# Robust Project

# Deliverable D.2.1.

# Analysis of test data from European laboratories


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***Milano, 10/12/2005***

# INDEX

# 1 Introduction

This document contains the results of activities conducted inside Work Package (WP) 2 of the ROBUST project.

The basic purpose of this task was as follows:

- Analysis of existing data obtained from European laboratories to investigate any possible correlation between severity indices and performance criteria.
- Analysis of existing data obtained from European laboratories to investigate any differences between tests houses, based on existing data.
- Application of the results obtained in WP3 to a set of raw data obtained from EU laboratories.
- Correlation between barrier performance and biomechanics criteria.

# 2 Analysis of existing data obtained from European laboratories

A collection of 174 data sets from full scale TB11 crash tests have been obtained from European laboratories. They contained the following information:

- year of test
- vehicle make
- vehicle test mass
- data sample rate
- actual speed and angle
- barrier dynamic deflection
- ASI
- THIV/PHD

Data was received from seven Laboratories. Of the 174 TB11 tests, 111 were successful and 63 unsuccessful. Some tests have been received without PHD data. Data have been reported (in an anonymous format) at the end of this document.

In the following table the test houses that provided these test data have been identified:

| LABORATORY | Number of tests |
|---|---|
| Autostrade | 31 |
| BAST | 24 |
| Finland | 1 |
| LIER | 80 |
| MIRA | 1 |
| TRL | 9 |
| VTI | 28 |

*Table 1. Test results analysed*

## 2.1 Compliance with severity criteria

63 of the 174 tests failed at least one of the severity criteria. Only 14 (22%) failed both criteria; 21 (33%) failed ASI only and 28 (45%) failed THIV/PHD only

42 tests failed the THIV/PHD criterion; 13 failed by THIV alone, 25 by PHD alone and only 4 by both.

| COMPLIANCE | | THIV/PHD | | |
|---|---|---|---|---|
| | | PASS | FAIL | TOTAL |
| ASI | PASS | 111 | 28 | 139 |
| | FAIL | 21 | 14 | 35 |
| | TOTAL | 132 | 42 | 174 |

*Table 2: Severity indices distribution*

## 2.2 Correlation between ASI, THIV and PHD

A series of correlation analyses have been performed between the data sets made available by the test laboratories. In the following figures some of these are examined.

A first comparison is made between THIV and ASI values:

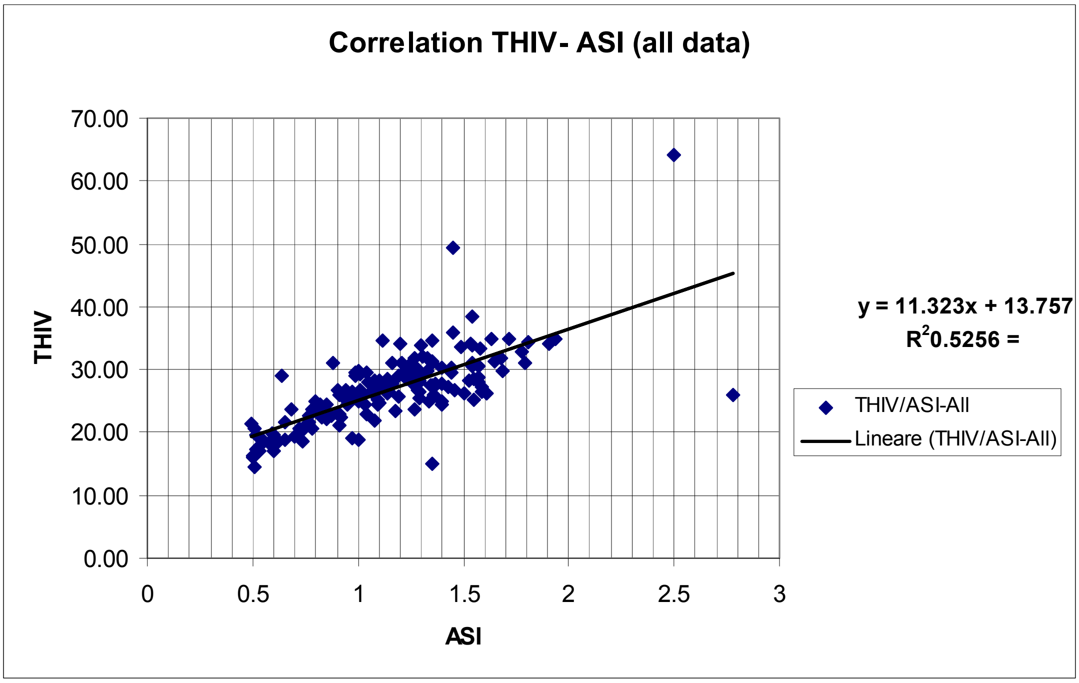


*Figure 1: THIV_ASI correlation.*

The above figure contains some singular results that have been removed to obtain the following figure:

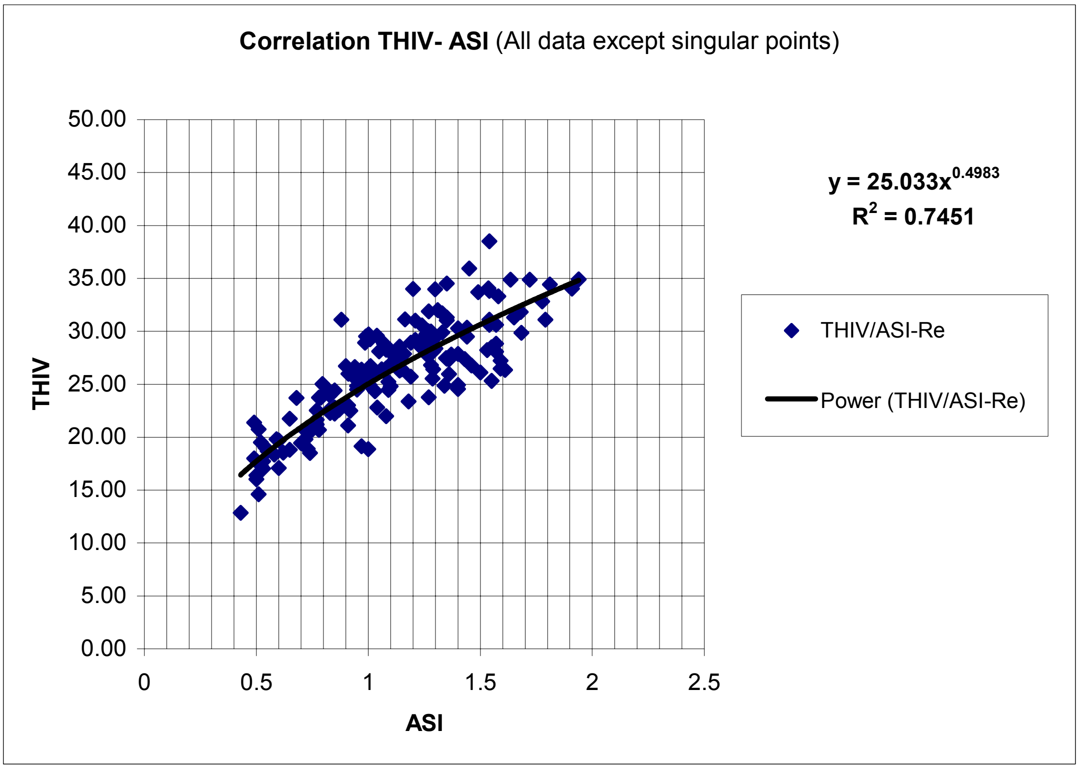


*Figure 2: THIV ASI correlation.*

This graph shows a fair correlation between ASI and THIV indices.

A further comparison is made to investigate the tendencies between the different laboratories. This comparison has been made between laboratories that have provided more than one data set:

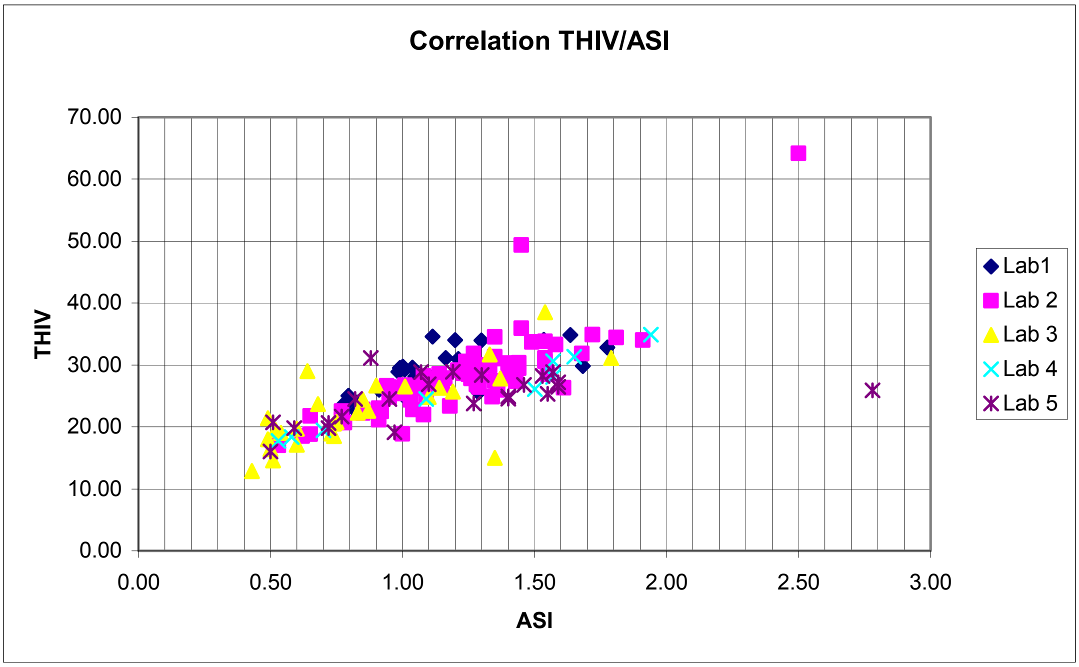


*Figure 3: ASI to THIV correlation within different Laboratories.*

It can be seen that, apart from the singular points, the tendencies between the different labs are similar. This can also be seen in the following table reporting the correlation functions for different laboratories.

| Lab | Corr. function |
|---|---|
| ALL | y = 25.033x0.4983 |
| 1 | y = 26.981x0.4305 |
| 2 | y = 24.018x0.3305 |
| 3 | y = 24.787x0.545 |
| 4 | y = 25.088x0.5596 |
| 5 | y = 23.637x0.4899 |

*Table 3: ASI-THIV correlation functions*

From Figure 2 it can be seen that the best correlation function is the following:

$$THIV = 25.033 \bullet ASI^{0.4989}$$

This equation has a correlation factor ($R^2$) of 0.7451.

This correlation function creates the following table:

| ASI | THIV |
|---|---|
| 1.0 | 25.033 |

| | |
|---|---|
| 1.4 | 29.61 |

*Table 4: ASI THIV*

It should be noted that at present, within EN1317-2, the current threshold value for THIV is quoted as 33kph.

The following graphs investigate the relationship between THIV and PHD, and between PHD and ASI:

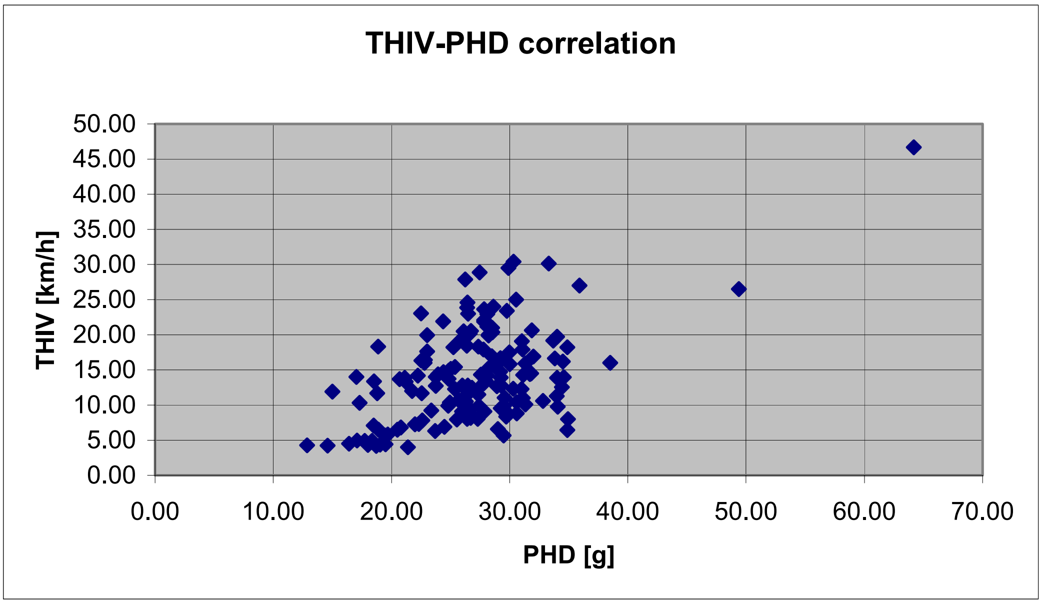


*Figure 4: THIV and PHD correlation*

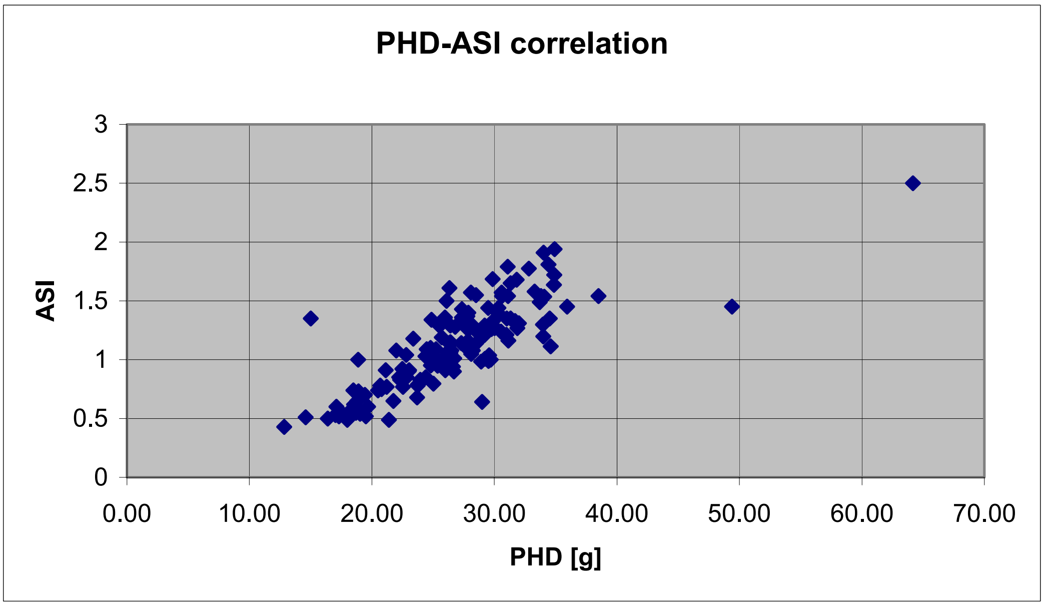


*Figure 5: PHD and ASI correlation*

The above results show no correlation between PHD and THIV or ASI.

## 2.3 *Correlation between Dynamic deflection and severity indices*

In the following figure, the correlation between severity indices and dynamic deflection is investigated:

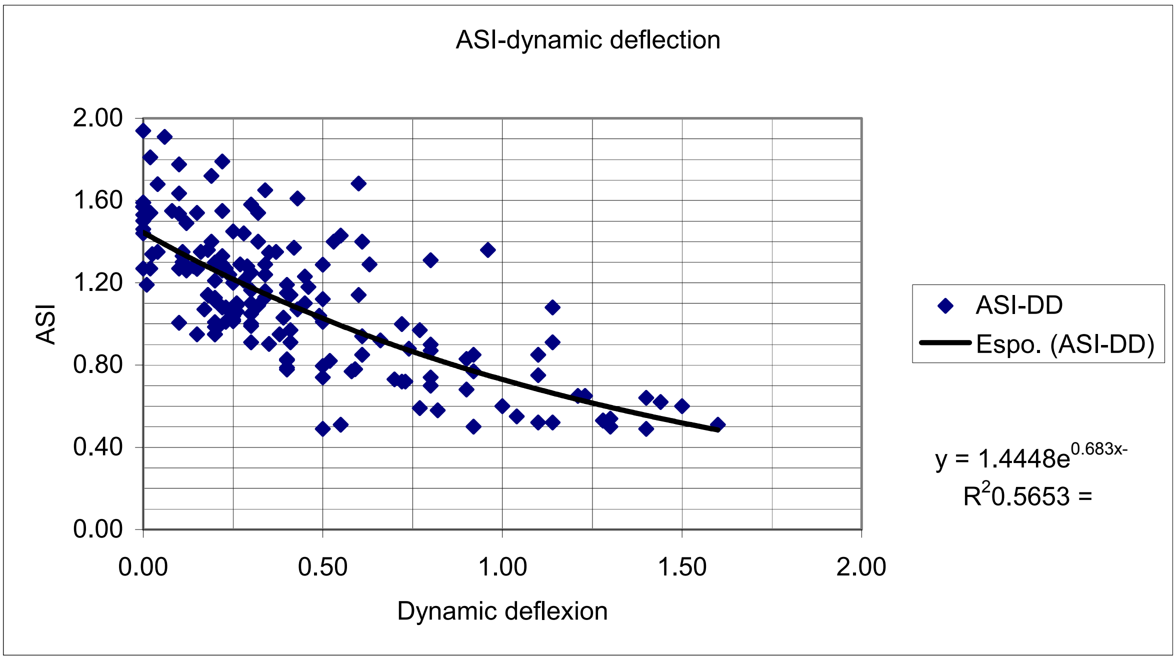


*Figure 6: ASI and dynamic deflection correlation.*

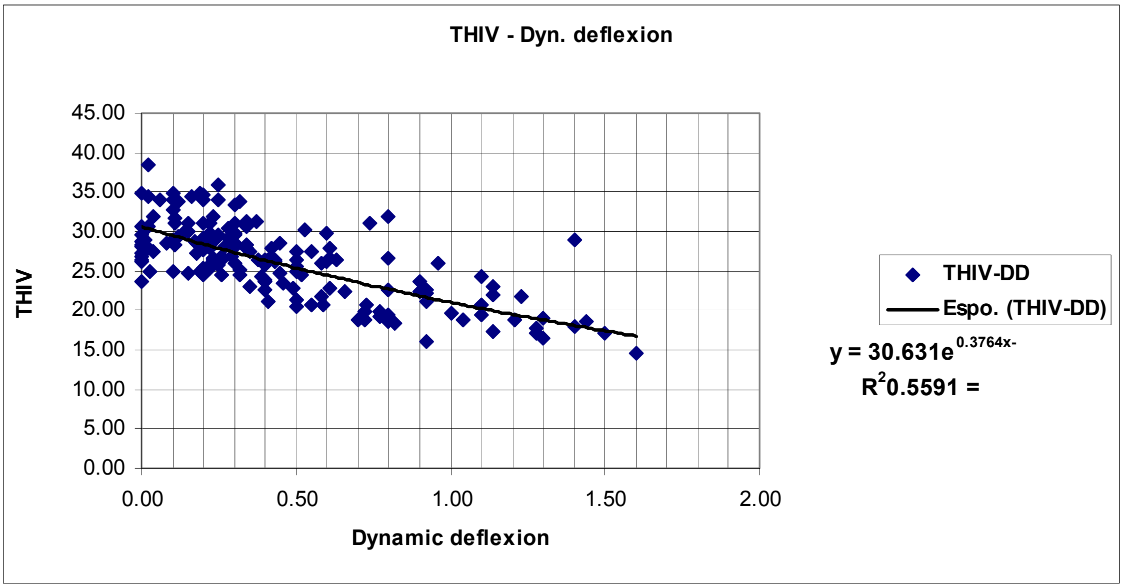


*Figure 7: THIV and dynamic deflection correlation*

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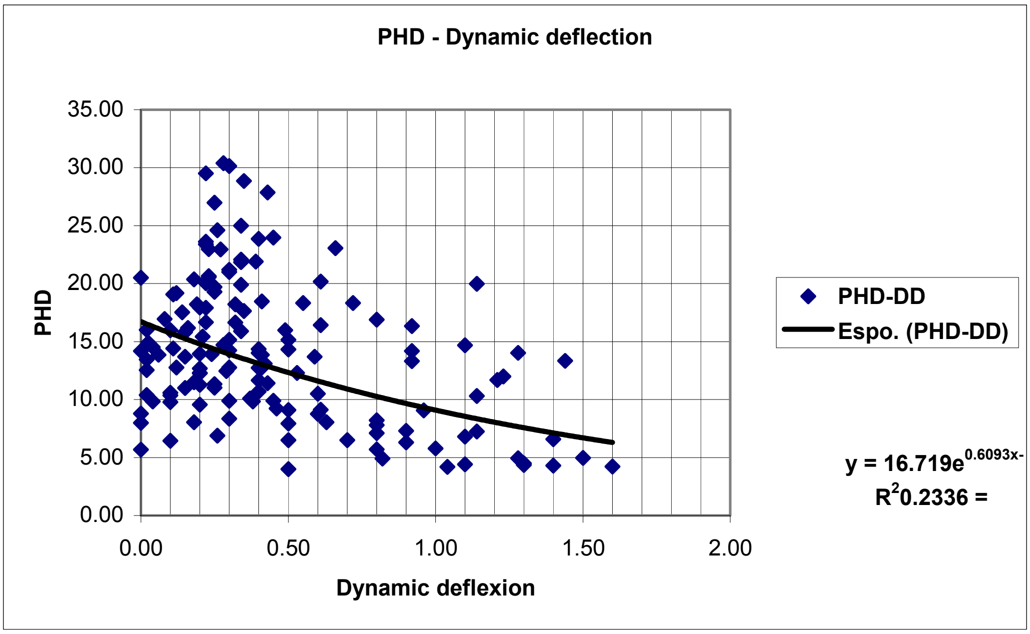


*Figure 8: PHD and dynamic deflection correlation*

The investigation shows a weak correlation between THIV, ASI and dynamic deflection and no correlation between PHD and dynamic deflection.

The correlation between ASI, THIV and dynamic deflection has again been analysed to investigate any different tendencies between the different laboratories.

These results show that there is only a very limited correlation between severity indices. It has already been demonstrated on previous occasions that from a scientific point of view, ASI, THIV and PHD are different things, and this is enough to explain the lack of correlation in many cases.

The main differences between the severity indices are:

- ASI uses three components of acceleration while THIV-PHD use a planar motion where the z acceleration component is not used.
- THIV – PHD use a critical time that corresponds to the time where the theoretical head impact against the conventional box representing the vehicle interior.
- THIV is affected by the yaw motion while ASI does not take this measure into account.

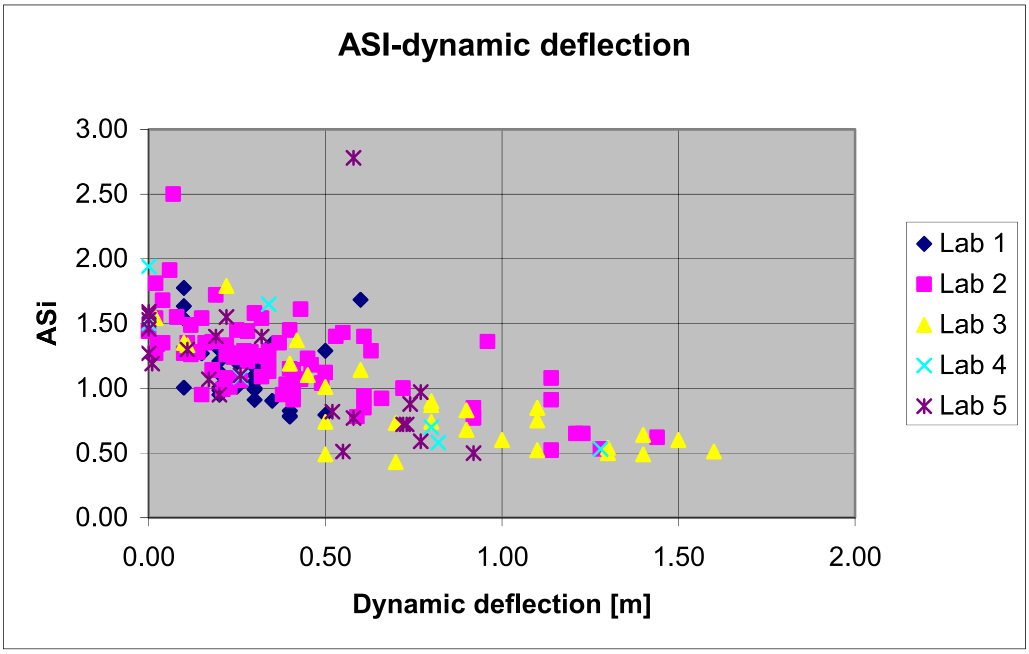


*Figure 9: ASI and dynamic deflection correlation at different laboratories.*

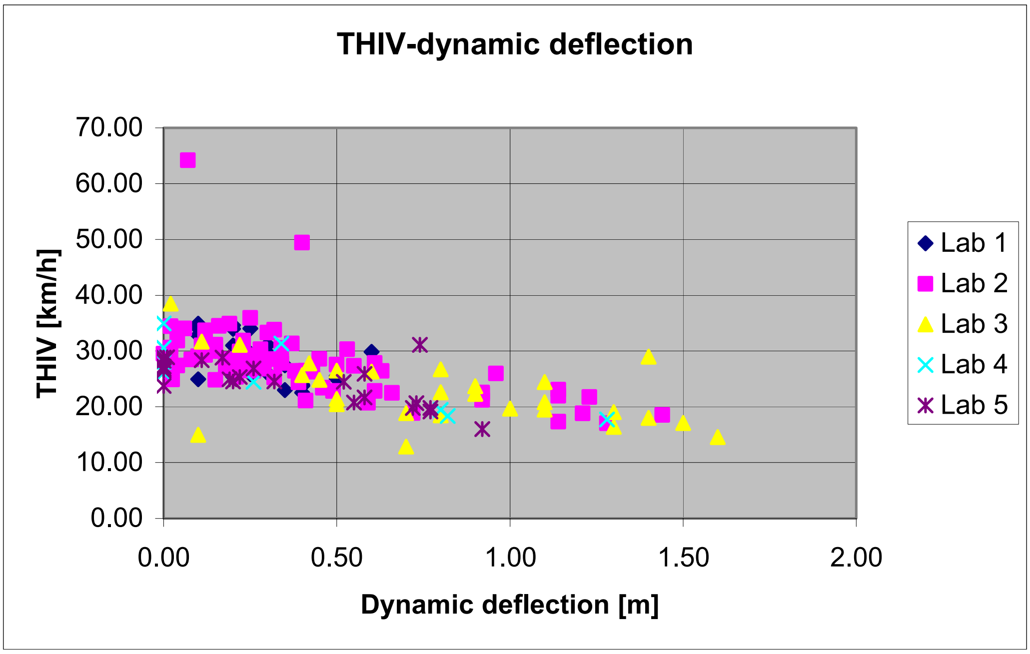


*Figure 10: THIV and dynamic deflection correlation at different laboratories*

From Figure 9 and Figure 10 it can be seen that the tendencies of these results are the same in all the laboratories. In the following table the correlation functions of different laboratories are reported. The differences between the correlation functions for Labs 4 and 5 are probably due to the small number of tests provided.

| Lab | Corr. Function |
|---|---|
| All | y = 1.4448e-0.683x |
| 1 | y = 1.2829e-0.5836x |
| 2 | y = 1.4973e-0.6099x |
| 3 | y = 1.3841e-0.6902x |
| 4 | y = 1.6442e-0.9867x |
| 5 | y = 1.4716e-0.8779x |

*Table 5: ASI-DD correlation function*

| Lab | Corr. Function |
|---|---|
| All | y = 30.631e-0.3764x |
| 1 | y = 32.827e-0.5464x |
| 2 | y = 32.141e-0.4018x |
| 3 | y = 27.476e-0.2846x |
| 4 | y = 29.923e-0.4634x |
| 5 | y = 27.801e-0.3747x |

*Table 6: THIV-DD correlation function*

# 3 Analysis of existing raw data

## *3.1 Introduction*

Inside Work Package 3 of ROBUST, techniques have been used to evaluate the severity indices and a problem related to the moving average used inside ASI and PHD has been identified.

The current definition of the ASI index includes the application of a moving average over 50 milliseconds to the acceleration data. The origin of this calculation procedure was based on research on the injury assessment of vehicle and aircraft occupants in phenomena such as re-entry space capsule impacts, combat airplane manoeuvres, and traversing slope embankments. These phenomena were deemed to have a common duration of less than 50 ms, or, if duration was longer, limited oscillations throughout the event. For this reason, computing an average over a period of 50 ms was used to obtain an average value to be compared with the tolerable limits.

Impacts against road restraint systems generally have a duration greater than 50 milliseconds, and show strong oscillations at different frequencies. For this reason, it is not completely justified that the above mentioned severity criteria can provide precise injury assessment. Also, the 50 ms moving average when applied over long acceleration pulses becomes a low-pass filter, but it does not behave like filters used conventionally for crash analysis.

From the point of view of calculus, the analysis of the ASI procedure has shown that the moving average used inside the ASI and PHD evaluations does not perform like a regular low-pass filter. A new procedure to evaluate the ASI value has been proposed. This new procedure uses a standard filtering technique instead of the moving average.

One of the problems that must be solved is the choice of the cut off frequency for this filtering. The objective of this part of the project was to find an answer to this problem by applying the modified version of the ASI formula to the database of raw data obtained from the test houses.

## *3.2 Raw data*

The raw data contained acceleration data in the three directions (x, y, and z) and yaw rate from TB11 tests. To guarantee anonymity no further information has been acquired on the tests.

## *3.3 Analysis of raw data*

The set of data has been analysed by comparing the ASI evaluated with the standard method currently within EN1317-1, with a new ASI evaluated calculated using a standard filtering technique (instead of the moving average).

**Standard ASI:**

The acceleration severity index ASI is a function of time, computed with the following equation (1):

$$ASI(t) = \left[(\bar{a}x/\hat{a}x)^2 + (\bar{a}y/\hat{a}y)^2 + (\bar{a}z/\hat{a}z)^2\right]^{1/2} \qquad (1)$$

where :

$\hat{a}x$, $\hat{a}y$ and $\hat{a}z$ are the limit values for the components of the acceleration along the body axis x, y and z;

$$\hat{a}x = 12g,\ \hat{a}y = 9g,\ \hat{a}z = 10g, \qquad (2)$$

$\bar{a}x$, $\bar{a}y$ and $\bar{a}z$ are the components of the acceleration of a selected point P on the vehicle, filtered with a CFC180 filter (refer to ISO 6487 for further information) and averaged over a moving time interval $\delta$ = 50 ms, so that:

$$\bar{a}x = \frac{1}{\delta}\int_t^{t+\delta} ax\,dt\,;\quad \bar{a}y = \frac{1}{\delta}\int_t^{t+\delta} ay\,dt\,;\quad \bar{a}z = \frac{1}{\delta}\int_t^{t+\delta} az\,dt\,; \qquad (3)$$

g = 9,81 $ms^{-2}$ and is the value for acceleration due to gravity.

ASI = max [ASI(t)] (4)

**Modified ASI:**

The modified ASI is a function of time, computed with the following equation (5):

$$ASI(t) = \left[(\bar{a}x/\hat{a}x)^2 + (\bar{a}y/\hat{a}y)^2 + (\bar{a}z/\hat{a}z)^2\right]^{1/2} \qquad (5)$$

where:

$\hat{a}x$, $\hat{a}y$ and $\hat{a}z$ are the limiting values for the components of acceleration along the body axis x, y and z;

$$\hat{a}x = 12g,\ \hat{a}y = 9g,\ \hat{a}z = 10g, \qquad (6)$$

$\bar{a}x$, $\bar{a}y$ and $\bar{a}z$ are the components of the acceleration of a selected point P of the vehicle, filtered first with a CFC180 filter and then with a 2-pole Butterworth filter (forward and backward to avoid time shift) to create a resultant 4-pole filter (CFC shaped filter).

g = 9,81 $ms^{-2}$ is the reference for the acceleration.

ASI = max [ASI(t)]

## 3.4 Butterworth filter

The filter proposed instead of the moving average is a 4-pole phase-less digital filter defined, for a specific cut-off frequency, by the following equations in the time domain:

$X(t)$ = input signal

$Y(t)$ = filtered signal

$T$ = sampling period

$CF$ = cut off frequency

- According to ISO 6487, the value of CF to be introduced in this equation is the cutoff frequency at -6dB, which equals 1,25 times the cutoff frequency at -3dB. Hence, the filters used in the study are defined by their cutoff frequency at -6dB.
- According to ISO 6487, the value of CF is not the same as the CFC class value for a filter. For example, for CFC 180, the cutoff frequency at -3dB is 300, and the cutoff frequency at -6dB to be introduced in the equation is 300*1.25 = 375.

The filtered signal is defined by:

$$Y(t) = a_0 X(t) + a_1 X(t-1) + a_2 X(t-2) + b_1 Y(t-1) + b_2 Y(t-2) \qquad (7)$$

Where:

$$w_d = 2 \cdot \pi \cdot CF$$

$$w_a = \sin(w_d \cdot T/2)/\cos(w_d \cdot T/2)$$

$$a_0 = w_a^2 /(1.0 + \sqrt{2} \cdot w_a + w_a^2)$$

$$a_1 = 2 \cdot a_0$$

$$a_2 = a_0$$

$$b_1 = -2(w_a^2 - 1)/(1 + \sqrt{2} \cdot w_a + w_a^2)$$

$$b_2 = (-1 + \sqrt{2} \cdot w_a - w_a^2)/(1 + \sqrt{2} \cdot w_a + w_a^2)$$

Equation 7 is for a 2-pole filter. To obtain a 4-pole filter, signals are passed through the filter twice. The first time the signal is passed through in the forward direction, the second time in the rearwards direction (to cancel the time shift).

It has to be noted that even if this filter has been defined as a “CFC shaped filter”, the value of this CF (e.g., 12 Hz) does not correspond to the filter “CFC 12”

## 3.5 Results

The method described above has been applied to the available set of raw data to investigate the influence of different cut off frequencies on the results and to identify the most appropriate cut off frequency.

The following figure contains ASI values obtained with the standard technique (shown in dark blue and labelled ‘ASI’) and those calculated with the modified technique with different cut off frequencies from 10 Hz up to 20 Hz. Linear regressions are also reported.

In Appendix 2 the same results are reported in a tabular format.

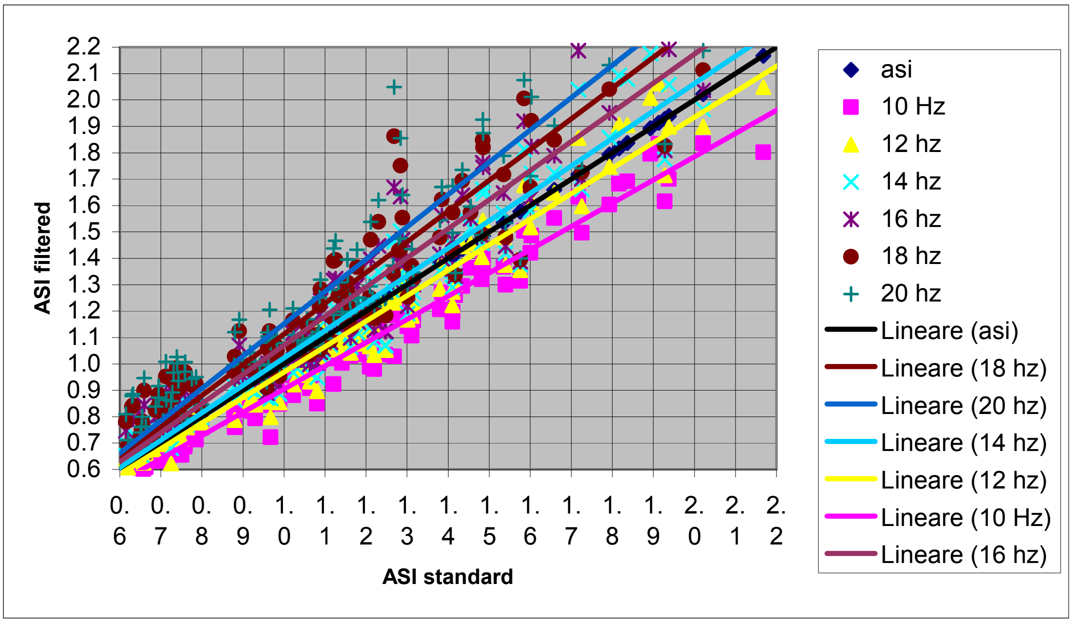


*Figure 11: Comparison between ASI standard and modified ASI*

By changing the cut off frequency, the modified ASI follows this change and the modified ASI value increases with an increase in the cut off frequency.

The final cut off frequency (12 Hz) has been identified as the one that has the best correlation with the current standard ASI formula. The objective is to avoid, if possible, modification of the current limits for the ASI formula.

The following figure shows the correlation between standard ASI and modified ASI using the above filtering technique with a 12 Hz cut off frequency.

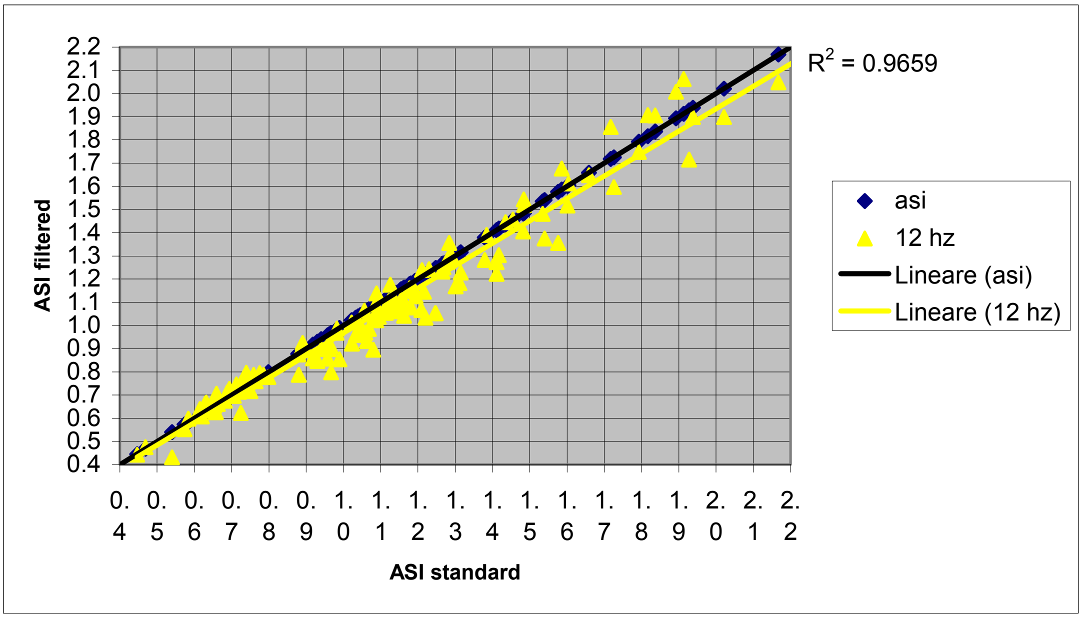


*Figure 12: Comparison between standard ASI and modified ASI at 12 Hz*

It can be seen that globally the tendency is similar between the two sets of ASI results, but some ASI values are decreased whilst some others are increased.

In any case, implementing this procedure implies that the values of the severity indices would suffer variations that may affect their classification according to the current EN 1317.

In general we can see a smaller influence on low values of ASI and a stronger influence on higher ASI values. This is probably related to the strong oscillations that are present in impacts with high ASI values which are filtered insufficiently by the moving average method.

It must be also be noted that if we perform the same statistical analysis but divide the population into different ranges of ASI, it can be seen that the most critical values (ASI from 1.0 to 1.4) are not the ones which best correspond to the 12 Hz filter (See figures).

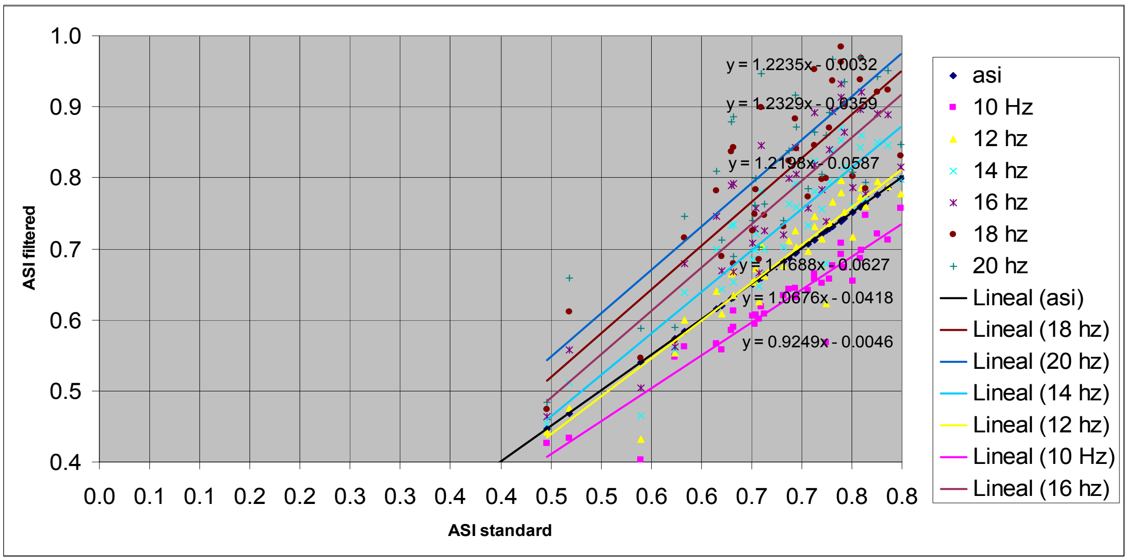


*Figure 13 ASI (0 – 0.8). Very good agreement to a cut-off frequency 12 Hz.*

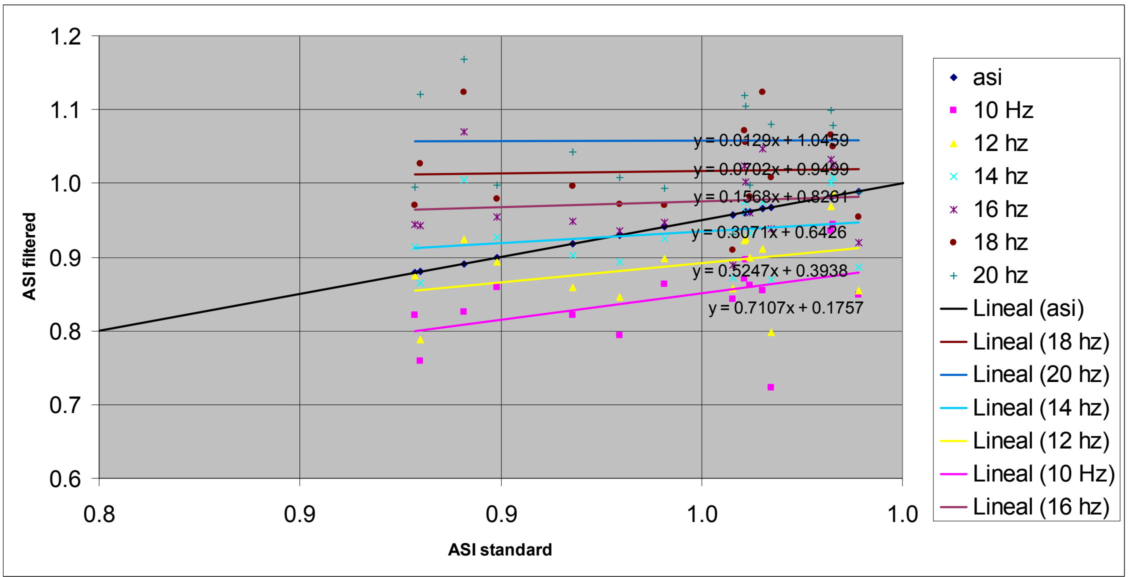


*Figure 14. (ASI 0.8 – 1.0). 12 Hz cut-off frequency slightly underpredicting. Note: Small slopes in linear functions*

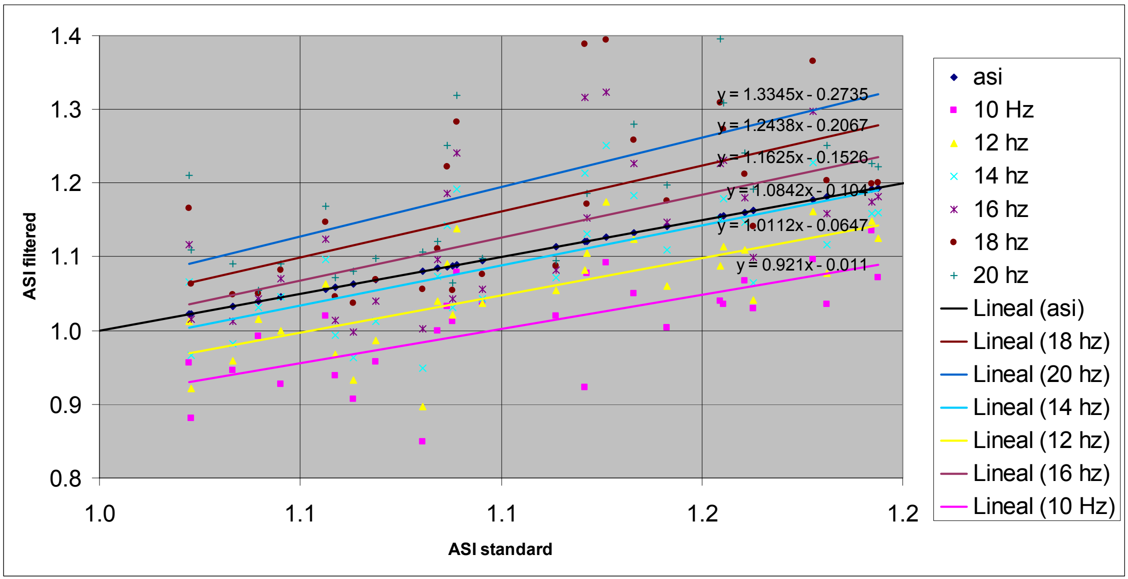


*Figure 15. (ASI 1.0 – 1.2). 12 Hz cut-off frequency slightly underpredicting*

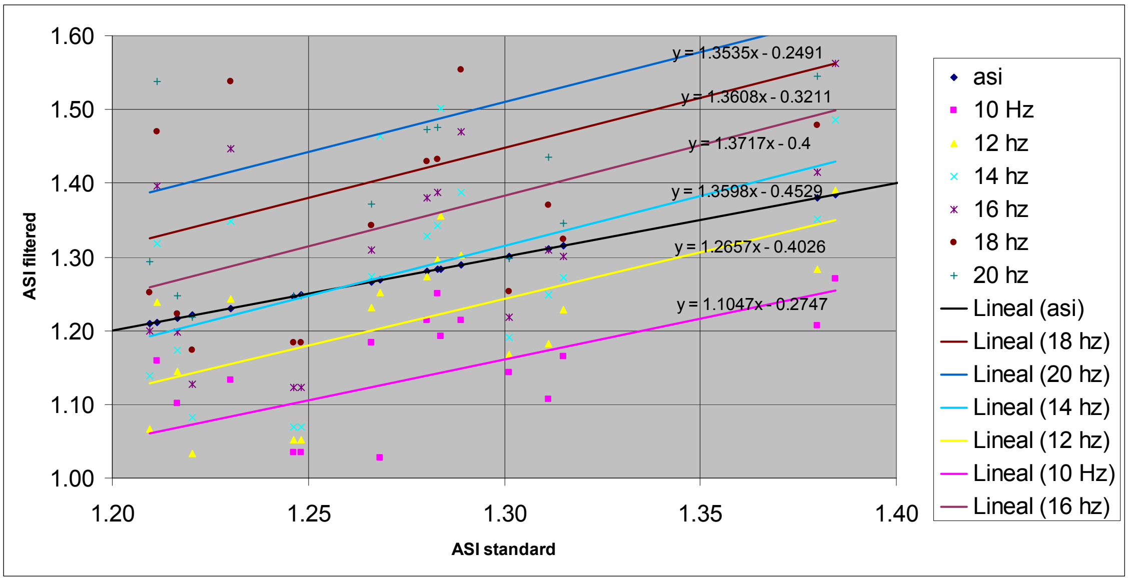


*Figure 16. (ASI 1.2 – 1.4). 12 and 14 Hz cut-off frequencies show the best agreement.*

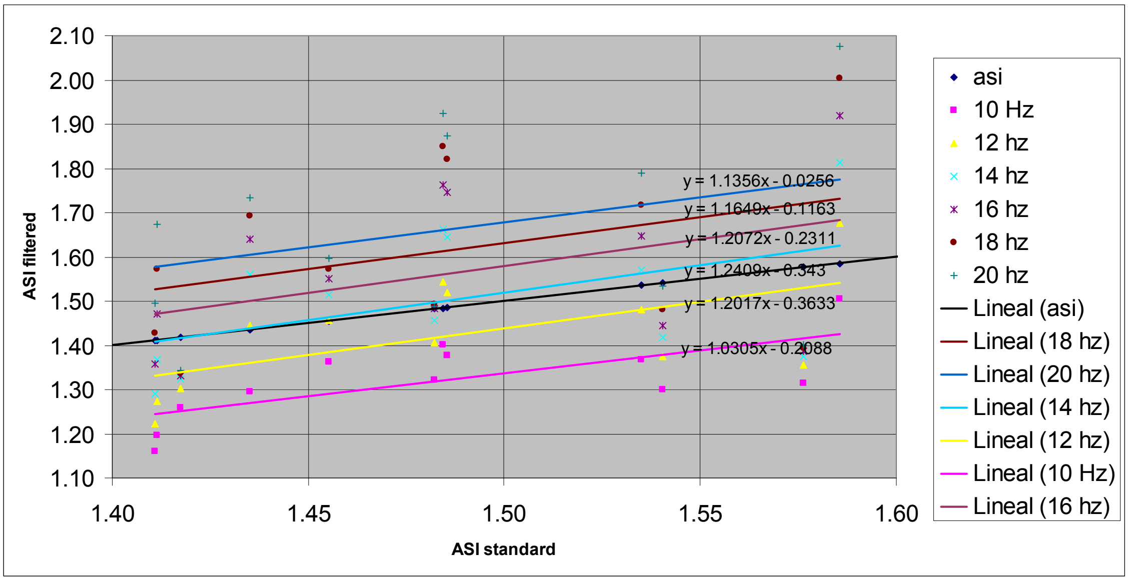


*Figure 17. (ASI 1.4 – 1.6). 12 and 14 Hz cut-off frequencies show the best agreement.*

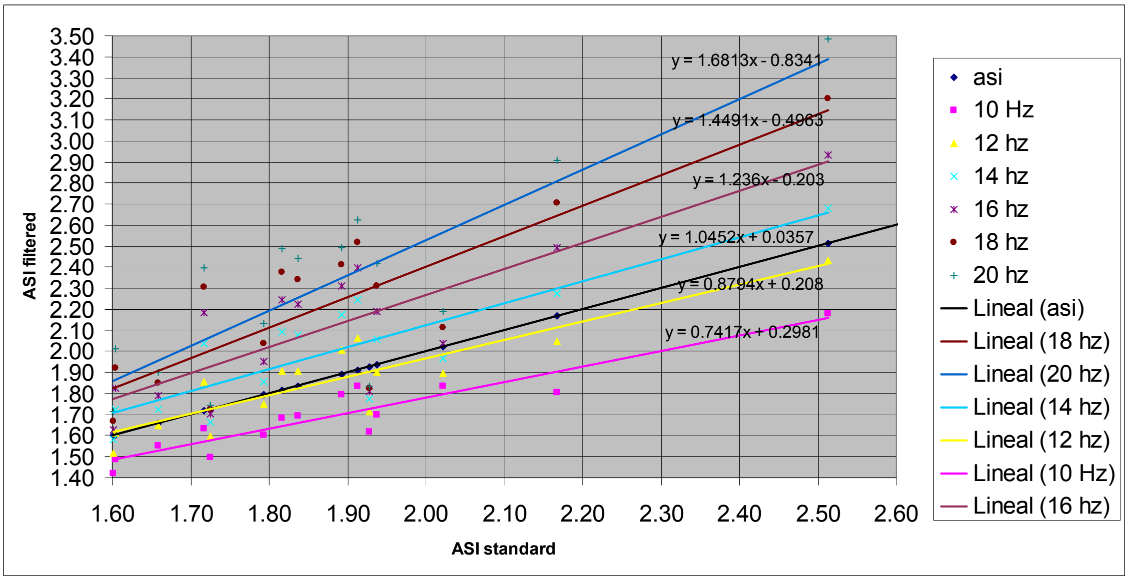


*Figure 18.(ASI  1.6). 12 and 14 Hz cut-off frequencies show the best agreement.*

# 4 Correlation between barrier performance and biomechanics criteria

EN 1317 should evaluate barrier performance using standard tests. This evaluation procedure contains the use of severity indices (ASI, THIV). Experience has shown that by using these evaluation procedures, barrier performance has strongly improved since the introduction of EN1317.

One of the proposals that the ROBUST project has evaluated is the use of injury criteria from instrumented dummies as an alternative to severity indices for the evaluation of barrier performance.

For this purpose, biomechanical and vehicle data from TB11 tests that included a Hybrid III instrumented dummy were collected and analysed. The data acquired were:

- Vehicle centre of gravity acceleration and yaw rate time histories
- Neck load time histories
- Dummy head acceleration time histories.

None of the tests failed the neck criteria for a purely frontal impact.

In the following table, severity indices and HIC values for 23 tests are reported.

| Test | ASI traditional | THIV | time of flight | PHD | HIC |
|---|---|---|---|---|---|
| | | m/s | s | g | |
| 34 | 1.266 | 31.396 | 0.205 | 12.441 | 4397.334 |
| 90 | 0.961 | 24.278 | 0.266 | 20.035 | 2615.130 |
| 58 | 1.181 | 33.238 | 0.165 | 16.609 | 2168.279 |
| 82 | 1.246 | 26.513 | 0.188 | 19.176 | 808.003 |
| 65 | 1.221 | 28.131 | 0.400 | 14.998 | 797.722 |
| 85 | 1.023 | 22.920 | 0.200 | 13.724 | 264.725 |
| 59 | 1.178 | 31.732 | 0.412 | 13.428 | 173.480 |
| 81 | 1.088 | 27.017 | 0.186 | 20.570 | 158.436 |
| 32 | 1.385 | 26.726 | 0.301 | 9.266 | 109.335 |
| 63 | 0.880 | 20.968 | 0.207 | 22.486 | 97.299 |
| 60 | 1.535 | 31.954 | 0.362 | 18.937 | 73.995 |
| 62S | 0.965 | 23.405 | 0.406 | 25.880 | 66.324 |
| 86 | 1.022 | 22.632 | 0.197 | 16.416 | 60.497 |
| 87 | 0.899 | 25.590 | 0.192 | 11.183 | 60.046 |
| 64S | 1.284 | 23.603 | 0.328 | 10.693 | 55.435 |
| 93 | 0.764 | 21.935 | 0.201 | 9.176 | 52.242 |
| 84 | 1.095 | 28.715 | 0.184 | 12.967 | 50.105 |
| 89 | 0.958 | 25.306 | 0.195 | 13.841 | 49.394 |
| 88 | 1.089 | 27.796 | 0.179 | 9.547 | 41.355 |
| 92 | 0.941 | 23.710 | 0.196 | 6.569 | 37.238 |

| | | | | | |
|---|---|---|---|---|---|
| 91 | 0.918 | 23.613 | 0.249 | 17.446 | 29.300 |
| 18 | 0.879 | 21.043 | 0.204 | 15.383 | 11.680 |
| 61S | 0.540 | 13.764 | 0.447 | 12.156 | 8.660 |

- 3 of 23 tests had HIC values exceeding the limit of 1000.
- In some cases the HIC value was greater than twice the 1000 limit, indicating a very severe impact.
- In some cases a high THIV value was recorded, however these tests would have failed in any case due to non-compliance with other test parameters.

The above table is also reported in the following figures comparing ASI and THIV to HIC values:

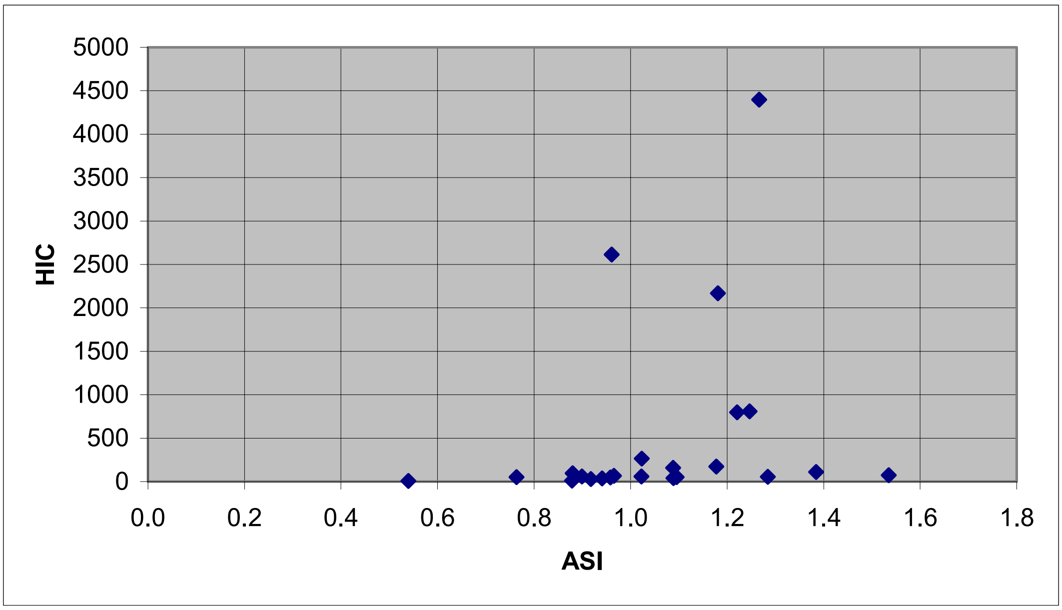


*Figure 19: ASI and HIC correlation*

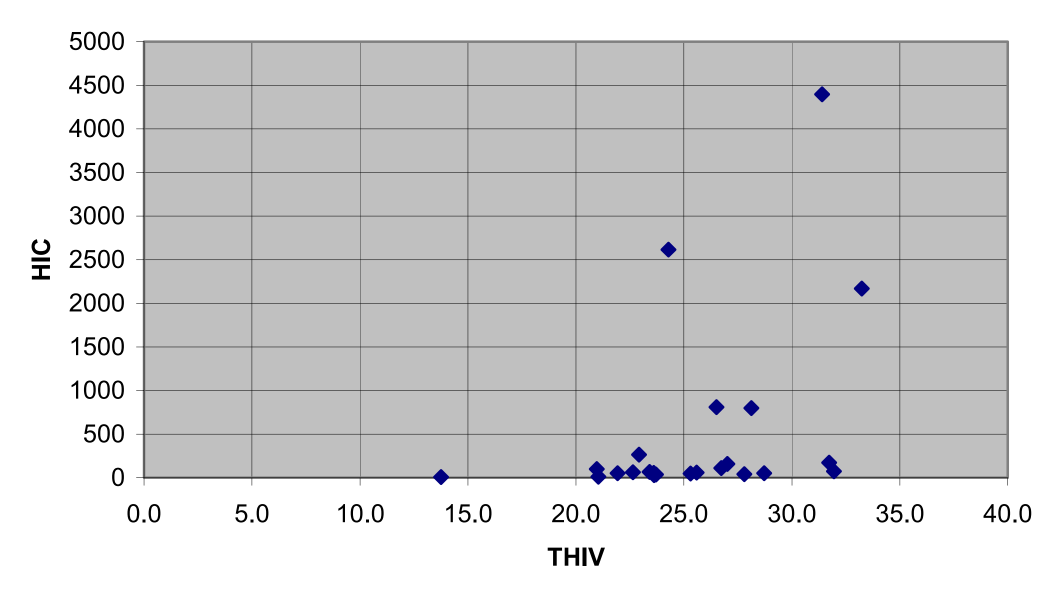


*Figure 20: THIV and HIC correlation*

The following observations can be made.

- The size of the data set is not statistically large enough to draw any final conclusions.
- EN1317-2 tests are fronto-lateral impacts and currently no specific dummies are available for this type of impact. Tests have only been performed with Hybrid III dummies and these have been developed for frontal-only impacts.
- When analysing the HIC criterion, even very 'bad' barriers produced very low injury criteria for the dummy measurements.
- A high value of HIC can only be seen if there is a direct impact between the head of the dummy and the barrier (this can be seen with other methods).
- Dummy measurements can be heavily influenced by differences in the vehicle behaviour and structure.
- Severity indices are used to rank and compare barrier performances; they are not to give a direct measure of the risk of injuries.
- Other dummy-based injury criteria that are used in crash safety, such as chest deflection, lumbar spine loads, etc. were not analysed in this task due to unavailability of data.

These observations lead to the conclusion that, at present, dummies should not be used to evaluate the performance of a barrier in isolation.

The use of dummy measurements in the evaluation of barrier performance, impact severity and ranking (EN1317 scope) is not suggested.

The acquisition of relevant dummy data is suggested so as to acquire information for future revisions of EN1317.

An appropriate dummy could be used to verify head impacts with the barrier. This could later become a fail criterion for future tests.

# Appendix 1

In this Appendix, the table used for the correlation analysis is reported in an anonymous format.

| Speed | Angle | Dyn Deflection | Sampling Rate | ASI | THIV | PHD |
|---|---|---|---|---|---|---|
| 93.6 | 20.0 | 0.25 | 2500.00 | 1.02 | 26.29 | 11.32 |
| 99.08 | 20.0 | 0.15 | 2500.00 | 1.27 | 30.02 | 15.83 |
| 99.36 | 20.0 | 0.40 | 2500.00 | 0.78 | 23.74 | 12.73 |
| 99.43 | 20.0 | 0.50 | 2500.00 | 1.29 | 25.52 | 7.93 |
| 99.72 | 20.0 | 0.40 | 2500.00 | 0.79 | 23.76 | 14.02 |
| 99.72 | 20.0 | 0.20 | 2500.00 | 0.95 | 25.37 | 12.27 |
| 99.77 | 20.0 | 0.29 | 10000.00 | 1.28 | 26.81 | 12.45 |
| 99.98 | 20.0 | 0.10 | 2500.00 | 1.54 | 34.07 | 9.77 |
| 100 | 20.0 | 0.25 | 2500.00 | 1.01 | 25.87 | 19.28 |
| 100.00 | 21.0 | 0.80 | 2000.00 | 1.31 | 32.00 | 16.90 |
| 100.03 | 20.0 | 0.60 | 2500.00 | 1.68 | 29.86 | 8.77 |
| 100.08 | 20.0 | 0.40 | 2500.00 | 0.82 | 22.55 | 11.67 |
| 100.08 | 20.0 | 0.30 | 2500.00 | 0.91 | 26.00 | 12.75 |
| 100.08 | 20.0 | 0.25 | 2500.00 | 1.20 | 34.01 | 19.71 |
| 100.08 | 20.0 | 0.20 | 2500.00 | 1.30 | 33.98 | 11.28 |
| 100.10 | 21.0 | 0.34 | 16000.00 | 1.65 | 31.32 | 15.90 |
| 100.11 | 20.0 | 0.50 | 10000.00 | 1.12 | 27.56 | 14.34 |
| 100.19 | 20.0 | 0.39 | 10000.00 | 1.03 | 24.36 | 21.91 |
| 100.22 | 20.0 | 0.21 | 10000.00 | 0.99 | 25.36 | 15.42 |
| 100.39 | 20.0 | 0.11 | 10000.00 | 1.35 | 31.02 | 19.08 |
| 100.40 | 19.50 | 0.80 | 16000.00 | 0.70 | 19.44 | 5.70 |
| 100.4 | 20 | 0.19 | 10000.00 | 1.4 | 24.912 | |
| 100.41 | 20.0 | 0.22 | 10000.00 | 1.08 | 28.24 | 20.04 |
| 100.44 | 20.0 | 0.40 | 2500.00 | 0.83 | 23.95 | 14.36 |
| 100.44 | 20.0 | 0.35 | 2500.00 | 0.90 | 23.01 | 17.63 |
| 100.44 | 20.0 | 0.25 | 2500.00 | 1.04 | 29.57 | 11.03 |
| 100.44 | 20.0 | 0.30 | 2500.00 | 1.16 | 31.13 | 14.25 |
| 100.44 | 20.0 | 1.14 | 10000.00 | 0.52 | 17.30 | 10.32 |
| 100.50 | 20.0 | 0.32 | 10000.00 | 1.09 | 25.23 | 18.23 |
| 100.53 | 20.0 | 0.02 | 10000.00 | 1.54 | 30.61 | 10.39 |
| 100.60 | 20.0 | 0.26 | 10000.00 | 1.09 | 24.48 | 6.90 |
| 100.61 | 20.0 | 0.55 | 10000.00 | 1.43 | 27.36 | 18.32 |
| 100.75 | 20.0 | 0.40 | 10000.00 | 1.45 | 49.39 | 26.51 |
| 100.79 | 20.0 | 0.10 | 2500.00 | 1.78 | 32.81 | 10.57 |
| 100.8 | 20.0 | 0.30 | 2500.00 | 1.00 | 29.70 | 8.35 |
| 100.8 | 20.0 | 0.20 | 2500.00 | 1.11 | 34.59 | 13.93 |
| 100.80 | 20.0 | 1.28 | 20000.00 | 0.53 | 17.73 | 4.92 |
| 100.80 | 20.0 | 0.00 | 10000.00 | 1.57 | 30.60 | 8.80 |
| 100.8 | 20 | 0.01 | 10000.00 | 1.19 | 28.908 | |
| 100.81 | 20.0 | 0.32 | 10000.00 | 1.54 | 33.81 | 16.64 |
| 100.90 | 20.0 | 0.82 | 16000.00 | 0.58 | 18.36 | 4.90 |

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|---|---|---|---|---|---|---|
| 101.00 | 20.0 | 0.34 | 10000.00 | 1.29 | 28.22 | 19.89 |
| 101.00 | 20.0 | 0.00 | 10000.00 | 1.94 | 34.92 | 8.00 |
| 101.01 | 20.0 | 0.72 | 10000.00 | 1.00 | 18.88 | 18.33 |
| 101.06 | 19.9 | 0.22 | 10000.00 | 1.26 | 29.75 | 23.41 |
| 101.15 | 20.0 | 0.00 | 10000.00 | 1.44 | 29.49 | 5.68 |
| 101.16 | 20.0 | 0.30 | 2500.00 | 0.99 | 29.52 | 9.88 |
| 101.16 | 20.0 | 0.20 | 2500.00 | 1.01 | 29.24 | 9.56 |
| 101.20 | 20.0 | 1.44 | 10000.00 | 0.62 | 18.53 | 13.35 |
| 101.20 | 20.0 | 0.23 | 10000.00 | 1.27 | 31.87 | 20.64 |
| 101.20 | 21.0 | 1.04 | 10000.00 | 0.55 | 18.70 | 4.20 |
| 101.29 | 20.0 | 0.12 | 10000.00 | 1.26 | 29.27 | 12.77 |
| 101.32 | 20.0 | 0.10 | 2500.00 | 1.01 | 24.93 | 10.37 |
| 101.4 | 20 | 0 | 10000.00 | 1.53 | 28.224 | |
| 101.5 | 20.0 | 0.20 | 2500.00 | 1.13 | 27.78 | 17.93 |
| 101.52 | 20.0 | 0.20 | 2500.00 | 0.98 | 28.92 | 12.68 |
| 101.52 | 20.0 | 0.30 | 2500.00 | 1.05 | 28.12 | 21.18 |
| 101.52 | 20.0 | 0.49 | 10000.00 | 1.04 | 22.81 | 15.98 |
| 101.52 | 20.0 | 0.02 | 10000.00 | 1.27 | 27.98 | 13.46 |
| 101.52 | 20.0 | 0.22 | 10000.00 | 1.33 | 29.89 | 29.51 |
| 101.52 | 20.0 | 0.15 | 10000.00 | 1.54 | 31.11 | 11.00 |
| 101.55 | 20.7 | 0.41 | 10000.00 | 1.14 | 26.47 | 12.77 |
| 101.60 | 20.0 | 0.59 | 10000.00 | 0.78 | 20.68 | 13.70 |
| 101.60 | 20.0 | 0.63 | 10000.00 | 1.29 | 26.40 | 8.06 |
| 101.6 | 20 | 0.2 | 10000.00 | 0.95 | 24.516 | |
| 101.66 | 20.0 | 1.21 | 10000.00 | 0.65 | 18.80 | 11.69 |
| 101.66 | 20.0 | 0.22 | 10000.00 | 1.26 | 27.83 | 23.63 |
| 101.66 | 20.0 | 0.96 | 10000.00 | 1.36 | 25.96 | 9.07 |
| 101.69 | 20.0 | 1.14 | 10000.00 | 0.91 | 23.03 | 19.97 |
| 101.72 | 20.2 | 0.38 | 10000.00 | 0.95 | 26.42 | 9.84 |
| 101.80 | 20.0 | 0.92 | 10000.00 | 0.85 | 22.23 | 14.19 |
| 101.80 | 20.0 | 0.07 | 10000.00 | 2.50 | 64.18 | 46.68 |
| 101.83 | 20.0 | 0.26 | 10000.00 | 1.06 | 26.42 | 24.61 |
| 101.83 | 20.0 | 0.22 | 10000.00 | 1.29 | 29.22 | 16.67 |
| 101.88 | 20.0 | 0.30 | 2500.00 | 1.10 | 28.17 | 15.15 |
| 101.88 | 20.0 | 0.35 | 2500.00 | 1.35 | 27.45 | 28.85 |
| 101.89 | 20.0 | 0.92 | 10000.00 | 0.77 | 22.53 | 16.33 |
| 101.95 | 20.0 | 0.15 | 10000.00 | 0.95 | 24.82 | 13.71 |
| 101.95 | 19.9 | 0.18 | 10000.00 | 1.14 | 28.54 | 20.37 |
| 101.95 | 20.0 | 0.30 | 10000.00 | 1.58 | 33.30 | 30.14 |
| 101.98 | 20.0 | 0.40 | 10000.00 | 1.15 | 26.41 | 23.86 |
| 102.00 | 20 | 0.5 | 8000.00 | 0.49 | 21.40 | 4.00 |
| 102.00 | 20 | 1.0 | 12500.00 | 0.6 | 19.70 | 5.80 |
| 102.00 | 20 | 1.1 | 12500.00 | 0.85 | 24.40 | 14.70 |
| 102.01 | 20.0 | 0.66 | 10000.00 | 0.92 | 22.50 | 23.06 |
| 102.06 | 20.0 | 0.61 | 10000.00 | 1.40 | 27.87 | 9.11 |
| 102.09 | 19.9 | 0.61 | 10000.00 | 0.94 | 26.61 | 20.17 |
| 102.18 | 20.0 | 0.23 | 10000.00 | 1.01 | 26.72 | 20.56 |
| 102.18 | 20.0 | 0.03 | 10000.00 | 1.34 | 24.86 | 14.91 |
| 102.2 | 20 | 0.58 | 10000.00 | 2.78 | 25.92 | |
| 102.21 | 20.0 | 0.53 | 10000.00 | 1.40 | 30.29 | 12.30 |
| 102.24 | 20.0 | 0.20 | 2500.00 | 1.21 | 30.99 | 12.29 |

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|---|---|---|---|---|---|---|
| 102.24 | 20.1 | 0.61 | 10000.00 | 0.85 | 22.82 | 16.42 |
| 102.24 | 19.9 | 0.41 | 10000.00 | 0.97 | 26.37 | 18.47 |
| 102.3 | 20 | 0.55 | 10000.00 | 0.51 | 20.736 | |
| 102.3 | 20 | 0.92 | 10000.00 | 0.5 | 16.02 | |
| 102.4 | 20 | 0.73 | 10000.00 | 0.72 | 20.628 | |
| 102.41 | 20.0 | 0.43 | 10000.00 | 1.61 | 26.34 | 11.40 |
| 102.44 | 20.0 | 0.41 | 10000.00 | 0.91 | 21.12 | 13.86 |
| 102.47 | 20.0 | 0.18 | 10000.00 | 1.14 | 27.30 | 8.06 |
| 102.50 | 20.0 | 0.12 | 10000.00 | 1.49 | 33.70 | 19.19 |
| 102.56 | 20.0 | 0.43 | 10000.00 | 1.07 | 26.23 | 27.87 |
| 102.68 | 20.0 | 0.46 | 10000.00 | 1.18 | 23.38 | 9.23 |
| 102.7 | 20 | 0 | 10000.00 | 1.27 | 23.76 | |
| 102.71 | 20.0 | 1.23 | 10000.00 | 0.65 | 21.75 | 11.99 |
| 102.71 | 20.0 | 0.37 | 10000.00 | 1.35 | 31.32 | 10.08 |
| 102.71 | 20.0 | 0.28 | 10000.00 | 1.44 | 30.33 | 30.40 |
| 102.73 | 20.0 | 0.18 | 10000.00 | 1.36 | 27.35 | 11.48 |
| 102.73 | 20.0 | 0.19 | 10000.00 | 1.72 | 34.89 | 18.21 |
| 102.8 | 20 | 0 | 10000.00 | 1.46 | 26.784 | |
| 102.85 | 20.0 | 0.02 | 10000.00 | 1.81 | 34.41 | 12.53 |
| 102.91 | 20.0 | 0.28 | 10000.00 | 1.21 | 29.18 | 14.72 |
| 103.00 | 19 | 1.4 | 8000.00 | 0.49 | 18.00 | 4.30 |
| 103.00 | 20 | 0.1 | 8000.00 | 1.35 | 15.00 | 11.90 |
| 103.00 | 20.0 | 0.00 | 20000.00 | 1.57 | 28.08 | 14.20 |
| 103.06 | 20.0 | 0.27 | 10000.00 | 1.29 | 28.10 | 22.96 |
| 103.06 | 20.0 | 0.04 | 10000.00 | 1.35 | 27.40 | 9.85 |
| 103.06 | 20.0 | 0.16 | 10000.00 | 1.35 | 34.51 | 16.18 |
| 103.12 | 20.0 | 0.23 | 10000.00 | 1.08 | 26.49 | 22.99 |
| 103.12 | 19.7 | 0.24 | 10000.00 | 1.24 | 29.25 | 13.91 |
| 103.12 | 20.0 | 0.10 | 10000.00 | 1.27 | 29.03 | 15.98 |
| 103.2 | 20 | 0.26 | 10000.00 | 1.1 | 26.892 | |
| 103.2 | 20 | 0.77 | 10000.00 | 0.59 | 19.8 | |
| 103.2 | 20 | 0 | 10000.00 | 1.59 | 26.46 | |
| 103.21 | 20.0 | 0.14 | 10000.00 | 1.28 | 29.99 | 17.52 |
| 103.21 | 20.0 | 0.06 | 10000.00 | 1.91 | 34.02 | 13.86 |
| 103.24 | 20.0 | 0.45 | 10000.00 | 1.23 | 28.62 | 23.98 |
| 103.32 | 20.0 | 0.30 | 10000.00 | 1.25 | 28.51 | 21.00 |
| 103.4 | 20 | 0.77 | 10000.00 | 0.97 | 19.152 | |
| 103.4 | 20 | 0 | 10000.00 | 1.57 | 28.836 | |
| 103.4 | 20 | 0.17 | 10000.00 | 1.07 | 28.836 | |
| 103.50 | 20.0 | 0.00 | 20000.00 | 1.50 | 26.10 | 20.50 |
| 103.5 | 20 | 0.72 | 10000.00 | 0.72 | 19.8 | |
| 103.5 | 20 | 0.32 | 10000.00 | 1.4 | 24.552 | |
| 103.53 | 20.0 | 0.25 | 10000.00 | 1.45 | 35.92 | 26.98 |
| 103.6 | 20 | 0.74 | 10000.00 | 0.88 | 31.104 | |
| 103.65 | 20.0 | 0.34 | 10000.00 | 1.16 | 27.85 | 22.07 |
| 103.72 | 20.0 | 0.10 | 2500.00 | 1.64 | 34.87 | 6.45 |
| 103.8 | 20 | 0 | 10000.00 | 1.59 | 27.216 | |
| 103.9 | 20 | 0.11 | 10000.00 | 1.3 | 28.368 | |
| 104.00 | 20 | 0.9 | 10000.00 | 0.68 | 23.70 | 6.30 |
| 104.00 | 20 | 0.5 | 12500.00 | 1.1 | 24.80 | 9.90 |
| 104.00 | 20 | 0.0 | 10000.00 | 1.54 | 38.50 | 16.00 |

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|---|---|---|---|---|---|---|
| 104.01 | 20.0 | 0.08 | 10000.00 | 1.55 | 28.50 | 16.94 |
| 104.04 | 20.0 | 0.50 | 2500.00 | 0.79 | 25.01 | 15.15 |
| 104.04 | 20.0 | 1.14 | 10000.00 | 1.08 | 21.98 | 7.26 |
| 104.1 | 20 | 0.52 | 10000.00 | 0.82 | 24.48 | |
| 104.25 | 20.0 | 1.28 | 10000.00 | 0.53 | 17.02 | 14.02 |
| 104.34 | 20.0 | 0.34 | 10000.00 | 1.13 | 27.83 | 21.86 |
| 104.40 | 20.0 | 0.34 | 10000.00 | 1.24 | 30.55 | 24.99 |
| 104.4 | 20 | 0.58 | 10000.00 | 0.77 | 21.672 | |
| 104.6 | 20 | 0.22 | 10000.00 | 1.55 | 25.308 | |
| 104.80 | 20.0 | 0.92 | 10000.00 | 0.77 | 21.21 | 13.31 |
| 105.00 | 19 | 0.8 | 8000.00 | 0.87 | 22.60 | 7.80 |
| 105.00 | 20 | 0.4 | 12500.00 | 1.19 | 25.70 | 10.70 |
| 106 | 20 | 1.3 | 12500.00 | 0.5 | 16.4 | 4.50 |
| 106 | 19 | 1.6 | 8000.00 | 0.51 | 14.6 | 4.21 |
| 106.00 | 20 | 1.1 | 10000.00 | 0.52 | 19.50 | 4.40 |
| 106 | 19 | 1.3 | 8000.00 | 0.54 | 19.04 | 4.36 |
| 106.00 | 20 | 0.6 | 10000.00 | 1.14 | 26.30 | 10.50 |
| 106.00 | 20 | 0.4 | 12500.00 | 1.37 | 27.80 | 13.10 |
| 106.57 | 20.0 | 0.04 | 10000.00 | 1.68 | 31.83 | 14.52 |
| 107 | 20 | 1.4 | 10000.00 | 0.64 | 29 | 6.60 |
| 107.00 | 19 | 0.7 | 8000.00 | 0.73 | 18.90 | 6.50 |
| 107.00 | 20 | 0.8 | 12500.00 | 0.74 | 18.50 | 7.10 |
| 107.00 | 20 | 0.5 | 12500.00 | 0.74 | 20.50 | 6.50 |
| 107 | 20 | 1.1 | 12500.00 | 0.75 | 20.8 | 6.80 |
| 107 | 20 | 0.9 | 10000.00 | 0.83 | 22.3 | 7.30 |
| 107 | 20 | 0.8 | 10000.00 | 0.9 | 26.7 | 8.20 |
| 107.00 | 20 | 0.2 | 10000.00 | 1.79 | 31.10 | 17.90 |
| 108 | 20 | 0.1 | 10000.00 | 1.33 | 31.7 | 14.40 |
| 109.00 | 19 | 1.5 | 8000.00 | 0.6 | 17.10 | 4.96 |
| 110.00 | 19 | 0.7 | 8000.00 | 0.43 | 12.85 | 4.29 |
| 111.00 | 20 | 0.5 | 10000.00 | 1.01 | 26.50 | 9.10 |

# Appendix 2

| Standard ASI | Modified ASI | | | | | |
|---|---|---|---|---|---|---|
| | Cut off frequencies | | | | | |
| | 10 | 12 | 14 | 16 | 18 | 20 |
| 0.446 | 0.427 | 0.442 | 0.454 | 0.464 | 0.474 | 0.484 |
| 0.469 | 0.434 | 0.475 | 0.511 | 0.558 | 0.611 | 0.659 |
| 0.540 | 0.403 | 0.431 | 0.465 | 0.504 | 0.546 | 0.588 |
| 0.573 | 0.548 | 0.553 | 0.558 | 0.562 | 0.570 | 0.589 |
| 0.584 | 0.562 | 0.599 | 0.639 | 0.679 | 0.715 | 0.745 |
| 0.615 | 0.566 | 0.640 | 0.699 | 0.746 | 0.782 | 0.810 |
| 0.620 | 0.558 | 0.608 | 0.643 | 0.668 | 0.690 | 0.712 |
| 0.630 | 0.585 | 0.665 | 0.732 | 0.789 | 0.837 | 0.878 |
| 0.632 | 0.612 | 0.635 | 0.653 | 0.668 | 0.679 | 0.689 |
| 0.632 | 0.590 | 0.667 | 0.734 | 0.792 | 0.842 | 0.886 |
| 0.651 | 0.605 | 0.653 | 0.685 | 0.708 | 0.726 | 0.740 |
| 0.653 | 0.594 | 0.654 | 0.698 | 0.728 | 0.748 | 0.761 |
| 0.655 | 0.606 | 0.672 | 0.722 | 0.758 | 0.783 | 0.800 |
| 0.658 | 0.601 | 0.626 | 0.647 | 0.667 | 0.685 | 0.702 |
| 0.660 | 0.618 | 0.705 | 0.780 | 0.845 | 0.900 | 0.946 |
| 0.663 | 0.608 | 0.661 | 0.699 | 0.726 | 0.747 | 0.763 |
| 0.682 | 0.634 | 0.676 | 0.703 | 0.720 | 0.731 | 0.739 |
| 0.688 | 0.643 | 0.711 | 0.763 | 0.799 | 0.823 | 0.838 |
| 0.694 | 0.644 | 0.726 | 0.791 | 0.843 | 0.884 | 0.916 |
| 0.695 | 0.632 | 0.703 | 0.759 | 0.804 | 0.841 | 0.872 |
| 0.706 | 0.641 | 0.696 | 0.733 | 0.757 | 0.773 | 0.785 |
| 0.712 | 0.657 | 0.746 | 0.823 | 0.892 | 0.953 | 1.007 |
| 0.713 | 0.665 | 0.731 | 0.781 | 0.818 | 0.845 | 0.864 |
| 0.721 | 0.652 | 0.713 | 0.756 | 0.783 | 0.798 | 0.805 |
| 0.725 | 0.568 | 0.623 | 0.680 | 0.739 | 0.799 | 0.859 |
| 0.728 | 0.657 | 0.736 | 0.795 | 0.839 | 0.870 | 0.892 |
| 0.731 | 0.676 | 0.765 | 0.838 | 0.894 | 0.936 | 0.967 |
| 0.739 | 0.709 | 0.797 | 0.871 | 0.932 | 0.984 | 1.026 |
| 0.739 | 0.691 | 0.779 | 0.852 | 0.913 | 0.962 | 1.002 |
| 0.743 | 0.673 | 0.752 | 0.815 | 0.864 | 0.904 | 0.936 |
| 0.751 | 0.654 | 0.717 | 0.760 | 0.787 | 0.801 | 0.808 |
| 0.759 | 0.686 | 0.773 | 0.842 | 0.897 | 0.938 | 0.970 |
| 0.760 | 0.697 | 0.787 | 0.860 | 0.920 | 0.968 | 1.007 |
| 0.764 | 0.747 | 0.760 | 0.769 | 0.778 | 0.785 | 0.793 |
| 0.776 | 0.721 | 0.795 | 0.850 | 0.891 | 0.920 | 0.942 |
| 0.786 | 0.712 | 0.787 | 0.845 | 0.889 | 0.923 | 0.950 |
| 0.799 | 0.757 | 0.778 | 0.798 | 0.815 | 0.831 | 0.847 |
| 0.879 | 0.822 | 0.875 | 0.914 | 0.945 | 0.970 | 0.994 |
| 0.880 | 0.760 | 0.787 | 0.864 | 0.943 | 1.027 | 1.120 |
| 0.891 | 0.826 | 0.924 | 1.005 | 1.070 | 1.124 | 1.168 |
| 0.899 | 0.858 | 0.894 | 0.927 | 0.955 | 0.978 | 0.998 |
| 0.918 | 0.821 | 0.859 | 0.902 | 0.948 | 0.996 | 1.043 |
| 0.930 | 0.794 | 0.846 | 0.893 | 0.935 | 0.972 | 1.007 |
| 0.941 | 0.863 | 0.898 | 0.925 | 0.948 | 0.970 | 0.994 |
| 0.958 | 0.844 | 0.857 | 0.872 | 0.889 | 0.910 | 0.932 |

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|---|---|---|---|---|---|---|
| 0.961 | 0.870 | 0.923 | 0.974 | 1.023 | 1.071 | 1.120 |
| 0.961 | 0.896 | 0.925 | 0.961 | 1.002 | 1.056 | 1.105 |
| 0.962 | 0.861 | 0.899 | 0.932 | 0.960 | 0.981 | 0.998 |
| 0.965 | 0.854 | 0.910 | 0.975 | 1.046 | 1.124 | 1.206 |
| 0.967 | 0.722 | 0.798 | 0.869 | 0.938 | 1.008 | 1.080 |
| 0.982 | 0.936 | 0.968 | 1.001 | 1.033 | 1.066 | 1.099 |
| 0.983 | 0.944 | 0.986 | 1.008 | 1.025 | 1.049 | 1.079 |
| 0.989 | 0.848 | 0.854 | 0.886 | 0.920 | 0.954 | 0.988 |
| 1.022 | 0.956 | 1.012 | 1.066 | 1.117 | 1.165 | 1.210 |
| 1.023 | 0.881 | 0.921 | 0.967 | 1.015 | 1.063 | 1.110 |
| 1.033 | 0.946 | 0.959 | 0.982 | 1.013 | 1.049 | 1.090 |
| 1.040 | 0.993 | 1.015 | 1.031 | 1.043 | 1.050 | 1.055 |
| 1.045 | 0.928 | 0.999 | 1.045 | 1.070 | 1.082 | 1.091 |
| 1.056 | 1.020 | 1.063 | 1.097 | 1.124 | 1.148 | 1.169 |
| 1.059 | 0.939 | 0.968 | 0.994 | 1.014 | 1.046 | 1.072 |
| 1.063 | 0.908 | 0.933 | 0.964 | 0.998 | 1.037 | 1.081 |
| 1.069 | 0.958 | 0.986 | 1.013 | 1.040 | 1.068 | 1.098 |
| 1.080 | 0.849 | 0.896 | 0.948 | 1.003 | 1.056 | 1.107 |
| 1.084 | 0.999 | 1.041 | 1.073 | 1.096 | 1.111 | 1.121 |
| 1.087 | 1.033 | 1.091 | 1.143 | 1.186 | 1.222 | 1.252 |
| 1.088 | 1.013 | 1.022 | 1.031 | 1.042 | 1.054 | 1.064 |
| 1.089 | 1.079 | 1.139 | 1.192 | 1.240 | 1.283 | 1.319 |
| 1.095 | 1.038 | 1.038 | 1.042 | 1.056 | 1.076 | 1.098 |
| 1.114 | 1.020 | 1.054 | 1.072 | 1.082 | 1.088 | 1.095 |
| 1.121 | 0.923 | 1.081 | 1.213 | 1.316 | 1.389 | 1.437 |
| 1.121 | 1.078 | 1.106 | 1.131 | 1.153 | 1.172 | 1.186 |
| 1.126 | 1.091 | 1.175 | 1.251 | 1.323 | 1.394 | 1.466 |
| 1.133 | 1.050 | 1.124 | 1.183 | 1.227 | 1.259 | 1.280 |
| 1.141 | 1.003 | 1.061 | 1.110 | 1.148 | 1.176 | 1.197 |
| 1.155 | 1.039 | 1.088 | 1.152 | 1.226 | 1.309 | 1.395 |
| 1.155 | 1.036 | 1.113 | 1.178 | 1.231 | 1.273 | 1.308 |
| 1.161 | 1.067 | 1.110 | 1.148 | 1.181 | 1.212 | 1.242 |
| 1.163 | 1.030 | 1.042 | 1.064 | 1.099 | 1.141 | 1.191 |
| 1.178 | 1.097 | 1.161 | 1.228 | 1.297 | 1.366 | 1.433 |
| 1.181 | 1.035 | 1.077 | 1.116 | 1.158 | 1.203 | 1.251 |
| 1.192 | 1.135 | 1.148 | 1.159 | 1.175 | 1.199 | 1.226 |
| 1.194 | 1.072 | 1.126 | 1.160 | 1.182 | 1.201 | 1.222 |
| 1.209 | 0.989 | 1.067 | 1.138 | 1.200 | 1.251 | 1.293 |
| 1.211 | 1.159 | 1.238 | 1.318 | 1.396 | 1.470 | 1.538 |
| 1.217 | 1.101 | 1.145 | 1.174 | 1.198 | 1.222 | 1.247 |
| 1.221 | 0.980 | 1.034 | 1.082 | 1.128 | 1.173 | 1.219 |
| 1.230 | 1.133 | 1.243 | 1.349 | 1.447 | 1.538 | 1.620 |
| 1.246 | 1.035 | 1.053 | 1.070 | 1.123 | 1.183 | 1.247 |
| 1.248 | 1.035 | 1.053 | 1.070 | 1.123 | 1.183 | 1.247 |
| 1.266 | 1.183 | 1.232 | 1.273 | 1.309 | 1.342 | 1.372 |
| 1.268 | 1.028 | 1.251 | 1.465 | 1.668 | 1.863 | 2.049 |
| 1.280 | 1.214 | 1.274 | 1.329 | 1.381 | 1.429 | 1.473 |
| 1.283 | 1.249 | 1.297 | 1.342 | 1.388 | 1.432 | 1.476 |
| 1.284 | 1.192 | 1.355 | 1.502 | 1.634 | 1.751 | 1.855 |
| 1.289 | 1.214 | 1.303 | 1.387 | 1.470 | 1.554 | 1.640 |
| 1.301 | 1.143 | 1.168 | 1.191 | 1.219 | 1.254 | 1.298 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 1.311 | 1.108 | 1.183 | 1.248 | 1.309 | 1.371 | 1.435 |
| 1.315 | 1.164 | 1.228 | 1.272 | 1.301 | 1.324 | 1.346 |
| 1.380 | 1.207 | 1.283 | 1.352 | 1.416 | 1.479 | 1.545 |
| 1.385 | 1.270 | 1.390 | 1.486 | 1.562 | 1.623 | 1.670 |
| 1.411 | 1.160 | 1.222 | 1.289 | 1.359 | 1.428 | 1.495 |
| 1.411 | 1.197 | 1.273 | 1.368 | 1.470 | 1.573 | 1.673 |
| 1.418 | 1.260 | 1.303 | 1.323 | 1.332 | 1.337 | 1.344 |
| 1.435 | 1.295 | 1.446 | 1.559 | 1.639 | 1.694 | 1.735 |
| 1.455 | 1.364 | 1.456 | 1.515 | 1.550 | 1.573 | 1.596 |
| 1.482 | 1.321 | 1.405 | 1.457 | 1.484 | 1.493 | 1.489 |
| 1.484 | 1.401 | 1.543 | 1.662 | 1.762 | 1.848 | 1.925 |
| 1.485 | 1.377 | 1.519 | 1.644 | 1.745 | 1.820 | 1.875 |
| 1.535 | 1.368 | 1.481 | 1.571 | 1.646 | 1.717 | 1.788 |
| 1.540 | 1.299 | 1.375 | 1.419 | 1.446 | 1.481 | 1.533 |
| 1.576 | 1.314 | 1.355 | 1.376 | 1.387 | 1.394 | 1.400 |
| 1.586 | 1.505 | 1.677 | 1.813 | 1.919 | 2.005 | 2.076 |
| 1.601 | 1.420 | 1.517 | 1.580 | 1.627 | 1.669 | 1.711 |
| 1.604 | 1.486 | 1.612 | 1.722 | 1.824 | 1.920 | 2.011 |
| 1.659 | 1.553 | 1.648 | 1.724 | 1.789 | 1.848 | 1.903 |
| 1.717 | 1.633 | 1.856 | 2.039 | 2.186 | 2.304 | 2.399 |
| 1.725 | 1.497 | 1.597 | 1.662 | 1.701 | 1.726 | 1.742 |
| 1.793 | 1.603 | 1.748 | 1.858 | 1.951 | 2.040 | 2.132 |
| 1.816 | 1.682 | 1.906 | 2.092 | 2.246 | 2.377 | 2.490 |
| 1.837 | 1.691 | 1.905 | 2.079 | 2.223 | 2.342 | 2.443 |
| 1.892 | 1.795 | 2.008 | 2.176 | 2.309 | 2.413 | 2.493 |
| 1.913 | 1.833 | 2.062 | 2.247 | 2.397 | 2.521 | 2.623 |
| 1.928 | 1.616 | 1.715 | 1.775 | 1.809 | 1.826 | 1.834 |
| 1.938 | 1.700 | 1.899 | 2.058 | 2.192 | 2.308 | 2.416 |
| 2.022 | 1.835 | 1.898 | 1.965 | 2.037 | 2.113 | 2.187 |
| 2.168 | 1.802 | 2.048 | 2.276 | 2.493 | 2.703 | 2.908 |
| 2.513 | 2.182 | 2.433 | 2.681 | 2.934 | 3.201 | 3.484 |