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Data Acquisition
And Injury Calculation

Crash Protection

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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 TEST DATA

A complete Euro NCAP assessment consists of many tests. To ensure consistency in the general folder structure, this chapter details the required folder structure. For each (sub)test where measurements are performed on dummies, vehicles or other test equipment, all test data needs to be provided in ISO-MME 1.6 format and needs to be fully compliant with the ISO/TS 13499 standard. It should be noted that some filenames are also prescribed in this document. All data shall be provided using SI units unless specified otherwise.

1.1 General test series folder structure

The following folder structure, generated automatically in the Euro NCAP sharing platform, is to be used for all test series where the name of the main folder containing all tests consists of:

- The year of test
- OEM abbreviation
- Euro NCAP internal number (4 digits)
- Make and Model

Where Euro NCAP tests contain a number of sub-tests, the next paragraph details the folder structure, names of the sub-system test folders and where applicable the filenames.

On the highest level, the folder structure is as follows with on the right an example using the Volvo XC90 that is assumed to be tested in 2026 with a Euro NCAP internal number of 9999.

• **MAIN FOLDER NAME**	• **26-VOL-9999-Volvo XC90**	**Uploaded by:**
Frontal MPDB test folder	26-VOL-9999-MP1	Laboratory
Frontal FW test folder	26-VOL-9999-FW1	Laboratory
Frontal Sled & VT test folder	26-VOL-9999-VTF	OEM
Side MDB test folder	26-VOL-9999-MD1	Laboratory
Side Pole test folder	26-VOL-9999-PO1	Laboratory
Far side test folder	26-VOL-9999-FAR	OEM
Knee mapping test folder	26-VOL-9999-KNE	OEM
Whiplash tests folder	26-VOL-9999-WHL	Laboratory
Child Occupant Protection folder	26-VOL-9999-COP	Laboratory
VRU test folder	26-VOL-9999-VRU	Laboratory
Post crash folder	26-VOL-9999-RES	Laboratory
Inspection folder	26-VOL-9999-INS-*lab name*	Laboratory

Where a retest is performed, the identifier for that load case MP, FW etc. will have the last digit increased by 1. For example MP2 etc.

1.1.1 MPDB sub-test folders

MAIN FOLDER NAME	26-VOL-9999-Volvo XC90
…	…
Frontal MPDB test number	26-VOL-9999-MP1
Channel	Channel
Document	Document
Movie	Movie
Photo	Photo
Report	Report
Static	Static
MME-file	26-VOL-9999-MP1.mme
…	…

1.1.2 FW sub-test folders

MAIN FOLDER NAME	26-VOL-9999-Volvo XC90
…	…
Frontal FW test number	26-VOL-9999-FW1
Channel	Channel
Document	Document
Movie	Movie
Photo	Photo
Report	Report
Static	Static
MME-file	26-VOL-9999-FW1.mme
…	…

1.1.3 Virtual Testing & Sled for Frontal sub-test folders

The Frontal VT & Sled test data folder contains eight sub-test folders, two for sled tests and six for virtual tests. This is data provided to Euro NCAP by the OEM. Note: In accordance with the VTC protocol, Euro NCAP will assign a unique test number that must be visible in all of the physical sled tests.

• **MAIN FOLDER NAME**	• **26-VOL-9999-Volvo XC90**
…	…
Sled & VT Sled test folder	26-VOL-9999-VTF
Sled-Mid 50th & 95th	9999-SM_50_95-1
Sled-High 95th & 5th	9999-SH_95_05-1
Channel	Channel
Document	Document
Report	Report
Movie	Movie
Photo	Photo
MME-file	9999-SH_95_05-1.mme
Virtual-Low 50th & 5th	9999-VL_50_05-1
Virtual-High 5th & 95th	9999-VH_05_95-1
…	…
…	…

In the case that the driver and passenger are modelled separately (see Virtual Testing protocol 4.3), the virtual test data shall be provided in separate folders. For each of the 6 virtual tests, one folder shall be dedicated to the driver, another folder to the passenger. The suffixes "_dr" and "_pa" must added for separate driver and passenger test data folders. Example: 9999-VL_50_05_1_dr.

1.1.4 Side MDB sub-test folders

• **MAIN FOLDER NAME**	• **26-VOL-9999-Volvo XC90**
…	…
Side MDB test number	26-VOL-9999-MD1
Channel	Channel
Document	Document
Movie	Movie
Photo	Photo
Report	Report
Static	Static
MME-file	26-VOL-9999-MD1.mme
…	…

1.1.5 Side Pole sub-test folders

- **MAIN FOLDER NAME**
  - …
  - Side pole test number
    - Channel
    - Document
    - Movie
    - Photo
    - Report
    - Static
    - MME-file
  - …

- **26-VOL-9999-Volvo XC90**
  - …
  - 26-VOL-9999-PO1
    - Channel
    - Document
    - Movie
    - Photo
    - Report
    - Static
    - 26-VOL-9999-PO1.mme
  - …

1.1.6 Virtual Testing & Sled for Far side sub-test folders

The Far side VT & sled test data folder contains ten sub-test folders, two for sled tests and eight for virtual tests. This is data provided to Euro NCAP by the OEM. Note: In accordance with the VTC protocol, Euro NCAP will assign a unique test number that must be visible in the physical far side sled tests.

- **MAIN FOLDER NAME**
  - …
  - Far Side test number
    - Main AE-MDB Sled
    - Main AE-MDB Virtual
    - Main Pole Sled
      - Channel
      - Document
      - Report
      - Movie
      - Photo
      - MME-file
  - …

- **26-VOL-9999-Volvo XC90**
  - …
  - 26-VOL-9999-FAR
    - 9999-SAE_M_75R-1
    - 9999-VAE_M_75R-1
    - 9999-SPO_M_75R-1
      - Channel
      - Document
      - Report
      - Movie
      - Photo
      - 9999-SPO_M_75R-1.mme
  - …

1.1.7 Knee mapping sub-test folders

The Knee mapping test folder contains a number of sub-test folders, one for each knee mapping test. This is data provided to Euro NCAP by the OEM.

- **MAIN FOLDER NAME**
  - …
  - Knee mapping
    - <Test number>
    - <Test number>
      - Channel
      - Movie
      - Photo
        - MME-file
  -

- **26-VOL-9999-Volvo XC90**
  - …
  - 26-VOL-9999-KNE
    - 26-VOL-9999-KNE-1
    - 26-VOL-9999-KNE-2
      - Channel
      - Movie
      - Photo
        - 26-VOL-9999-KNE-2.mme
  - …

1.1.8 Whiplash sub-test folders

The Whiplash test folder contains 4 sub-test folders. Two contain the dynamic data from the two dynamic pulses tested; Medium and High. In addition, the static whiplash data is contained in a separate folder, which also contains the static measurement file. The whiplash test report and the summary data plot report will be filed in the main Whiplash folder.

- **MAIN FOLDER NAME**
  - …
  - Whiplash tests folder
    - <Whiplash Medium test number>
      - MME-file
    - <Whiplash High test number>
    - MME-file<Whiplash Static test number>
      - Static measurement file .xlsx
      - Whiplash test report .pdf
    - <Whiplash Rear test number>
      - Static measurement file .xlsx
      - Rear whiplash test report .pdf
      - Photo
  - …

- **26-VOL-9999-Volvo XC90**
  - …
  - 26-VOL-9999-WHL
    - 26-VOL-9999-WM1
      - 26-VOL-9999-WM1.mme
    - 26-VOL-9999-WH1
      - 26-VOL-9999-WH1 .mme
    - 26-VOL-9999-WHS
      - 26-VOL-9999-WHLStatic .xls
      - 26-VOL-9999-WHL .pdf
    - 26-VOL-9999-WHR
      - 26-VOL-9999-WHRStatic .xls
      - 26-VOL-9999-WHR .pdf
      - Photo
  - …

1.1.9 COP sub-test folders

The COP test folder contains 3 sub-test folders. They contain pictures and documents from both vehicle based assessment and the CRS installation checks as well as the vehicle manual (COP section). The COP test report will be filed in the main COP folder.

- **MAIN FOLDER NAME**
  - …
  - COP tests folder
    - CRS installation
    - Vehicle based assessment
    - Manual - CRS vehicle lists
    - COP test report .pdf
  - …

- **26-VOL-9999-Volvo XC90**
  - …
  - 26-VOL-9999-COP
    - CRS installation
    - Vehicle based assessment
    - Manual-CRS vehicle lists
    - 26-VOL-9999-COP .pdf
  - …

1.1.10 Vulnerable road user sub-test folders

The Vulnerable Road User test folder contains five sub-test folders. The document, photo, report and static folders containing general files from all tests including certification documents, test temperatures and grid/test point 3D measurements. The folder test data contains a folder for every tested point. For each of these tests there will be a separate sub-test folder (e.g. A10-5 folder), which needs to contain the channel and picture folders and the MME-file. The movie folder is needed where filming has been performed as defined in the film and photo protocol.

The test numbers for each sub-test consists of the Euro NCAP test number followed by the GRID point label.

The test report and the summary data plot report should be in the main report folder where the summary data plot report should contain all plots of all tests combined in one file called (26-VOL-9999-VRU.pdf).

- **MAIN FOLDER NAME**
  - …
  - VRU tests folder
    - Document
    - Photo – grid and selected points
    - Report
    - Static
    - Test data
      - <Adult Headform test number>
      - <Child Headform test number>
      - …
      - <Upper Legform test number>
      - …
      - <Legform test number>
        - Channel
        - Movie
        - Photo
        - Report
          - MME-file
  - …

- **26-VOL-9999-Volvo XC90**
  - …
  - 26-VOL-9999-VRU
    - Document
    - Photo
    - Report
    - Static
    - Test data
      - 9999-VRU-A10-5
      - 9999-VRU-C3+1
      - …
      - 9999-VRU-U+2
      - …
      - 9999-VRU-L-4
        - Channel
        - Movie
        - Photo
        - Report
          - 26-VOL-9999-VRU-L-4.mme
  - …

1.1.11 Post Crash folder structure

The Post Crash folder contains one sub-test folder for each crash test.

MAIN FOLDER NAME	**26-VOL-9999-Volvo XC90**
…	…
Post Crash	26-VOL-9999-RES
Direct hazard disabling.pdf	Direct hazard disabling.pdf
12v drop door opening	12v drop door opening
EDR delta V	EDR delta V

1.1.12 Inspection folder structure

The Inspection test folder contains one sub-test folder for each crash test.

MAIN FOLDER NAME	**26-VOL-9999-Volvo XC90**
…	…
Inspection	26-VOL-9999-INS
MPDB inspection photos	26-VOL-9999-MP1
FW inspection photos	26-VOL-9999-FW1
AE-MDB inspection photos	26-VOL-9999-MD1
Pole inspection photos	26-VOL-9999-PO1
…	…

1.2 ISO MME folder structure

The ISO MME folder structure is to be applied to all applicable tests and the files contained in these folders follow the ISO/TS 13499 standard. The main directory contains six folders and two files. The following folders and files (comment files when needed) need to be provided for every test performed, where the test number is the one as specified in the previous section.

For each file and folder (where necessary) the required contents are specified in detail in the paragraphs below.

- **TEST NUMBER**
  - Channel
  - Document
  - Movie
  - Photo
  - Report
  - Static
  - <test number>.mme
  - <test number>.txt

1.2.1 Channel folder

The channel folder contains all channels from the vehicle, impactors and dummies used in the test as defined in Section 2.

- **TEST NUMBER**
  - Channel
    - <test number>.xxx
    - <test number>.chn
  - …

1.2.2 Document folder

The document folder contains the calibration documents and temperature log files for the test dummies used in the test.

- **TEST NUMBER**
  - …
  - Document
    - < test number _ name of document file 1>
    - < test number _ name of document file d>
  - …

1.2.3 Movie folder

The movie folder contains the inspection quality films, using the exact names as specified in the Euro NCAP Film and Photo protocol.

- **TEST NUMBER**
  - …
  - Movie
    - < test number _ name of movie file 1>
    - < test number _ name of movie file m>
  - …

1.2.4 Photography folder

The photography folder contains the inspection quality photos in two folders “Before” and “After”, where the name of the photo file consists of the test number followed by a number as specified in the Euro NCAP Film and Photo protocol.

- **TEST NUMBER**
  - …
  - Photo
    - Before
    - < test number _ name of photo file 1>
    - < test number _ name of photo file p>
    - After
    - < test number _ name of photo file 1>
    - < test number _ name of photo file p>
  - …

1.2.5 Report folder

The report folder contains the test report containing the assessment data as described in the different test protocols and the data plots.

- **TEST NUMBER**
  - …
  - Report
    - < test number _ name of test report>
    - < test number _ name of data plots>
    - < test number _ Belt buckle force report>
    - < test number _ Door opening force report>
    - < test number _ High voltage report>
    - < test number _ Dummy temperatures .xls>
  - …

1.2.6 Static folder

The static folder contains the static measurements file where applicable containing the data as described in the different test protocols. In the MPDB test, this folder shall also contain the data required for the compatibility assessment and details of barrier reconstruction where applicable. Please note, the raw data file of the MPDB face scan is not required. In AE-MDB and pole impacts, this folder shall contain the post test door intrusion measurements. Where applicable, HPD and HCz reports shall be provided in the static folder for the relevant side or pole impact test.

- **TEST NUMBER**
  - Frontal MPDB test number
    - Static
    - < test number _ name of static measurement file>
    - < test number _ Compatibility assessment .xlsx>
  - …

  - Side MDB and Side Pole test number
    - Static
    - < test number _ Door intrusion measurements file
    - < test number _ HPD report file> (pole test only)
    - < test number _ HCz report file> (pole test only)
  - …

1.2.7 MME-file

The mme-file contains the information of the test where the type of test and subtype of test shall be selected from the table below.

- **TEST NUMBER**
  - …
  - <test number>.mme

The mme-file shall contain at least the following header:

Item	Header	Remarks
Data format edition number	:1.6	
Laboratory name	:<lab name>	
Customer name	:Euro NCAP	
Customer test ref. number	:<test number>	
Customer project ref. number	:<test series number>	4 digits number, e.g. 9999
Title	:Euro NCAP <rating year>	Rating year, e.g. 2026
Timestamp	:<date> <time>	Date and time of MME file
Type of the test	:<see table>	
Subtype of the test	:<see table>	
Date of the test	:<date>	Date of test
Name of test object 1	:<make and model>	Make and Model exactly as per Euro NCAP Dashboard
Ref. number of test object 1	:<VIN >	
Velocity test object 1	:<VUT speed>	Actual test velocity of VUT
Mass test object 1	:<VUT mass>	Test mass of the VUT
Driver position object 1	:<1/3>	LHD=1, RHD=3
Impact side test object 1	:<LE,RI>	
Name of test object 2	:<name of the target>	See 1.2.7.3
Velocity test object 2	:<target velocity>	Actual test velocity of target
Type of data source	:<type>	Simulation or Hardware

Additional mandatory lines when the “Type of data source” is Simulation:

Item	Header	Remarks
.Combined or Separate SimM	:<combined / separate>	Combined/Separate in case of combined/separate modelling.
.Simulation Model of dummy 1	:<dummy simulation model type> <name> <version> (<supplier>)	e.g. HIII vxx (Humanetics) In case of separate passenger model: NOVALUE
.Qualification Ref dummy 1	:<name of pdf>.pdf	Reference to Document name e.g. xxx.pdf. In case of separate passenger model: NOVALUE
.Simulation Model of dummy 2	:<dummy simulation model type> <name> <version> (<supplier>)	e.g. HIII vxx (Humanetics) In case of separate driver model: NOVALUE
.Qualification Ref dummy 2	:<name of pdf>.pdf	Reference to Document name e.g. xxx.pdf. In case of separate driver model: NOVALUE
.Solver Name	: <FE software name>	e.g. LS-Dyna
.Solver Version	:<FE software solver version>	e.g. ls-dyna_mpp_s_R9_3_1_x64_centos65_ifort131_sse2_openmpi183
.Solver Precision	:<Solver precision>	SP or DP
.Platform Name	:<name of platform on which simulations have been run>	e.g. centos78_openmpi2.1.3
.Number of CPUs	:<cores x CPUs>	e.g. 2x32
.Time step setting	:<min. time step size in seconds>	e.g. min. time step 1-e7 s
.Contact Type dummy -seat	:<contact type documentation>	e.g. S2S SOFT2 nu=0.2
.Contact Type dummy -belt	:<contact documentation>	e.g. S2S SOFT2 nu=0.
.Contact Type dummy -airbag	:<contact documentation>	e.g. S2S SOFT2 nu=0.
.Number of contacts	: <total number of contacts>	Number of contacts used in the overall simulation setup e.g. 10
.Number of elements	: <total number of elements>	e.g. 20000
.Mass of total setup in kg	:<total mass in kg>	e.g. 1500 (used for quality checks)
.Mass of dummy 1 in kg	:<total mass in kg>	e.g. 75 (used for quality checks) - mass of driver dummy In case of separate passenger model: NOVALUE
.Mass of dummy 2 in kg	:<total mass in kg>	e.g. 75 (used for quality checks) - mass of passenger dummy In case of separate driver model: NOVALUE
.Mass of seat 1 in kg	: <total mass in kg>	e.g. 50 (used for quality checks)
.Mass of seat 2 in kg	: <total mass in kg>	e.g. 50 (used for quality checks)

Note: the non-standard attributes need to be preceded by a point “.xxx”

1.2.7.1 Customer test ref. number

Element	Type of test	Sub-type of test	Customer test ref. number
Frontal Impact	Offset	MPDB-50	26-VOL-9999-MP?
	Full Width	FWDB-35	26-VOL-9999-FW?
	Sled & VT	Sled-Mid Sled-High Virtual-Low Virtual-Mid Virtual-High	9999-SM_50_95 9999-SH_95_05 9999-VL_50_05 9999-VL_05_50 9999-VM_50_95 9999-VM_50HBM 9999-VH_95_05 9999-VH_05_95
Side Impact	MDB	AEMDB-60	26-VOL-9999-MD?
	Pole	Pole-32	26-VOL-9999-PO?
	Far side	Main-AEMDB Main-Pole Robustness-AEMDB Robustness-Pole	9999-SAE_M_75R 9999-VAE_M_75R 9999-SPO_M_75R 9999-VPO_M_75R 9999-VAE_R_60R 9999-VAE_R_75H 9999-VPO_R_90R 9999-VPO_R_90H 9999-VPO_R_75H 9999-VPO_R_90R
Rear Impact	Whiplash	Rear-Mid Rear-High	26-VOL-9999-WM? 26-VOL-9999-WH?
VRU Impact	Head impact	Headform	26-VOL-9999-A? 26-VOL-9999-C?
	Pelvis & Leg impact	Upper Legform Legform	26-VOL-9999-U? 26-VOL-9999-L?

1.2.7.2 Type and Sub-type of test

The type and subtype of tests is summarised below:

Euro NCAP test	Type of Test	Sub-type of test
Frontal Offset	Frontal Impact	MPDB-50
Frontal FW	Frontal Impact	FWDB-35
Frontal Sled & VT	Frontal Impact	Virtual-Low Sled-Mid Virtual-Mid Sled-High Virtual-High
Side MDB	Side Impact	AEMDB-60
Side Pole	Side Impact	Pole-32
Side Far side	Side Impact	Main-AEMDB Main-Pole Robustness-AEMDB60 Robustness-AEMDB75high Robustness-AEMDB90 Robustness-AEMDB90high Robustness-Pole75high Robustness-Pole90
Rear Whiplash	Rear Impact	Rear-Mid Rear-High
VRU	VRU Impact	Headform Upper Legform Legform

1.2.7.3 Name of test object 2

Element	Sub-element	Name of test object 2
Frontal Impact	Offset	MPDB
	Full Width	FWDB
	Sled & VT	-
Side Impact	MDB	AE-MDB
	Pole	Pole
	Far side	-
Rear Impact	Whiplash	-
VRU Impact	Head impact	Adult Headform Child Headform
	Pelvis Leg impact	Upper Legform aPLI

1.2.8 Txt file

The text file contains details of any test artefacts, errors or warnings associated with the test and how they should be considered.

- **TEST NUMBER**
  - …
  - <test number>.txt

2 CHANNEL NAMES AND FILTERS

For each dummy, impactors and test objects used in the different Euro NCAP tests, both physical and virtual, the following channel names shall be used. All channels shall be supplied either unfiltered or prefiltered. The appropriate filters for calculation of injury criteria and plotting of these channels will be performed by the analysis software used.

2.1 Hybrid III 50%

Location	Parameter	ISO code	CFC
Head	Accelerations, A_x A_y A_z	??HEAD0000H3AC[X,Y,Z]P	1000
Neck	Forces, F_x F_y F_z	??NECKUP00H3FO[X,Y,Z]P	1000
	Moments, M_x M_y M_z	??NECKUP00H3MO[X,Y,Z]P	600
Chest	Accelerations, A_x A_y A_z	??CHST0000H3AC[X,Y,Z]P	180
	Deflection, D_{chest}	??CHST0003H3DSXP	180
	Temperature, T	??THSP0000H3TE0P	-
Pelvis	Accelerations, A_x A_y A_z	??PELV0000H3AC[X,Y,Z]P	600
Lumbar Spine	Forces, F_x F_z	??LUSP0000H3FO[X,Z]P	600
	Moments, M_y	??LUSP0000H3MOYP	600
Femurs	Forces, F_z	??FEMR[LE,RI]00H3FOZP	600
Knees	Displacements, D_{knee}	??KNSL[LE,RI]00H3DSXP	180
Upper Tibia	Forces, F_x F_z	??TIBI[LE,RI]UPH3FO[X,Z]P	600
	Moments, M_x M_y	??TIBI[LE,RI]UPH3MO[X,Y]P	600
Lower Tibia	Forces, F_x F_z (F_y)	??TIBI[LE,RI]LOH3FO[X,Y,Z]P	600
	Moments, M_x M_y	??TIBI[LE,RI]LOH3MO[X,Y]P	600

For virtual tests, the following channels are to be added:

Location	Parameter	ISO code	CFC
Head	Global Coordinates x,y,z	??HEAD0000H3DC[X,Y,Z]P	-
Chest	Global Coordinates x,y,z	??CHST0000H3DC[X,Y,Z]P	-
Pelvis	Global Coordinates x,y,z	??PELV0000H3DC[X,Y,Z]P	-
Complete dummy	Kinetic Energy	??EKINSU00H3EN00	-
	Internal Energy	??EINTSU00H3EN00	-
	Hourglass Energy	??EHOUSU00H3EN00	-
	Added Mass (absolute)	??MINCSU00H3MA00	-

THOR 50%

Location	Parameter	ISO code	CFC
Head	Acceleration, A_x A_y A_z	??HEAD0000T3AC[X,Y,Z]P	1000
	Angular rate sensor	??HEAD0000T3AV[X,Y,Z]P	60
2.2	Tilt sensor, X Y	??HEADPR00T3AN[X,Y]P	-
Neck cable	Force, F_z	??NECK[FR,RE]00T3FOZP	1000
Upper Neck	Forces, F_x F_y F_z	??NECKUP00T3FO[X,Y,Z]P	1000
	Moments, M_x M_y M_z	??NECKUP00T3MO[X,Y,Z]P	600
T1	Acceleration, A_x A_y A_z	??THSP0100T3AC[X,Y,Z]P	600
T4	Acceleration, A_x A_y A_z	??THSP0400T3AC[X,Y,Z]P	600
Clavicle	Force, F_x F_z (Inner & Outer)	??CLAVLE[IN,OU]T3FO[X,Z]P	600
Thorax	Distance, DC0	??CHST[LE,RI][UP,LO]T3DC0P	180
	Angle, Y Z	??CHST[LE,RI][UP,LO]T3AN[Y,Z]P	180
	Temperature, T	??THSP0000THTE0P	-
Mid Sternum	Acceleration, A_x	??STRN0000T3ACXP	600
Abdomen	Distance, DC0	??ABDO[LE,RI]00T3DC0P	180
	Angle, Y Z	??ABDO[LE,RI]00T3AN[Y,Z]P	180
	Acceleration, A_x	??ABDO0000T3AC[X,Y,Z]P	600
T12	Acceleration, A_x A_y A_z	??THSP1200T3AC[X,Y,Z]P	180
	Force, F_x F_y F_z	??LUSP0000T3FO[X,Y,Z]P	600
	Moment, M_x M_y	??LUSP0000T3MO[X,Y]P	600
Pelvis	Acceleration, A_x A_y A_z	??PELV0000T3AC[X,Y,Z]P	600
	Tilt sensor, X Y	??PELVPR00T3AN[X,Y]P	-
ASIS	Force, F_x,	??ILAC[LE,RI]00T3FOXP	600
	Moment, M_y	??ILAC[LE,RI]00T3MOYP	600
Acetabulum	Force, F_x F_y F_z	??ACTB[LE,RI]00T3FO[X,Y,Z]P	600
	Moment, M_y	??ACTB[LE,RI]00T3MOYP	600
Femurs	Force, F_x F_y F_z	??FEMR[LE,RI]00T3FO[X,Y,Z]P	600
	Moment, M_x M_y M_z	??FEMR[LE,RI]00T3MO[X,Y,Z]P	
Knees	Displacement, D_{knee}	??KNSL[LE,RI]00T3DSXP	180
Upper Tibia	Force, F_x F_z	??TIBI[LE,RI]UPT3FO[X,Z]P	600
Upper Tibia	Moment, M_x M_y	??TIBI[LE,RI]UPT3MO[X,Y]P	600
Lower Tibia	Force, F_x F_z	??TIBI[LE,RI]LOT3FO[X,Y,Z]P	600
	Moment, M_x M_y	??TIBI[LE,RI]LOT3MO[X,Y]P	600

Hybrid III 5%

Location	Parameter	ISO code	CFC
Head	Accelerations, A_x A_y A_z	??HEAD0000HFAC[X,Y,Z]P	1000
Neck	Forces, F_x F_y F_z	??NECKUP00HFFO[X,Y,Z]P	1000
2.3	Moments, M_x M_y M_z	??NECKUP00HFMO[X,Y,Z]P	600
Chest	Accelerations, A_x A_y A_z	??CHST0000HFAC[X,Y,Z]P	180
	Deflection, D_{chest}	??CHST0003HFDSXP	180
	Temperature, T	??THSP0000HFTE0P	-
Pelvis	Accelerations, A_x A_y A_z	??PELV0000HFAC[X,Y,Z]P	600
Iliac	Forces, F_x	??ILAC[LE,RI]00HFFOXP	600
	Moments, M_y	??ILAC[LE,RI]00HFMOYP	600
Lumbar Spine	Forces, F_x F_z	??LUSP0000HFFO[X,Z]P	600
	Moments, M_y	??LUSP0000HFMOYP	600
Femurs	Forces, F_z	??FEMR[LE,RI]00HFFOZP	600
Knees	Displacements, D_{knee}	??KNSL[LE,RI]00HFDSXP	180
Upper Tibia	Forces, F_x F_z	??TIBI[LE,RI]UPHFFO[X,Z]P	600
	Moments, M_x M_y	??TIBI[LE,RI]UPHFMO[X,Y]P	600
Lower Tibia	Forces, F_x F_z (F_y)	??TIBI[LE,RI]LOHFFO[X,Y,Z]P	600
	Moments, M_x M_y	??TIBI[LE,RI]LOHFMO[X,YP	600

For virtual tests, the following channels are to be added:

Location	Parameter	ISO code	CFC
Head	Global Coordinates x,y,z	??HEAD0000HFDC[X,Y,Z]P	-
Chest	Global Coordinates x,y,z	??CHST0000HFDC[X,Y,Z]P	-
Pelvis	Global Coordinates x,y,z	??PELV0000HFDC[X,Y,Z]P	-
Complete dummy	Kinetic Energy	??EKINSU00HFEN00	-
	Internal Energy	??EINTSU00HFEN00	-
	Hourglass Energy	??EHOUSU00HFEN00	-
	Added Mass (absolute)	??MINCSU00HFMA00	-

Hybrid III 95%

Location	Parameter	ISO code	CFC
Head	Accelerations, A_x A_y A_z	??HEAD0000HMAC[X,Y,Z]P	1000
Neck	Forces, F_x F_y F_z	??NECKUP00HMFO[X,Y,Z]P	1000
2.4	Moments, M_x M_y M_z	??NECKUP00HMMO[X,Y,Z]P	600
Chest	Accelerations, A_x A_y A_z	??CHST0000HMAC[X,Y,Z]P	180
	Deflection, D_{chest}	??CHST0003HMDSXP	180
	Temperature, T	??THSP0000HMTE0	-
Pelvis	Accelerations, A_x A_y A_z	??PELV0000HMAC[X,Y,Z]P	600
Lumbar Spine	Forces, F_x F_z	??LUSP0000HMFO[X,Z]P	600
	Moments, M_y	??LUSP0000HMMOYP	600
Femurs	Forces, F_z	??FEMR[LE,RI]00HMFOZP	600
Knees	Displacements, D_{knee}	??KNSL[LE,RI]00HMDSXP	180
Upper Tibia	Forces, F_x F_z	??TIBI[LE,RI]UPHMFO[X,Z]P	600
	Moments, M_x M_y	??TIBI[LE,RI]UPHMMO[X,Y]P	600
Lower Tibia	Forces, F_x F_z (F_y)	??TIBI[LE,RI]LOHMFO[X,Y,Z]P	600
	Moments, M_x M_y	??TIBI[LE,RI]LOHMMO[X,Y]P	600

For virtual tests, the following channels are to be added:

Location	Parameter	ISO code	CFC
Head	Global Coordinates x,y,z	??HEAD0000HMDC[X,Y,Z]P	-
Chest	Global Coordinates x,y,z	??CHST0000HMDC[X,Y,Z]P	-
Pelvis	Global Coordinates x,y,z	??PELV0000HMDC[X,Y,Z]P	-
Complete dummy	Kinetic Energy	??EKINSU00HMEN00	-
	Internal Energy	??EINTSU00HMEN00	-
	Hourglass Energy	??EHOUSU00HMEN00	-
	Added Mass (absolute)	??MINCSU00HMMA00	-

WorldSID 50%

Location	Parameter	ISO code	CFC
Head	Accelerations, A_x A_y A_z	??HEAD0000WSAC[X,Y,Z]P	1000
	Angular rate sensor	??HEAD0000WSAV[X,Y,Z]P	60
2.5 **Upper Neck**	Forces, F_x F_y F_z	??NECKUP00WSFO[X,Y,Z]P	1000
	Moments, M_x M_y M_z	??NECKUP00WSMO[X,Y,Z]P	600
Lower Neck	Forces, F_x F_y F_z	??NECKLO00WSFO[X,Y,Z]P	1000
	Moments, M_x M_y M_z	??NECKLO00WSMO[X,Y,Z]P	600
Shoulder	Forces, Fx, Fy, Fz	??SHLD[LE,RI]00WSFO[X,Y,Z]P	600
	Distance, R	??SHRI[LE,RI]00WSDC0P	180
	Rotation, α	??SHRI[LE,RI]00WSANZP	180
Thorax	Distance, R	??TRRI[LE,RI][01,02,03]WSDC0P	180
	Rotation, α	??TRRI[LE,RI][01,02,03]WSANZP	180
	Temperature, T	??THSP0000WSTE0P	-
T4	Accelerations, A_x A_y A_z	??THSP0400WSAC[X,Y,Z]P	180
Abdomen	Distance, R	??ABRI[LE,RI][01,02]WSDC0P	180
	Rotation, α	??ABRI[LE,RI][01,02]WSANZP	180
T12	Accelerations, A_x A_y A_z	??THSP1200WSAC[X,Y,Z]P	180
Lumbar Spine	Forces, F_x F_y F_z	??LUSP0000WSFO[X,Y,Z]P	600
	Moments, M_x M_y M_z	??LUSP0000WSMO[X,Y,Z]P	600
Pelvis	Accelerations, A_x A_y A_z	??PELV0000WSAC[X,Y,Z]P	600
	Forces, F_y	??PUBC0000WSFOYP	600
Femoral Neck	Forces, F_x F_y F_z	??FEAC[LE,RI]00WSFO[X,Y,Z]P	600

For virtual tests, the following channels are to be added:

Location	Parameter	ISO code	CFC
Head	Global Coordinates x,y,z	??HEAD0000WSDC[X,Y,Z]P	-
T4	Global Coordinates x,y,z	??THSP0400WSDC[X,Y,Z]P	-
T12	Global Coordinates x,y,z	??THSP1200WSDC[X,Y,Z]P	
Pelvis	Global Coordinates x,y,z	??PELV0000WSDC[X,Y,Z]P	-
Complete dummy	Kinetic Energy	??EKINSU00WSEN00	-
	Internal Energy	??EINTSU00WSEN00	-
	Hourglass Energy	??EHOUSU00WSEN00	-
	Added Mass (absolute)	??MINCSU00WSMA00	-

BioRID UN

Location	Parameter	ISO code	CFC
Head	Accelerations, A_x A_y A_z	??HEAD0000BRAC[X,Y,Z]P	60
	Velocity, V_x	??HEAD0000BRVEXV	30
2.6	Contact	??HERE000000EV00	-
Cervical Spine	Accelerations, A_x A_z	??CESP0400BRAC[X,Z]P	60
Neck Upper	Forces, F_x F_y F_z	??NECKUP00BRFO[X,Y,Z]P	1000
	Moments, M_x M_y M_z	??NECKUP00BRMO[X,Y,Z]P	600
Neck Lower	Forces, F_x F_y F_z	??NECKLO00BRFO[X,Y,Z]P	1000
	Moments, M_x M_y M_z	??NECKLO00BRMO[X,Y,Z]P	600
T1	Accelerations, A_x A_z	??THSP01[LE,RI]BRAC[X,Z]P	60
T8	Accelerations, A_x A_z	??THSP0800BRAC[X,Z]P	60
Lumbar Spine	Accelerations, A_x A_z	??LUSP0100BRAC[X,Z]P	60
Pelvis	Accelerations, A_x A_y A_z	??PELV0000BRAC[X,Y,Z]P	60

Q6

	Location	Parameter	ISO code	CFC
	Head	Accelerations, A_x A_y A_z	??HEAD0000Q6AC[X,Y,Z]P	1000
	Neck Upper	Forces, F_x F_y F_z	??NECKUP00Q6FO[X,Y,Z]P	1000
2.7		Moments, M_x M_y M_z	??NECKUP00Q6MO[X,Y,Z]P	600
	Thorax	Accelerations, A_x A_y A_z	??THSP0000Q6AC[X,Y,Z]P	180
		Displacement, D	??CHST0000Q6DSXP	180
		Temperature, T	??THSP0000Q6TE0P	-

Q10

	Location	Parameter	ISO code	CFC
2.8	**Head**	Accelerations, A_x A_y A_z	??HEAD0000QBAC[X,Y,Z]P	1000
	Neck Upper	Forces, F_x F_y F_z	??NECKUP00QBFO[X,Y,Z]P	1000
		Moments, M_x M_y M_z	??NECKUP00QBMO[X,Y,Z]P	600
	Shoulder (side only)	Accelerations, A_x A_y A_z	??THSP0000QBAC[X,Y,Z]P	180
	T1 (side only & non-struck side)	Acceleration, A_y	??THSP01[LE,RI]QBACYP	1000
	T4	Accelerations, A_x A_y A_z	??THSP0400QBAC[X,Y,Z]P	180
	Thorax	Temperature, T	??THSP0000QBTE0P	-
	Chest (frontal only)	Distance, R	??CHST[LO,UP]00QBDC0P	180
		Rotation, α	??CHST[LO,UP]00QBANZP	180
	Chest (side only)	Distance, R	??CHST[LE,RI][LO,UP]QBDC0P	180
		Rotation, α	??CHST[LE,RI][LO,UP]QBANZP	180
	Lumbar Spine	Forces, F_x F_y F_z	??LUSP0000QBFO[X,Y,Z]P	1000
		Moments, M_x M_y M_z	??LUSP0000QBMO[X,Y,Z]P	600
	Pelvis-Sacrum	Accelerations, A_x A_y A_z	??PELV0000QBAC[X,Y,Z]P	180
	Pelvis-Pubis (side only)	Forces, F_y	??PUBC0000QBFOYP	1000

Adult headform

Location	Parameter	ISO code	CFC
Head	Accelerations, A_x A_y A_z	D0HEAD0000PJAC[X,Y,Z]P	1000

2.9

Small adult / child headform

Location	Parameter	ISO code	CFC
Head	Accelerations, A_x A_y A_z	D0HEAD0000PSAC[X,Y,Z]P	1000

2.10

Upper legform

2.11

Location	Parameter	ISO code	CFC
Femur	Forces, F_x	D0FEMR[UP,LO]00PUFOXP	180
	Moments, M_y	D0FEMR[UP,MI,LO]00PUMOYP	180

Legform (aPLI)

2.12

Location	Parameter	ISO code	CFC
Upper Mass	Accelerations, A_x A_y A_z	??PELV0000PMAC[X,Y,Z]P	180
	Angular velocity	??PELV0000PMAV[X,Y]P	180
Femur	Moments, M_x	??FEMR[UP,MI,LO]00PMMOXP	180
Knee	Displacement, D_{MCL}	??KNEEMC00PMDS0P	180
	Displacement, D_{PCL}	??KNEEPC00PMDS0P	180
	Displacement, D_{ACL}	??KNEEAC00PMDS0P	180
Tibia	Moments, M_x	??TIBI[UP,LO]00PMMOXP	180
		??TIBIMI[UP,LO]PMMOXP	180

Vehicle in full scale tests

Location	Parameter	ISO code	CFC
B-Pillar	Accelerations, A_x A_y	[14,16]BPILLO0000AC[X,Y]P	60
Seatbelt, B3	Force, $F_{seatbelt}$	??SEBE0003B3FO0P	60
2.1 **Seatbelt, B6**	Force, $F_{seatbelt}$	??SEBE0003B6FO0P	60
Vehicle trunk	Angular rate sensor	18TUNN000000AV[X,Y,Z]P	60

Trolley

Location	Parameter	ISO code	CFC
2.1 **CoG**	Accelerations, A_x	M0MBARCG0000ACXP	60 180

Sled including BiW

2.15

Location	Parameter	ISO code	CFC
Sled	Accelerations, A_x	S0SLED000000ACXP	60
B-Pillar (for farside)	Accelerations, A_x A_y	[14,16]BPILLO0000AC[X,Y]P	60
Seatbelt, B3	Force, $F_{seatbelt}$	??SEBE0003B3FO0P	60

For virtual tests, the following channels are to be added for both combined and separate modelling:

Location	Parameter	ISO code	CFC
Seat	Kinetic Energy	[11,13]EKINSUSE00EN00	-
	Internal Energy	[11,13]EINTSUSE00EN00	-
	Hourglass Energy	[11,13]EHOUSUSE00EN00	-
	Added Mass (absolute)	[11,13]MINCSUSE00MA00	-

Virtual Tests

For virtual tests, the following channels are to be added:

Location	Parameter	ISO code	CFC
Contact Dummy – Seat	Force, F_x, F_y, F_z	??SEAT0000??FO[X,Y,Z]P	-
Contact Dummy – Seatbelt	Force F_x, F_y, F_z	??SEBE0000??FO[X,Y,Z]P	-
Global	Global Kinetic Energy	00EKINSU0000EN00	-
Global	Global Internal Energy	00EINTSU0000EN00	-
Global	Global Hourglass Energy	00EHOUSU0000EN00	-
Global	Global External Work	00EXWOSU0000EN00	-
Global	Added Mass (absolute)	00MINCSU0000MA00	-
Global	Total Energy	00ETOTSU0000EN00	-

3 INJURY CRITERIA CALCULATION

This chapter describes the calculation for each injury criterion including the filters that are applied to each channel used in these calculations. The analysis software used by the Euro NCAP labs will follow these calculations in detail.

For all of the calculations and for all of the dummies used, only the loading phase of the crash is considered. Usually, the loading phase for all dummies in the frontal tests will end at the point in time where the filtered head acceleration A_x crosses zero g after the minimum acceleration peak value. This does not apply to the far side occupant-to-occupant test, the loading phase to evaluate occupant-to-occupant interaction will end when all parts of both dummies are moving outboard.

It is up to Euro NCAP to confirm and determine the actual end of the loading phase.

Head criteria

3.1.1 Head resultant acceleration

3.1 The head resultant acceleration is calculated with the following formula:

$$A_R = \sqrt{{A_x}^2 + {A_y}^2 + {A_z}^2}$$

with:

A_x	Filtered Head Acceleration A_x	??HEAD0000??ACXA
A_y	Filtered Head Acceleration A_y	??HEAD0000??ACYA
A_z	Filtered Head Acceleration A_z	??HEAD0000??ACZA

3.1.2 HIC_{15}

The HIC_{15} value is calculated with the following formula:

$$HIC_{15} = (t_2 - t_1)\left(\frac{1}{(t_2 - t_1)}\int_{t_1}^{t_2} A_R dt\right)^{2.5}$$

with:

A_R Head Resultant Acceleration

3.1.3 Diffuse axonal multi-axis general evaluation (DAMAGE)

The DAMAGE criterion is calculated with the following formulae. Head rotational velocity, filtered at CFC 60, shall be used to generate rotational acceleration throughout the impact.

$$\begin{bmatrix} m_x & 0 & 0 \\ 0 & m_y & 0 \\ 0 & 0 & m_z \end{bmatrix} \begin{Bmatrix} \ddot{\delta}_x \\ \ddot{\delta}_y \\ \ddot{\delta}_z \end{Bmatrix} + \begin{bmatrix} c_{xx} + c_{xy} + c_{xz} & -c_{xy} & -c_{xz} \\ -c_{xy} & c_{xy} + c_{yy} + c_{yz} & -c_{yz} \\ -c_{xz} & -c_{yz} & c_{xz} + c_{yz} + c_{zz} \end{bmatrix} \begin{Bmatrix} \dot{\delta}_x \\ \dot{\delta}_y \\ \dot{\delta}_z \end{Bmatrix} +$$

$$\begin{bmatrix} k_{xx} + k_{xy} + k_{xz} & -k_{xy} & -k_{xz} \\ -k_{xy} & k_{xy} + k_{yy} + k_{yz} & -k_{yz} \\ -k_{xz} & -k_{yz} & k_{xz} + k_{yz} + k_{zz} \end{bmatrix} \begin{Bmatrix} \delta_x \\ \delta_y \\ \delta_z \end{Bmatrix} = \begin{bmatrix} m_x & 0 & 0 \\ 0 & m_y & 0 \\ 0 & 0 & m_z \end{bmatrix} \begin{Bmatrix} \ddot{u}_x \\ \ddot{u}_y \\ \ddot{u}_z \end{Bmatrix}$$

$$DAMAGE = \beta max_t\{|\vec{\delta}(t)|\}$$

$$\vec{\delta}(t) = [\delta_x(t) \quad \delta_y(t) \quad \delta_z(t)]^T, \ \beta = \text{scale factor}$$

$$\text{m} = \text{mass}, c_{ij} = \text{damping}, k_{ij} = \text{stiffness}$$

$$\ddot{\delta}, \dot{\delta}, \delta = acceleration, velocity, displacement$$

$$\ddot{u} = applied\ angular\ acceleration$$

$$m_x = 1\ kg, m_y = 1\ kg, m_z = 1\ kg$$

$$k_{xx} = 32142\ N/m, k_{yy} = 23493\ N/m, k_{zz} = 16935\ N/m,$$

$$k_{xy} = 0\ N/m, k_{yz} = 0\ N/m, k_{xz} = 1636.3\ N/m, a1 = 5.9148\ ms, \beta = 2.9903\ 1/m$$

$$[c] = a1 \times [k]$$

3.1.3.1 Frontal impact

When calculating DAMAGE for frontal impacts, a time window is specified to exclude certain secondary contacts between the head and vehicle interior. Note, this window does not apply to either HIC or 3ms exceedance calculations. The exclusion criteria are based upon those used by JNCAP.

This criterion will be evaluated during the loading and early rebound phases of the impact over a max period from T0 up to 200ms. The time window will be reduced to less than 200ms if, during head rebound, a secondary impact results in an external force on the head drops below -500N.

The external force acting on the head shall be calculated using the head x acceleration and upper neck x force using the formula below. End the calculation when: F external x < -500N

$$F_{external\ x} = -M_{Head} \times a_{Head\ x} + F_{Neck_{upper}x}$$

Where M_{Head} = 4.2kg.

3.1.3.2 Side impact

The DAMAGE criterion is currently under monitoring for use in side impacts. Data shall be gathered using the only the formulae in Section 3.1.3, a time window is yet to be defined for side impacts.

3.1.4 Head restraint contact time

The head restraint contact time is calculated with the following formula:

$$T_{HRC} = T_{HRC,end} - T_{HRC,start}$$

with:

$T_{HRC,start}$	Time of first contact of head and HR after T=0	??HERE000000EV00
$T_{HRC,end}$	Time where contact is lost	??HERE000000EV00

Head restraint contact time $T_{HRC(Start)}$ is defined as the time (calculated from T=0) of first contact between the rear of the ATD head and the head restraint, where the subsequent continuous contact duration exceeds 40ms. For the purposes of assessment, $T_{HRC(Start)}$ shall be rounded to the nearest millisecond. Gaps up to 1ms are ignored if proven to be the result of poor electrical contact. $T_{HRC_{(end)}}$ is defined as the time at which the head first loses contact with the head restraint, where the subsequent continuous loss of contact duration exceeds 40ms.

3.1.5 Head rebound velocity

The head rebound velocity (in the horizontal/X direction) shall be determined using dummy head CoG target tracking from camera footage. Head rebound velocity shall be calculated as follows:

$$V_{Rebound} = V_{Head\ CoG\ (abs)} - V_{Sled\ (abs)}$$

Where:

$V_{Rebound}$ = Instantaneous rebound X-velocity of the head c-of-g, relative to the sled

$V_{Head\ CoG\ (abs)}$ = Instantaneous X-velocity of head centre of gravity, absolute.

$V_{Sled\ (abs)}$ = Instantaneous X-velocity of sled, absolute.

3.1.6 T1 x-acceleration

The T1 x-acceleration value is calculated with the following formula:

$$T1 = \frac{T1_{left} + T1_{right}}{2}$$

with:

$T1_{left}$	Filtered left T1 acceleration	??THSP01LEBRACXD
$T1_{right}$	Filtered right T1 acceleration	??THSP01RIBRACXD

The maximum, $T1_{max}$, should be generated from this average T1 channel, considering only the portion of data from T-zero until $T\text{-}HRC_{(end)}$ as follows:

$$T1_{max} = \underset{T-HRC_{(end)}}{\mathrm{Max}} [T1(t)]$$

Neck criteria

3.2.1 Neck extension bending moment @ OC

The neck extension bending moment is calculated with the following formula:

3.2 $M_{OCy} = M_y - F_x \cdot d$

with:

M_y	Filtered Bending Moment	??NECKUP00??MOYB
F_x	Filtered Shear Force	??NECKUP00??FOXB
d	0.01778m for all HIII series and 0.0195m for WorldSID	

3.2.2 Neck lateral flexion bending moment @ OC

The neck lateral flexion bending moment is calculated with the following formula:

$M_{OCx} = M_x + F_y \cdot d$

with:

M_x	Filtered Bending Moment	??NECKUP00WSMOXB
F_y	Filtered Shear Force	??NECKUP00WSFOYB
d	0.0195m WorldSID	

3.2.3 Neck extension bending moment

The neck extension bending moment is calculated with the following formula:

$M_y = abs(\min(M_y))$

with:

M_y	Filtered Bending Moment for THOR	??NECKUP00T3MOYB
M_y	Filtered Bending Moment for WorldSID	??NECKLO00WSMOYB

3.2.4 Neck lateral flexion bending moment @ Neck base

The neck lateral flexion bending moment is calculated with the following formula:

$Mx_{(base\ of\ neck)} = \max(\ \mathrm{abs}(Mx_M - Fy_m \times Dz)\ )$

with:

MxM =	Filtered Bending Moment	??NECKLO00WSMOXB
FyM =	Filtered Shear Force	??NECKLO00WSFOYB
Dz =	0.0145m for WorldSID (ISO 15830)	

$My_{(base\ of\ neck)} = \ |\min(My_M + Fx_M * Dz)|$

with:

MyM =	Filtered Bending Moment	??NECKLO00WSMOYB
FxM =	Filtered Shear Force	??NECKLO00WSFOXB
Dz =	0.0145m for WorldSID (ISO 15830)	

3.2.5 Upper and lower neck shear force and tension

Positive shear shall indicate head-rearwards motion and positive tension should be associated with pulling the head upwards, generating a tensile force in the neck. Firstly, the Fx and Fz channels shall be filtered as defined in Section 2.6. Peak values shall be determined for each of the forces, considering only the portion of data from T-zero until T-HRC(end), as follows:

$$Fx_{max} = \underset{T-HRC_{(end)}}{\text{Max}} [Fx(t)]$$

$$Fz_{max} = \underset{T-HRC_{(end)}}{\text{Max}} [Fz(t)]$$

3.2.6 NIC

The NIC value is calculated with the following formula:

$$NIC = 0.2 \cdot A_{rel} + {v_{rel}}^2$$

with:

$$A_{rel} = T1 - A_{x,head}$$

$$v_{rel} = \int A_{rel}$$

T1	Average T1 acceleration	
$A_{x,head}$	Filtered Head Acceleration A_x	??HEAD0000BRACXD

3.2.7 Nkm

The Nkm value is calculated with the following formula:

$$Nkm(t) = N_{ep}(t) + N_{ea}(t) + N_{fp}(t) + N_{fa}(t)$$

with:

$$N_{ep}(t) = \frac{M_{ocye}(t)}{-47.5Nm} + \frac{F_{xp}(t)}{-845N}$$

$$N_{ea}(t) = \frac{M_{ocye}(t)}{-47.5Nm} + \frac{F_{xa}(t)}{845N}$$

$$N_{fp}(t) = \frac{M_{ocyf}(t)}{88.1Nm} + \frac{F_{xp}(t)}{-845N}$$

$$N_{fa}(t) = \frac{M_{ocyf}(t)}{88.1Nm} + \frac{F_{xa}(t)}{845N}$$

$$M_{OCy}(t) = M_y(t) - D \cdot F_x(t)$$

$F_x(t)$	Filtered Upper Neck Shear Force F_x	??NECKUP00BRFOXB
$M_y(t)$	Filtered Upper Neck Moment M_y	??NECKUP00BRMOYB
D	0.01778m	
$F_{xp}(t)$	negative portion of $F_x(t)$	

$F_{xa}(t)$ positive portion of $F_x(t)$
$M_{ye}(t)$ negative portion of $M_{OCy}(t)$
$M_{yf}(t)$ positive portion of $M_{OCy}(t)$

When the 4 criteria are calculated, particular forces and moments must be set to 0. This is an AND condition. That is if one of the summands is zero, the condition is also zero. Consider only the portion of data from T-zero until T-$_{HRC(end)}$.

Shoulder criteria

3.3.1 Lateral shoulder force

3.3 The Lateral Shoulder Force is calculated with the following formula:

$$Fy_{shoulder} = abs\left(\min\left(F_y(t)\right)\right)$$

with:

F_y	Filtered Shoulder Force F_y	??SHLD[LE,RI]00WSFOYB

3.3.2 Lateral shoulder rib displacement

The lateral shoulder rib displacement is calculated with the following formula:

$$Dy_{shoulder} = \max\left(D_y(t) - D_y(0)\right)$$

with:

$$D_y(t) = R(t) \cdot \sin(\Phi(t))$$

R(t)	Filtered Shoulder sensor length	??SHRI[LE,RI]00WSDC0C
Φ(t)	Filtered Shoulder sensor rotation	??SHRI[LE,RI]00WSANZC
$D_y(0)$	Lateral Shoulder Rib Displacement @ t=0	

Further details regarding definitions for measurement coordinate system, sensor offsets and polarities, and post-processing can be found in ISO/TS21002.

Chest criteria

3.4.1 Chest deflection

The chest deflection value is calculated with the following formula:

$$D_{chest} = \max\left(D_{chest}(t)\right)$$

3.4 with:

$D_{chest}(t)$	Filtered Chest Deflection D_{chest}	??CHST0003??DSXC

3.4.2 Chest rib displacement

The chest rib displacement is calculated with the following formula:

$$D_{rib} = max\left(\sqrt{D_x(t)^2 + D_y(t)^2 + D_z(t)^2}\right)$$

with:

$$D_x(t) = \delta \cdot sin\left(\Phi_y(t)\right) + R(t) \cdot cos(\Phi_z(t)) \cdot cos\left(\Phi_y(t)\right) - D_x(0)$$
$$D_y(t) = R(t) \cdot sin(\Phi_z(t)) - D_y(0)$$
$$D_z(t) = \delta \cdot cos\left(\Phi_y(t)\right) - R(t) \cdot cos(\Phi_z(t)) \cdot sin\left(\Phi_y(t)\right) - D_z(0)$$

$R(t)$	Filtered Chest Rib sensor length	??CHST[LE,RI][UP,LO]T3DC0C
$\Phi_y(t)$	Filtered Chest Rib sensor rotation	??CHST[LE,RI][UP,LO]T3ANYC
$\Phi_z(t)$	Filtered Chest Rib sensor rotation	??CHST[LE,RI][UP,LO]T3ANZC
$D_{[x,y,z]}(0)$	Chest Rib Displacement in x,y,z direction @ t=0	
δ	+15.65mm for Upper Chest Rib and -15.65mm for Lower Chest Rib	

Definitions regarding measurement coordinate system, sensor offsets and polarities, and post-processing can be found in ISO/TS21002. Where a vehicle is equipped with pretensioners that activate before T0, the displacement prior to activation shall be used for $D_{x,y,z}(0)$.

Rmax is used for the injury calculation.

3.4.3 Chest displacement

The Q10 chest displacement in the MPDB test is calculated for the upper and lower measurement system with the following formula:

$$D_{rib} = max\left(\sqrt{D_x(t)^2 + D_y(t)^2}\right)$$

with:

$$D_x(t) = R(t) \cdot cos(\Phi_z(t)) - D_x(0)$$
$$D_y(t) = R(t) \cdot sin(\Phi_z(t)) - D_y(0)$$

$R(t)$	Filtered sensor length	??CHST[LO,UP]00QBDC0C
$\Phi_z(t)$	Filtered sensor rotation	??CHST[LO,UP]00QBANZC
$D_{[x,y]}(0)$	Chest Displacement @ t=0	

Definitions regarding measurement coordinate system, sensor offsets and polarities, and post-processing can be found in ISO/TS21002. Where a vehicle is equipped with pretensioners that activate before T0, the displacement prior to activation shall be used for $D_{[x,y]}(0)$.

3.4.4 Seatbelt force

The Seatbelt force modifier is calculated with the following formula:

$$F_{seatbelt} = \max\left(F_{seatbelt}(t)\right)$$

with:

$F_{seatbelt}$	Filtered Seatbelt Force	??SEBE0003B3FO0D

3.4.5 Lateral Thoracic Rib Displacement

The lateral thoracic rib displacement is calculated with the following formula:

$$Dy_{thorax} = \max\big(D_y(t) - D_y(0)\big)$$

with:

$$D_y(t) = R(t) \cdot \sin(\Phi(t))$$

R(t)	Filtered Thoracic sensor length	??TRRI[LE,RI]01WSDC0C
Φ (t)	Filtered Thoracic sensor rotation	??TRRI[LE,RI]01WSANZC
$D_y(0)$	Lateral Thoracic Rib Displacement @ t=0	

Definitions regarding measurement coordinate system, sensor offsets and polarities, and post-processing can be found in ISO/TS21002.

3.4.6 Viscous Criterion

The VC is calculated with the following formula:

$$VC = sf \cdot V(t) \times C(t)$$

With:

sf 1.3 for HIII-95, 1.3 for HIII-50, 1.3 for HIII-05 and 1.0 for WorldSID

$$V(t) = \frac{8(D_{chest}(t+1) - D_{chest}(t-1)) - (D_{chest}(t+2) - D_{chest}(t-2))}{12\Delta t}$$

$$C(t) = \frac{D_{chest}(t)}{D_{constant}}$$

$D_{chest}(t)$ Filtered Chest Deflection D_{chest} ??CHST0003??DSXC
for WorldSID use calculated Lateral Thoracic Rib Displacement Dy_{thorax}

Δt Time step

$D_{constant}$ 0.254 for HIII-95, 0.229 for HIII-50, 0.187 for HIII-05, 0.170 for WorldSID and 0.163 for Q10

Abdominal criteria

3.5.1 T12 resultant acceleration

The T12 resultant acceleration is calculated with the following formula:

3.5 $$A_R = \sqrt{{A_x}^2 + {A_y}^2 + {A_z}^2}$$

with:

A_x	Filtered T12 Acceleration A_x	??THSP1200WSACXC
A_y	Filtered T12 Acceleration A_y	??THSP1200WSACYC
A_z	Filtered T12 Acceleration A_z	??THSP1200WSACZC

3.5.2 Abdominal rib displacement (THOR)

The abdominal rib displacement is calculated with the following formula:

$$D_{rib} = max(D_x(t))$$

with:

$$D_x(t) = R(t) \cdot cos(\Phi_z(t)) \cdot cos(\Phi_y(t)) - D_x(0)$$

R(t)	Filtered Abdominal Rib sensor length	??ABDO[LE,RI]00T3DC0C
$\Phi_y(t)$	Filtered Abdominal Rib sensor rotation	??ABDO[LE,RI]00T3ANYC
$\Phi_z(t)$	Filtered Abdominal Rib sensor rotation	??ABDO[LE,RI]00T3ANZC
$D_{[x,y,z]}(0)$	Abdominal Rib Displacement in x,y,z direction @ t=0	

Definitions regarding measurement coordinate system, sensor offsets and polarities, and post-processing can be found in ISO/TS21002. Where a vehicle is equipped with pretensioners that activate before T0, the displacement prior to activation shall be used for $D_{x,y,z}(0)$.

3.5.3 Lateral abdominal rib displacement

The lateral abdominal rib displacement is calculated with the following formula:

$$Dy_{abdomen} = \max\left(D_y(t) - D_y(0)\right)$$

with:

$$D_y(t) = R(t) \cdot \sin(\Phi(t))$$

R(t)	Filtered Abdominal sensor length	??ABRI[LE,RI]01WSDC0C
$\Phi(t)$	Filtered Abdominal sensor rotation	??ABRI[LE,RI]01WSANZC
$D_y(0)$	Lateral Abdominal Rib Displacement @ t=0	

Definitions regarding measurement coordinate system, sensor offsets and polarities, and post-processing can be found in ISO/TS21002.

3.5.4 Viscous criterion

The VC is calculated with the following formula:

$$VC = sf \cdot V(t) \times C(t)$$

With:

sf 1.0 for WorldSID

$$V(t) = \frac{8(D_{y,abdomen}(t+\Delta t) - D_{y,abdomen}(t-\Delta t)) - (D_{y,abdomen}(t+2\Delta t) - D_{y,abdomen}(t-2\Delta t))}{12\Delta t}$$

$$C(t) = \frac{D_{y,abdomen}(t)}{D_{constant}}$$

$Dy_{abdomen}(t)$ Calculated Lateral Abdominal Rib Displacement

Δt Time step

$D_{constant}$ 0.170 for WorldSID

3.6 Lower extremity criteria

3.6.1 Iliac force drop

The iliac force drop value is calculated with the following formula:

$$IFD = \max(IFD(t))$$

With:

$$IFD(t) = F_{iliac}(t + 0.001s) - F_{iliac}(t)$$

F_{iliac} (t)	Filtered Iliac Force F_{iliac}	??ILAC[LE,RI]00??FOXB

3.6.2 Acetabulum force

The resultant acetabulum force value is calculated with the following formula for time intervals where $F_{acetabulum,X}$ is in compressive load:

$$F_{acetabulum} = \max\left(\sqrt{F_{acetabulum,X}^2 + F_{acetabulum,Y}^2 + F_{acetabulum,Z}^2}\right)$$

With:

$F_{acetabulum,X}$	Filtered Femur Force $F_{acetabulum,X}$	??ACTB[LE,RI]00T3FOXB
$F_{acetabulum,Y}$	Filtered Femur Force $F_{acetabulum,Y}$	??ACTB[LE,RI]00T3FOYB
$F_{acetabulum,Z}$	Filtered Femur Force $F_{acetabulum,Z}$	??ACTB[LE,RI]00T3FOZB

3.6.3 Knee displacement

The knee displacement value is calculated with the following formula:

$$D_{knee} = |\min(D_{knee}(t))|$$

With:

$D_{knee}(t)$	Filtered Knee Displacement D_{knee}	??KNSL[LE,RI]00??DSXC

3.6.4 Femur force

The femur force value is calculated with the following formula:

$$F_{femur} = \text{abs}\left(\min\left(F_{femur}(t)\right)\right)$$

With:

$F_{femur}(t)$	Filtered Femur Force F_{femur}	??FEMR[LE,RI]00??FOZB

3.6.5 Tibia index

The tibia index is calculated with the following formula:

$$If\ F_z < 0\ and\ M_R(t)\ \neq 0\ then: TI(t) = \left|\frac{M_R(t)}{(M_R)_C}\right| + \left|\frac{F_z(t)}{(F_z)_C}\right|$$

$$If\ F_z \geq 0\ and\ M_R(t)\ \neq 0\ then: TI(t) = 0$$

with:

$$M_R(t) = \sqrt{M_x(t)^2 + M_y(t)^2}$$

$M_x(t)$	Filtered Bending Moment M_x	??TIBI[LE,RI][UP,LO]??MOXB
$M_y(t)$	Filtered Bending Moment M_y	??TIBI[LE,RI][UP,LO]??MOYB
F_z	Filtered Force F_z	??TIBI[LE,RI][UP,LO]??FOZB
$(M_R)_C$	225Nm for HIII-50 & THOR, 114Nm for HIII-05, 306Nm for HIII-95	
$(F_z)_C$	35.9kN for HIII-50 & THOR, 22.9kN for HIII-05, 44.1kN for HIII-95	

4 VEHICLE & SLED CRITERIA CALCULATION

This section describes the calculation for each vehicle criteria including the filters that are applied (where applicable) to each channel used in these calculations. The analysis software used by the Euro NCAP labs will follow these calculations in detail.

4.1 Occupant load criterion

The calculation for the test vehicle and trolley OLC in the MPDB test is as follows.

Measured X-acceleration (A_X) on the centre of gravity of MPDB shall be filtered using CFC180.

The acceleration from the backup CoG accelerometer shall only be used for the OLC calculation where there is a channel failure of the primary accelerometer.

The filtered acceleration pulse shall be integrated with the following equation to derive the velocity course of the barrier:

$$V_t = \int A_X(t)\, dt + V_0$$

Where V_0 is the initial velocity at $t = 0s$.

$OLC_{SI-unit}$, t_1 and t_2 can be calculated with solving the following equation system:

$$\begin{cases} \int_{t=0}^{t=t_1} V_0\, dt - \int_{t=0}^{t=t_1} V(t)\, dt = 0.065 \\ \int_{t=t_1}^{t=t_2} \left(V_0 - OLC_{SI-unit} \times (t - t_1)\right) dt - \int_{t=t_1}^{t=t_2} V(t)\, dt = 0.235 \\ V_0 - OLC_{SI-unit} \times (t_2 - t_1) = V(t_2) \end{cases}$$

Where:

- t_1 is end of the free-flight-phase of a virtual dummy in vehicle or on the barrier along a displacement of 0.065m, and
- t_2 is end of the restraining-phase of a virtual dummy in vehicle or on the barrier along a displacement of 0.235m after the free-flight-phase (i.e. in total 0.300m displacement for the virtual dummy).

OLC shall be converted from SI units into g (standard gravity) with the conversion factor of 1g = 9.81m/s²

4.2 Whiplash seatback dynamic deflection

The seatback dynamic deflection is defined as the maximum change in angle achieved at any time during the test between the T zero position and $T\text{-}_{HRC(end)}$. Measure the seatback dynamic deflection from the targets defined in the Euro NCAP Film and Photo protocol as follows:

- Define a line between the upper and lower seatback targets, ST2 and ST3.
- Define a second line between the forward and rearward sled base targets, B1 and B2.
- Calculate the angle between these two lines at the T-zero position. The instantaneous seatback deflection is defined as the instantaneous difference in angle between the T-zero position and the deflected position. Track the change in instantaneous angle between these two lines, throughout the dynamic test.

4.3 Compatibility criteria

$\mathrm{CC} = \mathrm{OLC}_C + \mathrm{SD} + \mathrm{BO}$

with:

$$OLC_C = \begin{cases} 0 & OLC \leq 25g \\ OLC_N * 25 & 25g < OLC \leq 40g \\ 25 & OLC > 40g \end{cases}$$

$$SD = \begin{cases} SD_N * 25 & OLC \leq 25g \\ SD_N * ([25 + OLC_N * 75] - [OLC_N * 25]) & 25g < OLC \leq 40g \\ SD_N * 75 & OLC > 40g \end{cases}$$

$$OLC_N = \frac{OLC - 25}{40 - 25}$$

$$SD_N = \frac{SD - 50}{150 - 50}$$

where:

CC	Compatibility criteria in percentage
OLC	Occupant Load Criterion modifier based on the OLC of the MPDB trolley in g
SD	Standard Deviation modifier based on the deformation of the PDB element
BO	Bottoming-Out modifier based on the deformation of the PDB element

Please note, for the purposes of the compatibility modifier, data is required at a sampling rate of 20kHz. The calculation of velocity change (dV), a CFC of 180 shall be used.