SAE INTERNATIONAL

SURFACE VEHICLE INFORMATION REPORT

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H-III50M Ankle Update to Eliminate Signal Noise

RATIONALE

This Information Report is intended to provide a comprehensive background and validation document of a recommended solution for an electrical signal noise issue that was created by the 1996 NHTSA regulated version of the 45 degree foot ankle bumper design.

FOREWORD

In 1986, the Hybrid III 50th Percentile Male Test Dummy was specified in the NHTSA final rule (Federal Register Vol. 51, No. 143, page 26688-26710) to replace the Hybrid II Test Dummy. The ankle joint of the feet in the regulation had approximately 30 degrees dorsiflexion. In 1991, Ford petitioned NHTSA to increase the ankle dorsiflexion. In 1996, NHTSA updated the final rule to incorporate an improved ankle dorsiflexion design, which allows 45 degree dorsiflexion. The design also introduced an ankle bumper to prevent potential metal-to-metal contact. The modified NHTSA drawings in 1996 are 78051-600, -601, and -611, and 730-1 and -2.

In 2007, IIHS identified signal noise from the foot accelerometer signals in high-speed frontal crashes. An investigation concluded the noise was generated by two possible areas of the current ankle design. The first location is the possible metal-to-metal contact between the ankle joint ball shaft and the bumper retainer. The second location is between the ankle ball shaft and its mounting hole in the welded foot assembly. In 2008, SAE Hybrid III Task Force initiated a task to redesign the ankle joint, seeking solutions to eliminate the potential metal-to-metal contact while maintaining the ankle range of motion as specified in the 1996 NHTSA final rule. This information report summarizes the final design and the validation test results from the SAE Hybrid III Task Force. This design concept could also be applied to the Hybrid III Small Female and Large Male ankle joint designs.

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1. SCOPE AND PURPOSE

This Information Report documents the signal noise discovered with the 1996 NHTSA regulated version of the 45 degree foot, 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 J2856 User's Manual for the 50th Percentile Male Hybrid III Dummy, September 2009.

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

2.2.2 Reprographic Technologies

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 E - Hybrid III Test Dummy - December 1998

3. ABREVIATIONS

IIHS Insurance Institute for Highway Safety

H-III50M Hybrid III 50th Percentile Male Crash Test Dummy

H-III TF Hybrid III Task Force

SHCS Socket Head Cap Screw

FHCS Flat Head Cap Screw

NHTSA National Highway Traffic Safety Administration - of the United States Department of Transportation

4. TECHNICAL REQUIREMENTS

4.1 1996 Regulation Limbs

The H-III50M dummy was first adopted in Part 572 in July 1986, Federal Register Vol. 51, N0. 143, and amended in December 26, 1996, Federal Register Vol 61, No. 249. The NHTSA amendment in 1996 introduced a new design to increase ankle dorsiflexion and femur flexion ranges. These regulations define drawings for the construction of the dummy as well as performance criteria through certification tests in Part 572 Subpart E. The 1996 version of the drawing package defines the 1996 NHTSA regulation of the dummy. Drawings 78051-600, -601, and -611, and 7310-1, and -2 from this drawing package are most relevant and are included in Appendix A.

4.1.1 Description of Problem

High-speed frontal crash tests conducted by IIHS with HIII50M dummy (with the 1996 version of the ankle design) have shown signal noise in the foot accelerometer signals. Post crash investigation of the dummy revealed the noise was generated by two possible areas of the current ankle design. One is the possible metal-to-metal contact between the ankle joint ball shaft and the bumper retainer. The second location is between the ankle ball shaft and its mounting hole in the welded foot assembly. The signal noise can propagate through the dummy's lower leg, which has been shown to produce signal noise in the tibia and femur load cell signals. The signal noise can artificially increase peak injury measures, even after appropriate filtering is applied. In some cases peak injury measure timing from the lower extremity channels occur during a period of ringing in the foot accelerometer channels. In those cases, IIHS had used exclusion zones to limit the reporting of peak lower extremity injury measures to time periods occurring before or after the known time period with signal noise.

Despite the addition of the rubber ankle joint bumpers that were introduced in the 1996 revision, the IIHS test data has shown metal-to-metal contact can still occur. In order to address this problem, the SAE Hybrid III Task Force members agreed to redesign the ankle joint. As part of this revision, the Task Force also decided to improve the mechanical interface at the foot and lower tibia load cell attachment points, which could be another source of mechanical noise.

4.1.2 Tests Demonstrating Problem

IIHS identified the signal noise from foot accelerometer channels in high-speed frontal crash tests. Typical accelerations from the feet are shown in Figure 1.

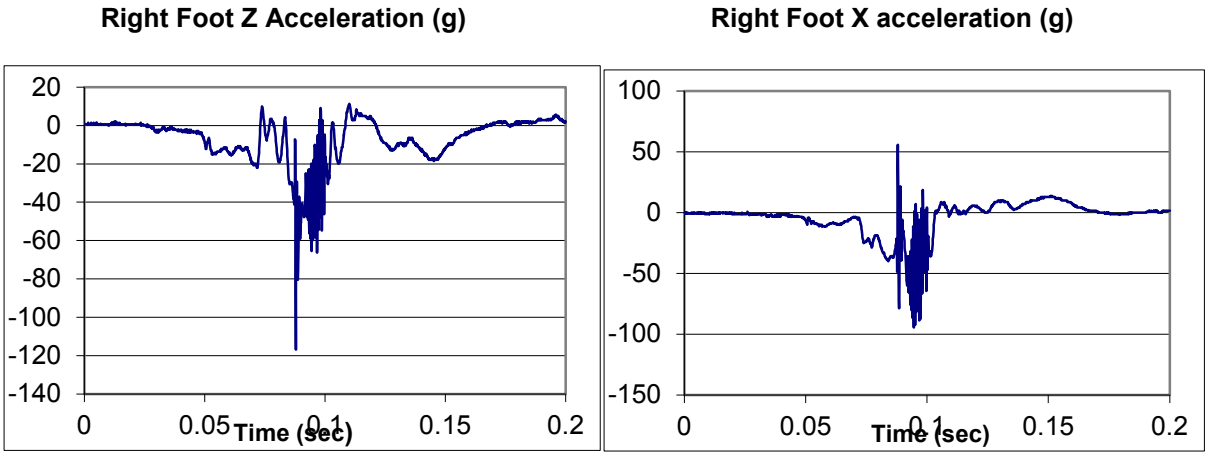

FIGURE 1 - FOOT ACCELERATIONS WITH THE ANKLE DESIGN IN 1996 NHTSA REGULATION (TEST CEF 0508)

4.2 Recommended Ankle Joint Update

4.2.1 Description of Solution

In order to prevent the metal-to-metal contact between the ball shaft and the ankle shell in the Hybrid III ankle joint, the ankle bumper metal insert and the ball retainer have been merged to allow some metal material space to be taken by rubber without changing the overall dimension of the assembly. This change eliminates metal-to-metal contact. A dowel pin/hole feature has been added to prevent the ankle bumper from being installed in the wrong orientation. Figure 2 shows the new design.

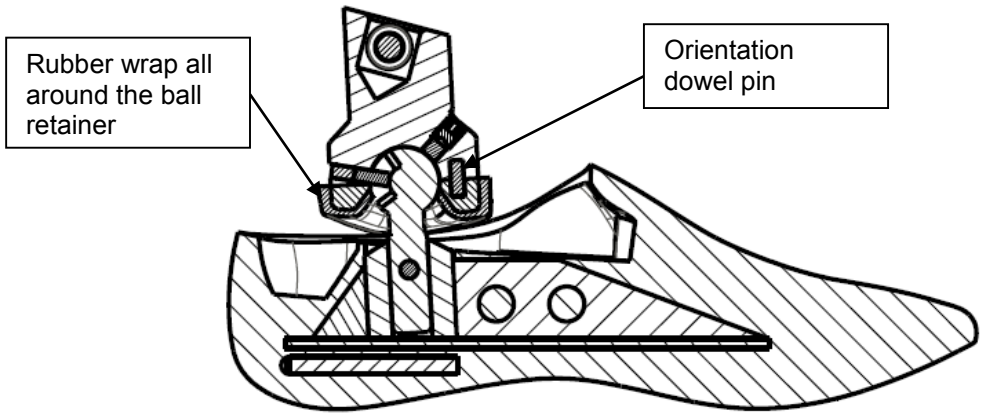

FIGURE 2 - DESIGN OF UPGRADED ANKLE JOINT

In addition to the modifications mentioned above, the ankle joint interface locations were improved to eliminate joint looseness, due to the machining tolerances specified for each part. The new design employs clamping nuts to reduce the slop, which eliminates any play at the two connection interfaces. Figure 3 shows the new ankle design with the clamping nut.

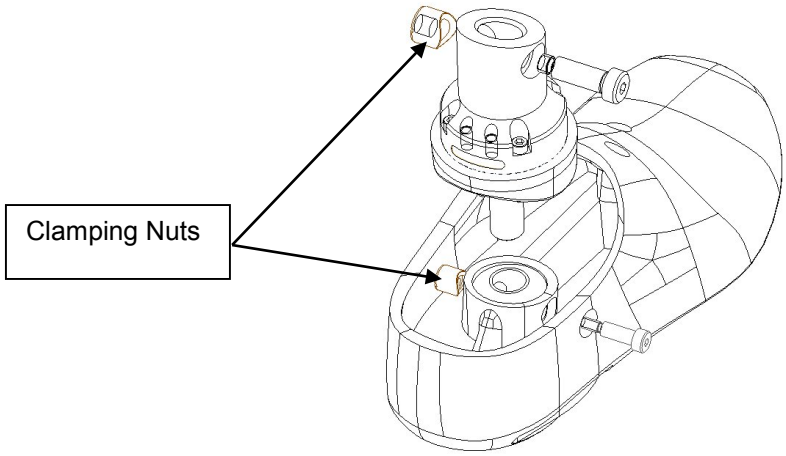

FIGURE 3 - DESIGN OF THE UPGRADED INTERFACES ABOVE AND BELOW THE ANKLE JOINT

Alignment marks were designed for the ankle shell and the shell of the foot bone to assist the alignment of the clamping nut to the shaft of the tibia bone or the ball shaft, see Figure 4. These alignment marks help to prevent potential damage to the half moon feature of the clamping nut due to the misalignment.

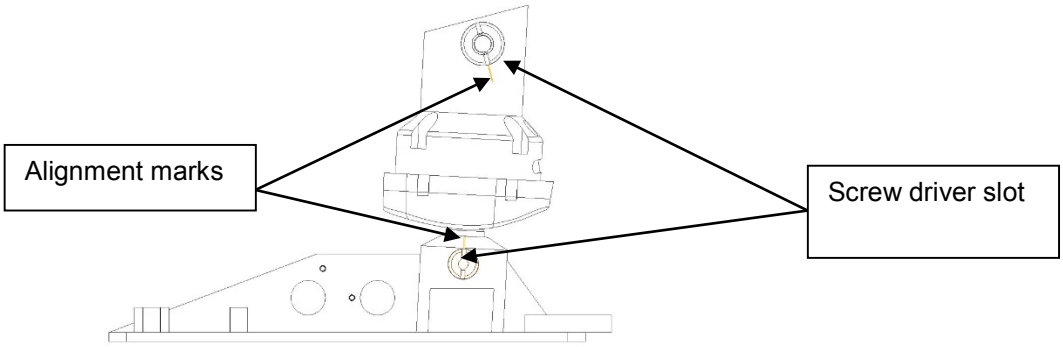

FIGURE 4 - ALIGNMENT MARKS FOR THE CLAMPING NUTS

4.2.2 Drawings

Drawings are provided to construct the upgraded ankle joint design.

4.2.2.1 To Make a New Ankle Bumper

To make a new ankle joint, the following updated drawings are required: 78051-640, -641, -642, -643, -644, -645, -646, -648, -649, -650, -651, -652, and -653.

4.2.2.2 To Upgrade a 1996 Regulation Ankle Joint

The whole ankle joint and foot requires replacement. The foot bone can be modified by adding the counter bore to allow the implementation of the clamping nut between the ankle ball shaft and the foot.

4.2.3 Tests Demonstrating Acceptability

4.2.3.1 Vehicle Testing

Vehicle crash tests were conducted by IIHS to verify if the new design is able to reduce or eliminate the signal noise issue as described in section 4.1.2. In each IIHS test an instrumented HIII 50M dummy was placed in the driver seating position. Figure 4 contains examples of the foot acceleration results using the new design in vehicle testing.

TABLE 1 - TEST MATRIX

Test ID	Ankle/Foot Design	Test Configuration	Vehicle Information	Accelerometer Signal Noise on Foot
CEF0508	Old	40 MPH, 40% frontal offset	2005 Chevy Uplander	Yes
CEF0507	Old	40 MPH, 40% frontal offset	2005 Ford Ranger	Minor noise
CF09004	New	30 MPH into 10 inch pole, 25% offset	2004 Chrysler Concorde	No
CF09005	New	35 MPH into 10 inch pole, 22% offset the pole	2005 Kia Rio	No
CF09006	New	40 MPH into 10 inch pole, 23% offset	2005 Kia Rio	No
CF09007	New	40 MPH into 10 inch pole, 24% offset	2004 Chrysler Concord	No

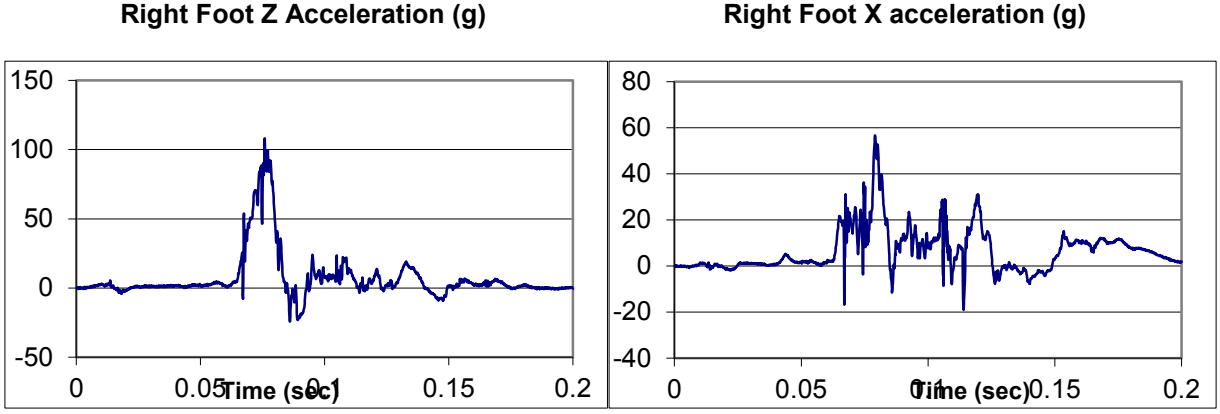

FIGURE 4 - FOOT ACCELERATIONS WITH THE NEW DESIGN (TEST CF09007)

4.2.3.2 Mass and Center of Gravity Verification

The center of gravity of the parts was measured and it meets the H-III50M specifications.

4.2.3.3 Pendulum Testing Comparing Original and Update Ankle Designs

Pendulum testing was also performed comparing the original and updated HIII50M ankles. An updated European Foot Impact was used to perform the tests. It was proven difficult to achieve a similar type of signal noise found in the IIHS vehicle testing. The conclusion of this study was that the ankles appeared to be similar in impacts to the ball of the foot in a component, pendulum type of testing. Figure 5 and 6 shows an example of the results.

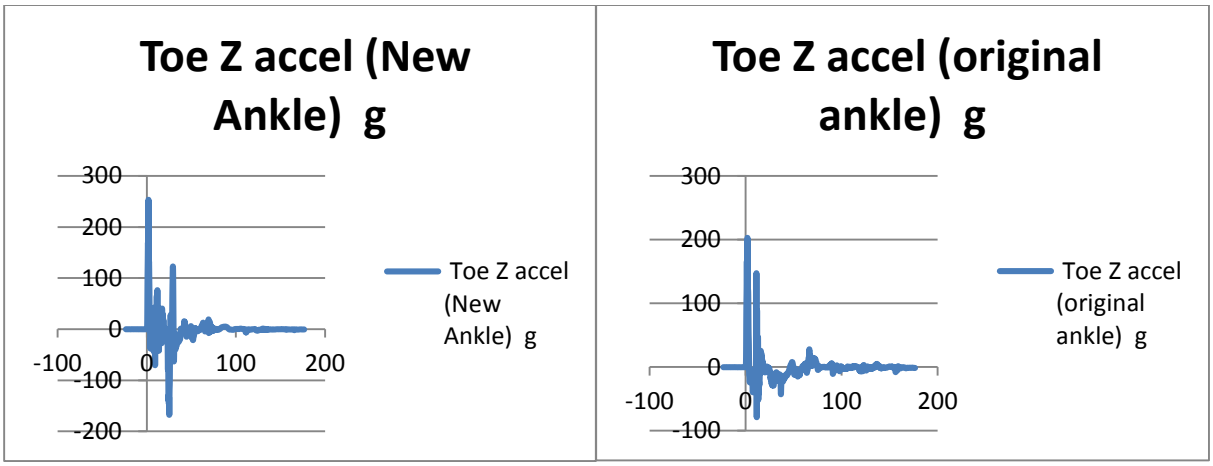

FIGURE 5 - EXAMPLES OF BALL OF FOOT PENDULUM IMPACTS

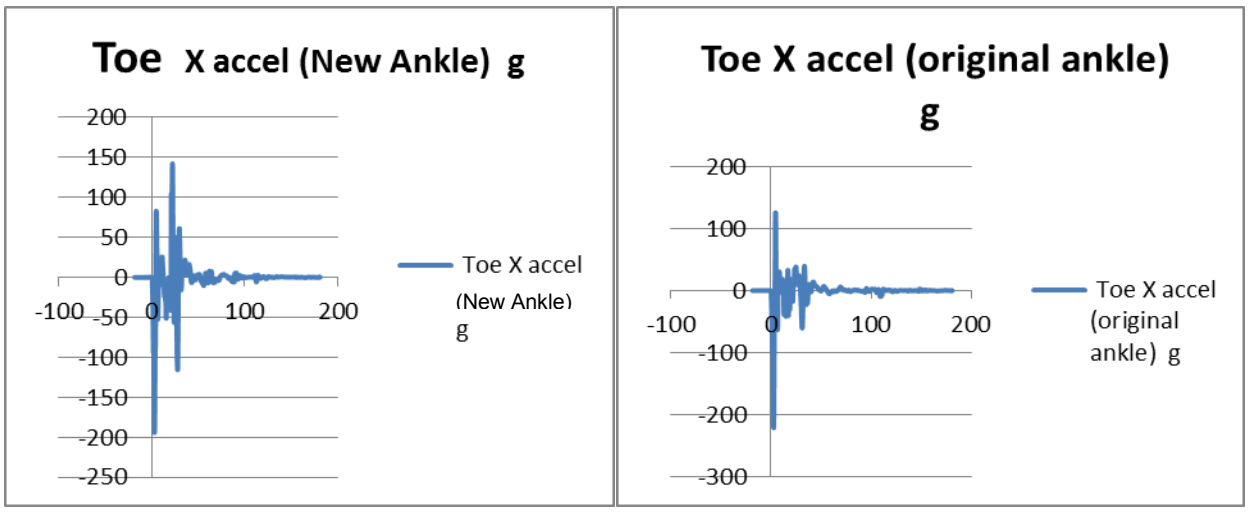

FIGURE 6 - EXAMPLES OF BALL OF FOOT PENDULUM IMPACTS

5. NOTES

5.1 Marginal Indicia

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PREPARED BY THE DUMMY TESTING AND EQUIPMENT COMMITTEE

APPENDIX A – DRAWINGS FOR DESIGN IN THIS STANDARD