

MADYMO Quality Report Release Update

SID-IIs facet Q model, version 1.1.2 (R7.4.1)

REPORT NUMBER: QSIDIIs-120531

DATE: May 2012

Table of contents

1	Introduction	1
1.1	Conventions	2
2	Dummy Properties	3
2.1	External dimensions	3
2.2	Mass measurements	4
3	Experiments	7
3.1	Tests overview	7
3.2	Descriptions of the tests	11
3.2.1	Dummy certification tests	11
3.2.2	Full dummy tests	15
3.2.3	Head component tests	17
3.2.4	Neck component tests	18
3.2.5	Arm component tests	18
3.2.6	Thorax component tests	20
3.2.7	Lumbar spine component tests	28
3.2.8	Pelvis component tests	30
3.2.9	Legs component tests	34
3.2.10	Thorax and arm assembly tests	37
3.2.11	Pelvis and leg assembly tests	38
4	Rating of the validation set	41
4.1	Overall rating results	41
5	Comparison of results	47
5.1	Range plots	47
5.1.1	Dummy signal	47
5.1.2	Environment signals	54
5.2	CPU Time information	56
A	Rating Method	57
A.1	Introduction	57
A.1.1	Rating a MADYMO dummy model	57
A.1.2	Comparing two scalar values	58
A.1.3	Comparing two signals	58
A.1.4	Adding scores	59
A.2	Additional information on calculation of dummy rating scores	59
A.2.1	Comparing two scalar values	59
A.2.2	Adding scores	60
A.2.3	Example	60
A.3	Results for more complex examples	62
B	Signal results	65
B.1	Full dummy tests	65
B.2	Head component tests	74
B.3	Neck component tests	76
B.4	Arm component tests	80
B.5	Thorax component tests	82
B.6	Lumbar component tests	117

2 Dummy Properties

This section shows the comparison of the dummy properties between the simulation models and hardware specifications. The comparison is made for the external dimensions and the mass measurements according to the specifications described in "Drawings and Specifications for SID-IIIsD Small Female Crash Test Dummy, Part 572, Subpart V, July 1st, 2008, NHTSA" and "User Manual, SID-IIIs Small Side Impact Dummy (SBL D), Rev C, 2007, FTSS."

2.1 External dimensions

This section shows the result of the external dimensions for the simulation models. The models were positioned according to the specification (see the picture below). Additional planes were added and contacts were defined. The penetrations found are measures for the dimensions.

The reference values of the H-point height and distance to seat back dimensions are used to position the reference planes of the rigid seat. From these two planes most of the dimensions are determined.

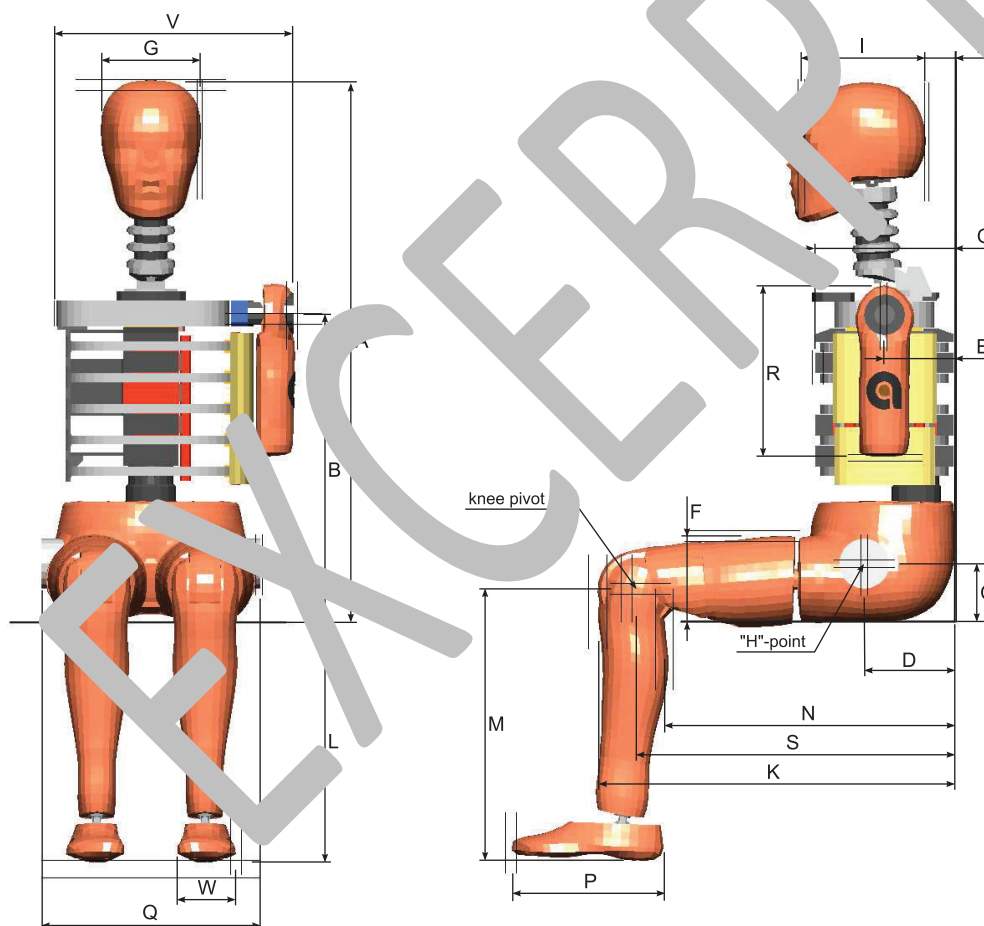


Figure 2.1 External dimensions setup specification.

In case of the four measurement requirements (A, D, I and S) presented in the table below, the dimensions of the model do not lie within the specified corridor. This is due to the fact, that the hardware specification values and their tolerances are contradictive with the values on technical drawings that are included in the same NHTSA document. In such conflicting cases, the model geometry fully corresponds to the dimensions as specified in the drawings themselves. Moreover, the same measurement

3 Experiments

For the validation and rating of the model, many experiments have been used. This chapter presents the descriptions of the experiments that are used for the quality rating. The information is as complete as possible, but is restricted to non-confidential data.

In the first section, all experiments used for the rating are listed in tables. These tables contain 8 columns. Below you can find the description of the column headers:

ID = Identification number

#F = number of loading signals (forces and moments/torques) measured

#P = number of positional signals (displacements and rotations) measured

#V = number of velocity signals measured

#A = number of acceleration signals measured

#I = number of injury values rated

In the second section of this chapter, more detailed descriptions are presented in order to give the reader more insight in the exact validation set. For tests that originally were conducted by clients, this detailed description is not printed because of confidentiality reasons; if extra information with respect to what is offered in this report can be supplied.

3.1 Tests overview

All experiments that have been used, are listed in the tables below. The total experimental validation set is divided into different test groups. Each table represents a different test group. The ID of the experiment includes a reference to the category:

The first table below, summarizes the set of certification tests that were performed according to the standard specifications for the hardware dummy. The results of the simulated certification tests were positively verified against the hardware certification factors, but they were excluded from the calculation of the quality rating.

C = dummy certification test

F = full dummy test,

H = head component test,

N = neck component test,

A = arm component test,

T = thorax component test,

L = lumbar spine component test,

P = pelvis component test,

G = legs component test,

X = thorax/arm assembly test,

S = pelvis/legs assembly test.

Table 3.1 Dummy certification tests

ID	Description	Conditions	#F	#P	#V	#A	#I
C1	Certification head, lateral drop test, left/right side	height 0.20 m				2	
C2	Certification neck, pendulum, left/right side	velocity 5.6 m/s		2	1		2
C3	Certification shoulder, pendulum, 13.97 kg	velocity 4.3 m/s		1		2	
C4	Certification thorax with arm, pendulum, 13.97 kg	velocity 6.7 m/s	4			3	
C5	Certification thorax no arm, pendulum, 13.97 kg	velocity 4.3 m/s	3			3	

35 deg. between the head mid-sagittal plane and the impact surface.

Figure 3.1 shows the simulation setup.

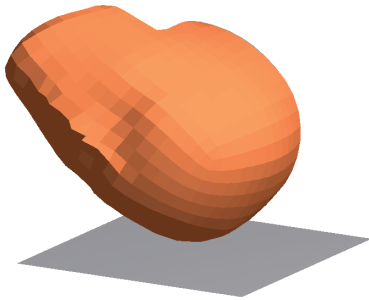


Figure 3.1 Head certification test - simulation setup at $t = 0$ ms.

C2 The test represents the standard neck certification as specified in the "NHTSA Final rule, 49 CFR Part 572 [Docket No. NHTSA-25442]" dated December 2006, with further changes introduced by "NHTSA Final rule amendment, 49 CFR Part 572 [Docket No. NHTSA-2009-0003]" announced in July 2009. In the test, the neck is mounted to the pendulum and equipped with the head form. The pendulum is released and hits the horn comb at the velocity of 5.0 m/s.

Figure 3.2 shows the simulation setup.

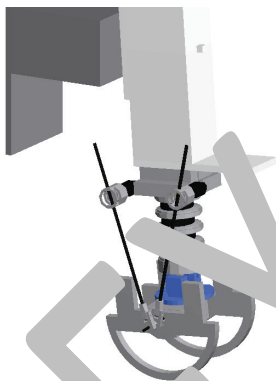


Figure 3.2 Neck certification test - simulation setup at $t = 0$ ms.

C3 The test represents the standard shoulder certification as specified in the "NHTSA Final rule, 49 CFR Part 572 [Docket No. NHTSA-25442]" dated December 2006, with further changes introduced by "NHTSA Final rule amendment, 49 CFR Part 572 [Docket No. NHTSA-2009-0003]" announced in July 2009. In the test, the dummy is seated on a rigid bench (developed within the WorldSID design program). The impactor centre line is aligned with the pivot axis of the upper arm.

Figure 3.3 shows the simulation setup.

4 Rating of the validation set

This chapter shows the rating values calculated for the complete validation set presented in this report. The signals of all tests were numerically rated in an automated process as described in Appendix A. The tables list the combined rating values of all tests, consisting of 3 component values (3 criteria) for each signal:

- peak value
- timing of the peak
- shape of the curve throughout the test

4.1 Overall rating results

In this section the rating results are presented in tables. The first four tables list the overall rating results for the dummy model. The first three give the score per rating criterion; the fourth one gives the combined score (combining the scores from all three rating criteria). In these tables, the second column shows the weight factor that was applied to the score of each test group for calculating the total scores. The sum of the test group weight factors is always 1.0. In the third column of the tables, the scores are given in percentages, with 100% indicating a perfect match with the experimental data.

Below the first four tables, additional tables present the combined rating results of the individual tests in each test group. The tests (referred to by their test ID) are given the same test weight factor. The sum of the test weight factors in a test group is always 1.0. Using the combination of test weight factors and test group weight factors, the score from each individual test contributes equally to the total score for the complete dummy validation test set.

The first test group lists only the certification tests (indicated with the ID starting with the letter C) showing that both total rating value as well as individual ratings for each test are equal to zero. This is due to the fact that the simulation results are not compared with the experiments but are checked against the certification requirements.

Table 4.1 Rating results for the model using the Peak criterion only

Group	Weight	Model
Total		77.6%
Dummy certification tests	0.0000	00.0%
Full dummy tests	0.0526	70.2%
Head component tests	0.0632	93.5%
Neck component tests	0.0210	83.2%
Arm component tests	0.0632	94.1%
Thorax component tests	0.3263	79.5%
Lumbar spine component tests	0.0947	67.5%
Pelvis component tests	0.1579	78.9%
Leg component tests	0.1263	88.0%
Thorax/arm assembly tests	0.0632	68.2%
Pelvis/leg assembly tests	0.0316	58.6%

5 Comparison of results

This chapter shows results that are obtained directly from the experiments and simulations. Range plots are shown in the first section. A range plot provides information on the range in which the model has been evaluated, for each signal separately. By adding lines indicating the level of correlation, the range plots also provide information about the quality of the prediction of a certain signal.

The last section of this chapter contains information about the runtimes of the simulations. This gives the user an impression of what can be expected when running their own applications.

Time history plots of all signals are given in Appendix B. With these, an engineer can visually judge the quality of the simulation results. It also helps to interpret the rating results presented earlier in this report, since the rating value can be compared with the visual information from the curves.

5.1 Range plots

In this section, all range plots are presented. The range plots show the results of a particular signal over different tests. The peak value of the signal during a simulation is represented by a point in the graph. The horizontal location of the point is proportional to the experimental test signal peak. In general this corresponds to the test severity. The vertical position is proportional to the simulation peak results. If the simulation reproduces the signals of the experiment exactly, the point is on the 100% line which is the line at 45 degrees, printed with a solid line type in the graph. If the point with a positive value is below this line, the simulation has a lower peak than the experiment, which indicates an underprediction of the simulation. When it is above the line, then the simulation overpredicts. Two additional lines are drawn in each plot. If the point is within the cone drawn by the dashed lines, the peak score is above 80%.

Each result in the range plots is shown using a coloured marker. Table 1.1 in the Introduction lists all markers used in this report.

The range plots are divided over two subsections. In the first subsection, range plots are presented that refer to signals measured with the standard sensors in the dummy. The second subsection adds the signals that refer to environment (non-dummy) measurements like impactor signals, etc.

5.1.1 Dummy signals

This section shows the range plots derived from the standard sensor signals of the dummy. The plots are arranged top-down: from the head to the feet of the dummy.

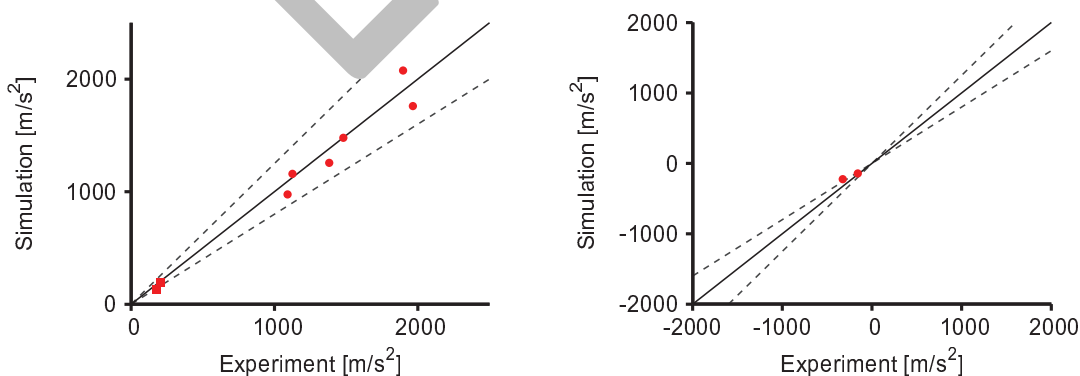


Figure 5.1 Head_AccR (left); Head_AccY (right)

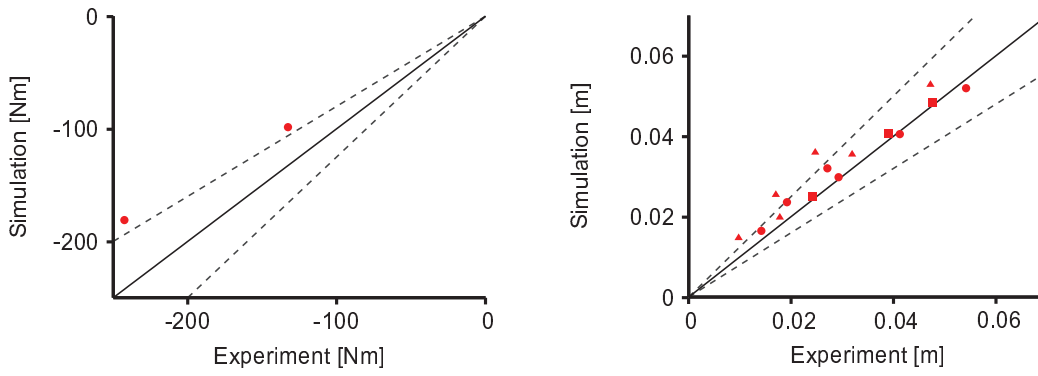


Figure 5.5 NeckLow_MomX (left); RibShoulder_Dis (right)

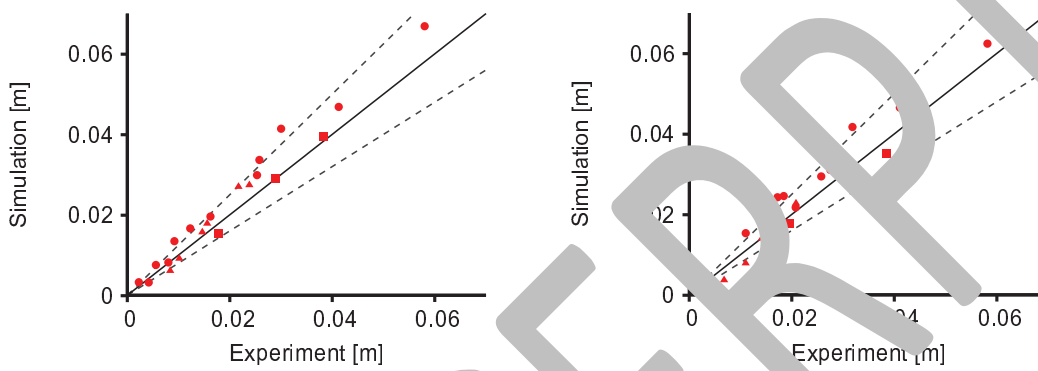


Figure 5.6 RibThoraxUp_Dis (left); RibThoraxMid_Dis (right)

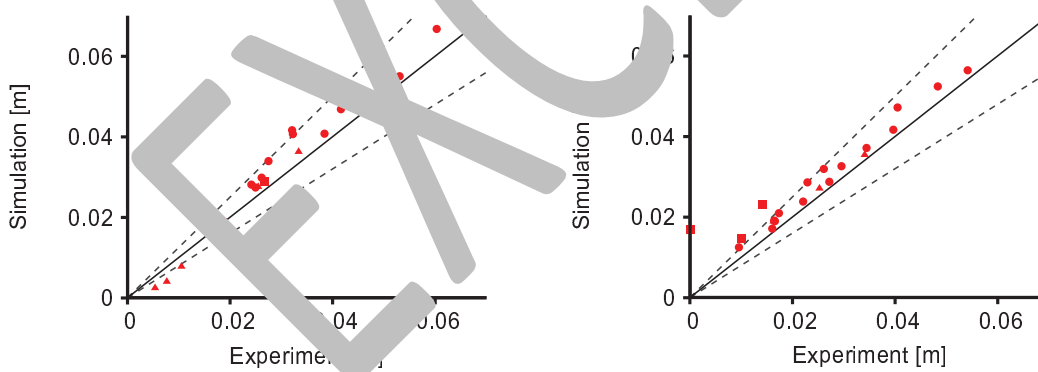


Figure 5.7 RibThoraxLow_Dis (left); RibAbdomenUp_Dis (right)

B Signal results

In this Appendix the signals of the tests that are described within the report are presented.

B.1 Full dummy tests

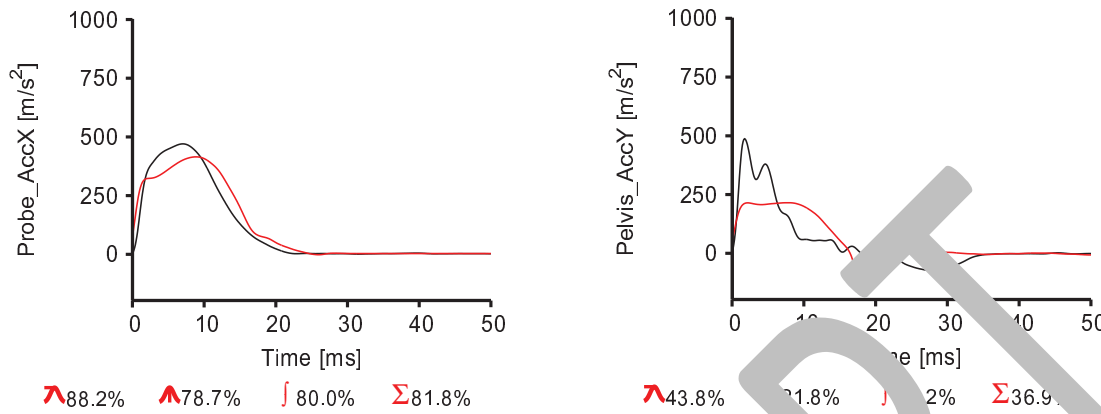


Figure B.1 Test F1 Probe_AccX (l); Test F1 Probe_AccY (r)

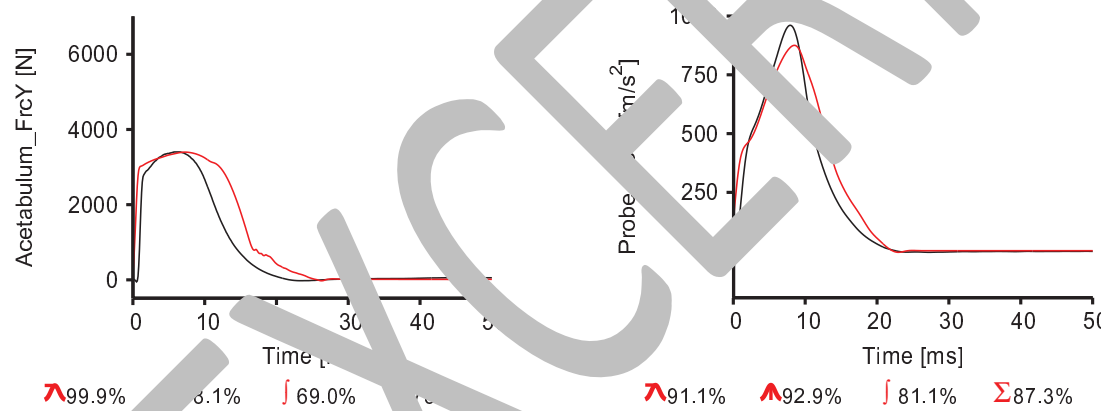


Figure B.2 Test F1 Acetabulum_FrcY (l); Test F2 Probe_AccX (r)

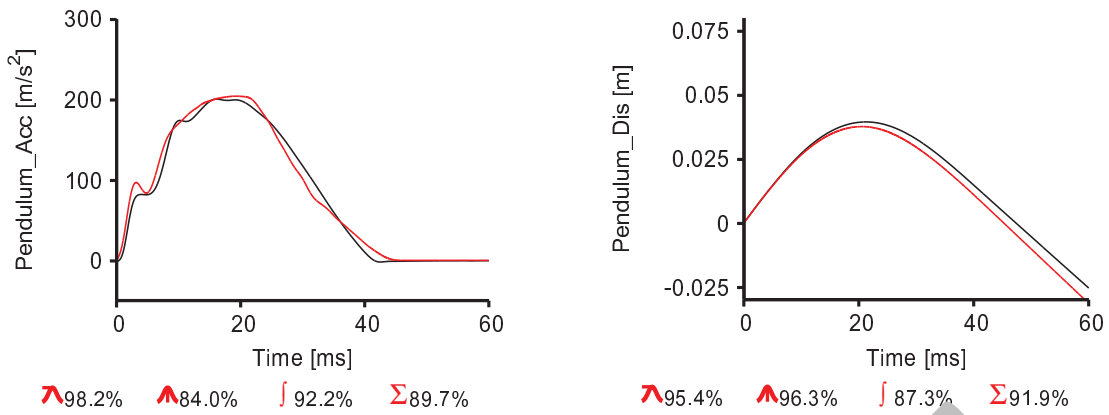


Figure B.108 Test T21 Pendulum_Acc (l); Test T21 Pendulum_Dis (r)

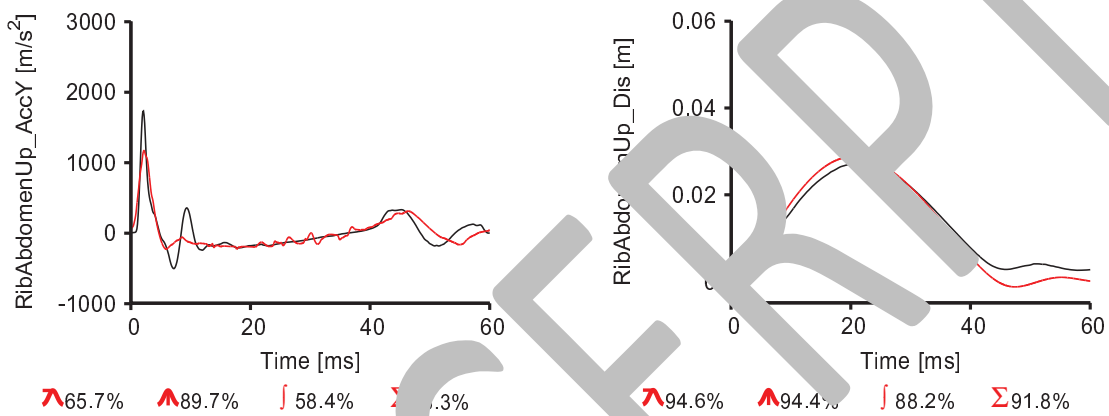


Figure B.109 Test T21 RibAbdomenUp_AccY (l); Test T21 RibAbdomenUp_Dis (r)

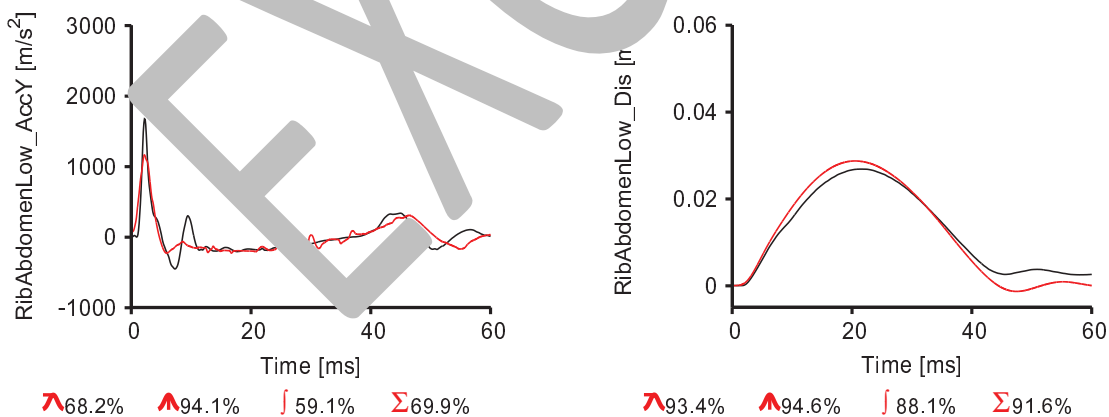


Figure B.110 Test T21 RibAbdomenLow_AccY (l); Test T21 RibAbdomenLow_Dis (r)