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H-III5F Spine Box Update to Eliminate Noise

RATIONALE

The Hybrid III Dummy Family Task Force has recommended a change to the H-III5F dummy to fix a design defect that causes data artifacts. This report is needed to document the problem and the solution to this problem recommended by the task force.

FOREWORD

In the late 1980's the *Centers 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 December 11, 2007 meeting of the SAE Hybrid III Dummy Family Task Force, data was presented showing that there was a problem with the 2002 version of the design of the spine box for the Small Female dummy which could cause mechanical noise artifacts in sled and crash test data. Possible solutions to this problem were discussed, and it was agreed to develop a new spine box design to eliminate the possibility of this noise being generated. A new design was discussed, prototypes built and tested, and the design revised until, at the January 13, 2009 meeting, it was agreed to document the design in an Information Report so that it can recommended by the Task Force.

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1. SCOPE AND PURPOSE

This Information Report documents the problems with the 2002 regulated version of the spine box, and defines a recommended solution to resolve the problem.

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.

Code of Federal Regulations Part 572 Test Dummies Specifications - Anthropomorphic Test Dummy for Applicable Test Procedures

Available from Reprographic Technologies, 9107 Gaither Road, Gaithersburg, MD 20877, (301) 419–5070 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. ABBREVIATIONS

H-III5F	Hybrid III 5th Percentile Small Female Crash Test Dummy
Hybrid-III AF05 (in Figure 13)	Hybrid III 5th Percentile Small Female Crash Test Dummy
SHCS	Socket Head Cap Screw
FHCS	Flat Heat Cap Screw
NHTSA	National Highway Traffic Safety Administration - of the United States Department of Transportation

4. TECHNICAL REQUIREMENTS

4.1 2002 Regulation Spine Box

The H-III5F dummy in Federal Regulation was first adopted into CFR Part 572 via 65 FR 10968 on March 1, 2000, and subsequently amended via 67 FR 46413 on July 15, 2002. These regulations define drawings for the construction of the dummy as well as dynamic performance criteria through certification tests in Part 572 Subpart O. The 2002 version of the H-III5F drawing package defines the current version of the dummy. Drawings 880105-000 (page 3 of 8), 880105-300, 880105-328, 880105-1000 (sheet 3 of 3) from this drawing package are most relevant to this issue, and are included in Appendix A.

4.1.1 Description of Problem

In the thorax region of the H-III5F, the spine box (880105-1000) is attached to the thorax load cell simulator (880105-328) by six 5/16-18 x ½" SHCS (item 29 on 880105-300). Since the holes in the spine box are 0.323" diameter and the screws have a maximum diameter of 0.313", there is always clearance between the screws and the spine box wall. As the H-III5F is exposed to the accelerations involved in sled or crash testing, the screws can loosen and the spine box will slip under the screw heads until it hits the sides of the screws. This motion produces high amplitude, high frequency mechanical noise on accelerometers within the dummy - which is an artifact of the dummy. A secondary effect of this rocking motion is that the spine box can move approximately +/- 1 degree relative to the thorax load cell structural replacement (see Figure). This moves the head position relative to the pelvis fore and aft based on how the spine box is in contact with the screws.

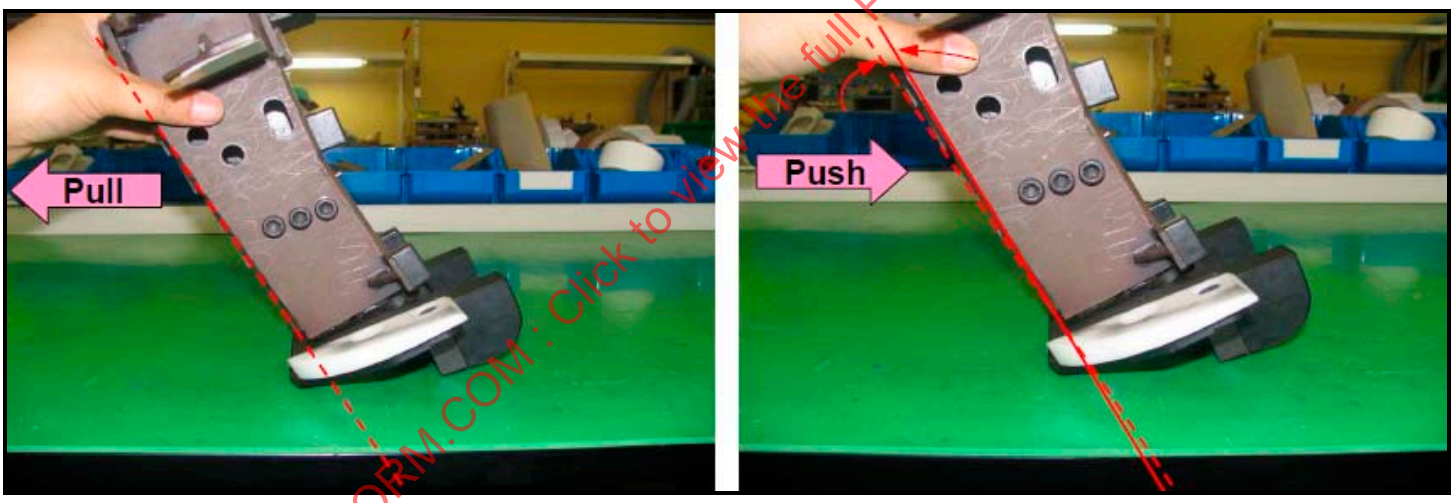

FIGURE 1 - SPINE ROCKING ON SCREWS

4.1.2 Tests Demonstrating Problem

The data in Figure 2 was presented at the Dec. 11, 2007 meeting showing the noise spikes that were thought to be produced by the spine rocking during the impact event. This data was produced from a 35 mph belted sled test. Figure 3 shows data that was presented at the same meeting showing noise spikes in 35 mph frontal rigid barrier tests that are hypothesized to be from the spine rocking as well.

The test data in green was obtained initially (with an unknown bolt torque) and we could not understand the cause of the abnormal peak-G. We tried to reproduce the phenomenon as shown with the resulting plots in red.

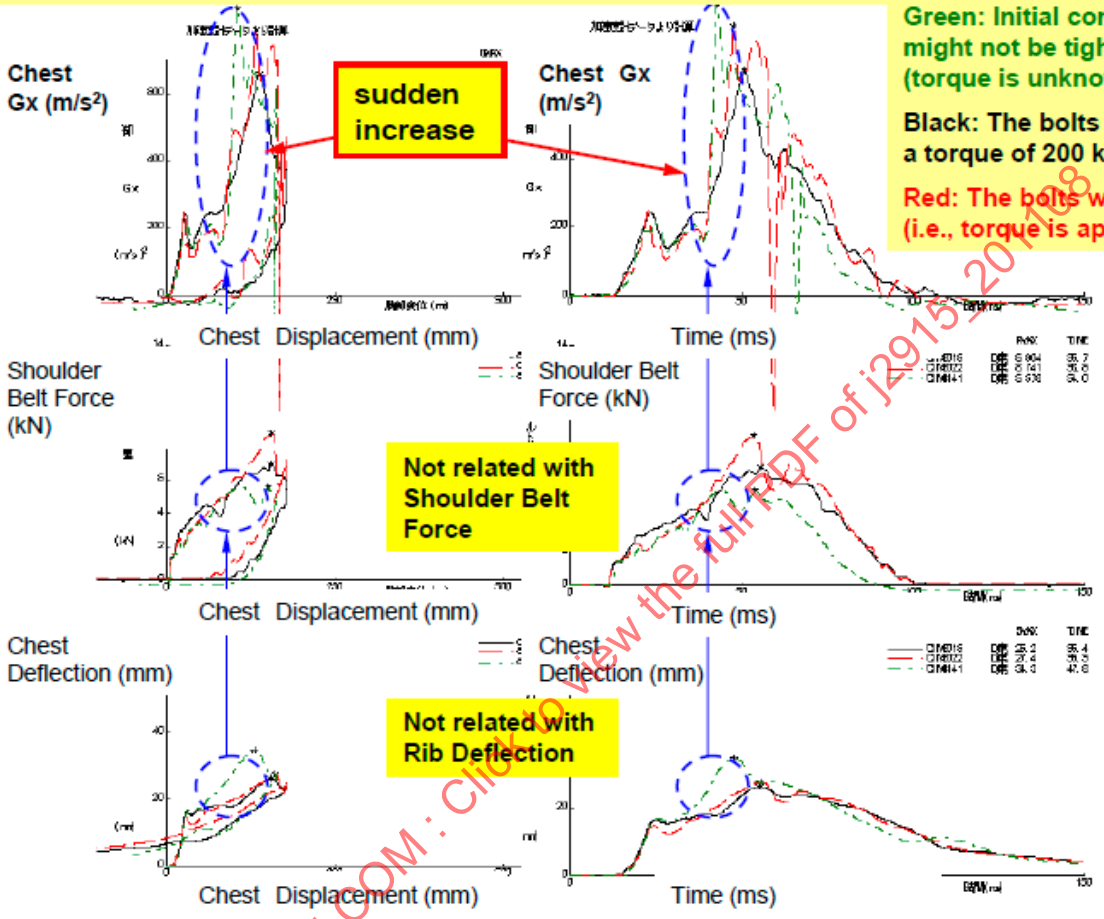

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FIGURE 2 – SLED DATA DEMONSTRATING PROBLEM

NHTSA Research Test Results: We could find 3 similar wave patterns in the NHTSA test results (from the web) from 8 vehicles; H-III AF05 was positioned on the driver and passenger sides (16 cases in total).

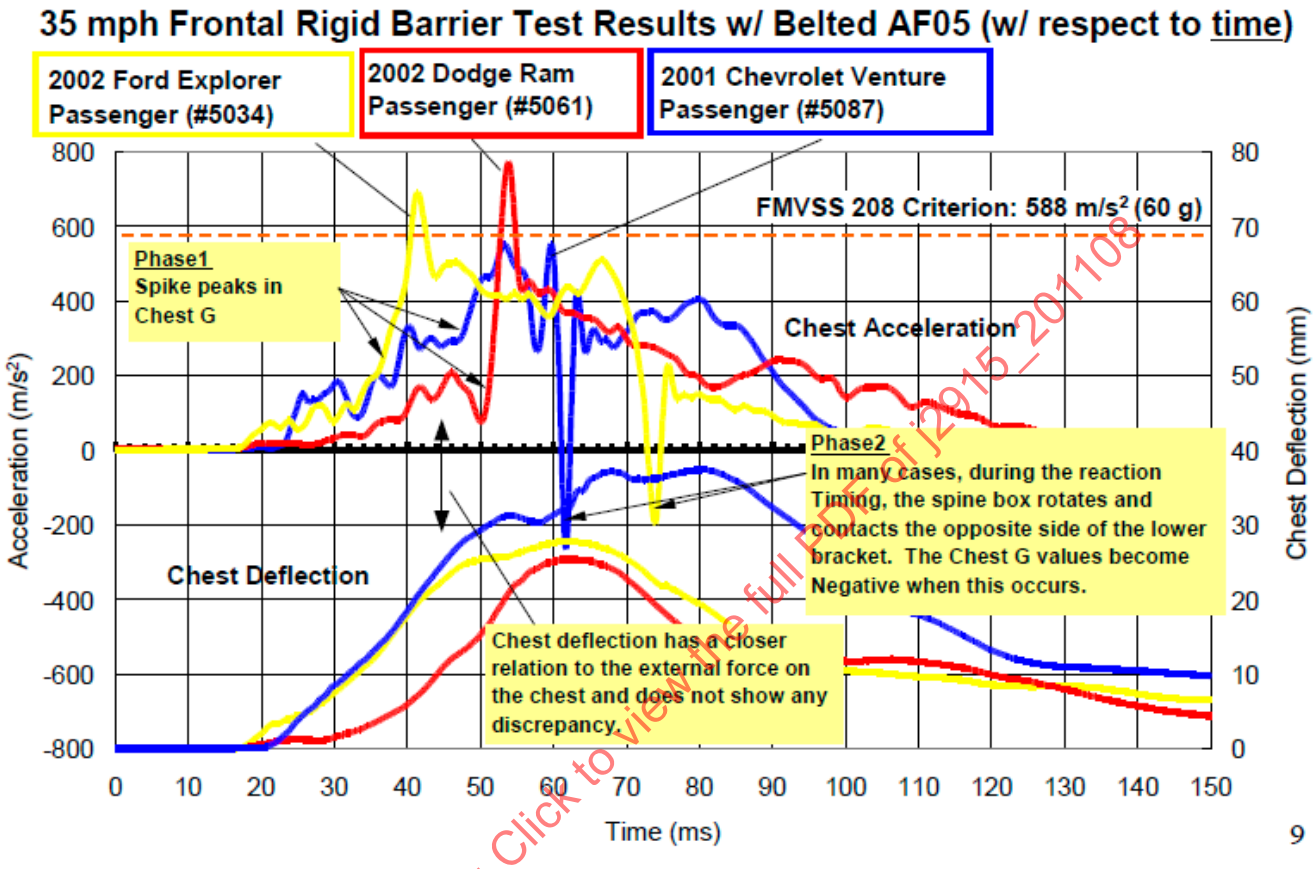


FIGURE 3 - BARRIER CRASH DATA DEMONSTRATING THE PROBLEM

4.1.3 Interim Measure

An interim stop-gap measure to minimize the problem until the spine box can be permanently fixed, is to re-tighten the six SHCS before every test. The six screws must be loosened and then re-tightened to the proper torque between *every* sled or crash test. It has been found that keeping the screws tight in this manner will usually prevent the slippage and mechanical noise from occurring. A sample tightening procedure that can be followed is included in Appendix B.

4.2 Recommended Spine Box Update

4.2.1 Description of Solution

To eliminate the possibility of motion, the screws that attach the spine box to the load cell structural replacement are changed from standard SHCS to 5/16-18 SHCS that have a 90 degree chamfer like a FHCS as seen in Figure 4. These screws are already used in the DOT-SID dummy in Part 572 Subpart F. To have sufficient wall thickness to add the countersink to the spine box, a steel plate is welded on each side. The screw holes have 90 degree countersinks added. This allows the screws to lock the spine box into a unique position, and lets the chamfer of the screw grip to the countersink in the spine box. The screws are torqued to 28 Nm.

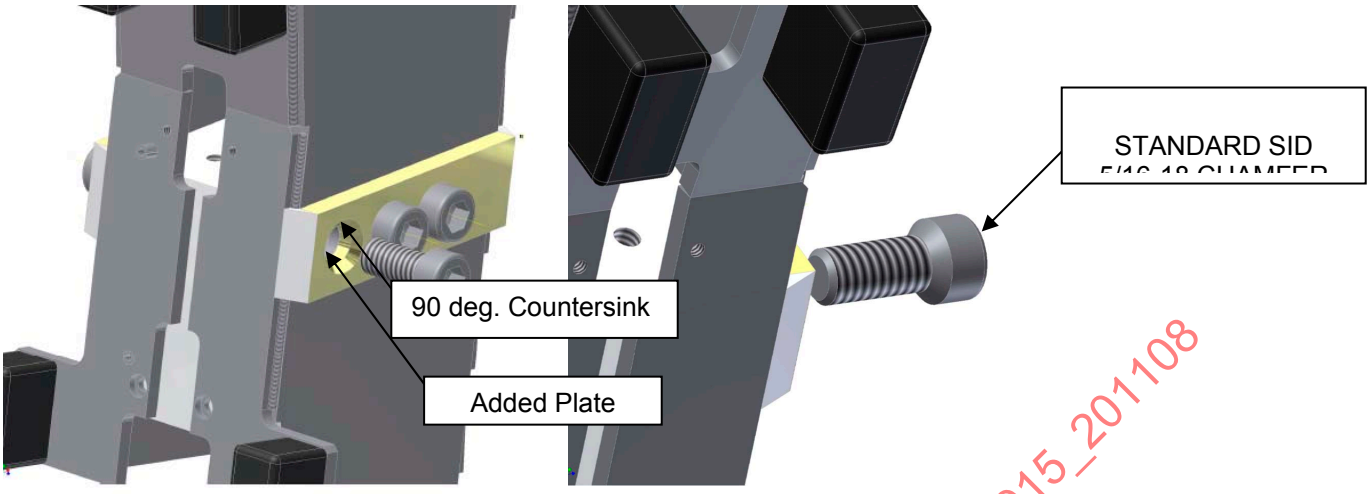


FIGURE 4 - DESIGN OF UPGRADED SPINE BOX

4.2.2 Drawings

Drawings are provided to construct the spine box either from scratch when building a new dummy or to upgrade an existing dummy by updating the spine box and screws.

4.2.2.1 To Make a New Spine Box

To make a new spine box from scratch, drawings 880105-1045, 880105-1047, and SID-076-6 are used as shown in Figure 5 through Figure 9 as well as the drawings listed on 880105-1045 that are used directly from the 2002 drawing package.

4.2.2.2 To Upgrade a 2002 Regulation Spine Box

An existing spine box can be modified by using drawings 880105-1045-MOD (Figure 10), 880105-1048 (Figure 11), and 880105-1049 (Figure 12) shown in the corresponding figures.

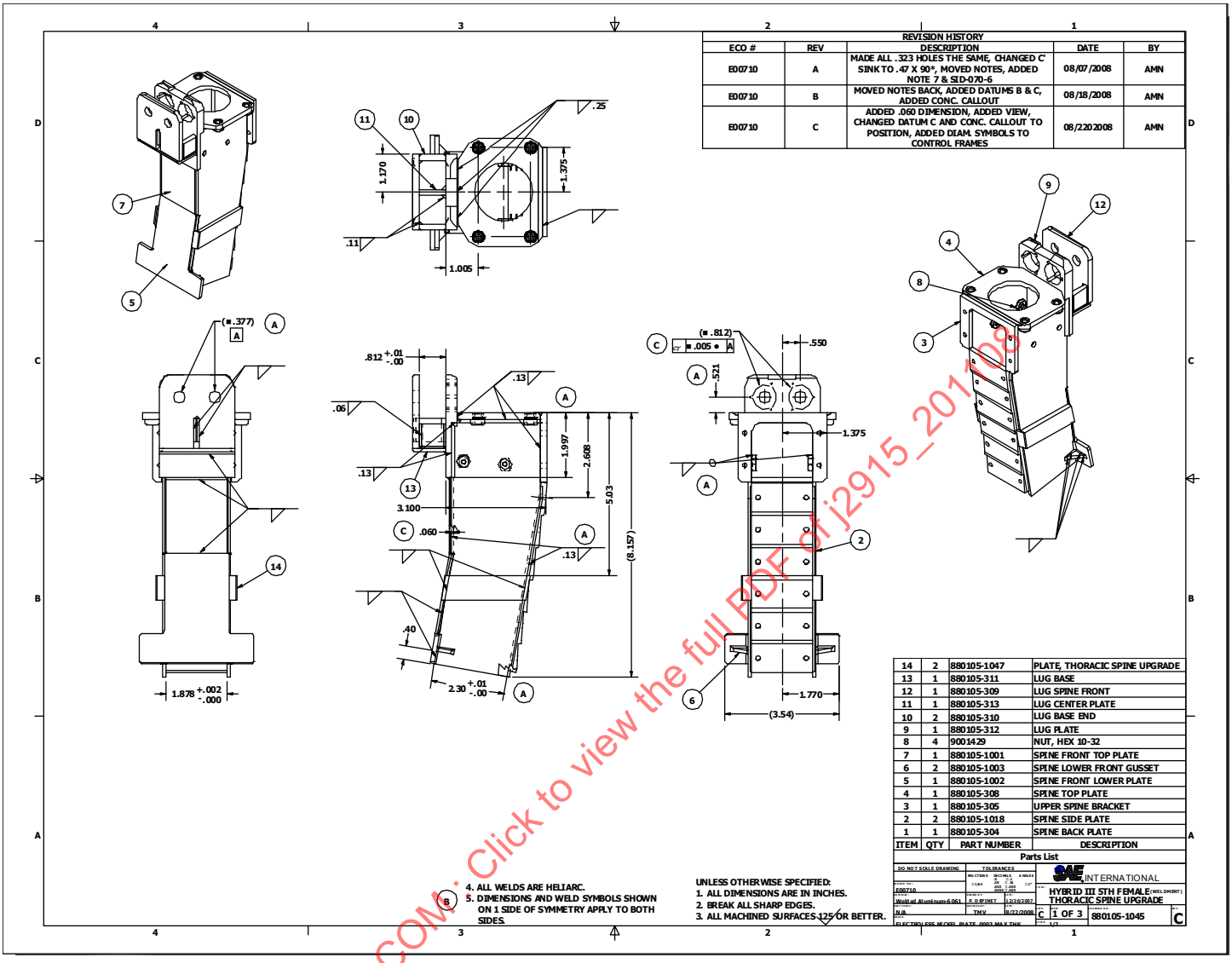


FIGURE 5 - 880105-1045 SHEET 1 OF 3

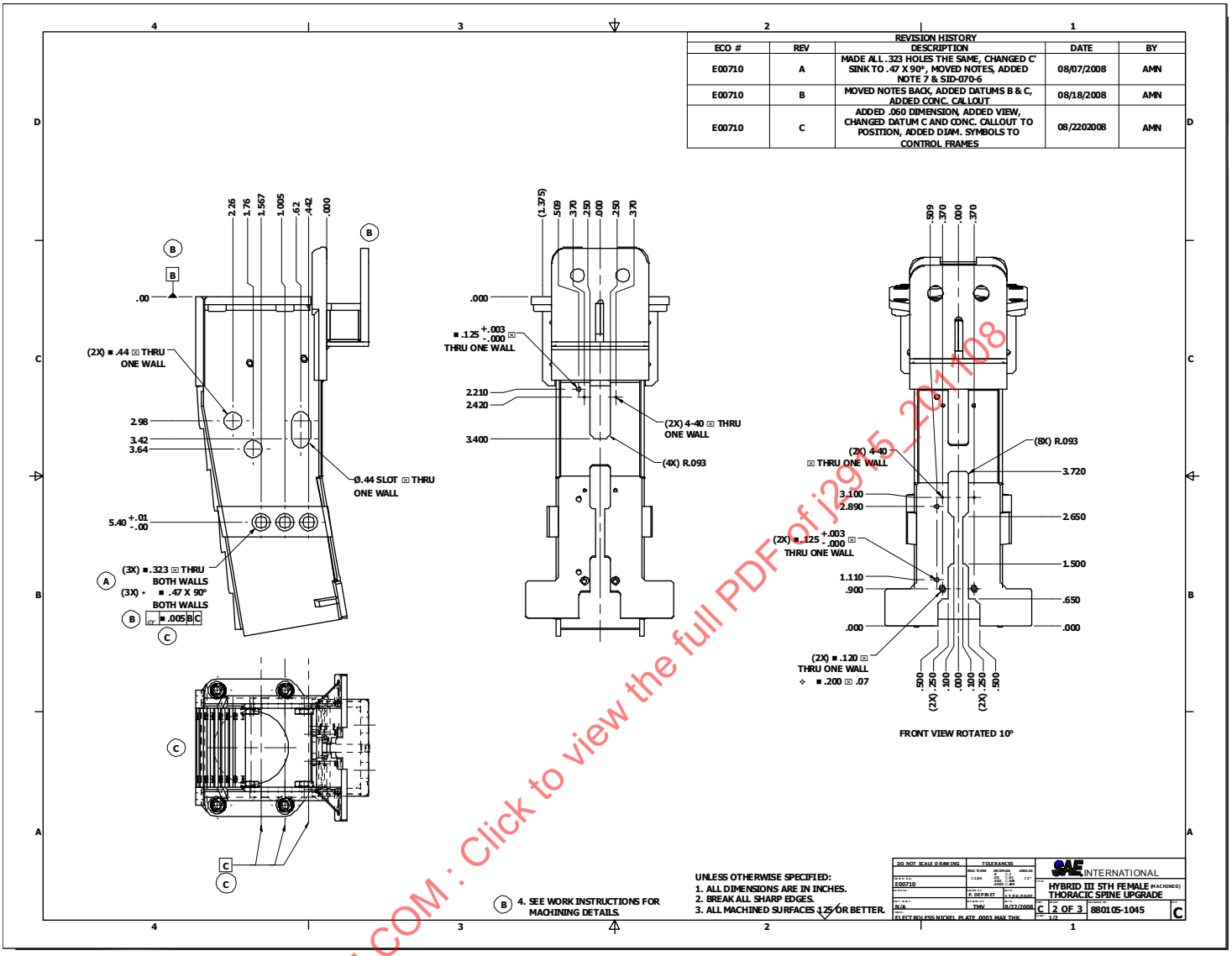


FIGURE 6 - 880105-1045 SHEET 2 OF 3

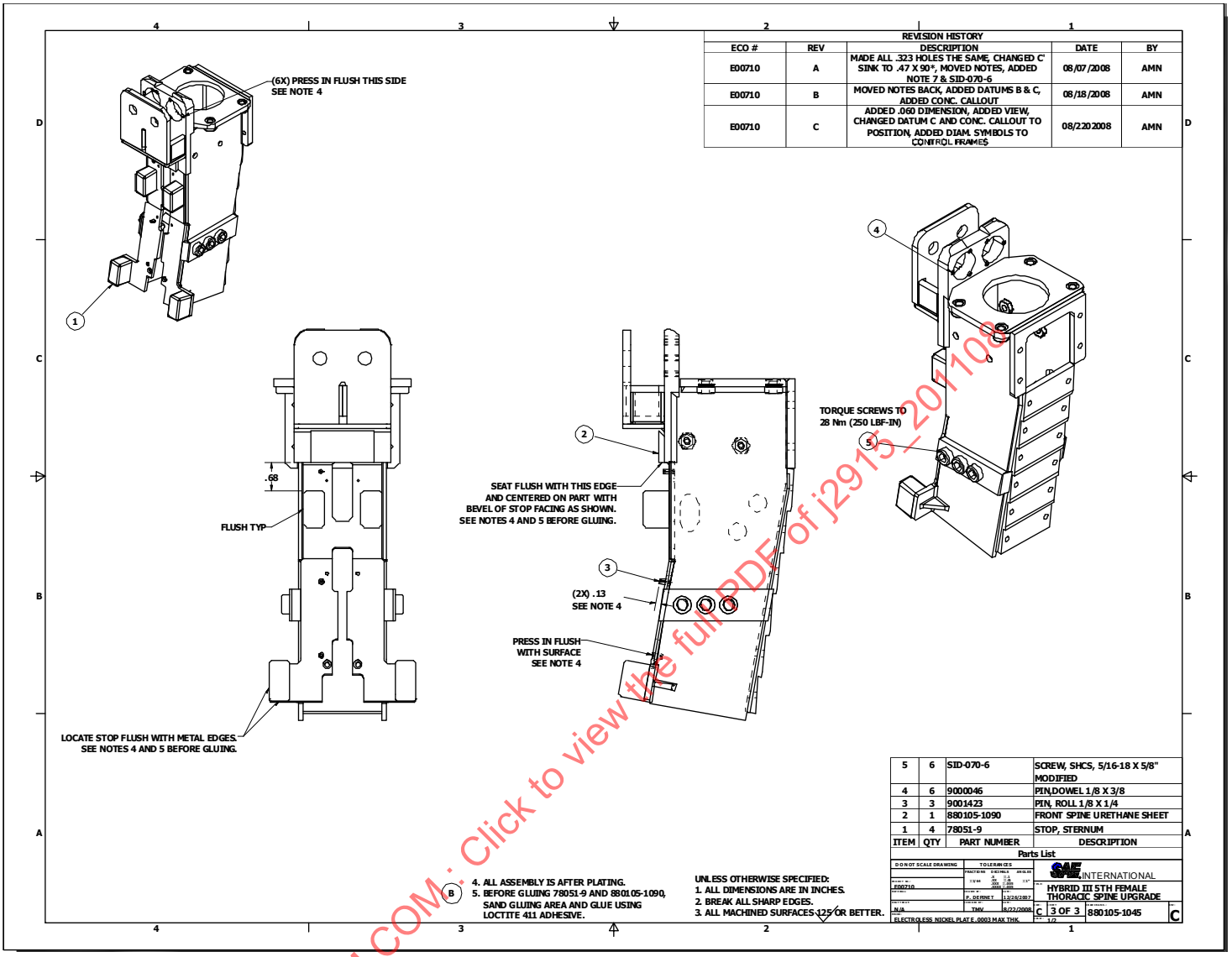


FIGURE 7 - 880105-1045 SHEET 3 OF 3

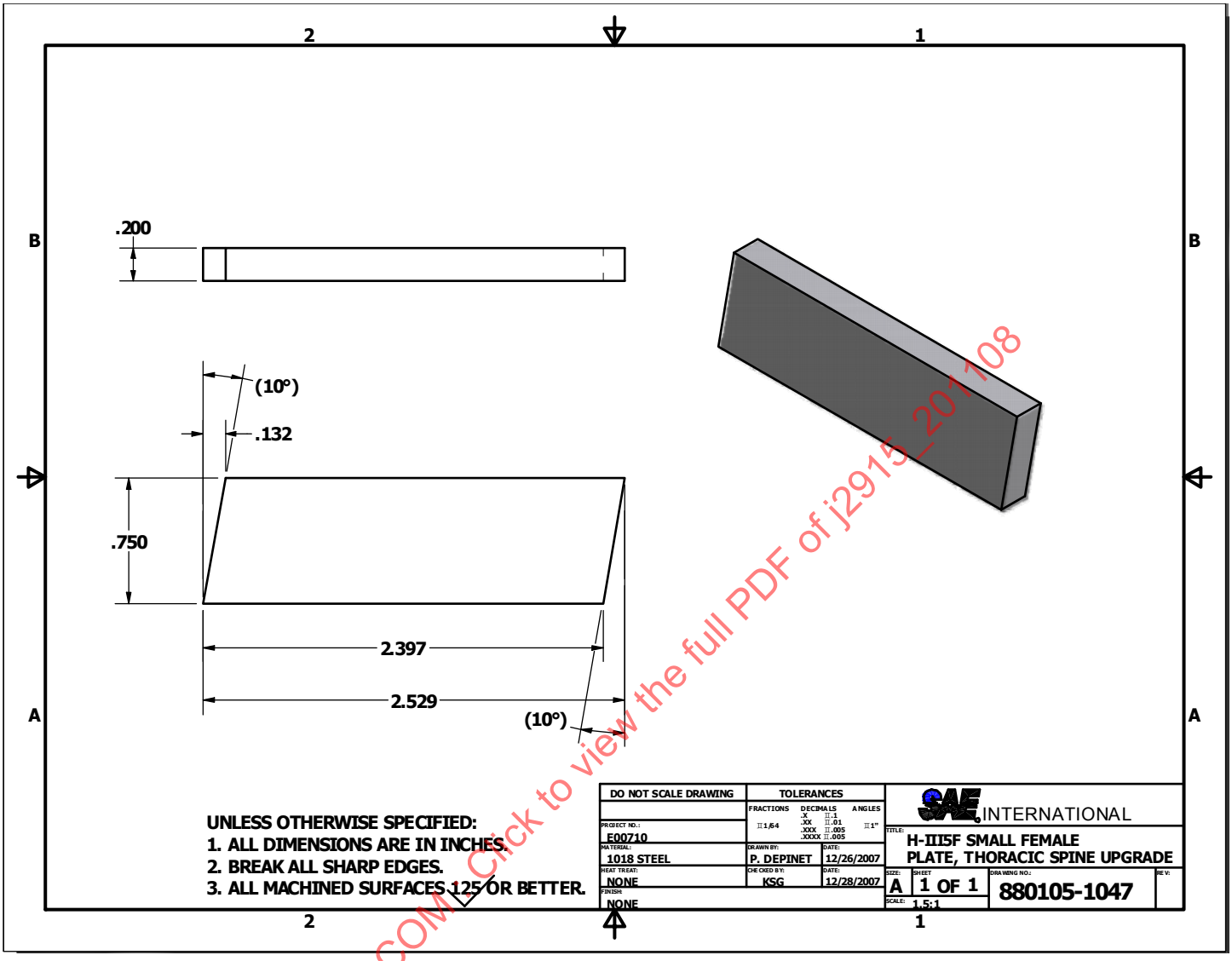


FIGURE 8 - 880105-1047

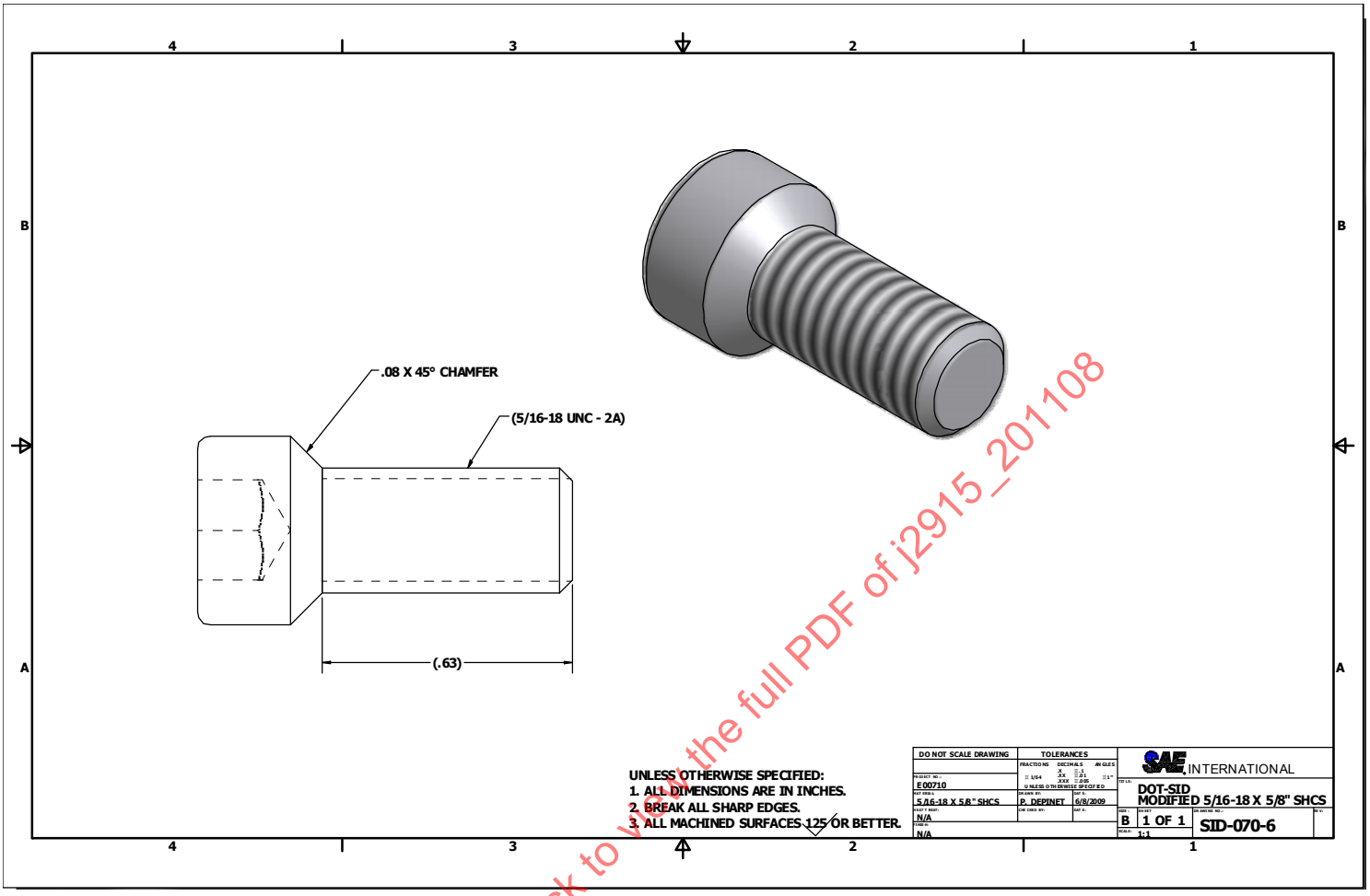


FIGURE 9 - SID-070-6

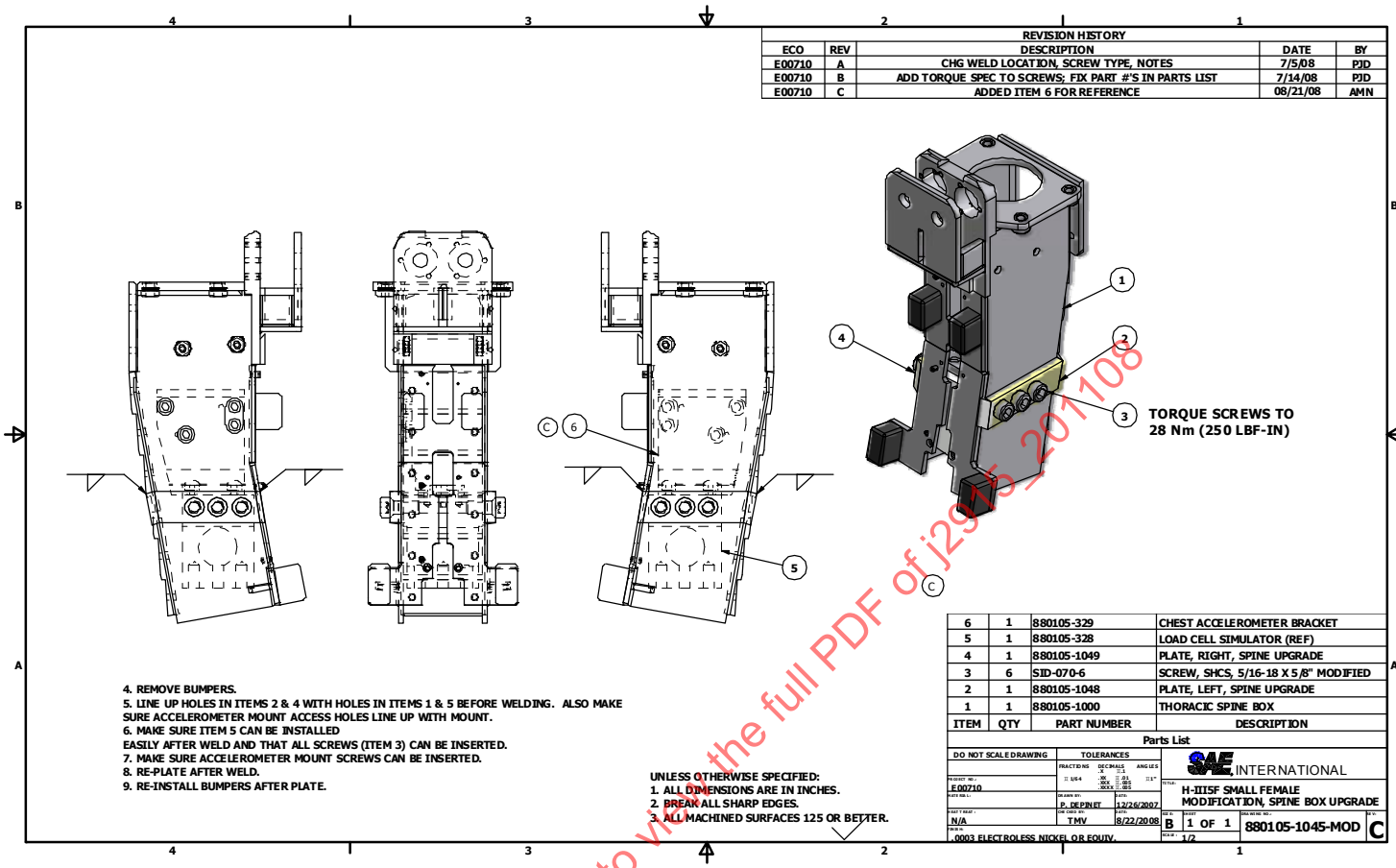


FIGURE 10 - 880105-1045-MOD

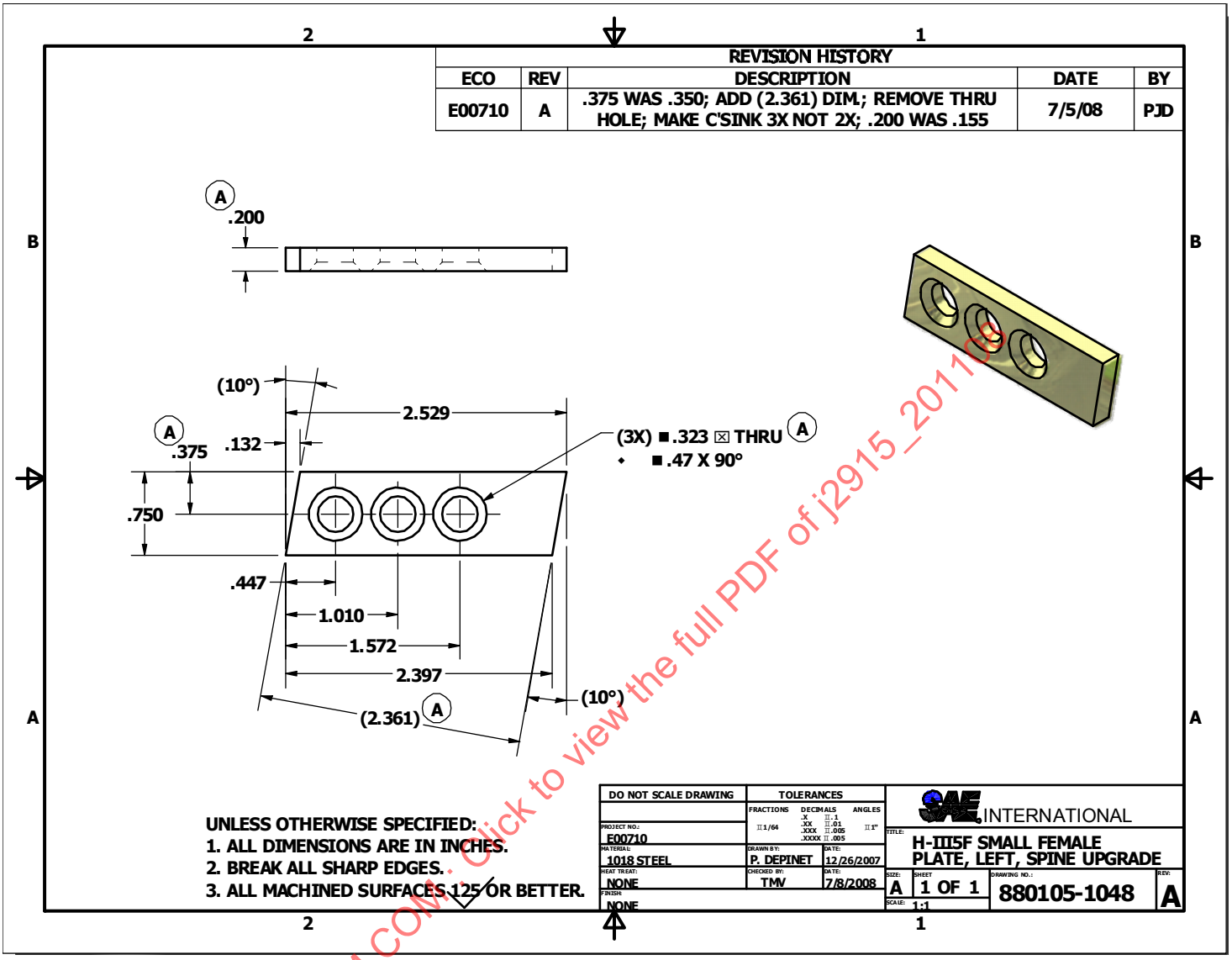


FIGURE 11 - 880105-1048

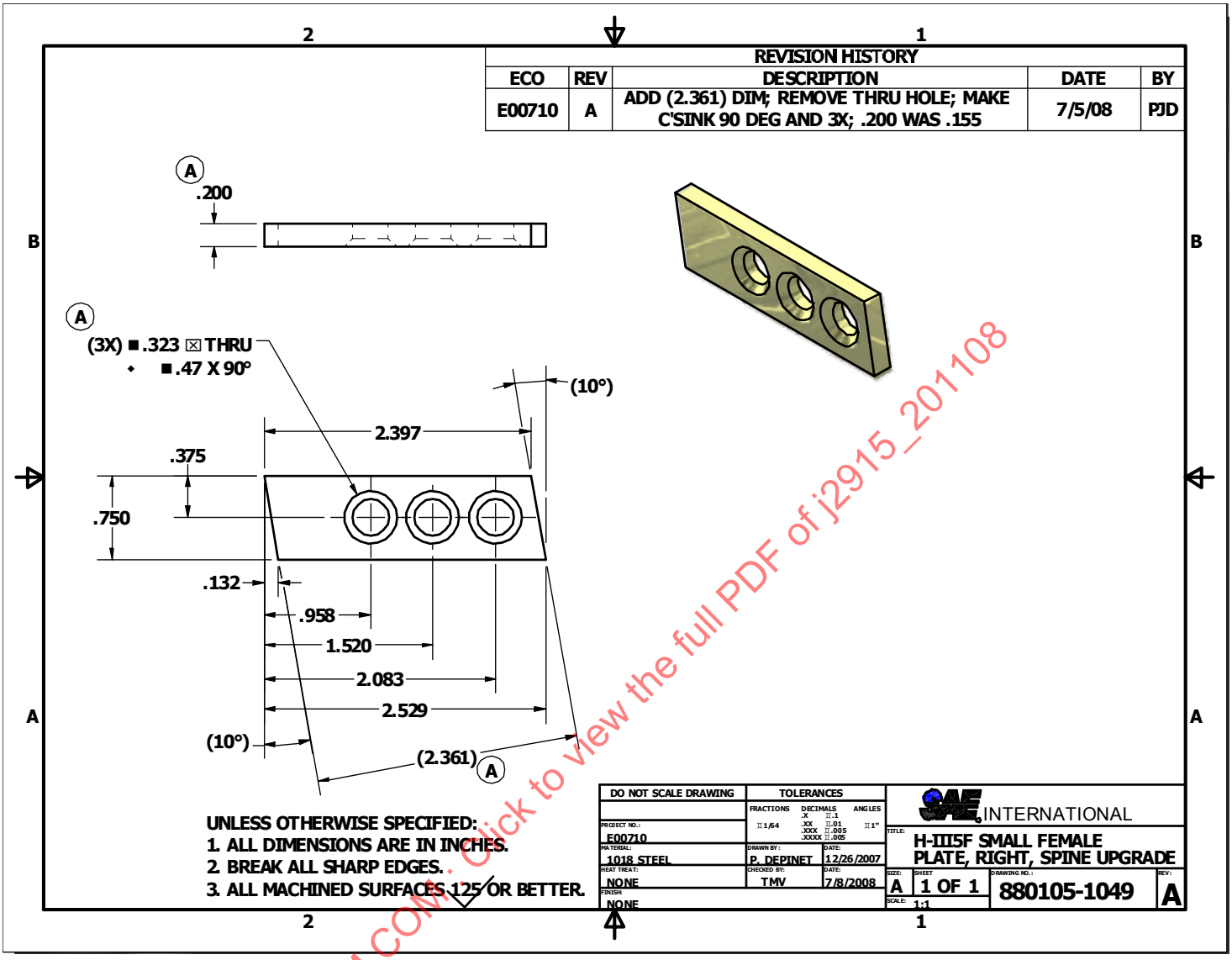


FIGURE 12 - 880105-1049

4.2.3 Tests Demonstrating Acceptability

4.2.3.1 Sled Testing

A sled test series was undertaken for the Hybrid III Family Task Group to evaluate whether the new spine box design performed differently from the old spine box and to see if it loosened up over four consecutive tests. Figure through Figure document the test plan and results. This series showed that the new spine box has equivalent performance and did not loosen over four tests.

4.2.3.2 Mass and Center of Gravity Verification

The new spine box causes a small (~0.077 kg) increase in upper torso mass from the added side plates. This is a small increase compared to the 0.28 kg mass tolerance for the upper torso mass. Since these plates are located very near the center of gravity of the upper torso, the effect on the center of gravity of the assembly should be minimal.

5. NOTES

5.1 Marginal Indicia

A change bar (l) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this document. An (R) symbol to the left of the document title indicates a complete revision of the document, including technical revisions. Change bars and (R) are not used in original publications, nor in documents that contain editorial changes only.

PREPARED BY THE HYBRID III DUMMY FAMILY TASK FORCE OF THE DUMMY DEVELOPMENT AND EVALUATION ADVISORY GROUP OF THE HUMAN BIOMECHANICS AND SIMULATION STEERING COMMITTEE IN COOPERATION WITH THE DUMMY TESTING AND EQUIPMENT COMMITTEE

Sled Tests Results

Test Condition
- To Simulate 35mph Frontal Crash Test
- Small SUV
- Passenger Seat
- 3-pt seat belt with pretensioner and load limiter
- No airbag deployment to observe the kinematics of thorax

Test Matrix:
- Hybrid-Ⅲ AF05（ original vs. new spine box)

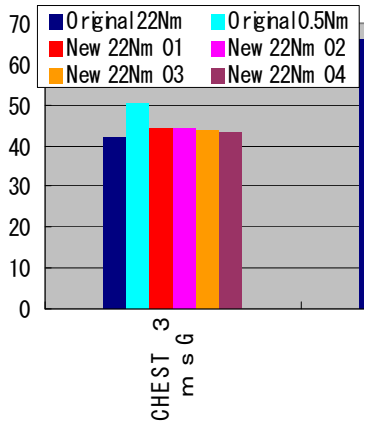
  Original Spine Box
  - 1 case with 22Nm (tightened)
  - 1 case with 0.5Nm (loosened)

  New Spine Box
  - 4 cases with 22Nm (tightened)

FIGURE 13 - EVALUATION SERIES TEST PLAN

Peak values

		Original22Nm	Original0.5Nm	New 22Nm #1	New 22Nm #2	New 22Nm #3	New 22Nm #4
CHEST 3msG	G	42.1	50.1	44.2	44.4	43.6	43.3
CHEST DEFLECTION	mm	26.2	27.1	26.2	26	26.8	28.4
CHEST Upper Fx	N	416.7	514.9	451.8	462.1	431.4	463.8
CHEST Upper Fy	N	85.4	187.2	133.1	95.7	82.3	109.8
CHEST Upper Fz	N	215.9	253.6	177	151	144	145.9
CHEST Lower Fx	N	1199.9	1806.2	1147.3	1089.1	907.4	787.4
CHEST Lower Fy	N	109.1	88.9	98.6	74.5	23.7	39.5
CHEST Lower Fz	N	566.1	529.9	784	585.3	861.3	763.5
SHOULDER BELT(MAX)	N	4446.0	4505.0	4832	4493	No Data	4664



With the new spine box (N=4), C*V = 1.0% for the Chest 3msG peaks.

Repeatability is good.

FIGURE 14 - EVALUATION SERIES RESULTS SUMMARY

Graphs

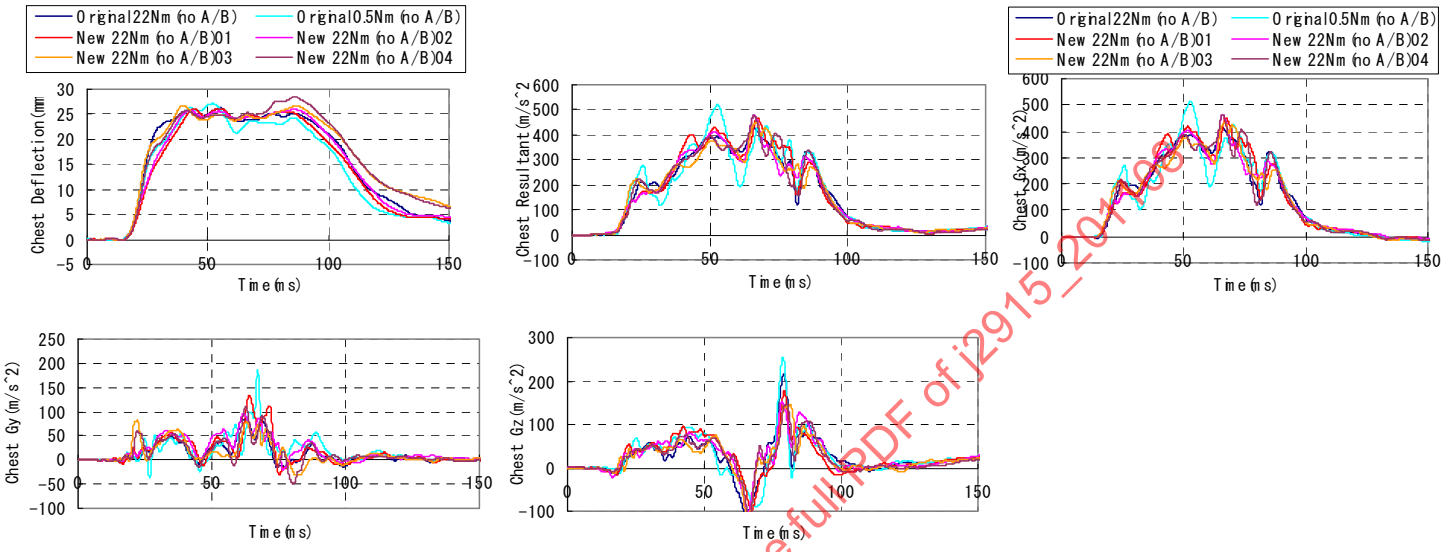


FIGURE 15 - EVALUATION SERIES GRAPHS

Kinematics: Difference in kinematics was not observed between Original and New spine box in the cases with the bolt tightened by 22Nm.

FIGURE 16 - EVALUATION SERIES KINEMATICS

APPENDIX A- RELEVANT 2002 REGULATION DRAWINGS