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EUROPEAN NEW CAR
ASSESSMENT PROGRAMME

Technical Bulletin

Data format and Injury Calculation

Version 1.0

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DRAFT

Preface

Euro NCAP makes use with a number of different test laboratories around Europe, who perform the official Euro NCAP tests. This Technical Bulletin describes how the test data should be acquired and supplied to Euro NCAP to ensure consistency throughout all data used.

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1 TEST DATA

1.1 Data Format

All test data needs to be provided in ISO-MME 1.6 or ISO-MME 2.0 format and needs to be fully compliant with the ISO/TS 13499 standard.

1.1.1 Folder structure

The folder structure and the files contained in these folders follow the ISO/TS 13499 standard. The main directory contains seven folders and two files as detailed in the paragraphs below.

1.1.1.1 ISO-MME 1.6

The following folders and files need to be provided for every test performed, where the testnumber is the testnumber as provided by Euro NCAP:

| | |
|------------------------------------|---------------------------------|
| <testnumber> | Main Directory |
| - Channel | Sub Directory |
| o <testnumber>.xxx | Channel data file |
| o <testnumber>.chn | Channel overview file |
| - Document | Sub Directory |
| o <name of document file 1> | Document file 1 |
| o ... | |
| o <name of document file d> | Document file d |
| o <testnumber>_Document.txt | Document comment file |
| - Movie | Sub Directory |
| o <name of movie file 1> | Movie file 1 |
| o ... | |
| o <name of movie file m> | Movie file m |
| o <testnumber>_Movie.txt | Movie comment file |
| - Object | Sub Directory |
| o <testnumber>_Reference.txt | Reference system comment file |
| o <name of object file 1> | Object information file 1 |
| o ... | |
| o <name of object file o> | Object information file o |
| o <testnumber>_Object.txt | Object comment file |
| - Photo | Sub Directory |
| o <name of photo file 1> | Photo file 1 |
| o ... | |
| o <name of photo file p> | Photo file p |
| o <testnumber>_Photo.txt | Photo comment file |
| - Report | Sub Directory |
| o <name of report file 1> | Report file 1 |
| o ... | |
| o <name of report file r> | Report file r |
| o <testnumber>_Report.txt | Report comment file |
| - Static | Sub Directory |
| o <name of static measurment file> | Static measurement file |
| o <testnumber>_Static.txt | Static measurement comment file |
| - <testnumber>.mme | Test information file |
| - <testnumber>.txt | Test comment file |

1.1.1.2 ISO-MME 2.0

The following folders and files need to be provided for every test performed, where the testnumber is the testnumber as provided by Euro NCAP:

| | |
|--------------------------------|-----------------------------------|
| <testnumber> | Main Directory |
| - Channel | Sub Directory |
| o <testnumber>_Channel.mmi | Channel information file |
| o <name of channel file 1>.mmd | Channel data file 1 |
| o ... | |
| o <name of channel file c>.mmd | Channel data file c |
| o <testnumber>_Channel.txt | Channel comment file |
| - Document | Sub Directory |
| o <testnumber>_Document.mmi | Document information file |
| o <name of document file 1> | Document file 1 |
| o ... | |
| o <name of document file d> | Document file d |
| o <testnumber>_Document.txt | Document comment file |
| - Movie | Sub Directory |
| o <testnumber>_Movie.mmi | Movie information file |
| o <testnumber >_Movie.mmd | Movie data file |
| o <name of movie file 1> | Movie file 1 |
| o ... | |
| o <name of movie file m> | Movie file m |
| o <testnumber>_Movie.txt | Movie comment file |
| - Object | Sub Directory |
| o <testnumber>_Reference.mmi | Reference system information file |
| o <testnumber >_Reference.mmd | Reference system data file |
| o <testnumber>_Reference.txt | Reference system comment file |
| o <name of object file 1> | Object information file 1 |
| o ... | |
| o <name of object file o> | Object information file o |
| o <testnumber>_Object.txt | Object comment file |
| - Photo | Sub Directory |
| o <testnumber>_Photo.mmi | Photo information file |
| o <name of photo file 1> | Photo file 1 |
| o ... | |
| o <name of photo file p> | Photo file p |
| o <testnumber>_Photo.txt | Photo comment file |
| - Report | Sub Directory |
| o <testnumber>_Report.mmi | Report information file |
| o <name of report file 1> | Report file 1 |
| o ... | |
| o <name of report file r> | Report file r |
| o <testnumber>_Report.txt | Report comment file |
| - Static | Sub Directory |
| o <testnumber>_Static.mmi | Static measurement info file |
| o <testnumber>_Static.mmd | Static measurement data file |
| o <testnumber>_Static.txt | Static measurement comment file |
| - <testnumber>.mme | Test information file |
| - <testnumber>.txt | Test comment file |

1.1.2 MME-file

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

```
Data format edition number    1.6 or 2.0
....
Customer name                  Euro NCAP
Customer test ref number      <testnumber>
Title                          Euro NCAP <year of test>
Type of the test               <see list in 1.1.2.1>
Subtype of the test           <see list in 1.1.2.1>
Regulation                    <protocol version>
Name of test object 1         <make and model>
Class of test object 1       <Euro NCAP vehicle class>
Ref. number of test object 1 <VIN number>
...
```

1.1.2.1 List with type and subtype of the test

| Euro NCAP test | Type of Test | Subtype of test |
|-----------------------|---------------------|--|
| Frontal ODB | Frontal | ODB |
| Frontal FW | Frontal | FW |
| Side MDB | Side | MDB |
| Side Pole | Side | Pole |
| Whiplash | Whiplash | Low Medium High |
| Pedestrian | Pedestrian | Headform Upper Legform Lower Legform |

1.2 Channel names and filters

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

1.2.1 Hybrid III 50% Male

| Location | Parameter | ISO code | CFC | Injury Calculation |
|---------------------|----------------------------------|-----------------------------|------|--|
| Head | Accelerations, A_x A_y A_z | ??HEAD0000H3AC[X,Y,Z]P | 1000 | Peak Resultant acceleration HIC ₁₅ Resultant 3msec exceedence |
| Neck | Forces, F_x F_y F_z | ??NECKUP00H3FO[X,Y,Z]P | 1000 | Tension continuous exceedence Shear (F_x) continuous exceedence Peak Extension (M_y) |
| | 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 | Peak resultant acceleration Resultant 3 msec exceedence Peak deflection Viscous Criterion |
| | Deflection, D_{chest} | ??CHST0003H3DSXP | 180 | |
| Pelvis | Accelerations, A_x A_y A_z | ??PELV0000H3AC[X,Y,Z]P | | |
| Lumbar Spine | Forces, F_x F_z | ??LUSP0000H3FO[X,Z]P | | |
| | Moments, M_y | ??LUSP0000H3MOYP | | |
| Femurs (L & R) | Forces, F_z | ??FEMR[LE,RI]00H3FOZP | 600 | Compressive Axial Force ($-F_z$) continuous exceedence |
| Knees (L & R) | Displacements, D_{knee} | ??KNSL[LE,RI]00H3DSXP | 180 | Peak displacement |
| Upper Tibia (L & R) | Forces, F_x F_z | ??TIBI[LE,RI]UPH3FO[X,Z]P | 600 | Peak Tibia Compression ($-F_z$) Tibia Index |
| | Moments, M_x M_y | ??TIBI[LE,RI]UPH3MO[X,Y,Z]P | 600 | |
| Lower Tibia (L & R) | Forces, F_x F_z (F_y) | ??TIBI[LE,RI]LOH3FO[X,Y,Z]P | 600 | Peak Tibia Compression ($-F_z$) Tibia Index |
| | Moments, M_x M_y | ??TIBI[LE,RI]LOH3MO[X,Y,Z]P | 600 | |

1.2.1.1 Hybrid III 5% Female

| Location | Parameter | ISO code | CFC | Injury Calculation |
|------------------------|----------------------------------|-----------------------------|------|--|
| Head | Accelerations, A_x A_y A_z | ??HEAD0000HFAC[X,Y,Z]P | 1000 | Peak Resultant acceleration HIC_{15} Resultant 3msec exceedence |
| Neck | Forces, F_x F_y F_z | ??NECKUP00HFFO[X,Y,Z]P | 1000 | Tension continuous exceedence Shear (F_x) continuous exceedence Peak Extension (M_y) |
| | 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 | Peak resultant acceleration Resultant 3 msec exceedence Peak deflection Viscous Criterion |
| | Deflection, D_{chest} | ??CHST0003HFDSXP | 180 | |
| Pelvis | Accelerations, A_x A_y A_z | ??PELV0000HFAC[X,Y,Z]P | | |
| Iliac (L & R) | Forces, F_x | ??ILAC[LE,RI]00HFFOXP | | |
| | Moments, M_y | ??ILAC[LE,RI]00HFMOYP | | |
| Lumbar Spine | Forces, F_x F_z | | | |
| | Moments, M_y | | | |
| Femurs (L & R) | Forces, F_z | ??FEMR[LE,RI]00HFFOZP | 600 | Compressive Axial Force (- F_z) Continuous exceedence |
| Knees (L & R) | Displacements, D_{knee} | ??KNSL[LE,RI]00HFDSXP | 180 | Peak displacement |
| Upper Tibia (L & R) | Forces, F_x F_z | ??TIBI[LE,RI]UPHFFO[X,Z]P | 600 | Peak Tibia Compression (- F_z) Tibia Index |
| | Moments, M_x M_y | ??TIBI[LE,RI]UPHFMO[X,Y,Z]P | 600 | |
| Lower Tibia (L & R) | Forces, F_x F_z (F_y) | ??TIBI[LE,RI]LOHFFO[X,Y,Z]P | 600 | Peak Tibia Compression (- F_z) Tibia Index |
| | Moments, M_x M_y | ??TIBI[LE,RI]LOHFMO[X,Y,Z]P | 600 | |

1.2.1.2 WorldSID 50% Male

| Location | Parameter | | CFC | Injury Calculation |
|----------|----------------------------------|-------------------------------|------|--|
| Head | Accelerations, A_x A_y A_z | ??HEAD0000WSAC[X,Y,Z]P | 1000 | HIC ₁₅ Peak acceleration 3msec exceedence (cumulative) |
| 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 | |
| Shoulder | Forces, F_x , F_y , F_z | ??SHLD[LE,RI]00WSFO[X,Y,Z]P | 600 | Peak lateral force |
| | Displacement, D | ??SHRI[LE,RI]00WSDS0P | 600 | Peak displacement |
| | Rotation, α | ??SHRI[LE,RI]00WSANZP | 600 | Viscous criterion |
| Thorax | Displacement, D | ??TRRI[LE,RI][01,02,03]WSDS0P | 600 | Peak displacement |
| | Rotation, α | ??TRRI[LE,RI][01,02,03]WSANZP | 600 | Viscous criterion |
| Abdomen | Displacement, D | ??ABRI[LE,RI][01,02]WSDS0P | 600 | Peak displacement |
| | Rotation, α | ??ABRI[LE,RI][01,02]WSANZP | 600 | Viscous criterion |
| T12 | Accelerations, A_x A_y A_z | ??THSP1200WSAC[X,Y,Z]P | 180 | Peak acceleration |
| | Forces, F_x F_y F_z | ??LUSP1200WSFO[X,Y,Z]P | 600 | Peak force |
| | Moments, M_x M_y M_z | ??LUSP1200WSMO[X,Y,Z]P | 600 | Peak moment |
| Pelvis | Accelerations, A_x A_y A_z | ??PELV0000WSAC[X,Y,Z]P | 600 | Peak acceleration |
| | Forces, F_y | ??PUBC0000WSFOYP | 600 | Peak force |
| Femur | Forces, F_x F_y F_z | ??FEMR[LE,RI]00WSFO[X,Y,Z]P | 600 | Peak force |

1.2.1.3 BioRID-II

| Location | Parameter | | CFC | Injury Calculation |
|------------------------------|----------------------------------|---------------------------|------|---|
| Head | Accelerations, A_x A_y A_z | ??HEAD0000BRAC[X,Y,Z]P | 60 | NIC |
| | Velocity, V_x | ??HEAD0000BRVEXV | 30 | Head rebound velocity |
| | Contact | ??HERE0000BREXV00 | | Head contact time |
| 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 | Nkm Neck shear (+ F_x) Neck tension (+ F_z) |
| | Moments, M_x M_y M_z | ??NECKUP00BRMO[X,Y,Z]P | 600 | Nkm |
| 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 | |
| Thoracic Spine T1 (L & R) | Accelerations, A_x A_z | ??THSP01[LE,RI]BRAC[X,Z]P | 60 | T1-acceleration NIC |
| Thoracic Spine 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 | |

1.2.1.4 Q1 ½

| Location | Parameter | ISO code | CFC | Injury Calculation |
|----------|---|------------------------|------|---|
| Head | Accelerations, A _x A _y A _z | ??HEAD0000Q2AC[X,Y,Z]P | 1000 | Peak Resultant acceleration Resultant (+ve) 3msec exceedence |
| Neck | Forces, F _x F _y F _z | ??NECKUP00Q2FO[X,Y,Z]P | 1000 | Peak Tensile Force F _z |
| | Moments, M _x M _y M _z | ??NECKUP00Q2MO[X,Y,Z]P | 600 | Peak resultant acceleration Resultant (+ve) 3msec exceedence |
| Chest | Accelerations, A _x A _y A _z | ??THSP0000Q2AC[X,Y,Z]P | 180 | Peak Acceleration |
| | Deflection | ??CHST0000Q2DSXP | 180 | Peak Resultant acceleration Resultant (+ve) 3msec exceedence |

1.2.1.5 Q3

| Location | Parameter | ISO code | CFC | Injury Calculation |
|----------|---|------------------------|------|---|
| Head | Accelerations, A _x A _y A _z | ??HEAD0000Q3AC[X,Y,Z]P | 1000 | Peak Resultant acceleration Resultant (+ve) 3msec exceedence |
| Neck | Forces, F _x F _y F _z | ??NECKUP00Q3FO[X,Y,Z]P | 1000 | Peak Tensile Force F _z |
| | Moments, M _x M _y M _z | ??NECKUP00Q3MO[X,Y,Z]P | 600 | Peak resultant acceleration Resultant (+ve) 3msec exceedence |
| Chest | Accelerations, A _x A _y A _z | ??THSP0000Q3AC[X,Y,Z]P | 180 | Peak Acceleration |
| | Deflection | ??CHST0000Q3DSXP | 180 | Peak Resultant acceleration Resultant (+ve) 3msec exceedence |

1.2.1.6 Adult Headform

| Location | Parameter | ISO code | CFC | Injury Calculation |
|----------|----------------------------------|------------------------|------|--------------------|
| Head | Accelerations, A_x A_y A_z | D0HEAD0000PAAC[X,Y,Z]P | 1000 | HIC ₁₅ |

1.2.1.7 Child Headform

| Location | Parameter | ISO code | CFC | Injury Calculation |
|----------|----------------------------------|------------------------|------|--------------------|
| Head | Accelerations, A_x A_y A_z | D0HEAD0000PCAC[X,Y,Z]P | 1000 | HIC ₁₅ |

1.2.1.8 Upper Legform

| Location | Parameter | ISO code | CFC | Injury Calculation |
|----------|----------------|--------------------------|-----|--------------------|
| Femur | Forces, F_x | D0FEMR[UP,LO]00PUFOXP | 180 | Sum of Forces |
| | Moments, M_y | D0FEMR[UP,MI,LO]00PUMOYP | 180 | Bending Moment |

1.2.1.9 Lower Legform (Flex-PLI)

| Location | Parameter | ISO code | CFC | Injury Calculation |
|----------|-------------------------|--|-----|----------------------|
| Femur | Moments, M_x | D0FEMR[UP,MI,LO]00PFMOXP | 180 | |
| Knee | Accelerations, A_y | D0KNEE0000PFACYP | 180 | |
| | Displacement, D_{ACL} | D0KNEEAC00PFDSZP | 180 | ACL/PCL |
| | Displacement, D_{LCL} | D0KNEELC00PFDSZP | 180 | |
| | Displacement, D_{MCL} | D0KNEEMC00PFDSZP | 180 | MCL |
| | Displacement, D_{PCL} | D0KNEEPC00PFDSZP | 180 | ACL/PCL |
| Tibia | Moments, M_x | D0TIBI[UP,LO]00PFMOXP D0TIBIMI[UP,LO]PFMOXP | 180 | Tibia Bending Moment |

1.2.1.10 Vehicle

| Location | Parameter | ISO code | CFC | Injury Calculation |
|----------|------------------------------|---------------------------|-----|--------------------------|
| B-Post | Accelerations, A_x A_y | [14,16]BPILLO0000AC[X,Y]P | 60 | |
| Seatbelt | Force, F_{seatbelt} | ??SEBE0003B3FO0P | 60 | Seat belt force modifier |

1.2.1.11 Trolley

| Location | Parameter | ISO code | CFC | Injury Calculation |
|----------|----------------------|------------------|-----|--------------------|
| CoG | Accelerations, A_x | M0MBARCG0000ACXP | 60 | |

1.2.1.12 Sled

| Location | Parameter | ISO code | CFC | Injury Calculation |
|----------|----------------------|------------------|-----|--------------------|
| Sled | Accelerations, A_x | S0SLED000000ACXP | 60 | |

2 INJURY CRITERIA CALCULATION

This chapter describes the calculation for each injury criteria used within Euro NCAP, 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.

2.1 Head criteria

2.1.1 Head Resultant Acceleration

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 |

2.1.2 HIC₁₅

The HIC₁₅ 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 |
|-------|-----------------------------|

2.1.3 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 | ??HERE0000BREV00 |
| $T_{HRC,end}$ | Time where contact is lost | ??HERE0000BREV00 |

Gaps up to 1ms are ignored if proven to be the result of poor electrical contact.

2.1.4 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 |

2.2 **Neck criteria**

2.2.1 Neck extension bending moment

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

$$(M_y)_i = M_y - F_x \cdot d$$

with:

| | | |
|----------------|------------------------------------|------------------|
| M _y | Filtered Bending Moment | ??NECKUP00??MOYB |
| F _x | Filtered Shear Force | ??NECKUP00??FOXB |
| d | 0.01778m for HIII-50M and HIII-05F | |

2.2.2 NIC

The NIC value is calculated with the following formula:

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

with:

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

$$v_{rel} = A_{rel}$$

| | | |
|---------------------|---|------------------|
| T1 | Average T1 acceleration | |
| A _{x,head} | Filtered Head Acceleration A _x | ??HEAD0000BRACXD |

2.2.3 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:

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

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

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

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

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

$F_x(t)$ 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 $M_{ocy}(t)$

2.3 **Shoulder criteria**

2.3.1 Lateral Shoulder Force

The Lateral Shoulder Force is calculated with the following formula:

$$F_{y_{shoulder}} = \max(F_y(t))$$

with:

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

2.3.2 Lateral Shoulder Rib Displacement

The Lateral Shoulder Rib Displacement is calculated with the following formula:

$$D_{y_{shoulder}} = \max(D_y(t) - D_y(0))$$

with:

$$D_y(t) = L(t) \cdot \cos(\alpha(t))$$

| | | |
|-------------|---|-----------------------|
| $L(t)$ | Filtered Shoulder IR-TRACC length | ??SHRI[LE,RI]00WSDS0C |
| $\alpha(t)$ | Filtered Shoulder IR-TRACC rotation | ??SHRI[LE,RI]00WSANZC |
| $D_y(0)$ | Lateral Shoulder Rib Displacement @ t=0 | |

2.4 **Chest criteria**

2.4.1 Chest Deflection

The Chest Deflection value is calculated with the following formula:

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

with:

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

2.4.2 Seatbelt force modifier

The Seatbelt force modifier is calculated with the following formula:

$$MA_{seatbelt}(t) = \frac{1}{n} \sum_{j=0}^{n-1} F_{seatbelt}(t + j)$$

with:

| | | |
|----------------|--------------------------------------|------------------|
| $F_{seatbelt}$ | Filtered Seatbelt Force | ??SEBE0003B3FO0A |
| n | number of samples equivalent to 20ms | |

2.4.3 Lateral Thoracic Rib Displacement

The Lateral Thoracic Rib Displacement is calculated with the following formula:

$$D_{y_{thorax}} = \max(D_y(t) - D_y(0))$$

with:

$$D_y(t) = L(t) \cdot \cos(\alpha(t))$$

| | | |
|-------------|---|-----------------------|
| $L(t)$ | Filtered Thoracic IR-TRACC length | ??TRRI[LE,RI]01WSDS0C |
| $\alpha(t)$ | Filtered Thoracic IR-TRACC rotation | ??TRRI[LE,RI]01WSANZC |
| $D_y(0)$ | Lateral Thoracic Rib Displacement @ t=0 | |

2.4.4 Viscous Criterion

The VC is calculated with the following formula:

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

With:

sf 1.3 for HIII-50M, 1.3 for HIII-05F 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

$D_{constant}$ 0.229 for HIII-50M, 0.187 for HIII-05F and 0.170 for WorldSID

2.5 **Abdomen criteria**

2.5.1 T12 Resultant Acceleration

The T12 Resultant Acceleration is calculated with the following formula:

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

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

2.5.2 Lateral Abdominal Rib Displacement

The Lateral Abdominal Rib Displacement is calculated with the following formula:

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

with:

$$D_y(t) = L(t) \cdot \cos(\alpha(t))$$

$L(t)$ Filtered Abdominal IR-TRACC length ??ABRI[LE,RI]01WSDS0C

$\alpha(t)$ Filtered Abdominal IR-TRACC rotation ??ABRI[LE,RI]01WSANZC

$D_y(0)$ Lateral Abdominal Rib Displacement @ t=0

2.6 Lower extremities criteria

2.6.1 Knee Displacement

The Knee Displacement value is calculated with the following formula:

$$D_{knee} = \max(D_{knee}(t))$$

With:

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

2.6.2 Tibia Index

The Tibia Index is calculated with the following formula:

$$TI(t) = \left(\frac{M_R(t)}{(M_R)_C} \right) + \left(\frac{F_z(t)}{(F_z)_C} \right)$$

with:

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

M_x Filtered Bending Moment M_x ??TIBI[LE,RI][UP,LO]??MOXB

F_z Filtered Bending Moment F_z ??TIBI[LE,RI][UP,LO]??FOZB

$(M_R)_C$ 225Nm for HIII-50M and 115Nm for HIII-05F

$(F_z)_C$ 35.9N for HIII-50M and 22.9N for HIII-05F