Version 1.0
May 2025

Passive Safety
HIII 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).

CONTENTS

1 INTRODUCTION

This document supports the Euro NCAP Supporting Protocol - Crash Protection - Virtual Testing 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 stage 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 5th percentile female (HF), Hybrid III 50th percentile male (H3) and Hybrid III 95 percentile male (HM).

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

https://openvt.eu/EuroNCAP/HIII-Qualification-BASt-Tests

https://openvt.eu/EuroNCAP/Safe-up-setup-HIII

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:

- CP025 - Hybrid III 5th Percentile Female dummy specification and certification
- CP027 - Hybrid III 50th Percentile Male dummy specification and certification
- CP028 - Hybrid III 95th Percentile Male dummy 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 match in all setups and between stages
- Active 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 with some time 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 curve trend 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 of the same percentile. This aspect is not currently covered by the certification requirement of Stage 1.

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

Table 1: Stage 2 configurations per dummy percentile

3.1Simulation setup

The setups must be built and conforming to the specifics described by the related certification requirement. At least 20 ms computation time before t0 (starting of the loading) must be simulated to be able to remove any bias. Additional computation time must be simulated (see new Table). Gravity shall be applied. Control cards must match in all tests.

Zeit	NEEX	NEFX	THLS	THHS	ULIL/ULIR
	200 ms	200 ms	100 ms	100 ms	50 ms

Table 2. Computation time for each stage 2 loadcase

3.2 Reference data

Reference signal data are provided under the link provided in the Introduction. (<Name_Database_Inhalt_Referenz_stage 2_curves>)

3.3 Output

Table 2 lists all required ISOMME outputs per test setup. Signals must be sampled with a frequency of 20 kHz. Units and directions of each channel must be aligned to the reference data, which is recorded and provided in SAE J211 standard.

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*			D0CHST0003HMDSXC
	Chest acceleration			D0CHST0000HMACX
				D0CHST0000HMACY
				D0CHST0000HMACZ
THLS	Impactor acceleration	T0IMPA000000ACXD	T0IMPA000000ACXD	
	Chest compression*	D0CHST0003HFDSXC	D0CHST0003H3DSXC	
	Chest acceleration	D0CHST0000HFACX	D0CHST0000H3ACX	
		D0CHST0000HFACY	D0CHST0000H3ACY	
		D0CHST0000HFACZ	D0CHST0000H3ACZ	
ULIL/ULIR		T0IMPA000000ACXD	T0IMPA000000ACXD	T0IMPA000000ACXD

*polynom calibrated

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

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 EuroNCAP 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 should be used.

3.4.1 Initial bias removal

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

- Determine the time point when the pendulum or impactor acceleration is larger than 5 g
- Realign the test channels with respect to t0.
- Move all test channels 10 ms to the right to evaluate initial part of the signal.

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 3. The provided reference data must be used as reference curves, whereas the simulation data must be used as evaluated curves.

Table 4. Intervals of channel evaluation for each loadcase

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

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 3. All weighting factors per channel, sensor and load case 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 (w_i) per channel for the acceleration of the thorax impactor test

Dummy	Channel	w_i
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 test per dummy size percentile. The sled tests differs in the magnitude of the pulse used. 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 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 small adaptations (see Figure 1 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)

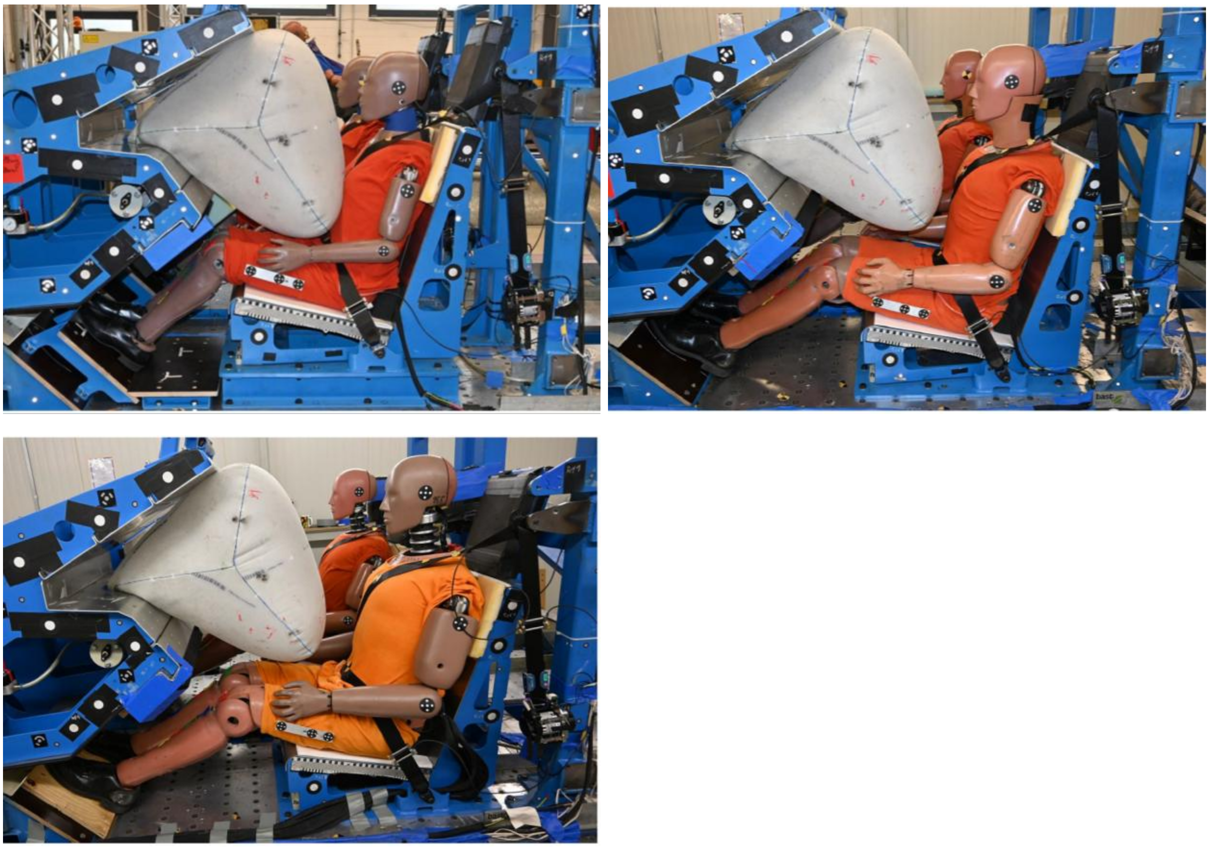

Figure 1: PDB/BASt sled environment for HF (top left), H3 (top right) and HM (bottom)

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) was generated based on BASt internal test with VW ID4 (model version 2022)

The two sled pulses are reported in Figure 2.

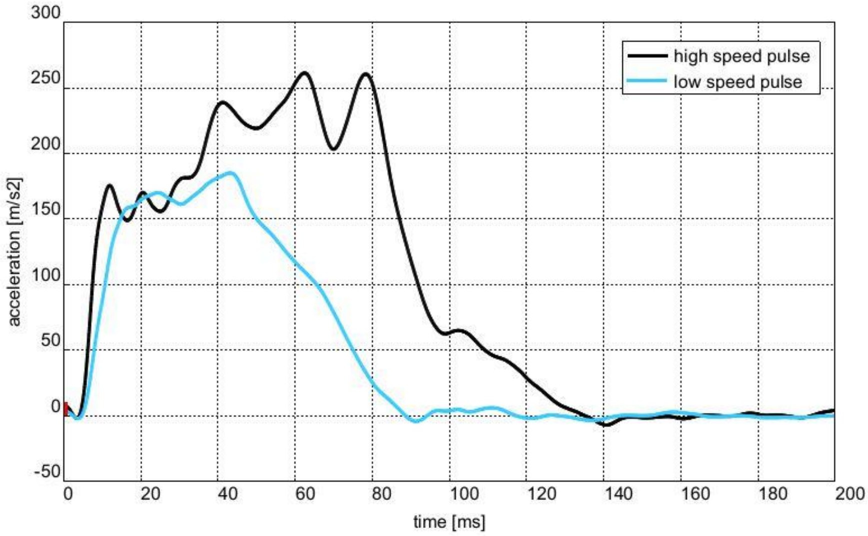

Figure 2: Acceleration profile for high speed pulse (initial velocity of 68 km/h, black) and low speed pulse (initial velocity of 35 km/h, cyan)

4.3 Reference data

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

Reference CAE data for the low and high speed sleds: mesh for sled environment, boundary conditions restraint settings and target position reference for model's posture alignment for

- HF
- H3
- HM

Reference signal data for

- Low speed sled test with initial velocity of 9,72 m/s
- High speed sled test with initial velocity of 18,88 m/s

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 3. 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.

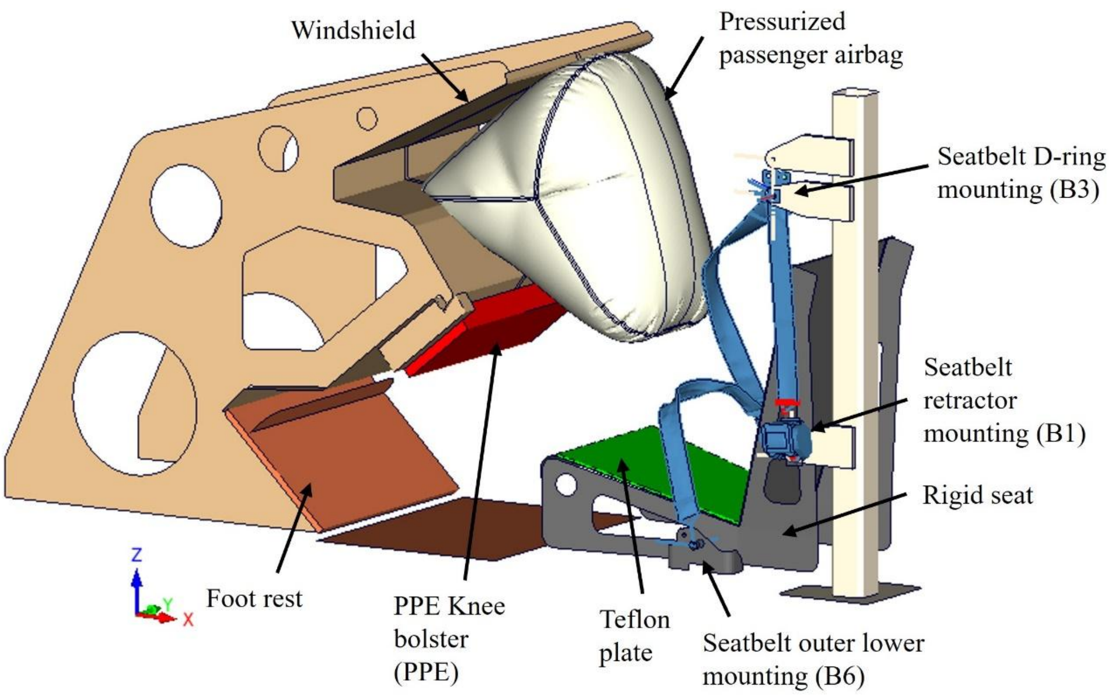

Figure 3: Sled environment as CAD image with description of individual parts

The dummy model is seated on a rigid seat pan. Between dummy and seatpan a 6,5 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 180 mm (height) x 60 mm (thickness) Expanded Polypropylene foam (EPP, density 60 kg/m³). The knee bolster foam is fixed on a 30 mm thick plywood which is fixed to the steel dashboard structure. Wooden parts were modelled through an EPP foam with density of 200 kg/m3. The 3-point belt is not connected to the seat (left-hand drive car seat), but to the rigid frame though attachment points. The belt path corresponds to a driver configuration. 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 models (HF, H3 and HM PDB/BASt sled test) have been developed and are available under the links provided in 4.3.1. 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 defied with coefficients of friction between:

- Dummy head – surrounding (e.g. airbag) : 0,5
- Dummy thorax, arms – surrounding: 0,3
- Dummy pelvis – surrounding: 0,2
- Dummy legs, feet – surrounding: 0,5
- Dummy – belt: 0,2
- Teflon plate - seat pan: 0,2

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 be used for the belt retractor.

Table 7: Activation time belt retractor

Pulse	**Low speed**			**High speed**		
Dummy	**HF**	**H3**	**HM**	**HF**	**H3**	**HM**
TTF Pretensioner [ms]	12			12		
TTF 2nd stage load limiter	22			50	-	-

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 for positioning dummy

Tilt angles [degree]			
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 for positioning dummy

Points coordinates [mm]									
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 Joint L	-30 ± 10	-110 ± 10	400 ± 10	20 ± 10	-130 ± 10	320 ± 10	70 ± 10	-135 ± 10	335 ± 10
Knee Joint 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 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 ≥ 160 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 5 lists all required ISOMME outputs per test setup. Signals must be sampled with a frequency of 20 kHz. Units and directions of each channel must be aligned to the reference data, which is recorded and provided in SAE J211 standard.

Table 5: List of required outputs of Stage 3 PDB/BASt setup. L/R refers to Left/Right

Output	Location
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 Y
Forces	Upper Neck X/Y/Z
	Thoracic Spine X/Y/Z (only HF)
	Lumbar Spine X/Z (only HF, H3)
	Iliac Spine 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 Y (only HF, H3)
	Iliac Spine L/R Y (only HF)
	Femur L/R (only HF)
	Upper Tibia L/R X/Y
	Lower Tibia L/R X/Y
Displacement	Chest X

Miscellaneous	Seatbelt (B1, B3, B6)

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 EuroNCAP 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 7 below)

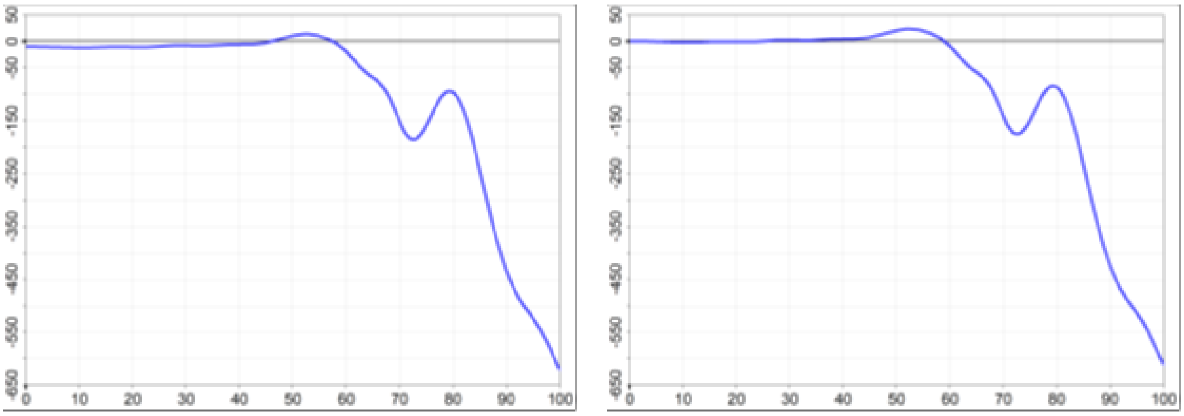

Figure 4: Channel bias removal

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 6. All necessary channels are listed in Table 5. The provided reference data must be used as reference curves, whereas the simulation data must be used as evaluated curves.

Table 6. Interval of evaluation for each PDB/BASt sled test

Load case	**Interval of evaluation**
HF Low und High Speed	10 – 95 ms
H3 Low und High Speed	10 – 110 ms

HM Low und High Speed	10 – 120 ms

4.5.2.2 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 **Error! Reference source not found.**4.

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 10: Weighting factors per dynamic output channel and sensor for HF, H3 and HM in the low speed (LS) nad 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

Table 11: Weighting factors per kinetik output channel and sensor for HF, H3 and HM in the low speed (LS) nad high speed (HS) PDB/BASt sled tests

Sensor	Channel	w_i					
		HF		H3		HM	
		LS	HS	LS	HS	LS	HS
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		
Iliac spine force left	S0ILACLE00H_FOXB						
Iliac spine force right	S0ILACRI00H_FOXB						
Femur force left	S0FEMRLE00H_FOZB						
Femur force right	S0FEMRRI00H_FOZB						
Upper Tibia force left	S0TIBILEUPH_FOXB	0,123	0,171	0,142	0,144	0,136	0,135
	S0TIBILEUPH_FOZB	0,843	0,776	0,858	0,856	0,828	0,819
Upper Tibia force right	S0TIBIRIUPH_FOXB	0,111	0,166	0,140	0,124	0,131	0,122
	S0TIBIRIUPH_FOZB	0,846	0,799	0,860	0,876	0,849	0,856
Lower Tibia force left	S0TIBILELOH_FOXB	0,200	0,261	0,134	0,140	0,135	0,134
	S0TIBILELOH_FOZB	0,774	0,713	0,866	0,860	0,834	0,839
Lower Tibia force right	S0TIBIRILOH_FOXB	0,221	0,269	0,127	0,148	0,145	0,140
	S0TIBIRILOH_FOZB	0,755	0,713	0,873	0,852	0,828	0,822
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		

Iliac spine moment left	S0ILACLE00H_MOYB						
Iliac spine moment right	S0ILACRI00H_MOYB						
Upper Tibia moment left	S0TIBILEUPH_MOXB	0,225	0,129	0,155	0,276	0,227	0,170
	S0TIBILEUPH_MOYB	0,775	0,871	0,845	0,724	0,773	0,830
Upper Tibia moment right	S0TIBIRIUPH_MOXB	0,147	0,108	0,321	0,369	0,192	0,239
	S0TIBIRIUPH_MOYB	0,853	0,892	0,679	0,631	0,808	0,761
Lower Tibia moment left	S0TIBILELOH_MOXB	0,180	0,111	0,215	0,209	0,273	0,550
	S0TIBILELOH_MOYB	0,820	0,889	0,785	0,791	0,727	0,450
Lower Tibia moment right	S0TIBIRILOH_MOXB	0,089	0,085	0,287	0,458	0,177	0,440
	S0TIBIRILOH_MOYB	0,911	0,915	0,713	0,542	0,823	0,560
Chest Deflection	S0CHST0000H_DSXC						
Diagonal belt force (B3)	S0SEBE0000B3FO0D						

5 STAGE 3 - FULL SCALE TESTS – TYPE 2 “AUTOLIV”

5.1 Loadcase Description

The validation load case consists of a generic frontal impact sled mimicking a mid-size European vehicle (Figure 1). 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 4), 3-pt seat belt system, shoulder belt retractor with 2kN pretensioner and 4kN load limiter, seat belt buckle with wire stalk, crash-locking tongue, and 2kN lap belt pretensioner, generic knee bolster (Figure 4), collapsible steering column, steering wheel and driver airbag (Figure 4). Steering wheel and steering column angle can be found in appendix A. The width of the seatbelt webbing (Rukaflex) was 47mm with a tension of 11,5kN 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 132N/mm. A rigid seatback with an 18° orientation to the vertical was used. Seat pan and sub pan angles can be found in appendix A. A 45°-foot support were also included.

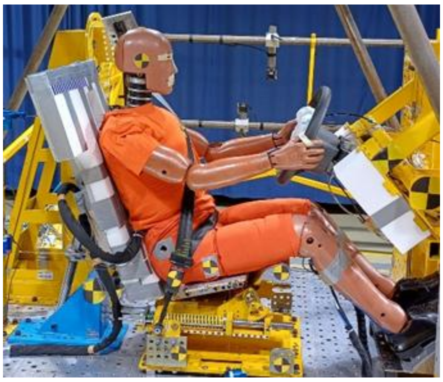
Figure 1: Generic Frontal Impact System Sled Set-up

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 100mm) 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 5.5kN with max deformation distance of 85mm.

The steering wheel was from a Volvo XC90 MY 2021. The generic airbag was a single chamber, coated fabric 55 litre bag with 2 x35mm 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 gasgenerator.

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 2.

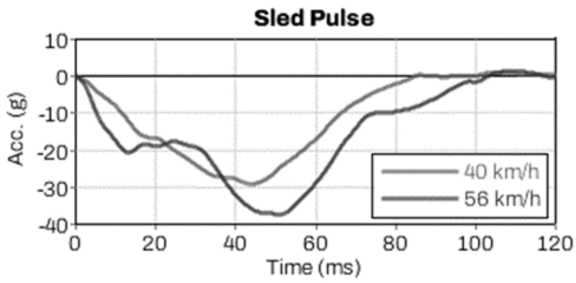

Figure 2: Time vs sled acceleration of the crash pulses at 40 km/h and 56 km/h used to perform the tests with the generic frontal system.

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/Safe-up-setup-HIII/-/tree/main/FRONTAL_IMPACT_SLED_MODEL?ref_type=heads

VPS frontal impact sled model:

- https://openvt.eu/EuroNCAP/Safe-up-setup-HIII/-/tree/main/VPS_Frontal_Impact_Sled_Model?ref_type=heads

Reference signal data for sled test with HIII 50M 40kph impact velocity

- https://openvt.eu/EuroNCAP/Safe-up-setup-HIII/-/tree/main/Test%20Data/H350M%2040kph/Autoliv-mean-H3-low_CFC60

Reference signal data for sled test with HIII 50M 56kph impact velocity

- https://openvt.eu/EuroNCAP/Safe-up-setup-HIII/-/tree/main/Test%20Data/H350M%2056kph/Autoliv-mean-H3-high_CFC60

Reference signal data for sled test with HIII 5F 40kph impact velocity

- https://openvt.eu/EuroNCAP/Safe-up-setup-HIII/-/tree/main/Test%20Data/H35F%2040kph/Autoliv-mean-HF-low_CFC60

Reference signal data for sled test with HIII 5F 56kph impact velocity

- https://openvt.eu/EuroNCAP/Safe-up-setup-HIII/-/tree/main/Test%20Data/H35F%2056kph/Autoliv-mean-HF-high_CFC60

Reference signal data for sled test with HIII 95M 40kph impact velocity

- https://openvt.eu/EuroNCAP/Safe-up-setup-HIII/-/tree/main/Test%20Data/H395M%2040kph/Autoliv-mean-HM-low_CFC60

Reference signal data for sled test with HIII 95M 56kph impact velocity

- https://openvt.eu/EuroNCAP/Safe-up-setup-HIII/-/tree/main/Test%20Data/H395M%2056kph/Autoliv-mean-HM-high_CFC60

3D faro scan H350

- https://openvt.eu/EuroNCAP/Safe-up-setup-HIII/-/tree/main/Test%20Data/3D_SCAN_HIII_50TH_PERCENTILE_MALE

3D faro scan H35F

- https://openvt.eu/EuroNCAP/Safe-up-setup-HIII/-/tree/main/Test%20Data/3D_SCAN_HIII_5TH_PERCENTILE_FEMALE

3D faro scan H395M

- https://openvt.eu/EuroNCAP/Safe-up-setup-HIII/-/tree/main/Test%20Data/3D_SCAN_HIII_95TH_PERCENTILE_MALE

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 3 & 4). The semi rigid seat model originates from the TUC homepage. The straps around the feet are modelled by means of friction.

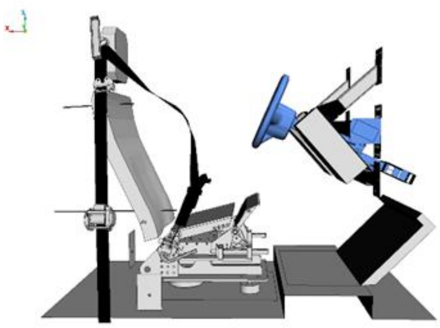

Figure 3: Generic frontal impact sled model

7.4.1.2 The dummy model is seated on a rigid seat pan of a semi-rigid seat (Figure 4 and Figure 5). 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 0.16-0.9:

- HIII – foot support: Fc = 0.9
- HIII – seatpan: Fc=0.3
- HIII – antisubmarining pan: Fc=0.35
- HIII – knee bolster: Fc=0.3
- HIII – driver airbag: Fc=0.3
- HIII – steering wheel: Fc=0.3
- HIII – ASIS: Fc=0.16
- HIII – 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.

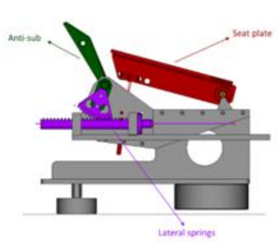	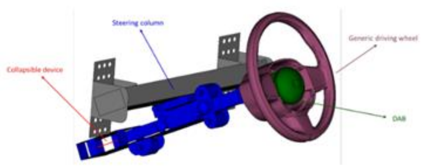	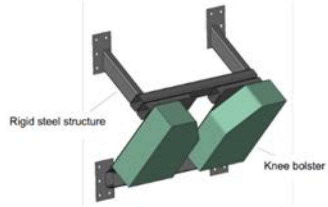
Semi-Rigid Seat	Steering column and steering wheel	Knee bolster

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

		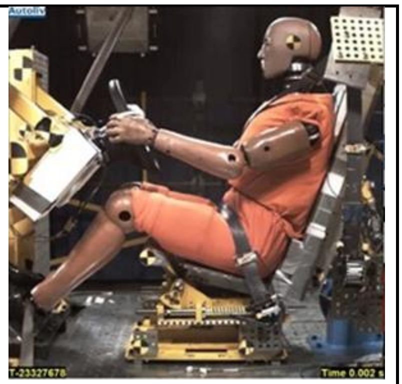
H350M	H35F	H395M

Figure 5: 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, shoulder belt to mouth and shoulder belt to neck distances are defined (Figure 5).

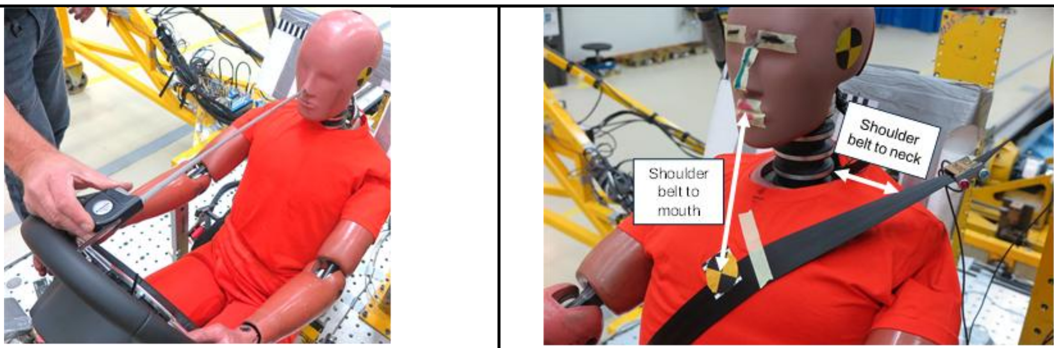

Figure 5: **Nose to Rim, Shoulder belt to Mouth and Shoulder Belt to Neck Measurements**

The target postures for the sled tests are provided in Table 12 - Table 14 for the H350M, table 2 for the H305 and table 3 for the H395

Table 12: Target position for H350M in Autoliv 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)		12(±2)/16(±2)	
Tibia angles LH/RH (Deg)		-47(±2)/-49(±1)	
Nose to upper rim (mm)	490		
Belt to neck (mm)	67(±3)		
Belt to mouth (mm)	175		

Table 13: Target position for H305F in Autoliv 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)		13(±1)/12(±1)	
Tibia angles LH/RH (Deg)		-52(±1)/-51(±1)	
Nose to upper rim (mm)	382		
Belt to neck (mm)	50(±3)		

Belt to mouth (mm)	160

Table 14: Target position for H395M in Autoliv 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(±1)/16(±1)	
Tibia angles LH/RH (Deg)		-54(±1)/53(±1)	
Nose to upper rim (mm)	485		
Belt to neck (mm)	77(±4)		
Belt to mouth (mm)	200		

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 ≥ 200 ms.

5.4 Outputs

5.4.1 Postprocessing of output channels

For each output channel generated, the sampling rate must be 20 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 15.

Table 15: List of required outputs of stage 3 Autoliv sled tests

Test	**Sled test slow / fast**
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/Z
	Iliac Spine L/R X (H305F)
	Femur L/R Z
	Upper Tibia L/R X/Y/Z (H350 & H305)
	Lower Tibia L/R X/Y/Z (H305 & H350)
Moments	Upper Neck X/Y/Z
	Lumbar Spine Y
	Iliac Spine L/R Y (H305F)
	Upper Tibia L/R X/Y (H350 & H305)
	Lower Tibia L/R X/Y (H350 & H305)
Displacement	Chest X
Miscellaneous	Seatbelt (B3)

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

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 CP 005
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 6 below)

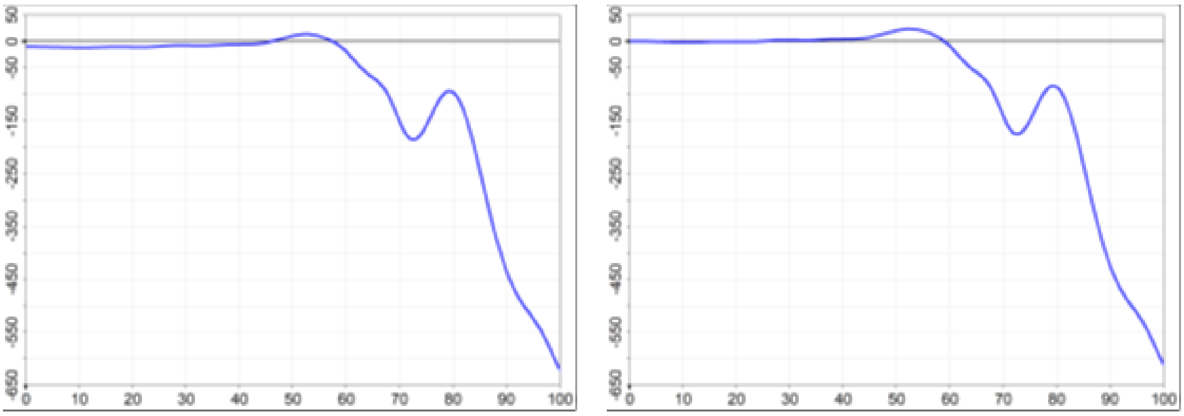

Figure 6: Channel bias removal

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 with CFC60, ‘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 16. All necessary channels are listed CP 005. The provided reference data must be used as reference curves, whereas the simulation data must be used as evaluated curves.

Table 16: Interval of evaluation for each Autoliv sled tests

Load case	Interval of evaluation
05F Low Speed	10 ms – 90 ms
05F High Speed	10 ms – 90 ms
50M Low Speed	10 ms – 100 ms
50M High Speed	10 ms – 110 ms
95M Low Speed	10 ms – 110 ms
95M High Speed	10 ms – 120 ms

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 17.

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 17: Weighting factors per channel and sensor for the Autoliv sled tests

Sensor	Channel	Weighting factor for load case					
		05F		50M		95M	
		Low	High	Low	High	Low	High
Head acceleration	S1HEAD0000H_ACXA	0.70	0.67	0.65	0.61	0.09	0.42
	S1HEAD0000H_ACYA	0.12	0.08	0.05	0.09	0.36	0.15
	S1HEAD0000H_ACZA	0.30	0.26	0.30	0.30	0.82	0.26
Head angular velocity	S1HEAD0000H_AVXD	0.17	0.16	0.16	0.18	0.67	0.03
	S1HEAD0000H_AVYD	0.58	0.45	0.75	0.68	0.07	0.19
	S1HEAD0000H_AVZD	0.25	0.38	0.10	0.14	0.21	0.05
Chest acceleration	S0CHST0000H_ACXC	0,62	0,58	0,75	0,73	0,69	0,64
	S0CHST0000H_ACYC	0,17	0,22	0,09	0,07	0,11	0,08
	S0CHST0000H_ACZC	0,21	0,20	0,16	0,20	0,20	0,28
Pelvis acceleration	S0PELV0000H_ACXB	0,42	0,46	0,56	0,57	0,59	0,60
	S0PELV0000H_ACYB	0,30	0,29	0,14	0,13	0,13	0,12
	S0PELV0000H_ACZB	0,28	0,24	0,29	0,31	0,28	0,28
Pelvis angular velocity	S0PELV0000H3AVYD						
Upper neck force	S0NECKUP00H_FOXA	0,29	0,27	0,31	0,26	0,21	0,19
	S0NECKUP00H_FOYA	0,03	0,07	0,04	0,07	0,06	0,05
	S0NECKUP00H_FOZA	0,68	0,66	0,64	0,67	0,73	0,76
Upper neck moment	S0NECKUP00H_MOXB	0,19	0,14	0,19	0,21	0,29	0,16
	S0NECKUP00H_MOYB	0,74	0,67	0,77	0,71	0,65	0,76
	S0NECKUP00H_MOZB	0,07	0,19	0,05	0,08	0,06	0,08
Lumbar spine force	S0LUSP0000H_FOXB	0,30	0,40	0,55	0,71	0,65	0,69
	S0LUSP0000H_FOZB	0,54	0,43	0,45	0,30	0,36	0,31
Lumbar spine moment	S0LUSP0000H_MOYB			0,77	0,79		
Iliac spine force left	S0ILACLE00H_FOXB						

Iliac spine force right	S0ILACRI00H_FOXB						
Iliac spine moment left	S0ILACLE00H_MOYB						
Iliac spine moment right	S0ILACRI00H_MOYB						
Femur force left	S0FEMRLE00H_FOZB						
Femur force Right	S0FEMRRI00H_FOZB						
Tibia left upper force X	S0TIBILEUPH3FOXB	0,08	0,07	0,12	0,09		
Tibia left upper force Z	S0TIBILEUPH3FOZB	0,93	0,94	0,88	0,91		
Tibia left upper moment X	S0TIBILEUPH3MOXB	0,34	0,30	0,18	0,21		
Tibia left upper moment Y	S0TIBILEUPH3MOYB	0,66	0,70	0,82	0,80		
Tibia left lower force X	S0TIBILELOH3FOXB	0,20	0,24	0,19	0,23		
Tibia left lower force Y	S0TIBILELOH3FOYB			0,02	0,03		
Tibia left lower force Z	S0TIBILELOH3FOZB	0,80	0,76	0,79	0,74		
Tibia left lower moment X	S0TIBILELOH3MOXB	0,27	0,26	0,25	0,19		
Tibia left lower moment Y	S0TIBILELOH3MOYB	0,73	0,75	0,75	0,81		
Tibia right upper force X	S0TIBIRIUPH3FOXB	0,07	0,10	0,12	0,13		
Tibia right upper force Z	S0TIBIRIUPH3FOZB	0,93	0,90	0,88	0,87		
Tibia right upper moment X	S0TIBIRIUPH3MOXB	0,23	0,24	0,29	0,31		
Tibia right upper moment Y	S0TIBIRIUPH3MOYB	0,77	0,76	0,71	0,69		
Tibia right lower force X	S0TIBIRILOH3FOXB	0,22	0,27	0,20	0,24		
Tibia right lower force Y	S0TIBIRILOH3FOYB			0,03	0,06		
Tibia right lower force Z	S0TIBIRILOH3FOZB	0,78	0,73	0,76	0,70		

Tibia right lower moment X	S0TIBIRILOH3MOXB	0,17	0,24	0,40	0,41		
Tibia right lower moment Y	S0TIBIRILOH3MOYB	0,83	0,76	0,60	0,59		
Chest Deflection	S0CHST0000H_DSXC						
Diagonal belt force (B3)	S0SEBE0000B3FO0D						

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 certification 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:

- CP025 - Hybrid III 5th Percentile Female dummy specification and certification
- CP027 - Hybrid III 50th Percentile Male dummy specification and certification
- CP028 - Hybrid III 95th Percentile Male dummy specification and certification

6.3 Stage 2 certification requirements

Following ISO requirements apply to each dummy percentile

Sensor	**Test**	**ISO Score**
Impactor acceleration	NEEX, NEFX, THLS, THHS, ULIL, ULIR	≥ 0,8
Chest acceleration	THLS, THHS	≥ 0,55
Angular rotation	NEEX, NEFX	≥ 0,75
Force	NEEX, NEFX	≥ 0,6
Moment	NEEX, NEFX	≥ 0,75
Chest displacement	THLS, THHS	≥ 0,85

6.4 Stage 3 certification 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

The following ISO requirements apply to each dummy percentile

Acceleration	Head	≥ 0.7
	Chest	≥ 0.5
	Pelvis	≥ 0.65
Angular rates	Head	≥ 0.5
	Chest	≥ 0.7 (only HM)
	Pelvis	≥ 0.55
Forces	Upper neck	≥ 0.5
	Thoracic spine	≥ 0.5 (only HF)
	Lumbar spine	≥ 0.5 (only HF, H3)
	Iliac spine L/R	≥ 0.5 (only HF)
	Femur L/R	≥ 0.3
	Upper Tibia	≥ 0.5
	Lower Tibia	≥ 0.5
Moments	Upper neck	≥ 0.5
	Thoracic spine	≥ 0.5 (only HF)
	Lumbar spine	≥ 0.6 (only HF, H3)
	Iliac spine L/R	≥ 0.5 (only HF)
	Femur L/R	Monitoring (only HF)
	Upper Tibia	Monitoring
	Lower Tibia	Monitoring
Displacement	Chest compression	≥ 0.7
Miscellaneous	Seatbelt	≥ 0.5 (B1, B3, B6)

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.