SAE International

SURFACE VEHICLE INFORMATION REPORT

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H-III5F Chest Jacket Harmonization

RATIONALE

The Hybrid III Small Female Jacket harmonization project was established to revise both existing chest jackets from the dummy manufacturers to match as close as possible to the existing NHTSA jacket drawing.

FOREWORD

In the late 1980's the *Center for Disease Control* (CDC) awarded Ohio State University a grant to develop multi-sized test dummies based on the Hybrid III design. To aid in this endeavor, the Mechanical Human Simulation Subcommittee of the Society of Automotive Engineers (SAE) formed a Task Group to define the specifications for an adult size small female dummy which would have, at least, the same level of biofidelity and measurement capacity as the 50th Hybrid III dummy. Throughout the 1990's this Small Female dummy was revised and improved until it was finally fully defined by a drawing package by NHTSA and adopted in U.S. Federal Regulations as a part of the Code of Federal Regulations Part 572. The 2002 version of this drawing package defines the currently regulated version of this dummy today.

At the April 20, 2006 meeting of the Hybrid III Dummy Family Task Force information was brought in showing that there was a difference between small female chest jackets between different dummy manufacturers. A petition was submitted to NHTSA on January 31, 2006 requesting corrections to the drawings of the small female dummy because these differences could affect the results in restraint system tests. Possible solutions to this problem were discussed, and it was agreed to develop a new harmonized design using the NHTSA drawing as guide.

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1. SCOPE AND PURPOSE

The Hybrid III Small Female Jacket harmonization project was established to revise both existing chest jackets from the dummy manufacturers to match as closely as possible to the existing NHTSA jacket drawing. This Information Report documents the new harmonized jacket that resulted from that project.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

SAE EA-25 User's Manual for the Small Adult Female Hybrid III Test Dummy

2.2 Related Publication

The following publications are provided for information purposes only and are not a required part of this SAE Technical Report.

2.2.1 Federal Publication

Available from the Superintendent of Documents, U.S. Government Printing Office, Mail Stop: SSOP, Washington, DC 20402-9320.

Motor Vehicle Regulation No. 572 Test Dummies Specifications - Anthropomorphic Test Dummy for Applicable Test Procedures

Available from Leet-Melbrook, Division of New RT, 18810, Woodfield Road, Gaithersburg, MD 20879, (301) 670-0090, as well as from the Department of Transportation Docket Management System

Parts Lists and Drawings Part 572 Subpart O – Hybrid III 5th Percentile Small Adult Female Crash Test Dummy (H-III5F Alpha Version) – June 2002

3. ABREVIATIONS

H-III5F Hybrid III 5th Percentile Small Female Crash Test Dummy,

FTSS First Technology Safety Systems, Inc.

DATD Denton ATD, Inc.

NHTSA National Highway Traffic Safety Administration

4. TECHNICAL REQUIREMENTS

4.1 General Jacket Requirements

Current NHTSA jacket specification package

- Breast Location
- Symmetrical Design
- Overall width, depth, height, and circumference
- Arm opening location and shape
- Weight specification
- Upper Torso Assembly CG Requirements

4.1.1 Description of Problem

This issue was first raised on April 20, 2006 during a meeting of the SAE Hybrid III Dummy Family Task Force. Both an FTSS and DATD jacket were passed around for inspection by the task force members. The task force members decided to begin a project to review the drawing specifications and add detail such that both dummy manufacturers would be able to make the same jacket.

Figure 1 depicts the differences discovered comparing two small female jackets:

FIGURE 1 - COMPARISON OF TWO TYPES OF SMALL FEMALE CHEST JACKETS

Gaps in the drawings and specification packages for the small female chest jacket were required to be filled in to complete the specification to complete the harmonization process. They were as follows:

- 3D model of jacket to fit dummy
- Additional contour information for both breast shape and location and overall jacket shape
- Determine which dimensions take precedent due to the fact that the Front View of the NHTSA drawing does not match side view. EX: Breast location in front view is 0.5 inch lower then side view
- Move clavicle bolt access holes to correct position
- Lack of complete zipper attachment information
- Lack of shoulder fit information to arm hole in jacket

4.1.2 Tests Demonstrating Problem

It was demonstrated that the two manufacturers' jackets were different enough that different chest deflections resulted with the same dummy was subjected to the same test condition with each jacket. Figure 2 is an example of this difference using a standard small female dummy in a standard thorax impact.

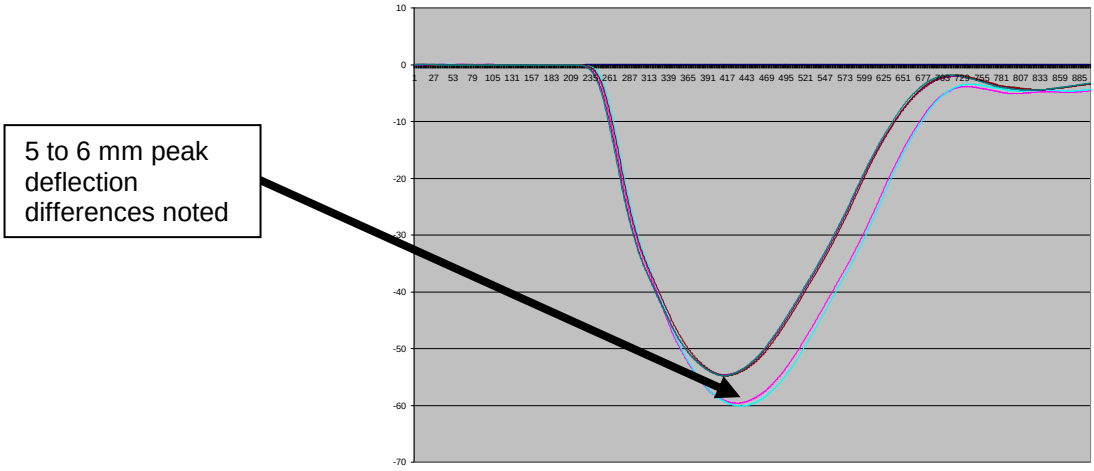

FIGURE 2 - COMPARISON OF TWO JACKETS USING SAME DUMMY FOR STANDARD THORAX IMPACT TEST

The Task Force also reviewed and examined the results from a 2006 study presented at the 50th STAPP conference: ***"The Effect of Breast Anthropometry On The Hybrid III 5th Female Chest Response"*** by Suzanne Tylko and Dominique Charlebois from Transport Canada and Alain Bussieres and Dainiaus Dalmotas from PMG Technologies. This study documented the dimensional differences as well as the performance differences of jackets in certification and crash tests. This clearly showed the need for harmonization.

4.2 Recommended Chest Jacket Updates

4.2.1 Technical Requirements

The following is the list of requirements that were used by the committee to direct DATD and FTSS to design and construct the harmonized jacket:

- Develop 3D model of jacket to fit dummy
- Additional contour information for both breast shape and location and overall jacket shape
- Revise NHTSA drawing so it is complete with front and side view matching Determine which dimensions take precedent due to the fact that the Front View of the NHTSA drawing does not match side view. EX: Breast location in front view is 0.5 inch lower then side view
- Move clavicle bolt access holes to correct position
- Add complete zipper attachment information
- Add shoulder fit information to arm hole in jacket in 3D model
- One piece jacket design (breast molded on)
- Nipple marking (no hole)
- Manufacturing tolerances (include shrinkage)

- Design fit check fixture (mandrel)
- Compare Rib Circumferences
- Perform thorax impact tests with jacket zipped and upzipped
- 3D mandrel to check fit of jacket over time for shrinkage
- Material hardness, a nominal 40 Durometer Shore A.
- Common wall thickness
- 0.38 to 0.50 inch thick with foam
- 0.18inch thick skin for breast w/o foam
- Common Opening for Zipper Placement (.75 inch per drawing)
- Scaled Shoulder Lip on Jacket, remove ledge

4.2.2 3D Shape of Chest Jacket

The 3D shape was developed by DATD and FTSS which was used to manufacture the molds at both facilities. This CAD model comes as close to the NHTSA drawing as could be achieved. The model is mirrored about the midsagittal plane to achieve symmetry. See Figure 3 for example of 3D shape.

FIGURE 3 - 3D SHAPE OF THE HARMONIZED SMALL FEMALE JACKET

4.2.3 2D Drawing of Chest Jacket

The 2D drawing was developed by DATD and FTSS which was used to manufacture the molds at both facilities. This drawing is an update of the NHTSA drawing to correct errors and lack of information. See Figures 4 - 6.

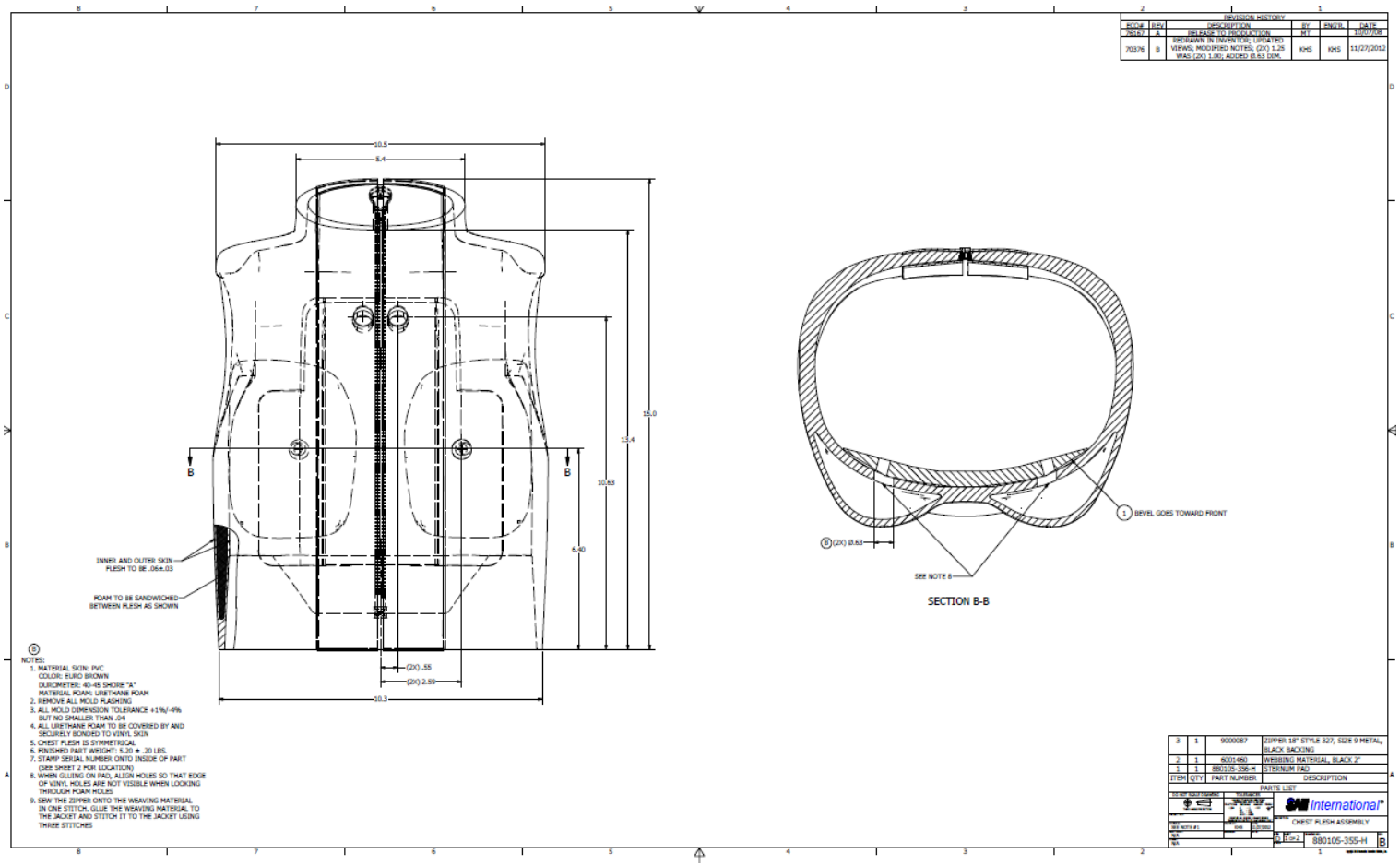

FIGURE 4 - FRONT VIEW CHEST JACKET DRAWING

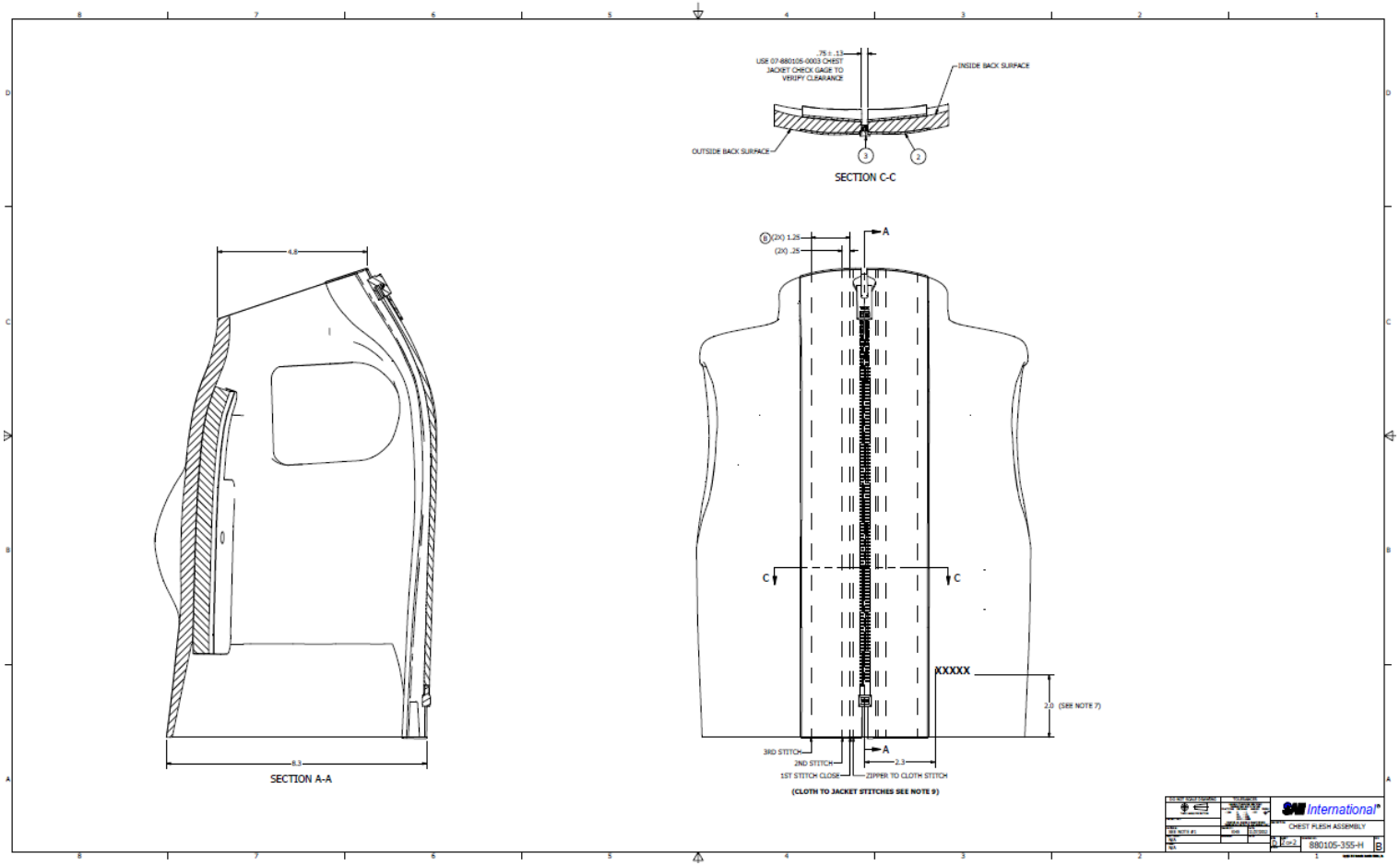

FIGURE 5 - SIDE VIEW OF CHEST JACKET

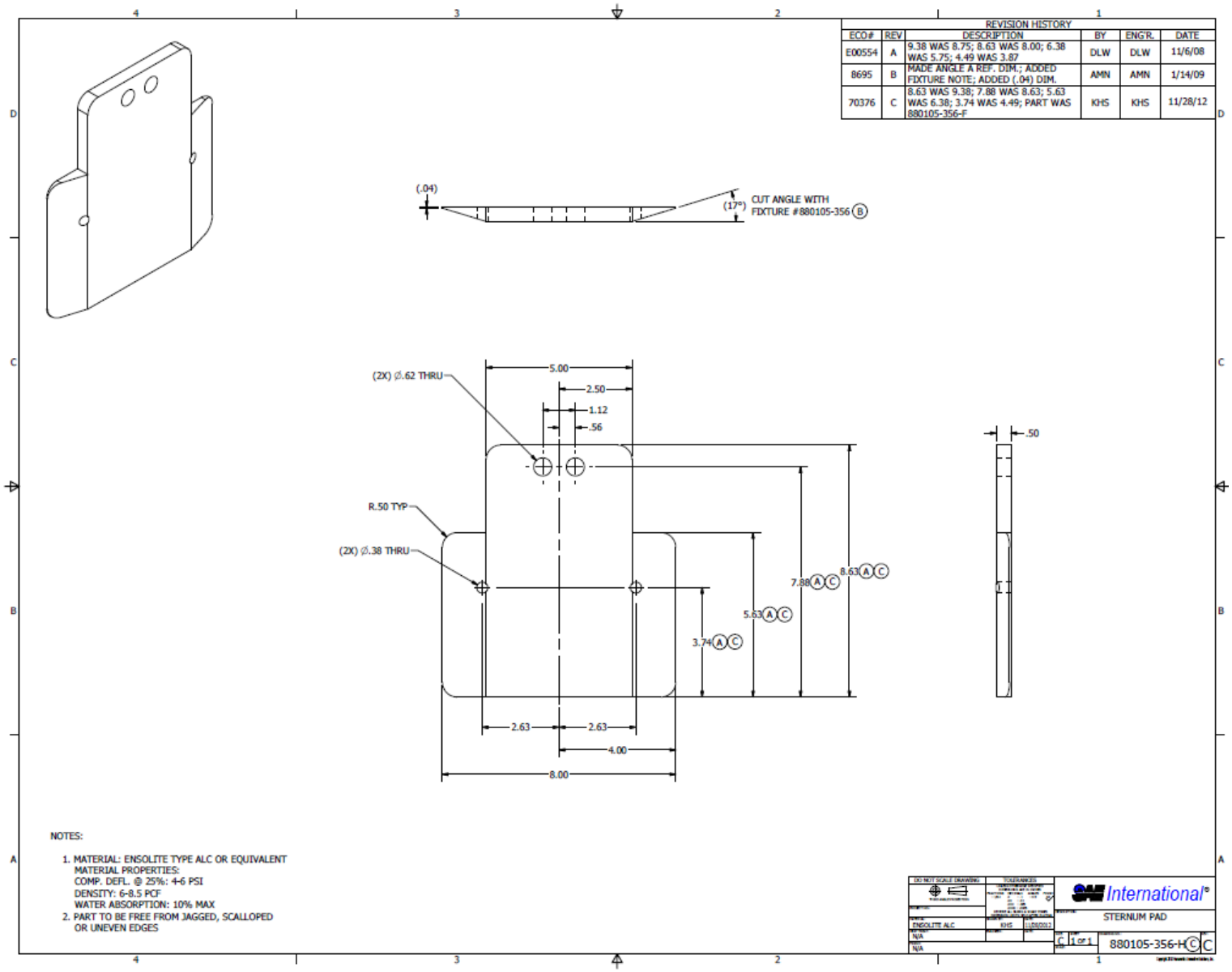

FIGURE 6 - REVISED CHEST JACKET PAD DRAWING

4.2.4 Drawing of Jacket Mandrel

The 3D shape and drawings were developed by DATD and FTSS which was used to manufacture the Mandrels at both facilities. The mandrel was developed to check jacket fit as a jacket becomes older. Due to the fact that some jackets shrink over time, it was determine that a method was required to measure this change. The mandrel (Figure 7-8) duplicates the nominal size of thorax, shoulder, and ribs so that it can be determine if a jacket has shrunk to a point that it is too tight to fit properly on the thorax of the dummy.

FIGURE 7 - 3D SHAPE OF INSIDE JACKET MANDREL

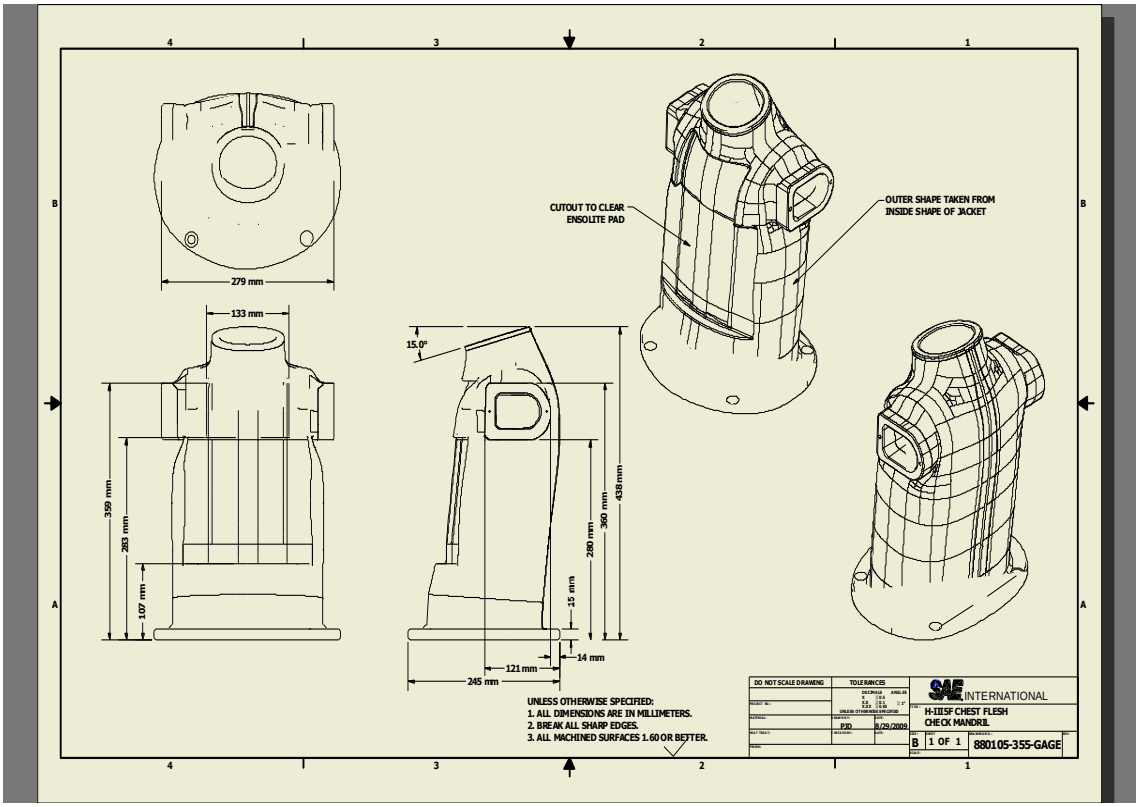

FIGURE 8 - MANDREL DRAWING

4.2.5 Thorax Impact Testing

Both FTSS and DATD manufactured three harmonized jackets from the molds generated from the specifications developed as part of this investigation. Both high and low speed thorax impact tests were conducted.

4.2.5.1 High Speed Thorax Testing

The results of the high speed thorax test results comparing both jackets on a single dummy tested in a standard thorax impact test in two different labs with two different dummies is shown in Figures 9-11. DATD data is on the top and FTSS data on the bottom for each figure.

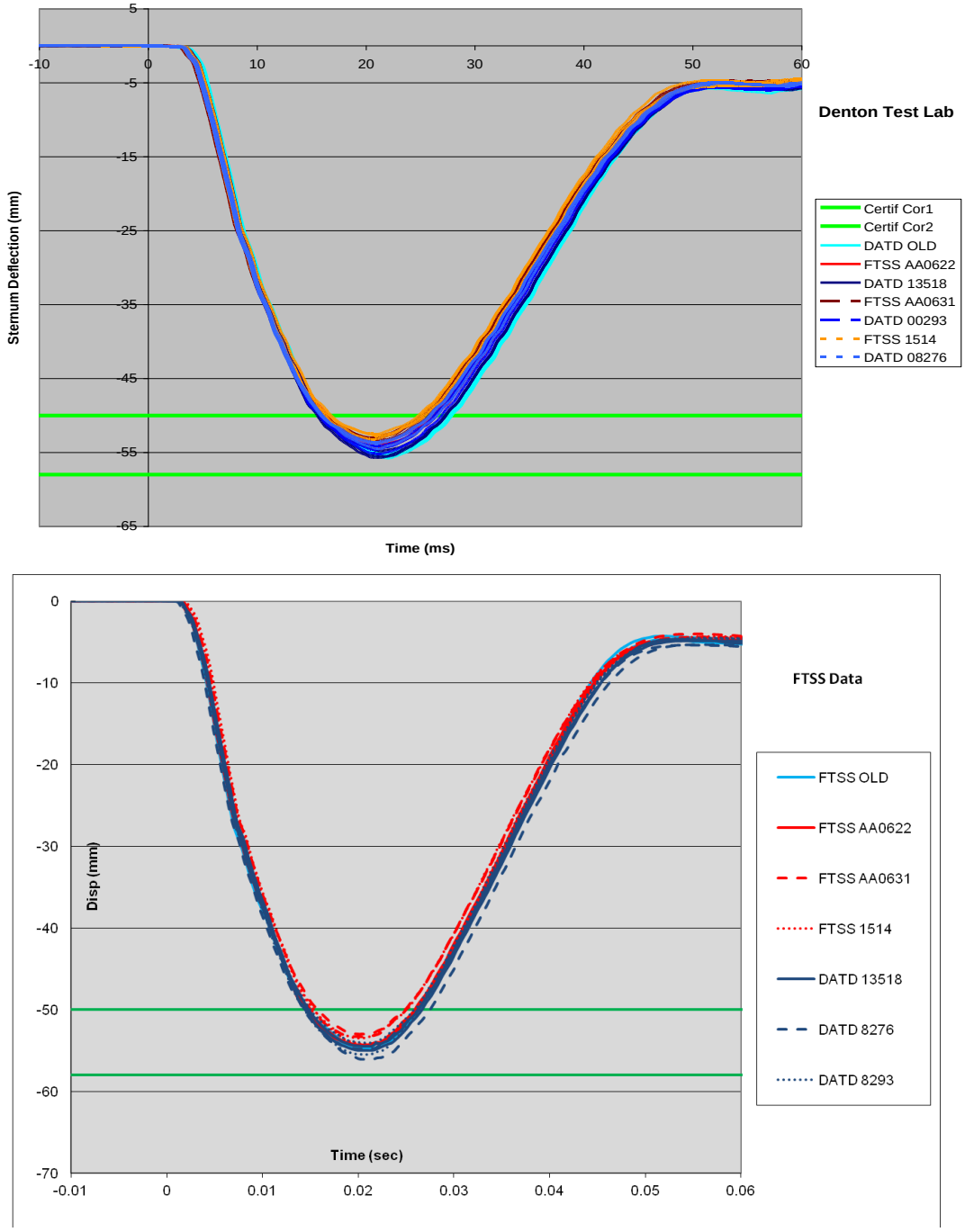

FIGURE 9 - COMPARISON OF STERNUM DISPLACEMENT OF AN OLD AND NEW JACKET ON SAME DUMMY

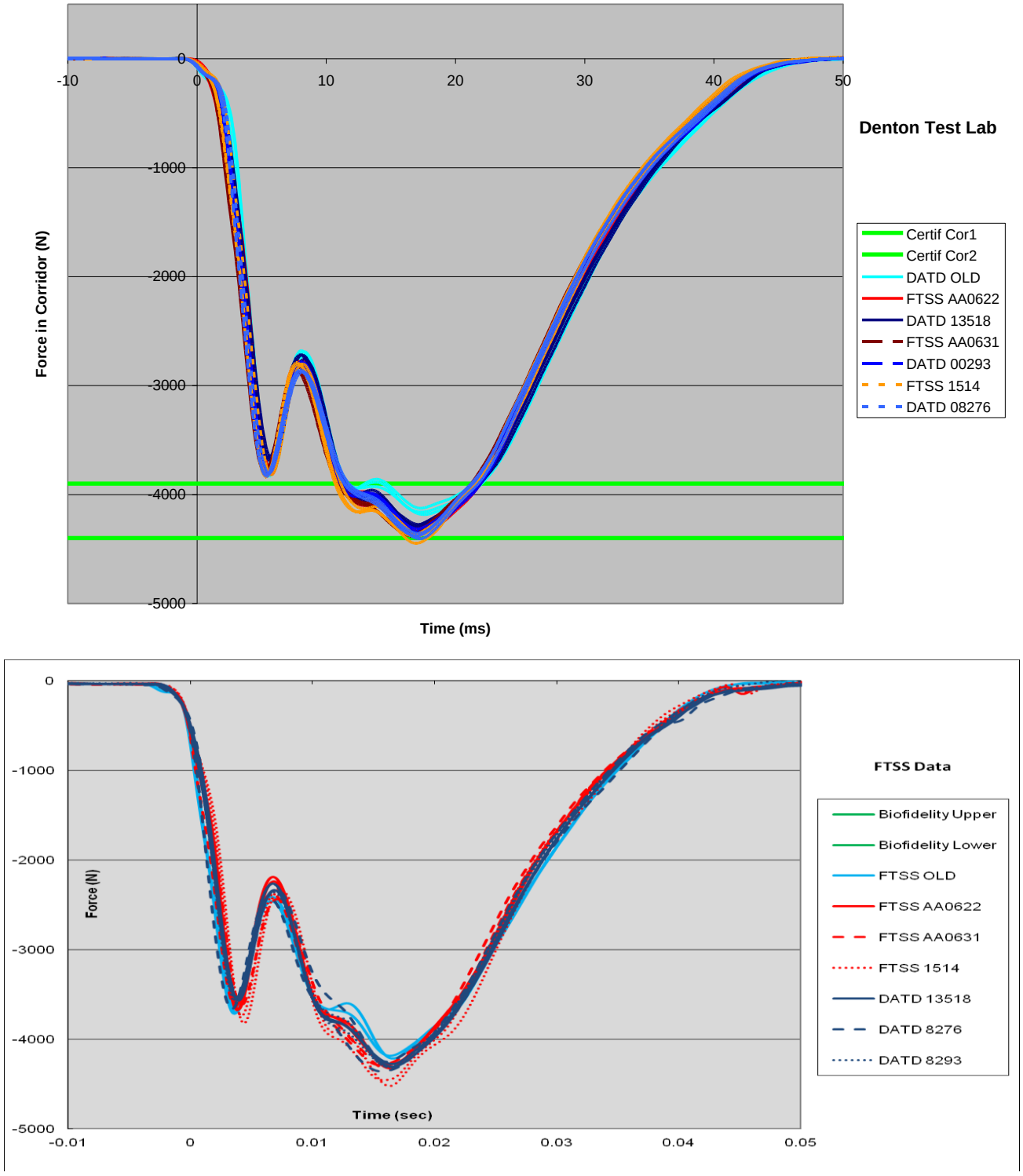

FIGURE 10 - COMPARISON OF PENDULUM FORCE OF AN OLD AND NEW JACKET ON THE SAME DUMMY

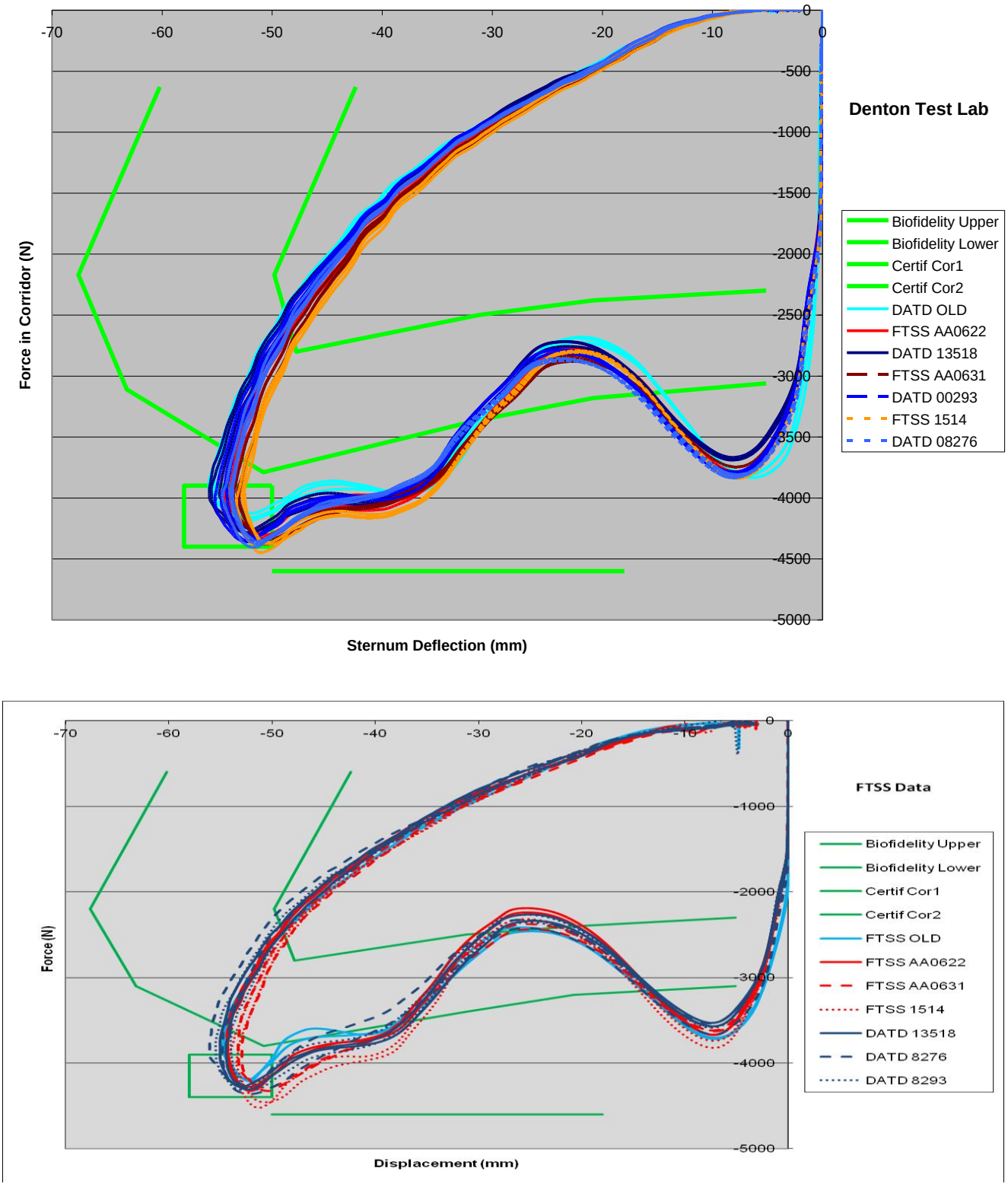

FIGURE 11 - COMPARISON OF FORCE VS DEFLECTION OF AN OLD AND NEW JACKET ON THE SAME DUMMY

The results shown in Figures 9-11 indicate that the harmonized jackets are interchangeable on a given dummy. Some dummies currently in use may require an adjustment to the damping material thickness due to the fact that the current rib sets in the field were set up with the original jackets and foam pads.

4.2.5.2 Low Speed Thorax Testing

For the low speed thorax testing two of the harmonized jackets were chosen and compared to the original jacket type from each manufacturers. The tests were performed in two different labs with two different dummies is shown in Table 1. The results indicate that the displacement and the peak force were changed very little between the different dummies and jackets, with hysteresis changing even less.

TABLE 1 - LOW SPEED TEST RESULTS

Dummy	Jacket #	Temperature (deg C)	Humidity (%RH)	Velocity (m/s)	Sternum Displacement (mm)	Peak Probe Force (kN)	Hysteresis (%)
				2.95 - 3.05	-21.8 - -17.4	2.07 - 1.78	65 - 72
DATD	Original	21.9	42.9	2.98	-20.34	-1.85	66
DATD	Original	21.9	42.2	2.98	-19.9	-1.897	66
DATD	Original	21.9	42.3	2.99	-20.29	-1.887	66
DATD	DATD 08276	21.9	42.4	2.99	-20.16	-1.908	66
DATD	DATD 08276	21.9	42.8	2.99	-20.43	-1.923	66
DATD	DATD 08276	21.9	42.6	2.99	-20.5	-1.938	66
DATD	FTSS 1514	21.9	42.8	2.99	-19.84	-1.939	66
DATD	FTSS 1514	21.9	43.7	2.99	-20.13	-1.927	66
DATD	FTSS 1514	21.9	44.4	2.99	-20.14	-1.952	66
FTSS	Original	21.8	46.1	2.97	-18.15	-1.94	74
FTSS	Original	21.8	45.7	2.98	-18.1	-1.969	73
FTSS	DATD 08276	21.6	39.3	3.01	-19.36	-1.984	72
FTSS	FTSS 1514	21.6	39.6	3	-18.53	-1.977	71
FTSS	FTSS 1514	21.6	39.9	3.01	-19.19	-1.98	71
FTSS	FTSS 1514	21.7	39.6	3.01	-19.18	-1.978	71

4.2.6 Torso Flexion Test Results

The torso flexion test was also conduct comparing the original DATD and FTSS jackets to the harmonized DATD and FTSS jackets as shown in Table 2. The harmonized jackets did not change significantly change the results of the original jacket torso flexion results.

TABLE 2 - TORSO FLEXION RESULTS

Dummy	Jacket	Temp. (deg C)	Humidity (%RH)	Velocity (deg/s)	Initial Angle (degrees)	Force at Maximum Angle (N)	Final Angle (degrees)
			Corridor Upper	1.5	20	390	8
			Corridor Lower	0.5	0	320	-8
DATD	Original	21.6	37	1	15.3	378	2.8
DATD	Original	21.6	37	1	16.3	361	2.4
DATD	Original	21.6	39	0.99	15.2	364	3.8
DATD	Original	21.5	39	0.99	16.2	372	2.7
DATD	08267	21.6	42	0.99	16.3	380	2.6
DATD	08267	21.5	39	1	16	383	2.1
DATD	08267	21.7	40	0.98	16.1	390	2.2
DATD	08267 w/shorten foam pad	21.6	39	1	15.7	377	2.4
DATD	08267 w/shorten foam pad	21.7	39	0.99	15.5	380	2.4
DATD	08267 w/shorten foam pad	21.6	39	0.99	15.8	382	2.2
FTSS	Original	21.8	40	1	15.3	382	3.1
FTSS	Original	21.6	39	1	15.4	379	3
FTSS	Original	21.5	37	1	15.6	373	3
FT	1514 w/shorten foam pad	21.6	40	1.01	16	360	2.6
FT	1514 w/shorten foam pad	21.8	41	1	16	370	2.6
FT	1514 w/shorten foam pad	21.7	38	1	16.1	360	2.6

4.2.7 Upper Torso Weight and Center of Gravity Verification

The jacket weight, and the upper torso weight and center of gravity were also verified for the revised jackets. Tables 3 and 4 clearly show that both jackets maintain the jacket and upper torso weight as well as the center of gravity of the upper torso assembly.

TABLE 3 - UPPER TORSO WEIGHT SUMMARY

JACKET MANUF.	JACKET	Mass	X axis	Y axis	Z axis
FTSS	1514	26.420	3.19	-0.09	-3.51
	0631	26.546	3.13	-0.09	-3.47
	0622	26.484	3.16	-0.07	-3.47
DATD	13518	26.436	3.11	-0.05	-3.49
	08293	26.426	3.11	-0.08	-3.44
	08276	26.440	3.11	-0.05	-3.44

TABLE 4 - JACKET WEIGHT AND TORSO ASSEMBLY WEIGHT AND CG COMPARISONS

Mfr	Zipper Cloth	S.N.	Jacket w/Zipper Wt.	Assembly Wt.	CG-X	CG-Z
			5.00 - 5.40	26.2 - 26.8	3.07 - 3.47	(-3.175 to -3.575)
DATD	Blue	8293	5.16	26.31	3.23	-3.41
DATD	Blue	8276	5.16	26.31	3.25	-3.42
DATD	Blue	13518	5.17	26.32	3.25	-3.43
FTSS	Red	1492	5.25	26.40	3.17	-3.49
FTSS	Red	AA0622	5.29	26.45	3.23	-3.56
FTSS	Red	AA0631	5.38	26.54	3.22	-3.47
FTSS	Red	1514	5.15	26.30	3.29	-3.55

4.2.8 Verification of shape comparison between DATD and FTSS Jacket

At the January 13, 2009 meeting of the SAE HIII Dummy Family Task Force Meeting a presentation was made showing an overlay of scans done of both the DATD and FTSS jackets as shown in Figure 12. The green color in the figure depicts no difference between the jackets. Some differences of 3 to 4 mm were shown around the neck opening and the arm opening. The greatest difference occurred at the lower part of the zipper. It was determined that this would be acceptable for this component.

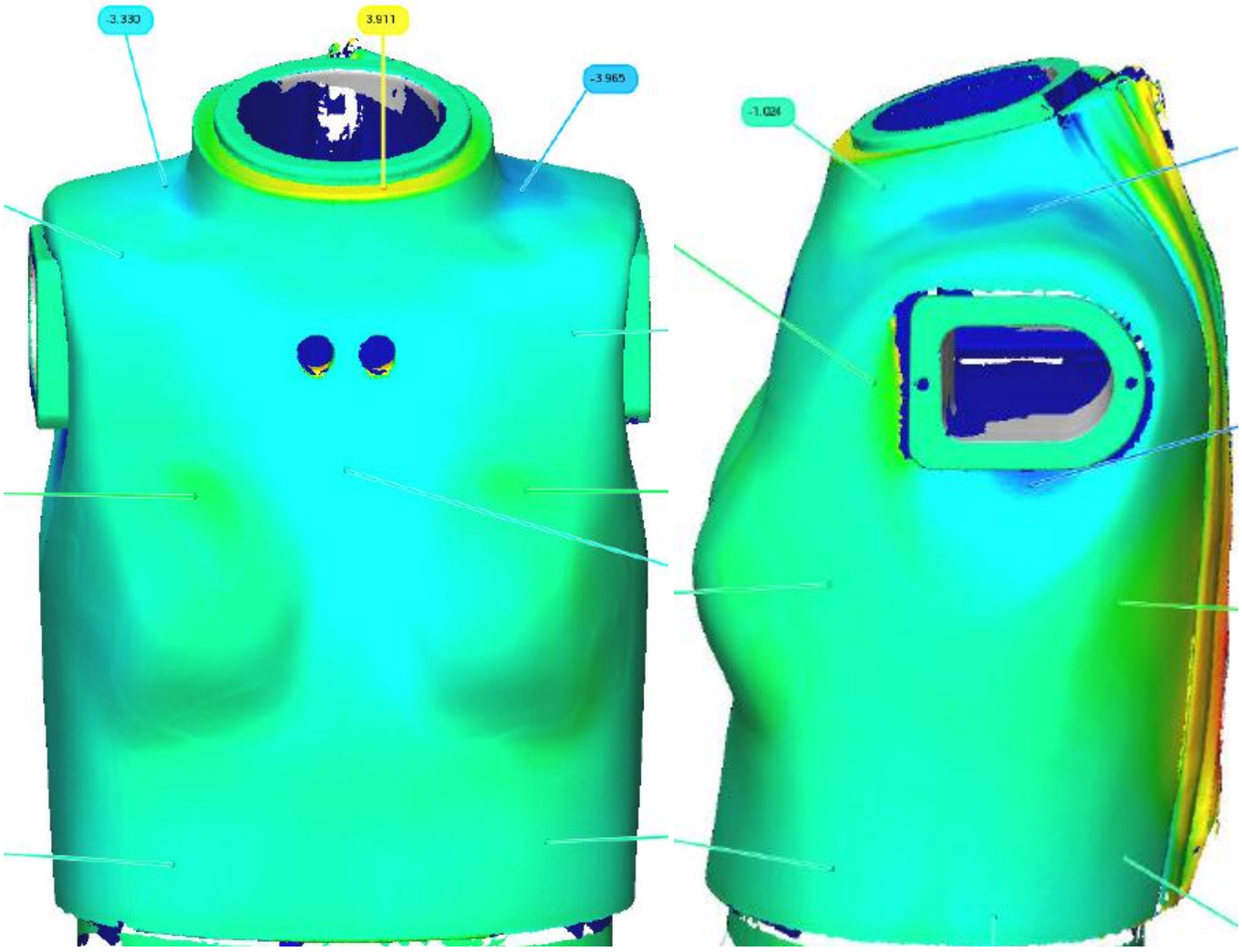

FIGURE 12 - SCAN OVERLAY OF THE DATD AND FTSS REVISED SMALL FEMALE JACKETS

5. NOTES

5.1 Marginal Indicia

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