0CHST0003H3DSXC | |
| | Chest acceleration | D0CHST0000HFACXC | D0CHST0000H3ACXC | |
| | | D0CHST0000HFACYC | D0CHST0000H3ACYC | |
| | | D0CHST0000HFACZC | D0CHST0000H3ACZC | |
| ULIL / ULIR | | T0IMPA000000ACXB | T0IMPA000000ACXB | T0IMPA000000ACXB |
| | | | + linear calibrated | *polynom calibrated |

## 3.4 Processing of signals

The following documents are referenced throughout this chapter and are essential to perform the calculation of the rating:

- ISO/TS 18571 Road vehicles – Objective rating metric for non-ambiguous signals
- ISO 6487, Road vehicles – Measurement techniques in impact tests – Instrumentation
- SAE J211-1, Instrumentation for impact test – Part 1: Electronic instrumentation.
- Euro-NCAP Technical Bulletin CP005 – Data acquisition and injury calculation

The references are given undated, therefore the latest version must be used.

Prior to any score calculations, all signal data from the simulations shall be pre-processed according to the instructions described below.

Filter channels based on Euro NCAP technical bulletin CP005 instructions according to SAE J211 or ISO 6487. Impactor and pendulum accelerations need to be filtered with CFC60 filter for all tests other than the ULIL and ULIR test where a CFC600 has to be used.

### 3.4.1 Signal treatment

The procedure which follows, must be applied to all channels of each stage 2 test.

- Apply initial bias removal of all channels, if necessary, between t = 0 ms and t = 10 ms by calculating the mean value of the given interval and offsetting the signal by the mean value (Figure 1.a).
- Determine the time point when the pendulum or impactor acceleration is larger than 5 g (Figure 1.b)
- Realign the test channels with respect to t0 (Figure 1.c).
- Move all test channels 10 ms to the right to evaluate initial part of the signal (Figure 1.d).

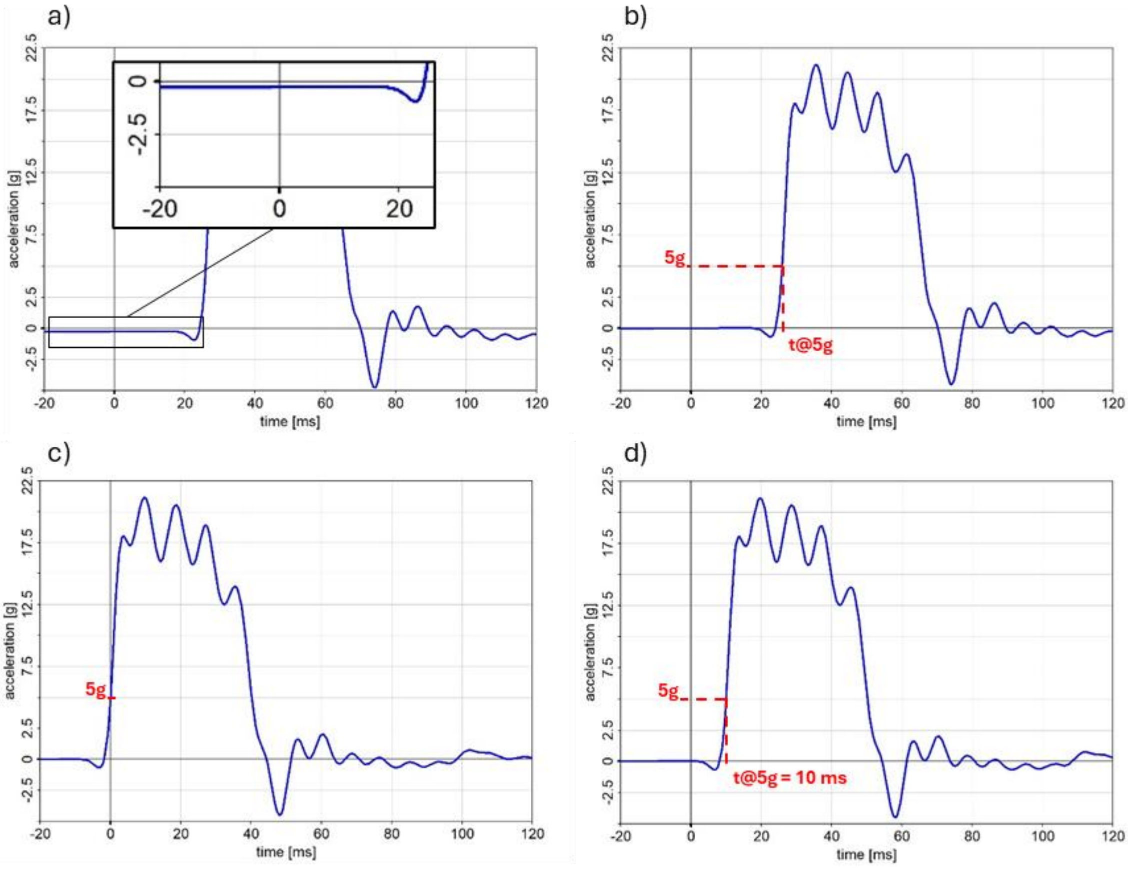



Figure 1: Signal treatment for stage 2 qualification

### 3.4.2 Calculation of scores

The overall evaluation is composed of several scores, which are calculated sequentially one after another.

### 3.4.3 Channel score

The score of a channel must be calculated for a specific interval by application of the ISO metric as specified in ISO/TS 18571. The interval of evaluation for each load case and for each channel is listed in Table 4. The provided reference data must be used as reference curves, whereas the simulation data must be used as evaluated curves.

Table 4. Intervals [ms] of channel evaluation for each loadcase

| Channel | NEEX | NEFX | THLS | THHS | ULIL/ULIR |
|---|---|---|---|---|---|
| Impactor acceleration | 0 - 50 | 5 - 70 | 5 - 60 | 5 - 70 | 10 - 18 |
| Angle Low Neck Joint | 10 - 170 | 10 - 125 | | | |
| Angle Upper Neck Joint | 10 - 170 | 10 - 125 | | | |
| Upper Neck Force, X | 10 - 170 | 10 - 125 | | | |
| Upper Neck Moment, Y | 10 - 170 | 10 - 125 | | | |
| Chest acceleration | | | 5 - 50 | 5 - 50 | |
| Chest compression | | | 5 - 60 | 5 - 70 | |

### 3.4.4 Sensor score

The sensor score needs to be calculated for the acceleration channel in the chest impact test (THLS and THHS). The sensor score is calculated by summarising all three weighted channel scores per sensor according to Equation 1. All weighting factors are listed in Table 5.

Equation 1

$$S_{Sensor} = \sum_{\mathrm{i}} w_i * S_i \ and \ i = X, Y, Z$$

with $w_i$ weighting factor of directional component of sensor

$S_i$ Channel score of directional component of sensor

Table 5: Weighting factors (wi) per channel for the acceleration of the thorax impactor test

| Dummy | Channel | wi |
|---|---|---|
| HF | D0CHST0000HFACX | 0.745 |
| | D0CHST0000HFACY | 0.039 |
| | D0CHST0000HFACZ | 0.216 |
| H3 | D0CHST0000H3ACX | 0.766 |
| | D0CHST0000H3ACY | 0.026 |
| | D0CHST0000H3ACZ | 0.208 |
| HM | D0CHST0000HMACX | 0.753 |
| | D0CHST0000HMACY | 0.032 |
| | D0CHST0000HMACZ | 0.215 |

# 4 STAGE 3 - FULL SCALE TESTS – TYPE 1 “PDB/BAST”

## 4.1 Dummy model suitability – full assembly simulation

In stage 3, the models’ application -specific suitability is checked at a full assembly level using two sled tests per dummy size percentile. The sled tests differ in the magnitude of the pulse. A low speed test with initial velocity of 9.72 m/s (35 km/h) and high speed pulse of 18.88 m/s (68 km/h) need to be simulated. Pulses are representing full frontal loading aligned with the x reference direction of the vehicle (SAE J211). For each dummy percentile, the sled environment is based on the same generic environment with some adaptations (see Figure 2 and Table 6). These are included in the provided finite element models of the setups. The restraint system is composed of a pressurized/deployed generic passenger airbag and a serial 3 point belt system with adjustable D-ring position and switchable load limiter (4.0/2.0 kN)

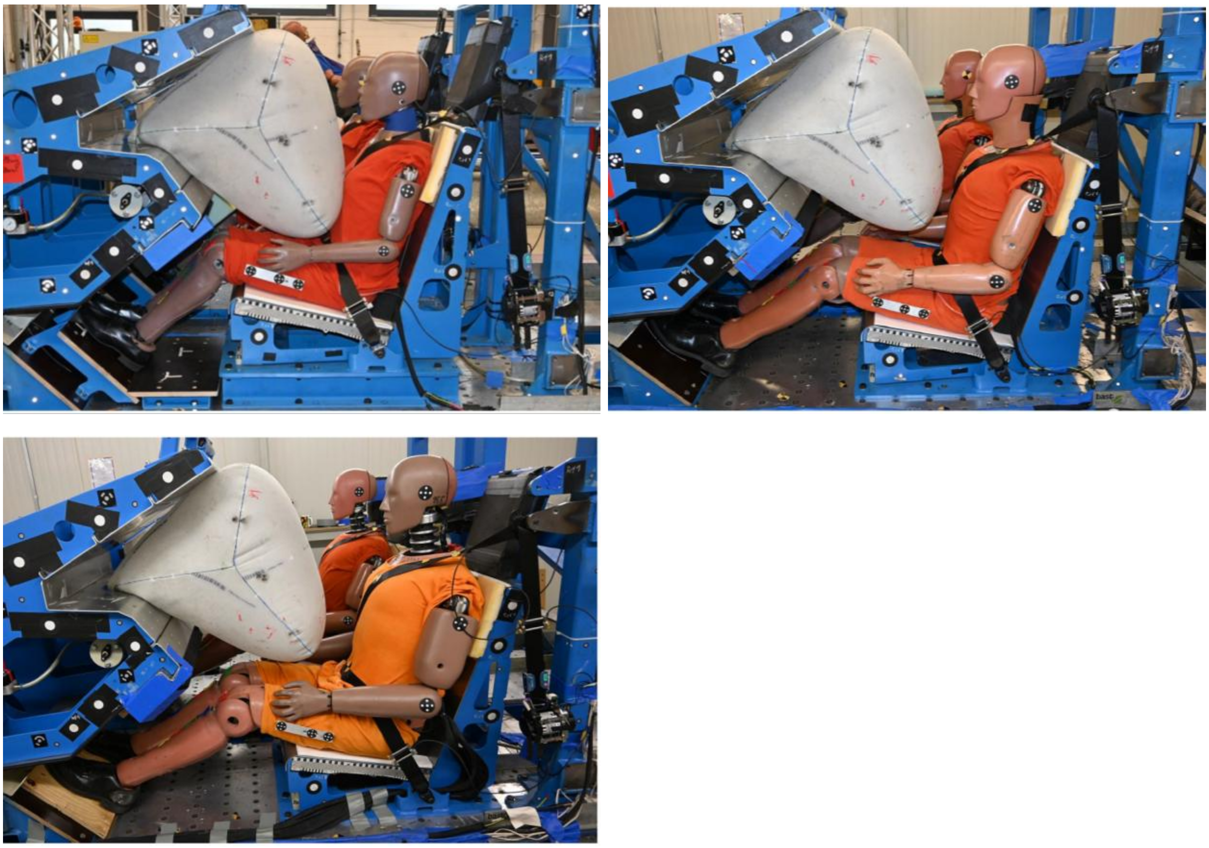


Figure 2: PDB/BASt sled environment for HF (top left), H3 (top right) and HM (bottom)

Table 6: Summary of differences of the PDB/BASt sled environment for each dummy percentile

| Dummy | B pillar position | Belt anchorage position | Seat x-position | Seat z-position | Wooden plate on foot rest | Plywood under the knee bolster |
|---|---|---|---|---|---|---|
| **HF** | nominal | high | 100 mm forward | 100 mm higher | additional foot rest and floor bolster | removed |
| **H3** | nominal | low | nominal | nominal | none | present |
| **HM** | 100 mm rearward | low | 100 mm rearward | nominal | 18 mm thick plate wrt H3 sled config. | present |

## 4.2 Reference sled pulses

Data for:

- Low speed sled test with initial velocity of 9.72 m/s (35 km/h) was generated within experiments performed in the SENIORS project (funded under EU Horizon 2020 research and innovation program, under grant agreement No. 636136)
- High speed sled test with initial velocity of 18.88 m/s (68 km/h) and delta v of 15.55 m/s (56 km/h) was generated based on BASt internal test with VW ID4 (model version 2022)

The two sled pulses are reported in Figure 3.

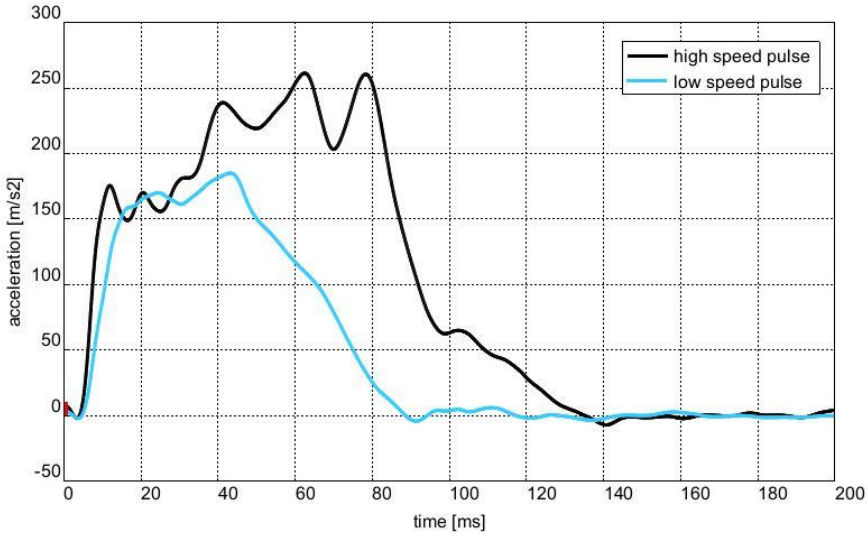



Figure 3: Acceleration profile for high speed pulse (initial velocity of 68 km/h, black) and low speed pulse (initial velocity of 35 km/h, cyan)

## 4.3 Reference data

The following finite element reference models and reference data sets are needed for this procedure:

Frontal impact sled model in LS-Dyna

https://openvt.eu/EuroNCAP/hiii-qualification/level-3-ls-dyna-models

VPS frontal impact sled model:

https://openvt.eu/EuroNCAP/hiii-qualification/level-3-vps-models

Reference signal data for sled test

https://openvt.eu/EuroNCAP/hiii-qualification/level-3-general-documentation-and-settings

No modifications of the reference finite element models and of the reference data are allowed other than prescribed from the qualification procedure. Any potential improvement to the reference finite elements models must be submitted to Euro NCAP secretary which will then evaluate if a new release is needed.

## 4.4 Simulation setup

### 4.4.1 Environment

The sled test setup consists of separated components assembled in a common rigid frame as shown in Figure 4. Apart of the rigid frame, the setup includes a rigid inclined seat pan, a rigid seatback, rigid footrest, a pre-inflated airbag, a dashboard, knee-cushion, windshield replacement, 3-point belt (driver configuration belt path according to left driver vehicle), retractor, and belt attachment points.

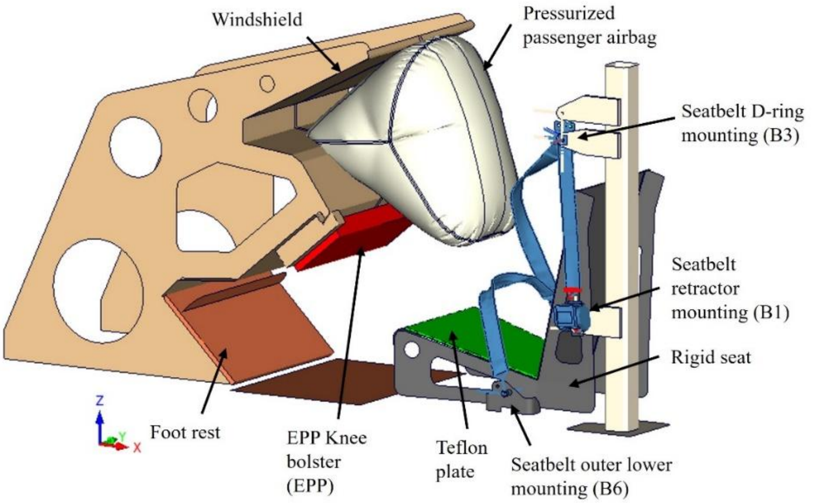



Figure 4: Sled environment as CAD image with description of individual parts

The dummy model is seated on a rigid seat pan. Between dummy and seatpan a 5 mm thick Teflon plate is used. The model's feet rest on a rigid wooden support, which is mounted on a rigid frame. The rigid frame is fixed onto the catapult sled system. The rigid dashboard in the area of potential contact with the knee is covered with a 500 mm (width) x 190 mm (height) x 60 mm (thickness) Expanded Polypropylene foam (EPP, density 60 kg/m$^3$). The knee bolster foam is fixed on a 30 mm thick plywood which is connected to the steel dashboard structure. Wooden parts were modelled through an EPP foam with density of 200 kg/m$^3$. The 3-point belt is not connected to the seat (left-hand drive car seat), but to the rigid frame through attachment points. The retractor model is a generic model which has been provided from Autoliv and harmonized to provide similar restraint characteristics with different kind of finite element solvers.

Percentile specific (HF, H3 and HM) models of the sled environment have been developed and are available under the links provided in 4.3. These models include all dummy percentile specific changes to the base setup which are summarized in Table 6.

#### 4.4.1.1 Contacts

The following contacts shall be defined with coefficients of friction between:

- Dummy head – surrounding (e.g. airbag): 0.5
- Dummy thorax. arms – surrounding: 0.3
- Dummy pelvis – surrounding: 0.2 (VPS) or 0.3 (LS-Dyna)
- Dummy legs. feet – surrounding: 0.5
- Dummy – belt: 0.2
- Teflon plate - seat pan: 0.17

All contacts shall be checked to work properly (no large penetrations or sticky nodes). The applied contact settings (type and friction coefficient) must be reported in the qualification documentation report.

#### 4.4.1.2 Activation Times

The activation time listed in Table 7 have been used for the belt retractor.

Table 7: Activation time [ms] belt retractor for the low and high speed sled tests

| Pulse | Low speed | High speed |
|---|---|---|
| TTF Pretensioner | 12 | 12 |
| TTF 2nd stage load limiter | 22 | - |

### 4.4.2 Dummy model Preparation

The dummy model is seated, targeting the hip point, head centre point and surface data in the physical test position. The target postures for the two sled tests are provided in reference CAE data files.

Due to the seat’s flat shape, the model’s deformation at the bottom shall be considered to avoid initial penetration between model’s bottom and seat plate when the model is seated.

The belt path shall be as close as possible to the provided reference belt path in the reference CAE file and adapted to the dummy's achieved body position.

Contact definitions between model and the generic environment are pre-defined and provided in the reference CAE file.

Information on the target postures for the sled tests are provided in Table 8 and Table 9.

Table 8: Reference tilt angles [degree] for positioning dummy

| Dummy | HF | | | H3 | | | HM | | |
|---|---|---|---|---|---|---|---|---|---|
| Axis | | y | | | y | | | y | |
| Head | 1.9 ± 2.5 | | | -0.3 ± 1.5 | | | -0.8 ± 1.5 | | |
| Torso | 12.4 ±1.5 | | | 8.0 ± 1.0 | | | 8.6 ± 1.0 | | |
| Pelvis | 21.3 ± 0.3 | | | 23.1 ± 0.3 | | | 22.8 ± 0.3 | | |

Table 9: Reference points coordinates [mm] for dummy positioning

| Dummy | HF | | | H3 | | | HM | | |
|---|---|---|---|---|---|---|---|---|---|
| **Axis** | x | y | z | x | y | z | x | y | z |
| **H-Point** | 300 ± 5 | | 340 ± 5 | 410 ± 5 | | 240 ± 5 | 490 ± 5 | | 260 ± 5 |
| **Head CoG** | 460 ± 10 | | 900 ± 10 | 530 ± 10 | | 900 ± 10 | 635 ± 10 | | 945 ± 10 |
| **Elbow L** | 390 ± 30 | -225 ± 30 | 475 ± 30 | 465 ± 30 | -265 ± 30 | 395 ± 30 | 560 ± 30 | -300 ± 30 | 415 ± 30 |
| **Elbow R** | 390 ± 30 | 225 ± 30 | 475 ± 30 | 465 ± 30 | 265 ± 30 | 395 ± 30 | 560 ± 30 | 300 ± 30 | 415 ± 30 |
| **Wrist L** | 190 ± 30 | -155 ± 30 | 460 ± 30 | 225 ± 30 | -185 ± 30 | 385 ± 30 | 310 ± 30 | -200 ± 30 | 410 ± 30 |
| **Wrist R** | 190 ± 30 | 155 ± 30 | 460 ± 30 | 225 ± 30 | 185 ± 30 | 385 ± 30 | 310 ± 30 | 200 ± 30 | 410 ± 30 |
| **Knee L** | -30 ± 10 | -110 ± 10 | 400 ± 10 | 20 ± 10 | -130 ± 10 | 320 ± 10 | 70 ± 10 | -135 ± 10 | 335 ± 10 |
| **Knee R** | -30 ± 10 | 110 ± 10 | 400 ± 10 | 20 ± 10 | 130 ± 10 | 320 ± 10 | 70 ± 10 | 135 ± 10 | 335 ± 10 |

### 4.4.3 Loading and other configurations

The following conditions must be considered:

- The sled must be loaded with pulses matching the provided reference signal data. The loading applied as acceleration-time boundary prescribed motion is as provided in reference CAE data files.
- The simulation must be performed with active gravity.
- Dummy model-related control cards must match in all three stages.
- End time ≥ 140 ms.

## 4.5 Output

### 4.5.1 Processing of signals

The following documents are referenced throughout this chapter and are essential to perform the calculation of the rating:

- ISO/TS 18571 Road vehicles – Objective rating metric for non-ambiguous signals
- ISO 6487, Road vehicles – Measurement techniques in impact tests – Instrumentation
- SAE J211-1, Instrumentation for impact test – Part 1: Electronic instrumentation.
- Euro-NCAP Technical Bulletin CP005 – Data acquisition and injury calculation

The references are given undated, therefore the latest version must be used.

Table 10 lists all required ISOMME outputs per test setup. Signals must be sampled with a frequency of 10 kHz. Units and directions of each channel must be aligned to the reference data, which is recorded and provided in SAE J211 standard.

Table 10: List of required outputs of Stage 3 PDB/BASt setup. L/R refers to Left/Right

| | Output | Location |
|---|---|---|
| Dummy | Accelerations | Head X/Y/Z |
| | | Chest X/Y/Z |
| | | Pelvis X/Y/Z |
| | Angular rates | Head X/Y/Z |
| | | Chest X/Y/Z (only HM) |
| | | Pelvis X/Y/Z |
| | Forces | Upper Neck X/Y/Z |
| | | Thoracic Spine X/Y/Z (only HF) |
| | | Lumbar Spine X/Y/Z (only HF, H3) |
| | | Iliac Wing L/R X (only HF) |
| | | Femur L/R Z |
| | | Upper Tibia L/R X/Z |
| | | Lower Tibia L/R X/Z |
| | Moments | Upper Neck X/Y/Z |
| | | Thoracic Spine X/Y/Z (only HF) |
| | | Lumbar Spine X/Y/Z (only HF, H3) |
| | | Iliac Wing L/R Y (only HF) |
| | | Femur L/R X/Y/Z (only HF) |
| | | Upper Tibia L/R X/Y |
| | | Lower Tibia L/R X/Y |
| | Displacement | Chest X |
| Miscellaneous | Force | Seatbelt (B1, B3, B6) |
| | Pullout | Seatbelt |

Prior to any score calculations, all signal data from the simulations shall be pre-processed according to the instructions described below.

Filter channels based on Euro NCAP technical bulletin CP005 instructions according to SAE J211 or ISO 6487.

4.5.1.1 Initial bias removal

Apply 'bias removal' of all channels between t = 5 ms and t = 10 ms by calculating the mean value of the given interval and offsetting the signal by the mean value (see Figure 5)

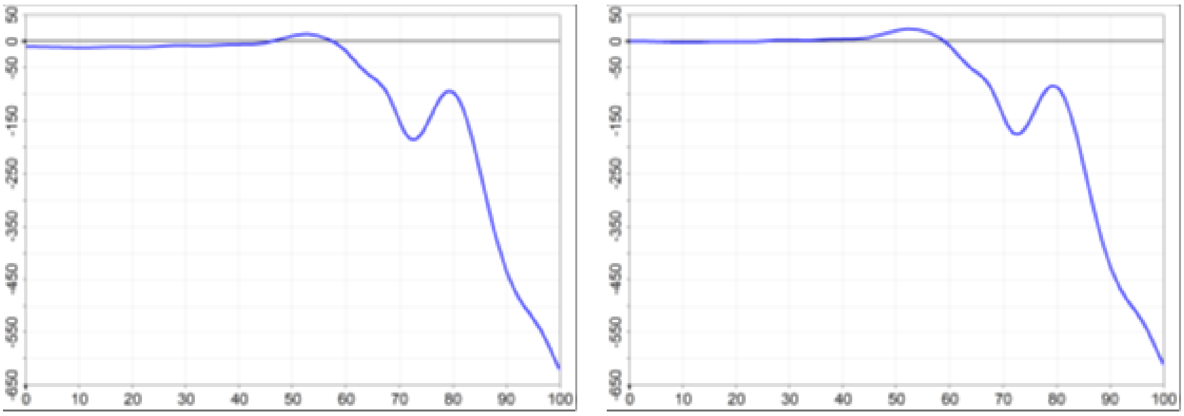


Figure 5: Channel bias removal

The test data has already been prepared, so that it can be directly used for the calculation of the ISO scores. In addition to filtering, 'bias removal' was applied for all channels between t = 5 ms and t = 10 ms.

### 4.5.2 Calculation of scores

The overall evaluation is composed of several scores, which are calculated sequentially one after another.

4.5.2.1 Channel score

The score of a channel must be calculated for a specific interval by application of the ISO metric as specified in ISO/TS 18571. The interval of evaluation for each load case and for each channel is listed in Table 11. The provided reference data must be used as reference curves, whereas the simulation data must be used as evaluated curves.

Table 11: Interval of evaluation [ms] per channel for the low and high speed PDB/BASt sled tests

| Channel | HF | H3 | HM |
|---|---|---|---|
| **Belt pullout** | 25 – 95 | 25 – 95 | 25 – 120 |
| **Belt force** | 10 – 110 | 10 – 120 | 10 – 120 |
| **Dummy outputs** | 10 – 95 | 10 – 110 | 10 – 120 |

#### 4.5.2.2 Sensor score

The sensor score is calculated by summarising all three weighted channel scores per sensor according to Equation 2. All weighting factors per channel, sensor and load case are listed in Table 12.

Equation 2

$$S_{Sensor} = \sum_{\mathrm{i}} w_i * S_i \; and \; i = X, Y, Z$$

with $w_i$ weighting factor of directional component of sensor
$S_i$ Channel score of directional component of sensor

Table 12: Weighting factors per output channel and sensor for HF, H3 and HM in the low speed (LS) and high speed (HS) PDB/BASt sled tests

| Sensor | Channel | $w_i$ | | | | | |
|---|---|---|---|---|---|---|---|
| | | HF | | H3 | | HM | |
| | | LS | HS | LS | HS | LS | HS |
| Head acceleration | S0HEAD0000H_ACXA | 0.675 | 0.612 | 0.709 | 0.644 | 0.609 | 0.530 |
| | S0HEAD0000H_ACYA | 0.077 | 0.063 | 0.034 | 0.014 | 0.020 | 0.061 |
| | S0HEAD0000H_ACZA | 0.248 | 0.325 | 0.257 | 0.342 | 0.371 | 0.409 |
| Chest acceleration | S0CHST0000H_ACXC | 0.661 | 0.666 | 0.613 | 0.615 | 0.599 | 0.528 |
| | S0CHST0000H_ACYC | 0.057 | 0.110 | 0.063 | 0.047 | 0.101 | 0.061 |
| | S0CHST0000H_ACZC | 0.282 | 0.224 | 0.324 | 0.338 | 0.300 | 0.411 |
| Pelvis acceleration | S0PELV0000H_ACXB | 0.624 | 0.589 | 0.598 | 0.585 | 0.584 | 0.639 |
| | S0PELV0000H_ACYB | 0.080 | 0.077 | 0.123 | 0.089 | 0.075 | 0.072 |
| | S0PELV0000H_ACZB | 0.296 | 0.334 | 0.279 | 0.327 | 0.340 | 0.289 |
| Head angular velocity | S0HEAD0000H_AVXD | 0.121 | 0.140 | 0.115 | 0.105 | 0.125 | 0.163 |
| | S0HEAD0000H_AVYD | 0.740 | 0.700 | 0.770 | 0.781 | 0.761 | 0.703 |
| | S0HEAD0000H_AVZD | 0.140 | 0.160 | 0.115 | 0.114 | 0.114 | 0.134 |
| Chest angular velocity | S0CHST0000H_AVXD | | | | | 0.098 | 0.122 |
| | S0CHST0000H_AVYD | | | | | 0.764 | 0.627 |
| | S0CHST0000H_AVZD | | | | | 0.138 | 0.250 |
| Pelvis angular velocity | S0PELV0000H_AVXD | 0.120 | 0.105 | 0.090 | 0.079 | 0.110 | 0.106 |
| | S0PELV0000H_AVYD | 0.688 | 0.710 | 0.780 | 0.720 | 0.689 | 0.657 |
| | S0PELV0000H_AVZD | 0.192 | 0.185 | 0.130 | 0.201 | 0.201 | 0.237 |
| Upper neck force | S0NECKUP00H_FOXA | 0.236 | 0.317 | 0.361 | 0.387 | 0.188 | 0.289 |
| | S0NECKUP00H_FOYA | 0.071 | 0.050 | 0.080 | 0.023 | 0.112 | 0.054 |
| | S0NECKUP00H_FOZA | 0.693 | 0.633 | 0.560 | 0.590 | 0.699 | 0.656 |
| Thoracic spine force | S0THSP0000HFFOXB | 0.257 | 0.155 | | | | |
| | S0THSP0000HFFOYB | 0.140 | 0.258 | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | S0THSP0000HFFOZB | 0.603 | 0.587 | | | | |
| Lumbar spine force | S0LUSP0000H_FOXB | 0.274 | 0.279 | 0.415 | 0.428 | | |
| | S0LUSP0000H_FOYB | 0.119 | 0.188 | 0.084 | 0.163 | | |
| | S0LUSP0000H_FOZB | 0.607 | 0.533 | 0.501 | 0.409 | | |
| Upper neck moment | S0NECKUP00H_MOXB | 0.177 | 0.105 | 0.171 | 0.141 | 0.267 | 0.161 |
| | S0NECKUP00H_MOYB | 0.759 | 0.832 | 0.702 | 0.803 | 0.628 | 0.761 |
| | S0NECKUP00H_MOZB | 0.064 | 0.063 | 0.127 | 0.056 | 0.105 | 0.078 |
| Thoracic spine moment | S0THSP0000HFMOXB | 0.225 | 0.338 | | | | |
| | S0THSP0000HFMOYB | 0.775 | 0.662 | | | | |
| Lumbar spine moment | S0LUSP0000H_MOXB | 0.155 | 0.273 | 0.128 | 0.213 | | |
| | S0LUSP0000H_MOYB | 0.793 | 0.666 | 0.819 | 0.753 | | |
| | S0LUSP0000H_MOZB | 0.052 | 0.061 | 0.053 | 0.035 | | |

# 5 Stage 3 - Full Scale Tests – Type 2 “Chalmers”

## 5.1 Loadcase Description

The validation load case consists of a generic frontal impact sled mimicking the basic interior of a mid-size European vehicle (Figure 6). The sled was comprising of generic floor pan, generic foot support, rigid and padded seat-back (support the occupant prior crash), semi rigid seat (Figure 6), 3-pt seat belt system, shoulder belt retractor with 2 kN pretensioner and 4 kN load limiter, seat belt buckle with wire stalk, crash-locking tongue, and 2 kN lap belt pretensioner, generic knee bolster (Figure 6), collapsible steering column, steering wheel and driver airbag (Figure 6). Steering wheel and steering column angle can be found in appendix A. The width of the seatbelt webbing (Rukaflex) was 47 mm with a tension of 11,5 kN at 10% elongation. The semi rigid seat was consisting of a seat pan and sub pan. The seat pan spring stiffness was 128N/mm, and sub pan springs stiffness were 132 N/mm. A rigid seatback with an 18° orientation to the vertical was used. Seat pan, sub pan and seatback angles were 15, 26 and 18 Degrees respectively. A 45°-foot support were also included. In all tests the pretensioner was fired at 10 ms, the lap belt pretensioner (PLP) at 15 ms, the airbag stage one at 10 ms and stage two at 15 ms.

Figure 6. Generic Frontal Impact System Sled Set-up

The coordinates for the retractor and D-loop of the belt system were based on a European mid-size sedan vehicle geometry. The generic knee bolster was rectangular (300 x 230 x 100 mm) Ethafoam 220 blocks. The steering column deformation force was controlled by deforming steel elements. The element used for the testing were 350 x 2 x 23 mm SSAB Domex 420LA steel elements resulting in a deformation force of approximately 5.5 kN with max deformation distance of 85 mm.

The steering wheel was from a Volvo XC90 MY 2021. The generic airbag was a single chamber, coated fabric 55 litre bag with 2 x35 mm diameter went holes. There was no cover over the airbag and the bag was fixated with paper tape. The inflator used was a pyrotechnic 2 stage gas-generator.

The feet of the dummies were strapped to limit motion of the lower extremities and increase the repeatability between the tests.

Two generic crash pulses representing 40 km/h and 56 km/h full frontal crashes were used to impulse the generic frontal system. The time vs. sled acceleration of the two crash pulses can be observed in Figure 7:

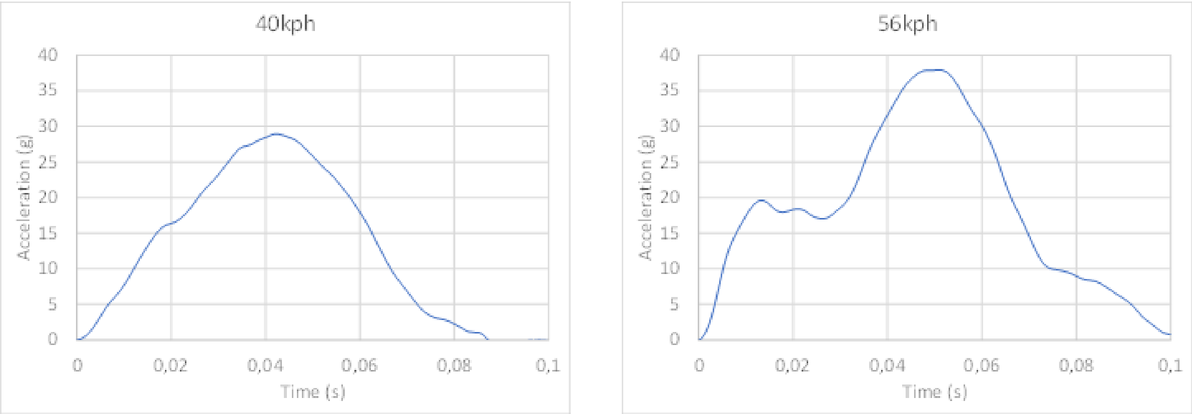



Figure 7. Time vs sled acceleration of the crash pulses at 40 km/h and 56 km/h used to perform the tests with the generic frontal system.

## 5.2 Reference Data

The following finite element reference models and reference data sets are needed for this procedure:

LS-DYNA frontal impact sled model:

https://openvt.eu/EuroNCAP/hiii-qualification/level-3-ls-dyna-models

VPS frontal impact sled model:

https://openvt.eu/EuroNCAP/hiii-qualification/level-3-vps-models

Reference signal data for sled tests:

https://openvt.eu/EuroNCAP/hiii-qualification/level-3-general-documentation-and-settings

No modifications of the reference finite element models and of the reference data are allowed other than prescribed from the qualification procedure. Any potential improvement to the reference finite elements models must be submitted to Euro NCAP secretary which will then evaluate if a new release is needed.

## 5.3 Simulation setup

### 5.3.1 Environment

The sled test setup consists of a generic frontal impact sled model mimicking the physical set up (Figure 6 and 8). The semi rigid seat model originates from the TUC homepage. The generic retractor and airbag models are from Autoliv. The straps around the feet are modelled by means of friction.

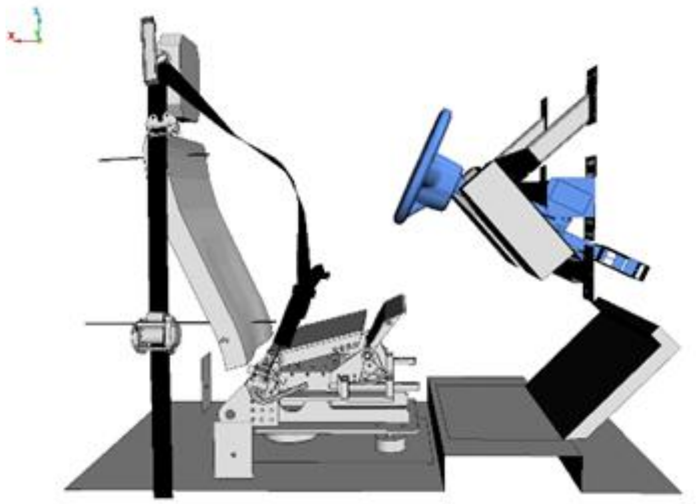


Figure 8: Generic frontal impact sled model

The dummy model is seated on the rigid seat pan of the semi-rigid seat (Figure 9 and Figure 10). The model's feet rest on a rigid support, which is mounted on a rigid frame. The rigid frame is fixed onto a hyge sled system. The 3-point belt is not connected to the seat (left-hand drive car seat), but to the rigid frame though attachment points.

### 5.3.2 Contacts

The following contacts shall be defined with coefficients of friction of 0.13-0.9:

- Dummy – foot support: Fc = 0.9
- Dummy – seat pan: Fc=0.3
- Dummy – antisubmarining pan: Fc=0.35
- Dummy – knee bolster: Fc=0.3
- Dummy – driver airbag: Fc=0.3
- Dummy – steering wheel: Fc=0.3
- Dummy – Belt and buckle: Fc=0.3

Contact definitions and frictions are defined in the sled model and shall not be modified.

All contacts shall be checked to work properly (no large penetrations or sticky nodes).

The applied contact settings (type and friction coefficient) must be reported in the qualification documentation report.

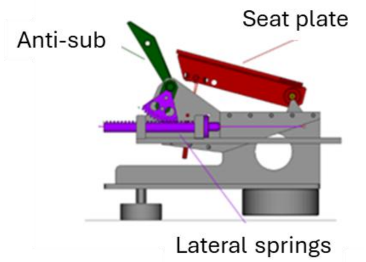
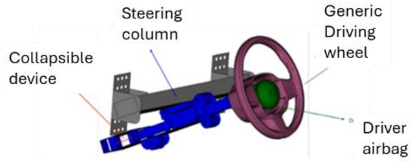
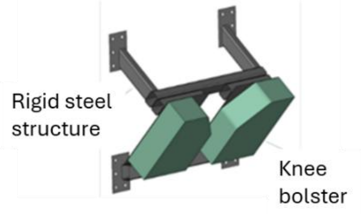
<table>
<tr>
<td>
</td>
<td>
</td>
<td>
</td>
</tr>
<tr>
<td>Semi-Rigid Seat</td>
<td>Steering column and steering wheel</td>
<td>Knee bolster</td>
</tr>
</table>

Figure 9: Sled environment as CAD image with description of individual parts

<table>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H3</td>
<td>HF</td>
<td>HM</td>
</tr>
</table>

Figure 10: Dummy in sled environment

### 5.3.3 Dummy Model Preparation

The dummy model is seated, targeting the hip point (H-point), head centre point and surface data of the physical test position. Nose to rim, elbow to elbow, shoulder belt to mouth, shoulder belt to neck and top of knee to sled distances are defined in **Error! Reference source not found.**. Foot to foot measurement is from centerline of left foot to centerline of right foot.

Figure 11: Nose to Rim, Elbow-to-Elbow, Shoulder belt to Mouth, Shoulder Belt to Neck and Top of Knee to Sled Measurements

The target postures for the sled tests are provided in Table 13 for the H3, Table 14 for the HF and Table 15 for the HM

Table 13: Target position for H3 in Chalmers Setup

| | X | Y | Z |
|---|---|---|---|
| H-point (mm) | -103 (+10) | | 162(+10) |
| Head angle (Deg) | | 0 (+1) | |
| Pelvis angle (Deg) | | 22(+1) | |
| Femur angles LH/RH (Deg) | | 14(+2)/14(+2) | |
| Tibia angles LH/RH (Deg) | | -48(+2)/-48(+2) | |
| Nose to upper rim (mm) | 490(+10) | | |
| Belt to neck (mm) | 67(+3) | | |
| Belt to mouth (mm) | 175(+10) | | |
| Foot to foot (c-c) (mm) | 220(+10) | | |
| Knee to knee (c-c) (mm) | 220(+10) | | |
| Top of knee to sled (mm) | 535(+10) | | |
| Wrist to wrist; screw-screw (mm) | 355(+10) | | |
| Elbow to elbow; closest flesh-flesh (mm) | 320(+10) | | |

Table 14: Target position for HF in Chalmers Setup

| | X | Y | Z |
|---|---|---|---|
| H-Point (mm) | -120(+10) | | -169(+10) |
| Head angle (Deg) | | 0(+1) | |
| Pelvis angle (Deg) | | 20(+1) | |
| Femur angles LH/RH (Deg) | | 12(+2)/12(+2) | |
| Tibia angles LH/RH (Deg) | | -51(+2)/-51(+2) | |
| Nose to upper rim (mm) | 382(+10) | | |
| Belt to neck (mm) | 50(+3) | | |
| Belt to mouth (mm) | 160(+10) | | |
| Foot to foot (c-c) (mm) | 220(+10) | | |
| Knee to knee (c-c) (mm) | 220(+10) | | |
| Top of knee to sled (mm) | 353(+10) | | |
| Wrist to wrist; screw-screw (mm) | 390(+10) | | |
| Elbow to elbow; closest flesh-flesh (mm) | 315(+10) | | |

Table 15: Target position for HM in Chalmers Setup

| | X | Y | Z |
|---|---|---|---|
| H-Point (mm) | -108(+10) | | 168(+10) |
| Head angle (Deg) | | 0(+1) | |
| Pelvis angle (Deg) | | 21(+1) | |
| Femur angles LH/RH (Deg) | | 15(+2)/15(+2) | |
| Tibia angles LH/RH (Deg) | | -54(+2)/-54(+2) | |
| Nose to upper rim (mm) | 485(+10) | | |
| Belt to neck (mm) | 77(+4) | | |
| Belt to mouth (mm) | 200(+10) | | |
| Foot to foot (c-c) (mm) | 250(+10) | | |
| Knee to knee (c-c) (mm) | 250(+10) | | |
| Top of knee to sled (mm) | 585(+10) | | |
| Wrist to wrist; screw-screw (mm) | 380(+10) | | |
| Elbow to elbow; flesh-flesh (mm) | 355(+10) | | |

The belt routing across the dummy model can be adjusted using the 3D faro scannings for the 3 dummy models.

### 5.3.4 Loading and other configurations

The following conditions must be considered:

- The sled must be loaded with pulses matching the provided reference signal data. The loading applied as ‘velocity-time’ boundary prescribed motion is provided in reference CAE data files.
- The simulation must be performed with active gravity.
- Dummy model-related control cards must match in all three stages.
- End time ≥ 120 ms.

## 5.4 Outputs

### 5.4.1 Postprocessing of output channels

For each output channel generated, the sampling rate must be 10 kHz. Units and directions of each channel must be aligned to the reference data, which is recorded and provided in SAE J211 standard.

For dummy model related outputs, the standard load cells of the dummy model must be used with their original orientation. A list of required outputs is provided in Table 16.

Table 16: List of required outputs of stage 3 Chalmers sled tests

| | Output | Sled test slow / fast |
|---|---|---|
| Dummy | Accelerations | Head X/Y/Z |
| | | Chest X/Y/Z |
| | | Pelvis X/Y/Z |
| | Angular rates | Head X/Y/Z |
| | | Pelvis Y |
| | Forces | Upper Neck X/Y/Z |
| | | Lumbar Spine X/Y(only HF)/Z |
| | | Iliac Spine L/R X (HF) |
| | | Femur L/R Z |
| | | Upper Tibia L/R X/Z (H3 & HF) |
| | | Lower Tibia L/R X/Y(only H3)/Z |
| | Moments | Upper Neck X/Y/Z |
| | | Lumbar Spine X (only HF)/Y |
| | | Iliac Spine L/R Y (HF) |
| | | Upper Tibia L/R X/Y (H3 & HF) |
| | | Lower Tibia L/R X/Y (H3 & HF) |
| | Displacement | Chest X |
| Seatbelt | Force | Seatbelt (B1, B3 & B6) |
| Retractor | Pull out | Seatbelt |
| Airbag | Pressure | Airbag |
| Steering column | Displacement | Steering column |

### 5.4.2 References

The following documents are referenced throughout this chapter and are essential to perform the calculation of the rating:

- ISO/TS 18571 Road vehicles – Objective rating metric for non-ambiguous signals
- ISO 6487, Road vehicles – Measurement techniques in impact tests – Instrumentation
- SAE J211-1, Instrumentation for impact test – Part 1: Electronic instrumentation
- Euro-NCAP Technical Bulletin CP005 – Data acquisition and injury calculation

The references are given undated, therefore the latest version must be used.

### 5.4.3 Pre-processing of signals

Prior to any score calculations, all signal data from the simulations shall be pre-processed according to the instructions described below.

1. Filter all channels according to the filter class specified in CP005

2. Apply ‘bias removal’ of all channels between t = 5 ms and t = 10 ms by calculating the mean value of the given interval and offsetting the signal by the mean value (see Figure 12)

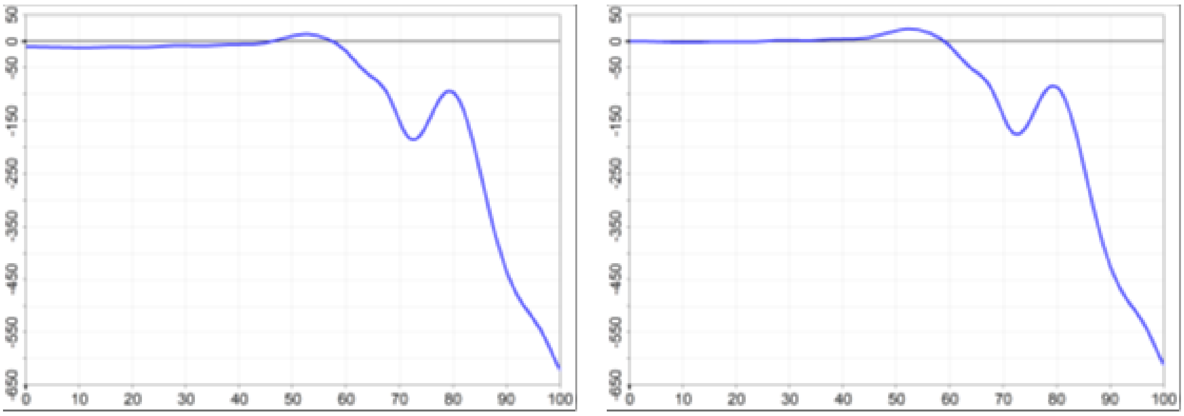



Figure 12: Channel bias removal

The test data has already been prepared, so that it can be directly used for the calculation of the ISO scores. In addition to filtering according to CP005, ‘bias removal’ was applied for all channels between t = 5 ms and t = 10 ms.

### 5.4.4 Calculation of scores

The overall evaluation is composed of several scores, which are calculated sequentially one after another.

#### 5.4.4.1 Channel score

The score of a channel must be calculated for a specific interval by application of the ISO metric as specified in ISO/TS 18571. The interval of evaluation for each load case is listed in Table 17. All necessary channels are listed in Table 18. The provided reference data must be used as reference curves, whereas the simulation data must be used as evaluated curves.

Table 17: Interval of evaluation (ms) for each Chalmers sled tests

| Channel | HF | | H3 | | HM | |
|---|---|---|---|---|---|---|
| | Low Speed | High Speed | Low Speed | High Speed | Low Speed | High Speed |
| Belt Pull out | 20 - 90 | 20 - 90 | 20 - 100 | 20 - 110 | 20 -120 | 20 -120 |
| Belt Force | 10 - 90 | 10 - 90 | 10 - 100 | 10 - 110 | 10 - 120 | 10 - 120 |
| Airbag Pressure | 35 - 90 | 35 - 90 | 35 - 100 | 35 -110 | 35 - 120 | 35 -120 |
| Dummy Outputs | 10 - 90 | 10 - 90 | 10 - 100 | 10 - 110 | 10 - 120 | 10 - 120 |

#### 5.4.4.2 Sensor score

The sensor score is calculated by summarising all three weighted channel scores per sensor according to Equation 3. All weighting factors per channel, sensor and load case are listed in Table 18.

Equation 3

$$S_{Sensor} = \sum_{i} w_i * S_i \ and \ i = X, Y, Z$$

with $w_i$ weighting factor of directional component of sensor
$S_i$ Channel score of directional component of sensor

Table 18: Weighting factors per channel and sensor for the Chalmers sled tests

| Sensor | Channel | Weighting factor for load case | | | | | |
|---|---|---|---|---|---|---|---|
| | | HF | | H3 | | HM | |
| | | Low | High | Low | High | Low | High |
| Head acceleration | S1HEAD0000H_ACXA | 0.698 | 0.674 | 0.653 | 0.612 | 0.553 | 0.533 |
| | S1HEAD0000H_ACYA | 0.079 | 0.120 | 0.047 | 0.063 | 0.089 | 0.043 |
| | S1HEAD0000H_ACZA | 0.222 | 0.206 | 0.300 | 0.325 | 0.358 | 0.424 |
| Head angular velocity | S1HEAD0000H_AVXD | 0.168 | 0.164 | 0.157 | 0.177 | 0.262 | 0.148 |
| | S1HEAD0000H_AVYD | 0.579 | 0.452 | 0.748 | 0.681 | 0.673 | 0.819 |
| | S1HEAD0000H_AVZD | 0.253 | 0.384 | 0.095 | 0.141 | 0.066 | 0.033 |
| Chest acceleration | S0CHST0000H_ACXC | 0.619 | 0.582 | 0.751 | 0.730 | 0.689 | 0.639 |
| | S0CHST0000H_ACYC | 0.174 | 0.220 | 0.094 | 0.072 | 0.111 | 0.081 |
| | S0CHST0000H_ACZC | 0.207 | 0.198 | 0.155 | 0.198 | 0.200 | 0.280 |
| Pelvis acceleration | S0PELV0000H_ACXB | 0.416 | 0.464 | 0.564 | 0.570 | 0.594 | 0.604 |
| | S0PELV0000H_ACYB | 0.304 | 0.293 | 0.141 | 0.125 | 0.125 | 0.119 |
| | S0PELV0000H_ACZB | 0.280 | 0.243 | 0.294 | 0.305 | 0.281 | 0.277 |
| Upper neck force | S0NECKUP00H_FOXA | 0.287 | 0.271 | 0.314 | 0.262 | 0.212 | 0.158 |
| | S0NECKUP00H_FOYA | 0.031 | 0.070 | 0.044 | 0.071 | 0.062 | 0.761 |
| | S0NECKUP00H_FOZA | 0.681 | 0.659 | 0.642 | 0.668 | 0.726 | 0.081 |
| Upper neck moment | S0NECKUP00H_MOXB | 0.194 | 0.144 | 0.185 | 0.206 | 0.289 | 0.158 |
| | S0NECKUP00H_MOYB | 0.740 | 0.665 | 0.768 | 0.711 | 0.654 | 0.761 |
| | S0NECKUP00H_MOZB | 0.066 | 0.190 | 0.047 | 0.083 | 0.057 | 0.081 |
| Lumbar spine force | S0LUSP0000H_FOXB | 0.299 | 0.404 | 0.549 | 0.705 | 0.645 | 0.694 |
| | S0LUSP0000H_FOZB | 0.540 | 0.431 | 0.451 | 0.295 | 0.355 | 0.306 |
| Lumbar spine moment | S0LUSP0000H_MOYB | | | 0.766 | 0.791 | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Tibia left upper force X | S0TIBILEUPH_FOXB | 0.075 | 0.065 | 0.121 | 0.094 | | |
| Tibia left upper force Z | S0TIBILEUPH_FOZB | 0.925 | 0.935 | 0.879 | 0.906 | | |
| Tibia left upper moment X | S0TIBILEUPH_MOXB | 0.337 | 0.296 | 0.177 | 0.205 | | |
| Tibia left upper moment Y | S0TIBILEUPH_MOYB | 0.663 | 0.704 | 0.823 | 0.795 | | |
| Tibia left lower force X | S0TIBILELOH_FOXB | 0.203 | 0.239 | 0.193 | 0.240 | | |
| Tibia left lower force Z | S0TIBILELOH_FOZB | 0.797 | 0.761 | 0.807 | 0.760 | | |
| Tibia left lower moment X | S0TIBILELOH_MOXB | 0.266 | 0.255 | 0.250 | 0.191 | | |
| Tibia left lower moment Y | S0TIBILELOH_MOYB | 0.734 | 0.745 | 0.750 | 0.809 | | |
| Tibia right upper force X | S0TIBIRIUPH_FOXB | 0.075 | 0.065 | 0.124 | 0.127 | | |
| Tibia right upper force Z | S0TIBIRIUPH_FOZB | 0.925 | 0.935 | 0.876 | 0.873 | | |
| Tibia right upper moment X | S0TIBIRIUPH_MOXB | 0.337 | 0.296 | 0.294 | 0.308 | | |
| Tibia right upper moment Y | S0TIBIRIUPH_MOYB | 0.663 | 0.704 | 0.706 | 0.692 | | |
| Tibia right lower force X | S0TIBIRILOH_FOXB | 0.218 | 0.273 | 0.209 | 0.257 | | |
| Tibia right lower force Z | S0TIBIRILOH_FOZB | 0.782 | 0.727 | 0.791 | 0.743 | | |
| Tibia right lower moment X | S0TIBIRILOH_MOXB | 0.172 | 0.244 | 0.404 | 0.406 | | |
| Tibia right lower moment Y | S0TIBIRILOH_MOYB | 0.828 | 0.756 | 0.596 | 0.594 | | |

# 6 QUALIFICATION REQUIREMENTS FOR HIII MODELS

## 6.1 General quality requirements

All simulated setups must meet the following quality criteria:

- Max. hourglass energy of full setup has to be < 10% of max. internal energy
- Max. mass added due to mass scaling to the total model is less than 5% of the total model mass at the beginning of the run
- Visual plausibility of animation must be checked: no intersections, sticky nodes, shooting nodes affecting the dummy kinematics (focus on contact between dummy and environment)

## 6.2 Stage 1 qualification requirements

Mass properties, external dimensions, range of motion, instrumentation and dummy dynamic qualification procedures must be according to following Euro NCAP Crash Protection technical bulletins:

- CP103 - Hybrid III 5th Percentile Female dummy specification and certification
- CP104 - Hybrid III 50th Percentile Male dummy specification and certification
- CP105 - Hybrid III 95th Percentile Male dummy specification and certification

## 6.3 Stage 2 qualification requirements

Table 19 lists ISO score requirements which apply to each dummy percentile stage 2 test

Table 19: ISO score requirements for stage 2 certification

| Sensor | Test | ISO Score |
|---|---|---|
| **Impactor acceleration** | NEEX, NEFX, THLS, THHS, ULIL, ULIR | ≥ 0.80 |
| **Chest acceleration** | THLS, THHS | ≥ 0.55 |
| **Angular rotation** | NEEX, NEFX | ≥ 0.75 |
| **Force** | NEEX, NEFX | ≥ 0.60 |
| **Moment** | NEEX, NEFX | ≥ 0.75 |
| **Chest displacement** | THLS, THHS | ≥ 0.85 |

## 6.4 Stage 3 qualification requirements

### 6.4.1 Quality requirements

The simulation of all Stage 3 certification must meet the following quality criteria:

- Max. hourglass energy of all dummy components has to be < 10% of max. internal energy of dummy
- Less than 10 mm H-point z-displacement in first 5 ms of the simulation

### 6.4.2 Validation requirement

Table 20 lists the ISO score requirements which apply to each dummy percentile, if not further specified. Both stage 3 sled test requirements must be fulfilled. Channels which are monitored are not going to be assessed but the ISO score must be delivered.

Table 20: ISO score requirements for stage 3 certification. L/R refers to Left/Right

| | | | PDB/BASt | Chalmers |
|---|---|---|---|---|
| Dummy | Acceleration | Head | ≥ 0.65 | ≥ 0.65 |
| | | Chest | ≥ 0.50 for low speed<br>≥ 0.60 for high speed | ≥ 0.50 for low speed<br>≥ 0.60 for high speed |
| | | Pelvis | ≥ 0.60 | ≥ 0.60 |
| | Angular rates | Head | ≥ 0.50 | ≥ 0.50 |
| | | Chest | ≥ 0.65 (only HM) | - |
| | | Pelvis | ≥ 0.50 | Monitoring |
| | Forces | Upper neck | ≥ 0.50 | ≥ 0.50 |
| | | Thoracic spine | ≥ 0.50 (only HF) | - |
| | | Lumbar spine | ≥ 0.50 (only HF, H3) | ≥ 0.50 |
| | | Iliac spine L/R* | ≥ 0.50 (only HF) | ≥ 0.50 (only HF) |
| | | Femur L/R*,1 | ≥ 0.50 | ≥ 0.50 (only HF, H3); HM monitoring |
| | | Upper & Lower Tibia+,1 | ≥ 0.50 | ≥ 0.50 |
| | Moments | Upper neck | ≥ 0.50 | ≥ 0.50 |
| | | Thoracic spine | ≥ 0.50 (only HF) | - |
| | | Lumbar spine | ≥ 0.60 (only HF, H3) | Monitoring |
| | | Iliac spine L/R* | ≥ 0.50 (only HF) | Monitoring |
| | | Femur L/R* | Monitoring (only HF) | Monitoring |
| | | Upper & Lower Tibia+ | Monitoring | Monitoring |
| | Displacement | Chest compression | ≥ 0.65 | ≥ 0.65 |
| Miscellaneous | Force | Seatbelt | ≥ 0.70 (B1, B3, B6) | ≥ 0.70 (B1, B3, B6) |
| | Pullout | Seatbelt | ≥ 0.60 | ≥ 0.60 |
| | Pressure | Airbag | - | ≥ 0.70 |
| | Displacement | Steering column | - | ≥ 0.65 only high speed |
| *average ISO limit between left and right ISO scores<br>+ average ISO limit of the left and right lower and upper tibia ISO scores<br>1 only Z-component, other relevant components (e.g. Tibia force in x-direction) to be delivered as monitoring | | | | |

# 7 DOCUMENTATION

To document the fulfilment of the qualification requirements, a report with diagrams showing all curves comparing simulation and reference curves must be provided.

All individual ISO scores and the resulting overall scores per load case (for each of the six load cases) must be provided as well as the overall score for stages 2 and 3.