SAE International™

SURFACE VEHICLE RECOMMENDED PRACTICE

SAE J2517 SEP2010

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Superseding J2517 SEP2006

Hybrid III Family Chest Potentiometer Calibration Procedure

RATIONALE

This current revision of this procedure adds additional calibration points for the Hybrid III dummies so extrapolation beyond the data points is not needed.

Updated Appendix A with a sample from H-III5F; Added reference to SAE J2570; Updated references for Engineering Aids to match the newly published J Documents; Added notes regarding the use of ball dimensions; Reworded the zero value setting range; Removed the sentence regarding inconsistent sequence of Xc values. Added additional Xc values to each of the dummies to eliminate the need for extrapolation; Added notes regarding the need to follow significant digits in calculations; Updated the committee name throughout document; Updated a few grammatical errors.

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1. SCOPE AND PURPOSE

This procedure establishes a recommended practice for establishing the sensitivity of the chest displacement potentiometer assembly used in the Hybrid III family of Anthropomorphic Test Devices (ATDs, or crash dummies). This potentiometer assembly is used in the Hybrid III family to measure the linear displacement of the sternum relative to the spine (referred to as chest compression). An inherent nonlinearity exists in this measurement because a rotary potentiometer is being used to measure a generally linear displacement. As the chest cavity is compressed the potentiometer rotates, however the relationship between the compression and the potentiometer rotation (and voltage output) is nonlinear.

Crash testing facilities have in the past used a variety of techniques to calibrate the chest potentiometer, that is to establish a sensitivity value (mm/ (volt/volt) or mm/ (mvolt/volt)). These sensitivity values are used to convert recorded voltage measurements to engineering units, in this case chest compression in mm. Some of these techniques intended to correct for the nonlinearity and others did not. Of those that did correct for the nonlinearity, there was a variation in techniques used. This variation in calibration procedures was in part identified by the SAE Dummy Testing Equipment Committee (DTEC), and led to overall variability in chest compression measurements between laboratories.

The intent of this recommended practice is to minimize the variations in chest deflection measurements between crash testing laboratories. Before this procedure was written, a round robin showed variations for the Small Female of 10% among 8 labs for the chest pot sensitivity value. A follow-up round robin of this procedure showed a worst case variation of 2.7% among 10 labs, with a standard deviation of 0.9%. The initial version of SAE J2517 released in May 2000 attempted to fix this problem by recommending a two-point calibration which was not intended to correct for the nonlinearity (which, for example, is as large as 3% for the Small Female but is small near the peak). It also did not require the measurement of a starting position of the potentiometer before each crash test, thus it did not correct for the difference in starting chest geometry between a subject dummy and its design intent. It was intended to be a simple and reproducible calibration procedure which crash test facilities could easily adopt with little or no modifications to their facilities. In practice, most laboratories did not adopt the procedure since it did not correct for the nonlinearities.

Recent attempts to reduce dummy-to-dummy and lab-to-lab variations at lower deflection levels (around 25 mm) have renewed interest in adopting a calibration procedure to correct for the nonlinearity of the measurement system. This current revision of this procedure uses a multipoint calibration with a third order regression to correct for the nonlinearities of the system with a standardized method. It requires changes in the calibration method of the transducer, the data collection procedures when used in a dummy, and the processing procedures after test data is collected. Following this standardized methodology will minimize linearity errors as well as lab-to-lab variations.

2. REFERENCES

2.1 Applicable Documents

2.1.1 SAE Publications

Available from SAE, 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 J211-1	Instrumentation for Impact Test—Part 1—Electronic Instrumentation
SAE J2570	Performance Specifications for Anthropomorphic Test Device Transducers
SAE J2706	Hybrid III Six-Year-Old Child Dummy User’s Manual
SAE J2856	User’s Manual for the 50th Percentile Male Hybrid III Test Dummy
SAE J2857	Hybrid III 3-Year-Old Child Dummy User’s Manual
SAE Engineering Aid 25	User’s Manual for the Small Adult Female Hybrid III Test Dummy
SAE Engineering Aid 26	User’s Manual for the Large Male Hybrid III Test Dummy

2.2 Related Publication

2.2.1 Federal Publication

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

Federal Safety Standards, Motor Vehicle Regulation No. 572, Test Dummies Specifications—Anthropomorphic Test Dummy for Applicable Test Procedures.

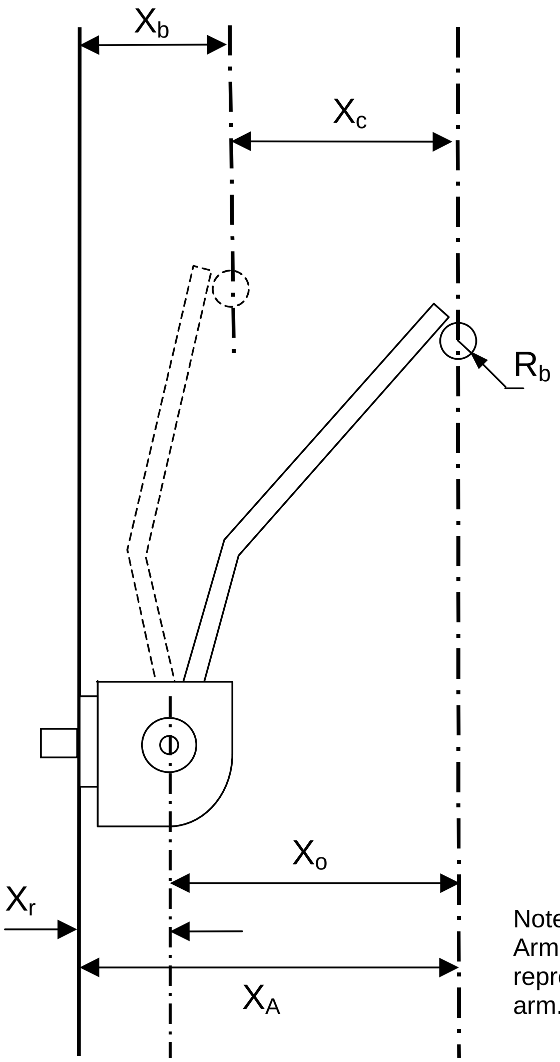
3. CALIBRATION PROCEDURE

3.1 Chest Potentiometer Assembly

The chest potentiometer assembly consists of the potentiometer, potentiometer bracket, arm connector and arm. These components will be treated as an assembly during the calibration process. The assembly should be removed from the dummy as described in SAE Documents J2856, J2706, J2857 and Engineering Aids 25 and 26. Next it should be placed in a fixture as described in 3.2, calibrated as described in 3.3, and replaced in the dummy. There should be no mechanical adjustments or disassembly of the potentiometer assembly once the calibration is completed. Any adjustments to the assembly would require re-calibration.

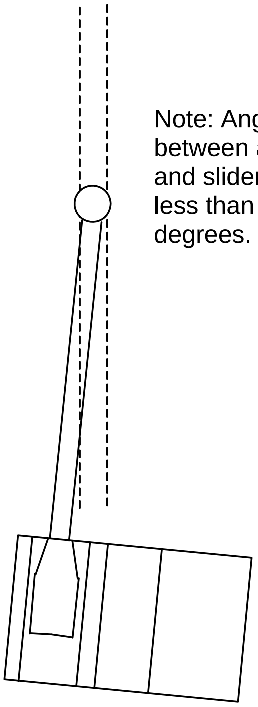
3.2 Calibration Fixture

The potentiometer assembly is placed in a calibration fixture that duplicates the nominal design position of arm, which is referenced as Xo in Figure 1. (This starting position represents the design position of the uncompressed chest.) The fixture should also be capable of stroking the arm relative to the potentiometer a distance of Xc as listed in Table 2. (This represents a position of the sternum when the chest is compressed.) The fixture does not need to be of a specific design, it simply needs to duplicate the position of the potentiometer at the points referenced in Table 2. As shown in Figure 2, the rotational position of the arm assembly about the longitudinal (fore–aft in dummy) axis is not critical. The potentiometer can either be installed in the fixture with the arm parallel to the slider track, or at a slight angle as installed in the dummy. (This angle between the slider track and arm should be less than 10 degrees, however.)



Note: Drawing not to scale.
Arm shape shown
represents adult dummy
arm.

FIGURE 1 - CALIBRATION FIXTURE
SIDE VIEW



Note: Angle
between arm
and slider track
less than 10
degrees.

FIGURE 2 - CALIBRATION FIXTURE
FRONT VIEW

NOTE: The dimensions given are to the center of the ball. If a fixture is used that goes to the edge of the ball, the ball radius Rb must be added to Xa to get the starting position.

TABLE 1 - CALIBRATION SETUP DIMENSIONS

Dummy Type	Initial Position, Xo, (mm)	Reference Dimension, Xa (mm)	Reference Dimension, Xb (mm)	Reference Dimension, Xr, (mm)	Ball Radius, Rb, (mm)
3 year old Hybrid III	40	50	15	10	3.2
6 year old Hybrid III	44	54	12	10	3.2
10 year old Hybrid III	62	72	26	10	3.2
Small female Hybrid III	67	81	27	14	4.8
50th percentile male Hybrid III	70	84	16	14	4.8
Large adult male Hybrid III	94	108	37	14	4.8

TABLE 2 - CALIBRATION POINTS

Dummy Type	Calibration Points, Xc, (mm)
3 year old Hybrid III	-6, -3, 0, 3, 6, 9, 12, 15, 18, 21, 24, 27, 30, 33, 36, 39
6 year old Hybrid III	-8, -4, 0, 4, 8, 12, 16, 20, 24, 28, 32, 36, 40, 44, 48
10 year old Hybrid III	-8, -4, 0, 4, 8, 12, 16, 20, 24, 28, 32, 36, 40, 42, 46, 50
Small Female Hybrid III	-10, -5, 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55,60
50th percentile male Hybrid III	-10, -5, 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75
Large adult male Hybrid III	-10, -5, 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80

3.3 Calibration Procedure

At the initial position, Xo, loosen the set screw locking the pot shaft to the arm coupling and adjust the pot so that the output reading is 0.0 V (±2.5 mV/V). Tighten the set screw to lock the pot shaft to the coupling, and recheck the Vo output level.

Set the fixture to each of the calibration points, Xc, shown in Table 2 within ±0.25 mm. Take a sensor output reading (S) at each of the Displacements (D) for the Xc calibration points listed in Table 2. Record the actual displacement values (D) in mm and the sensor output readings (S) in mV/V.

Complete a third order regression through the calibration data to relate the sensor output readings S (mV/V) to the displacement values D (mm) according to the following equation:

$$D = A*S^3 + B*S^2 + C*S + M \qquad \text{(Eq. 1)}$$

where:

D is the actual displacement in mm,
S is the sensor output reading in mV/V
A, B, C, and M are the calibration coefficients

From the regression analyses determine values for A, B, C, and M. These are the calibration coefficients that will be stored for the sensor and used to convert test data to engineering units. A sample of a calibration dataset is located in Appendix A of this procedure.

3.4 Use of the Calibration Coefficients

The potentiometer assembly should be re-installed in the dummy without any mechanical adjustment of the potentiometer. Prior to a crash test, the original zero offset level must be preserved by either not zeroing the potentiometer (by signal conditioning or post-processing) or the amount that was zeroed must be added during post-processing. During the test the absolute voltage output time history should be recorded. This voltage signal is then converted to engineering units by:

1. Convert voltage signal to mV/V at the sensor. This is the sensor reading S.

2. Convert the sensor reading S to displacement D by using the equation:

$$D = A*S^3 + B*S^2 + C*S + M \quad \text{(Eq. 2)}$$

where:

D is the displacement relative to the thorax design position in mm
S is the sensor output reading in mV/V
A, B, C, and M are the calibration coefficients

NOTE: Make sure to use sufficient significant digits on all coefficients to assure accuracy of the conversion to engineering units. It is recommended to use 5 significant digits (example 0.000012345).

3. Subtract the offset in the displacement D at time zero (To) from the displacement time history to get a zeroed deflection Dz. Dz is the deflection of the sternum relative to the spine box during the crash test.

4. NOTES

4.1 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 SAE CHEST POT CALIBRATION TASK GROUP
OF THE SAE DUMMY TESTING EQUIPMENT COMMITTEE
OF THE SAE HUMAN BIOMECHANICS AND SIMULATIONS STANDARDS STEERING COMMITTEE

APPENDIX A - SAMPLE HIII-5F CHEST POTENTIOMETER CALIBRATION VALUES

Calibration Points (Xc)	Measured Displacement D (mm)	Sensor Ouput Readings S (mV/V)	Actual Displacement (mm)	Error (mm)	Linearity (% F.S.)
-10	9.99	-21.594	10.02	-0.032	0.046
-5	4.99	-10.787	4.97	0.016	0.022
0	-0.01	-0.711	0.10	-0.111	0.158
5	-5.00	9.893	-5.20	0.197	0.281
10	-10.00	19.450	-10.11	0.113	0.162
15	-15.00	28.845	-15.07	0.074	0.106
20	-20.00	37.564	-19.79	-0.214	0.306
25	-25.02	46.616	-24.78	-0.236	0.337
30	-30.04	56.123	-30.15	0.107	0.152
35	-35.01	64.427	-34.92	-0.089	0.127
40	-40.00	73.342	-40.14	0.137	0.196
45	-45.00	81.599	-45.05	0.049	0.070
50	-50.01	89.887	-50.05	0.044	0.062
55	-55.03	98.088	-55.08	0.046	0.066
60	-60.02	105.896	-59.92	-0.100	0.143
				Max Non-Linearity	0.34

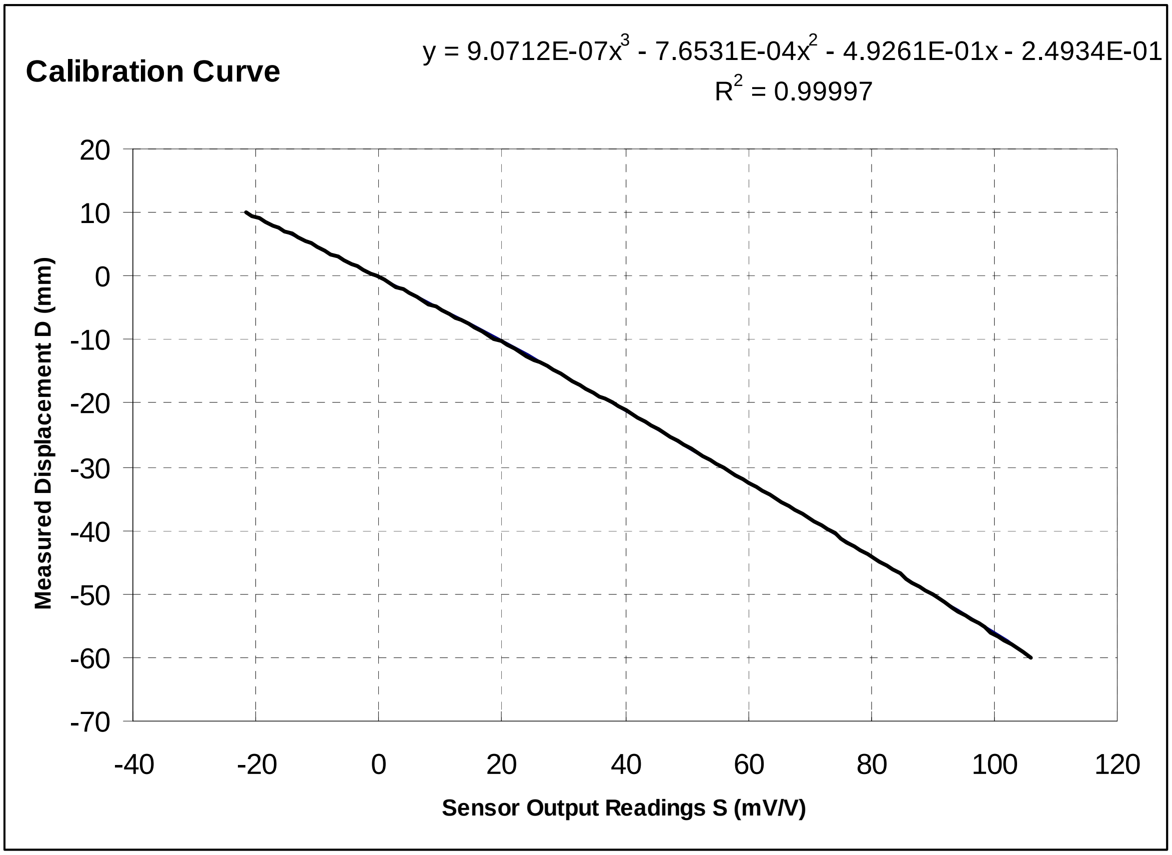


FIGURE A1 - CALIBRATION CURVE