The Engineering Society For Advancing Mobility Land Sea Air and Space®
INTERNATIONAL
400 Commonwealth Drive, Warrendale, PA 15096-0001

SURFACE VEHICLE STANDARD

SAE J2517

ISSUED JUN2000

Issued 2000-06

Submitted for recognition as an American National Standard

Hybrid III Family Chest Potentiometer Calibration Procedure

1. ***Scope***—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 non-linearity 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 non-linear.

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 non-linearity and others did not. Of those that did correct for the non-linearity, there was a variation in techniques used. This variation in calibration procedures was in part identified by the SAE Dummy Testing Equipment Subcommittee (DTES), and led to overall variability in chest compression measurements between laboratories.

The intent of this SAE 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 to test this procedure showed a worst case variation of 2.7% among 10 labs, with a standard deviation of 0.9%. The calibration procedure recommended here uses a two-point calibration and is not intended to correct for the non-linearity (which, for example, is as large as 3% for the Small Female but is small near the peak). It also does not require the measurement of a starting position of the potentiometer before each crash test, thus it does not correct for the difference in starting chest geometry between a subject dummy and its design intent. It is intended to be a simple and reproducible calibration procedure which crash test facilities can easily adopt with little or no modifications to their facilities. More complex procedures could in fact address the non-linearity, but at the likely cost of non-adoption by some facilities.

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2. *References*

2.1 Applicable Publications—The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest version of SAE publications shall apply.

2.1.1 SAE PUBLICATIONS—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001

SAE Engineering Aid 23—User's Manual for the 50th Percentile Male Hybrid III Test Dummy
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
SAE Engineering Aid 29—Hybrid III Six-Year-Old Child Dummy User's Manual
SAE Engineering Aid 31—Hybrid III 3-Year-Old Child Dummy User's Manual

2.2 Related Publications—The following publications are for information purposes only and are not a required part of this document.

2.2.1 SAE PUBLICATION—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001

SAE J211-1—Instrumentation for Impact Test—Part 1: Electronic Instrumentation

2.2.2 FEDERAL PUBLICATION—Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

FMVSS Part 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 Engineering Aids 23, 25, 26, 29, and 31. 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 1. (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 two points referenced in Table 1. 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.)

3.3 Calibration Procedure—A voltage reading, Vo, should be taken at the initial potentiometer position, Xo. Another reading, Vc, should be taken at the calibration point, Xc. The sensitivity (expressed in mm/(mvolt/volt)) of the potentiometer should be established as follows in Equation 1:

$$\text{Sensitivity} = Xc/((Vc - Vo)/\text{Vexcitation}) \qquad \text{(Eq. 1)}$$

Because laboratories may use different excitation values, the sensitivity values should be expressed as a function of the excitation value (thus it should be in the units mm/(mvolt/volt.))

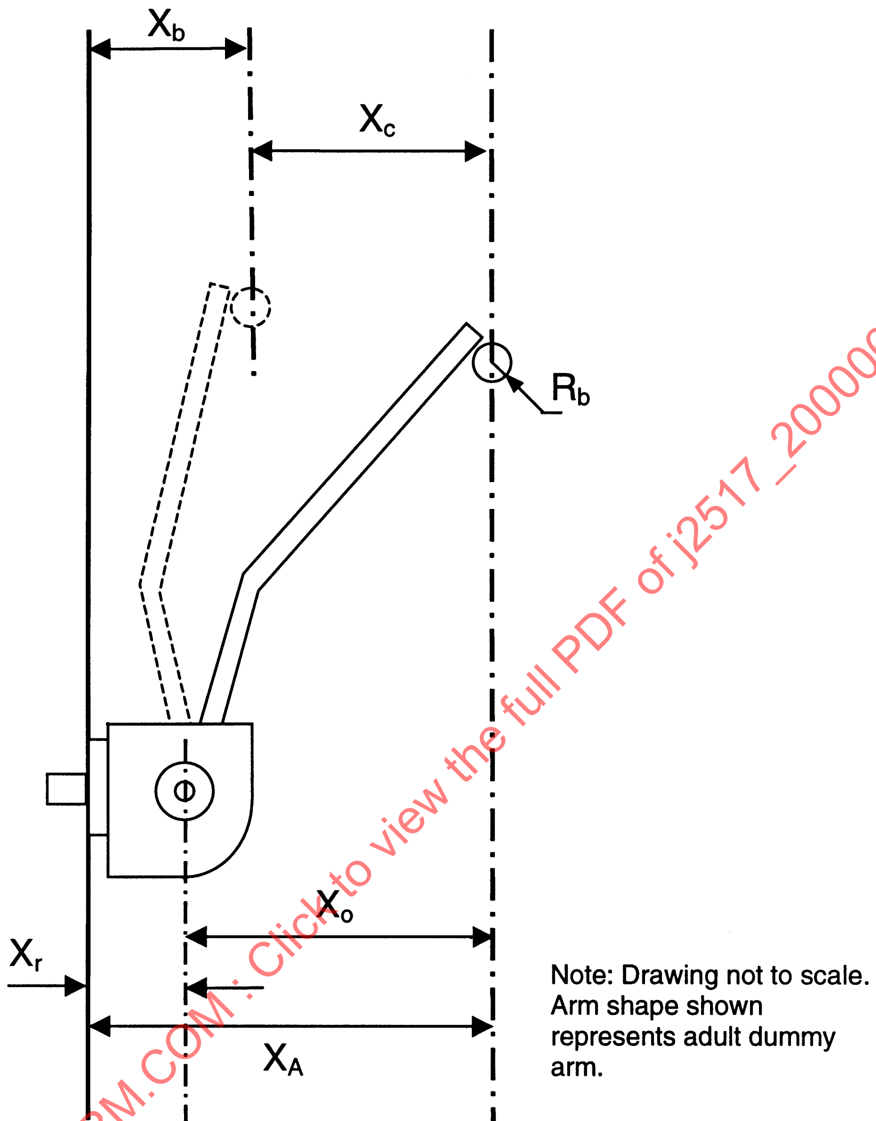

FIGURE 1—CALIBRATION FIXTURE—SIDE VIEW

TABLE 1—CALIBRATION DIMENSIONS

Dummy Type	Initial Position, Xo, (mm)	Calibration Point, Xc, (mm)	Reference Dimension, Xa (mm)	Reference Dimension Xb (mm)	Reference Dimension, Xr, (mm)	Ball Radius, Rb, (mm)
3 year old Hybrid III	40	35	50	15	10	3.2
6 year old Hybrid III	44	42	54	12	10	3.2
Small female Hybrid III	67	54	81	27	14	4.8
50th percentile male Hybrid III	70	68	84	16	14	4.8
Large adult male Hybrid III	94	71	108	37	14	4.8

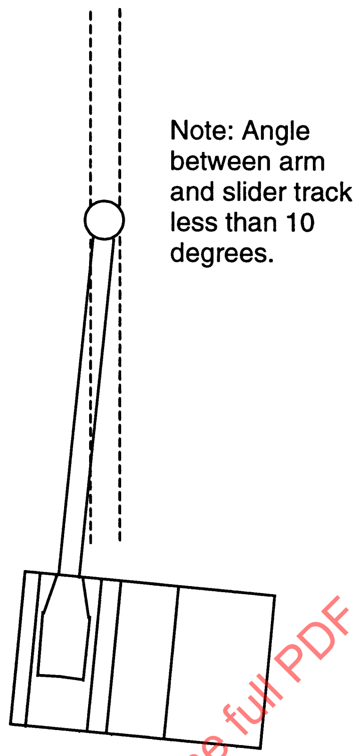

FIGURE 2—CALIBRATION FIXTURE—FRONT VIEW

3.4 Use of the Sensitivity Value—The potentiometer assembly should be re-installed in the dummy without any mechanical adjustment of the potentiometer. Prior to a crash test, the output from the potentiometer may be zeroed with either signal conditioning or post-processing to eliminate offsets. During the test, the voltage output time history should be recorded. This voltage signal is multiplied by the sensitivity value and then divided by the excitation voltage to calculate a time history of the chest compression. The effects of the non-linearity of the system will not be corrected using the procedure, however the error due to non-linearity should approach zero as the chest compression approaches the calibration distance, Xc.

4. Notes

4.1 Key Words—Chest compression, potentiometer, calibration, sensitivity, ATD, crash dummy.

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