

MADYMO Quality Report Release Update

ES-2(re) ellipsoid Q model version 1.1.3 (R7.4.1)

ES-2(re) facet Q model version 3.0.2 (R7.4.1)

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2 Dummy Properties

This section shows the comparison of the dummy properties between the simulation models and hardware specifications of the ES-2 dummy. The comparison is made for the external dimensions and the mass measurements according to the specifications described in "Agreement concerning the adoption of uniform technical prescriptions for wheeled vehicles, equipment and parts which can be fitted and/or be used on wheeled vehicles and the conditions for reciprocal recognition of approvals granted on the basis of these prescriptions, Revision 2, Addendum 94, Amendment 4., October 1st, 2004, UNECE" for the ES-2 standard dummy version (Europe) and "Parts list and drawings, EuroSID 2 with Rib Extensions, Part 572, Subpart U, February 29th, 2008, NHTSA" for the ES-2re version (United States).

2.1 External dimensions

This section shows the results of the external dimensions for the simulation models of the ES-2 and ES-2re dummies. The hardware requirements for both dummy versions are identical as presented in the table below. The models were positioned according to the specifications (see the picture below). Additional planes were added and contacts were defined. The illustrations 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 values, most of the dimensions are determined.

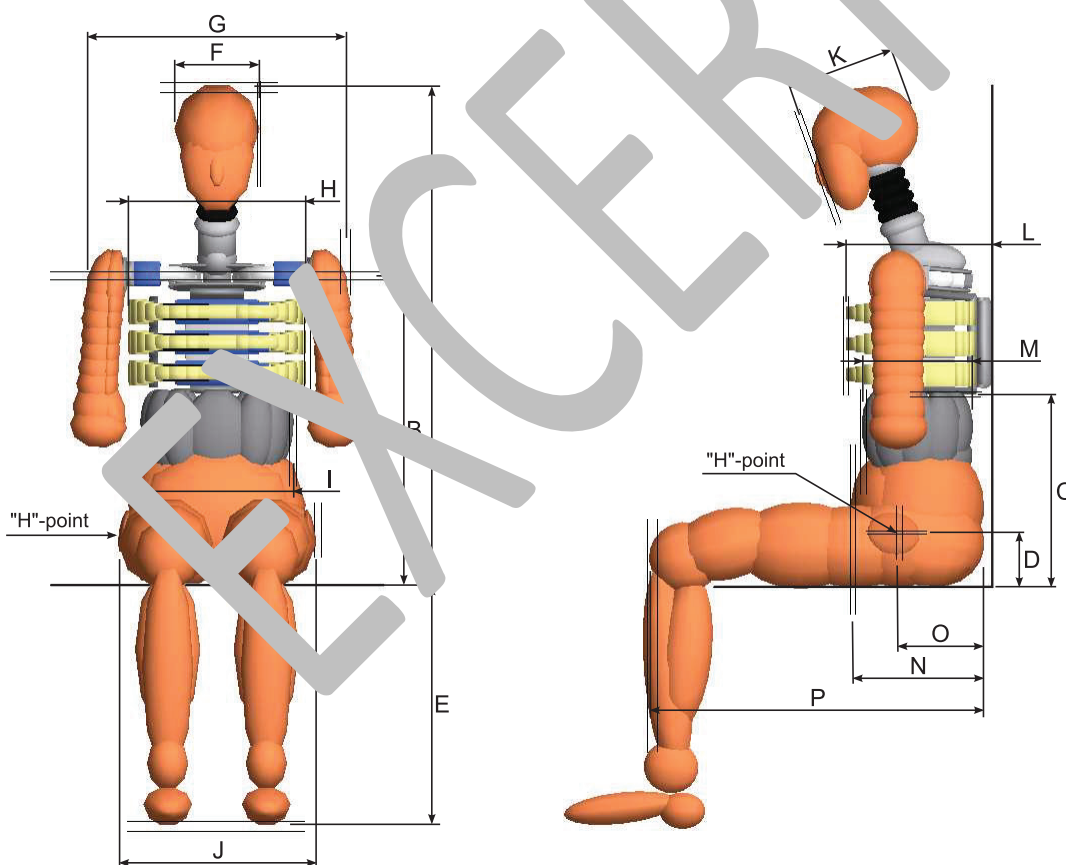


Figure 2.1 External dimensions setup specification.

The measurements presented in the table below were done for the models of the two dummy versions. The table presents the results for the standard version of the ES-2 dummy. In case of the ES-2re version

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 model certification and 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; the 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 two tables below summarise the set of certification tests that were performed in simulation conditions for the ES-2 and ES-2re respectively. The testing was done according to the standard specifications for the hardware dummies. The results of the simulated certification tests were positively verified against the hardware certification corridors for both dummies ES-2 and ES-2re, as specified in their regulatory requirements documentation (see chapter 2). The results of the ES-2 certification testing were also compared with hardware test results and included in the calculation of the quality rating.

C = dummy certification test,

F = full dummy test,

A = arm component test,

B = abdomen component test,

P = pelvis component test,

S = pelvis/legs assembly test.

Table 3.1 Certification tests ES-2

ID	Description	Conditions	#F	#P	#V	#A	#I
C1	Certification head, lateral drop, left/right	height 0.2 m				1	
C2	Certification neck, pendulum, left/right	velocity 3.4 m/s		4	1		
C3	Certification shoulder, pendulum, 23.4 kg	velocity 4.3 m/s				1	
C4	Certification rib, impactor drop, 7.78 kg	velocity 2.0 m/s		1			
C5	Certification rib, impactor drop, 7.78 kg	velocity 3.0 m/s		1			
C6	Certification rib, impactor drop, 7.78 kg	velocity 4.0 m/s		1			
C7	Certification lumbar, pendulum, left/right	velocity 6.05 m/s		4	1		

R8 In this test, the dummy (without suit and shoulder foam cap) is placed in an upright seated position on a flat, horizontal, rigid surface without back support. Two sheets of 2 mm thick Teflon are placed between the dummy and the surface. The dummy arms and legs are horizontal and the distance between the ankles is 100 +/- 5 mm. The thorax is positioned upright with the torso back plate vertical +/- 2 degrees. The centre line of the impactor is aligned with the centre of the H-point foam block +/- 5 mm. The impactor has a mass of 23.4 +/- 0.02 kg and a diameter of 152.4 +/- 0.25 mm. The pendulum is suspended by 8 long wires and the impact velocity with the pelvis is 4.3 +/- 0.1 m/s.

Figure 3.7 shows the simulation setup.

3.2.2 Full dummy tests

F1 In this test the dummy is seated on a supported rigid seat while being struck by a sled-driven side structure consisting of three rigid plates covered with foam padding. The three foam pads strike the dummy on thorax, abdomen and pelvis/leg region. Teflon sheets are placed between the dummy and the seat in order to reduce friction. The sled is accelerated and the impact faces strike the dummy at 7.70 m/s, without hitting the seat. Besides the dummy sensor output, the sled acceleration and the support forces behind the three padded plates are measured.

Figure 3.8 shows the simulation setup.



Figure 3.8 Full dummy sled test simulation setup at t = -11 ms.

F2 In this test the dummy is seated on a supported rigid seat while being struck by a sled-driven side structure consisting of three rigid plates covered with foam padding. The three foam pads strike the dummy on the thorax, abdomen and pelvis/leg region. Teflon sheets are placed between the dummy and the seat in order to reduce friction. The sled is accelerated and the impact faces strike the dummy at 9.72 m/s, without hitting the seat. Besides the dummy sensor output, the sled acceleration and the support forces behind the three padded plates are measured.

Figure 3.8 shows the simulation setup.

3.2.3 Arm component tests

A1 In this test the lower region of the upper arm is struck with a cylindrical impactor face with an impactor mass of 2.95 kg and impact velocity of 2.04 m/s. A support is placed 25 mm behind the arm to prevent too much bending. The impactor acceleration and the reaction forces in the shoulder fixture and arm support have been measured.

Figure 3.9 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 these 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 two test groups list only the certification tests for both ES-2 and ES-2re respectively, (indicated with the ID starting with the letter C for ES-2 and R for ES-2re). In case of the ES-2re the 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 to 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	M2
Total		78.2%	80.0%
Certification tests ES-2	0.3214	97.5%	93.6%
Certification tests ES-2re	0.0000	00.0%	00.0%
Full dummy tests	0.0714	63.0%	66.7%
Arm component tests	0.1071	85.5%	83.4%
Abdomen component tests	0.2143	68.0%	70.6%
Pelvis component tests	0.2143	85.7%	83.5%
Pelvis/leg assembly tests	0.0714	65.1%	78.4%

Table 4.2 Rating results for the model using the Peaktime criterion only

Group	Weight	Model	M2
Total		84.0%	82.0%
Certification tests ES-2	0.3214	89.7%	90.0%
Certification tests ES-2re	0.0000	00.0%	00.0%
Full dummy tests	0.0714	67.7%	71.3%
Arm component tests	0.1071	77.1%	74.6%
Abdomen component tests	0.2143	88.0%	86.5%

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.

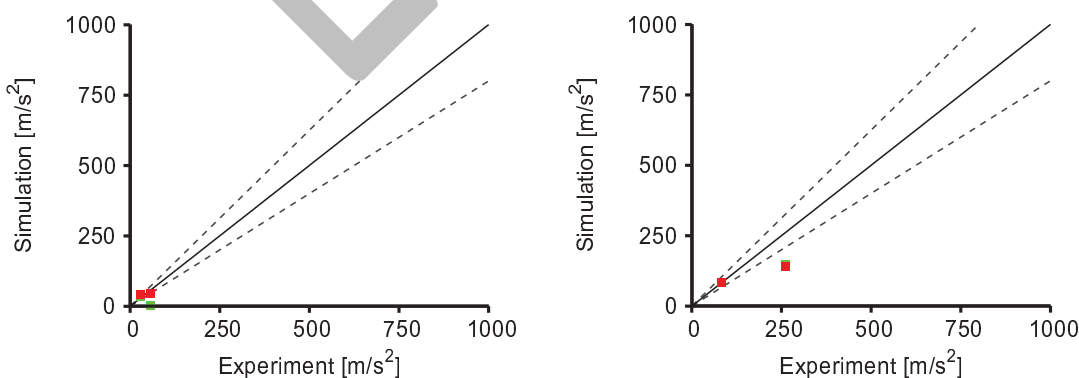


Figure 5.1 Head_AccX (left); Head_AccY (right)

B Signal results

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

B.1 Certification tests ES-2

B.1.1 Head

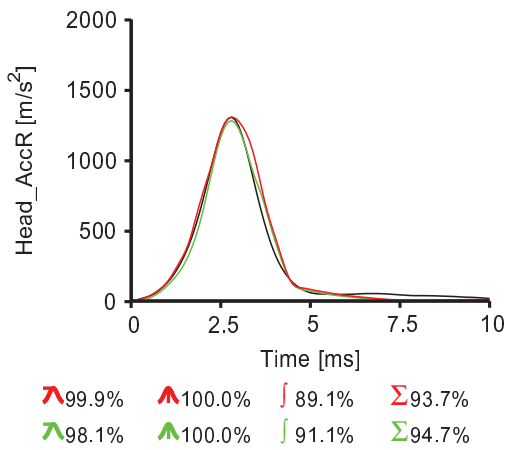


Figure B.1 Test C1 Head_AccR

B.1.2 Neck

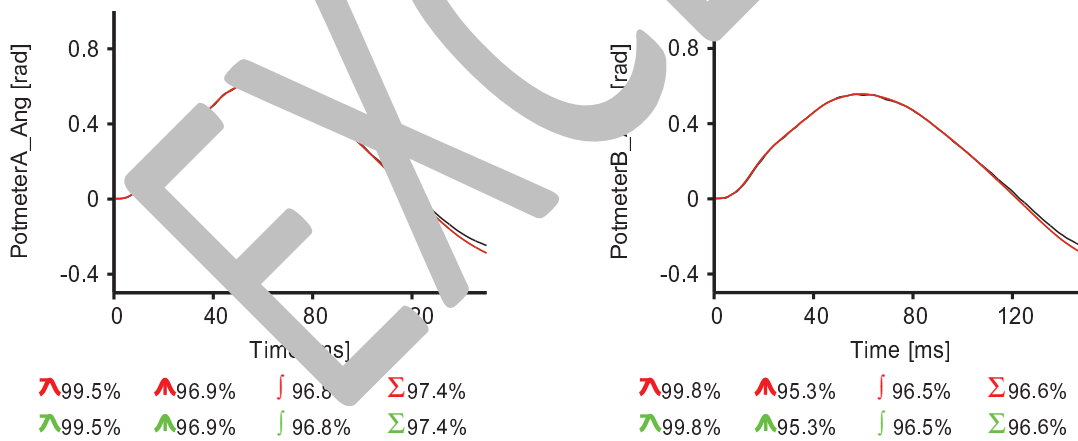


Figure B.2 Test C2 PotmeterA_Ang (l); Test C2 PotmeterB_Ang (r)

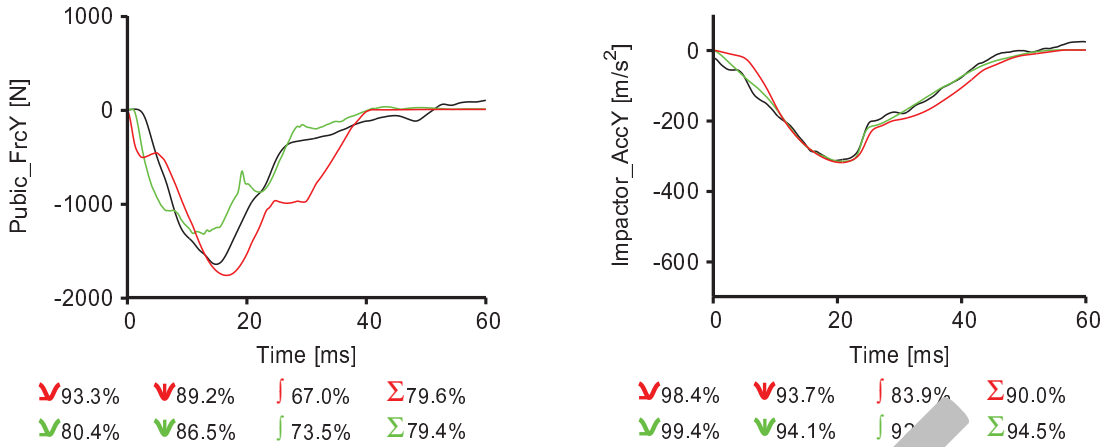


Figure B.70 Test P3 Pubic_FrcY (l); Test P4 Impactor_AccY (r)

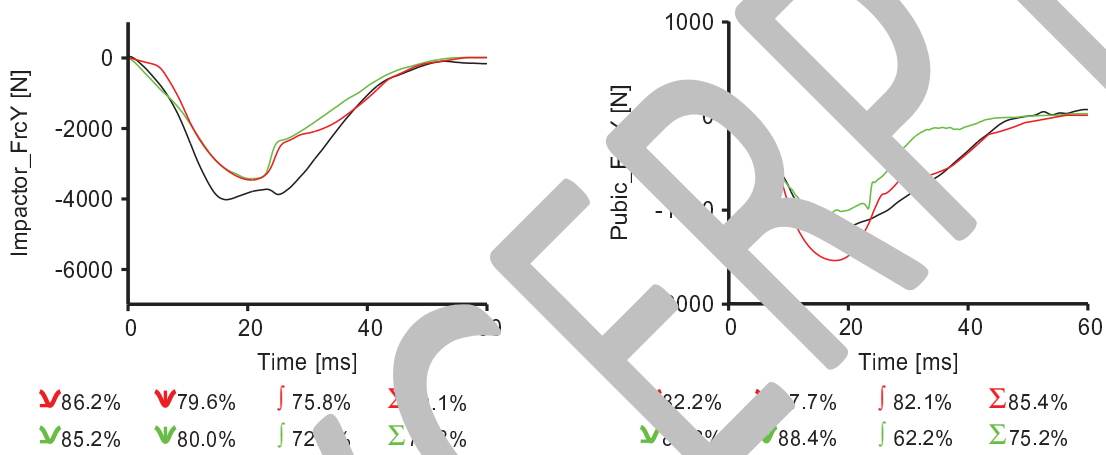


Figure B.71 Test P4 Impactor_FrcY (l); Test P4 Pubic_FrcY (r)

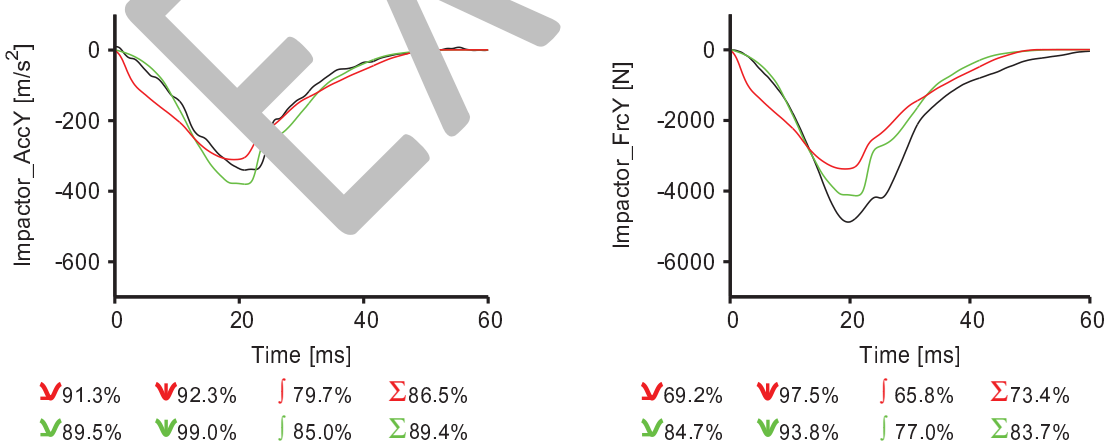


Figure B.72 Test P5 Impactor_AccY (l); Test P5 Impactor_FrcY (r)