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INTERNATIONAL
400 Commonwealth Drive, Warrendale, PA 15096-0001

SURFACE VEHICLE RECOMMENDED PRACTICE

An American National Standard

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(R) RECOMMENDED PRACTICE FOR ELECTRIC AND HYBRID ELECTRIC VEHICLE BATTERY SYSTEMS CRASH INTEGRITY TESTING

Foreword—This SAE Recommended Practice describes methods for evaluating Electric Vehicle (EV) performance when subjected to various FMVSS crash test procedures. It addresses battery retention, electrical isolation and electrolyte spillage. It is intended to provide Electric Vehicle designers with recommended tests and performance criteria relating to Electric and Hybrid Electric Vehicles. This document is the first of this type for Electric Vehicles and is based on limited test data. Accordingly, test personnel should exercise extreme caution when conducting the procedures described in this document. Each testing organization is encouraged, upon experience, to send comments and suggested revisions to these procedures. Please send comments or suggestions to: Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096-0001, attention: Electric Vehicle Safety Committee.

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1. ***Scope*****—**Electric and Hybrid Electric Vehicles contain many types of battery systems. Adequate barriers between occupants and battery systems are necessary to provide protection from potentially harmful factors and materials within the battery system that can cause injury to occupants of the vehicle during a crash. This SAE Recommended Practice is applicable to all Electric Vehicle and Hybrid Electric Vehicle battery designs, including those described in SAE J1797. The potentially harmful factors and materials addressed by this document include electrical isolation integrity, electrolyte spillage, and retention of the battery system.

1.1 **Purpose—**The purpose of this document is to define test methods and performance criteria which evaluate battery system spillage, battery retention, and electrical system isolation in Electric and Hybrid Electric Vehicles during specified crash tests.

1.2 **Field of Application—**The vehicles covered in this document are Electric and Hybrid Electric Vehicles with a gross vehicle weight of 4536 kg (10 000 lb) or less.

1.3 **Product Classification—**Not available.

1.4 **Form—**Not available.

2. ***References***

2.1 **Applicable Publications—**The following publications form a part of this specification to the extent specified herein. The latest issue of Federal Motor Vehicle Safety Standards or SAE publications shall apply.

Applicable FMVSS standards and regulations shall supersede any SAE Recommended Practices referenced in this document.

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

SAE J1715—Electric Vehicle Terminology
SAE J2344—Guidelines for Electric Vehicle Safety

2.1.2 FEDERAL MOTOR VEHICLE SAFETY STANDARDS—Code of Federal Regulations, Title 49, Part 400-499 which contains the current FMVSS regulations issued under Chapter V - National Highway Traffic Safety Administration—Available from Superintendent of Documents, Government Printing Office, Washington, DC 20408, Phone: 202-366-3238.

FMVSS Test Procedures

Available from Administration/Technical Reference Division, NHTSA, NAD-52. Phone: 202-366-4946

FMVSS 571.208 Standard No. 208—Occupant Crash Protection
FMVSS 571.214 Standard No. 214—Side Impact Protection
FMVSS 571.301 Standard No. 301—Fuel System Integrity

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

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

SAE TSB 001—SAE Technical Standards Board Rules and Regulations
SAE TSB 002—SAE Preparation of SAE Technical Reports
SAE TSB 003—Rules for the SAE Use of SI (Metric) Units
SAE J1115—Guidelines for Developing and Revising SAE Nomenclature and Definitions
SAE J1772— Electric Vehicle Conductive Coupling
SAE J1773— Electric Vehicle Inductive Coupling
SAE J1797— Packaging of Electric Vehicle Battery Modules
SAE J1798—Electric Vehicle Battery Performance
SAE Report—Format Guidelines for Electronic Capture of SAE Documents
SAE Committee Guidelines Manual

3. Definitions—The definitions provided in SAE J1715, shall apply to this document. The following definitions, which are not provided in SAE J1715, also apply:

3.1 Charging System—Means the device(s) and associated equipment necessary to properly recharge the traction battery in an Electric or Hybrid Electric Vehicle.

3.2 Battery System Components—Means the components comprising a traction battery system in an Electric or Hybrid Electric Vehicle. These include the battery modules, interconnects, venting systems, battery restraint devices, and battery box or container that holds the individual battery modules.

4. Technical Requirements

NOTE—During, before, and after functional Electric Vehicle crash testing, appropriate safety precautions must be taken to prevent possible injury to test personnel. Proper battery safety hazard training should be given to test personnel before testing.

4.1 Electric and Hybrid Electric Vehicle Testing Battery Preparation—The battery system in the test vehicle shall be in an operational configuration.

4.1.1 BATTERY COOLANT—For purposes of 4.4.1, battery coolant is not considered electrolyte. When necessary, a colorant, chemical analysis, or some other means may be used to distinguish between electrolyte and coolant spillage.

4.1.2 BATTERY STATE-OF-CHARGE—The battery system shall be fully charged prior to the crash test using the vehicle manufacturer's recommended charging procedures.

4.1.3 ENVIRONMENTAL PREPARATION—The environmental conditions shall be those specified in the relevant FMVSS test procedures.

4.2 Static Rollover Procedure—After each of the crash tests described in 4.3, the vehicle is statically rolled on a fixture according to the rollover procedure specified in FMVSS 571.301.

4.3 Crash Test Procedures—Electric and Hybrid Electric Vehicles shall meet the performance criteria established in 4.4 tested to the following crash procedures:

a. FMVSS 208 frontal impact (including the full frontal and 30 degree front angle impacts)
b. FMVSS 214 side impact
c. FMVSS 301 rear impact

4.4 Performance Criteria

4.4.1 ELECTROLYTE SPILLAGE

4.4.1.1 *Spillage Identification*—Before and after each of the test procedures in 4.2 and 4.3, the vehicle shall be inspected for electrolyte spillage. Verification of electrolyte may be determined by visual inspection, litmus paper testing, and/or chemical analysis of the fluid.

4.4.1.2 *Electrolyte Spillage Inside the Occupant Compartment*—No spillage of electrolyte is permitted into the occupant compartment when tested to the procedures specified in 4.2 and 4.3 of this document.

4.4.1.3 *Electrolyte Spillage Outside the Occupant Compartment*—When tested to any one of the crash tests specified in 4.3 and the subsequent vehicle rollover procedure specified in 4.2, the total electrolyte spillage from an Electric Vehicle or Hybrid Electric Vehicle shall not exceed 5.0 L. Total electrolyte spillage is determined from measurements taken from the time vehicle motion ceases after the crash test, during a 30-min period after vehicle motion ceases, and throughout the post-crash rollover test. This 5 L limit is intended to constrain electrolyte spillage only.

4.4.2 BATTERY RETENTION—Battery modules must stay restrained to the vehicle throughout the test procedures described in 4.2 and 4.3. Intrusion of battery system components into the occupant compartment is not permitted before, during, or after any of the crash and rollover tests.

4.4.3 ELECTRICAL ISOLATION—Electrical isolation between the traction battery system and vehicle conducting structure must be maintained at a minimum of 500 Ω/V (at the nominal traction voltage specified by the vehicle manufacturer) before and after each of the crash tests described in 4.3 and after the rollover test described in 4.2. For example, an Electric Vehicle having a nominal traction voltage of 300 V would be required to have a minimum of 150 000 Ω resistance between the battery system and the vehicle conducting structure. It is understood that during a crash, electrical isolation may be lost momentarily provided that it is subsequently restored. Appendix A describes a test procedure for determining electrical isolation. Vehicles, which by design have the traction batteries referenced to conducting portions of the vehicle structure, are excluded from the requirements of this section if the nominal traction voltage from both positive and negative terminals to conducting structure is less than hazardous voltage (as defined in SAE J2344).

PREPARED BY THE SAE ELECTRIC VEHICLE SAFETY COMMITTEE OF THE
SAE ELECTRIC VEHICLE STANDARDS FORUM COMMITTEE

APPENDIX A

MEASUREMENT OF ELECTRICAL ISOLATION

A.1 ***Introduction—***This Appendix describes a test procedure that may be used to determine electrical isolation between an Electric Vehicle traction battery system and the vehicle conducting structure. Paragraph 4.4.3 stipulates a minimum electrical isolation of 500 Ω/V. The following test procedure should be performed before and after each of the rollover and crash tests specified in 4.2 and 4.3 conducted to show adherence to performance criteria of 4.4.3.

A.2 ***Test Setup And Equipment—***The traction battery system shall be charged in accordance with 4.1.2 to provide a voltage at or above the nominal operating voltage, as defined by the vehicle manufacturer.

The traction battery system shall be connected to the vehicle propulsion system, and the vehicle ignition shall be in the 'on' (traction system energized) position.

The voltmeter used in this test shall measure DC values and have an internal resistance of at least 10 MΩ.

NOTE—Meter resistance is neglected in the calculation of Electrical Isolation in that which follows.

A.3 ***Test Procedure—***Measure and record the traction battery voltage (Vb) (see Figure A1). Before the vehicle crash test, Vb must be equal to or greater than the nominal operating voltage as defined by the vehicle manufacturer. It is anticipated that Vb after the vehicle crash will be approximately the same as Vb prior to the crash. After the crash, a Vb greater than zero is required in order to conduct the remainder of this procedure. If Vb after the crash is near zero, this indicates that a short/open across the traction battery has occurred, which precludes the remainder of this test procedure. A short across the traction battery may be conspicuous by virtue of arcing, fire, and/or component meltdown.

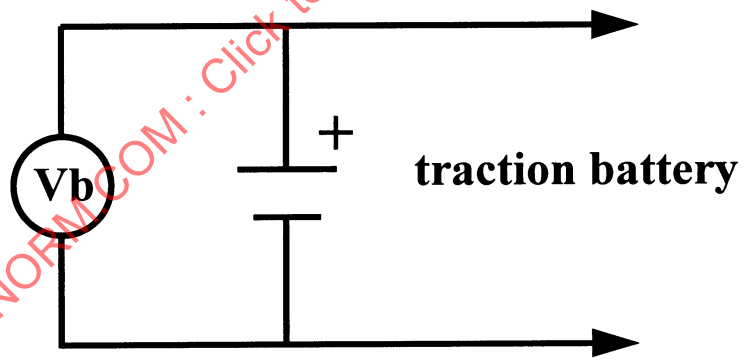

FIGURE A1—MEASUREMENT OF TRACTION BATTERY VOLTAGE

Measure and record the voltage (V1) between the negative side of the traction battery and the vehicle chassis (see Figure A2):

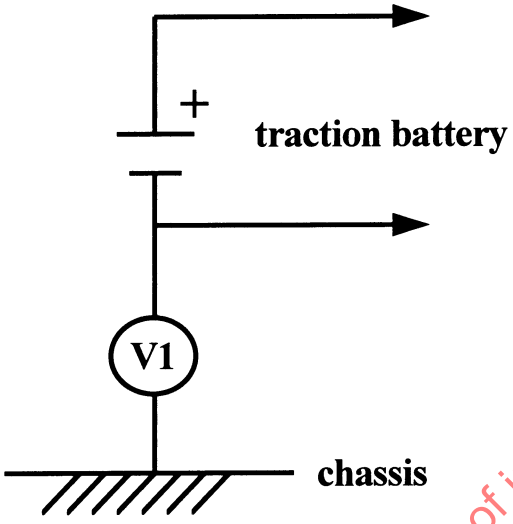

FIGURE A2—MEASURE OF THE VOLTAGE BETWEEN THE NEGATIVE SIDE OF THE TRACTION BATTERY AND THE VEHICLE CHASSIS

Measure and record the voltage (V2) between the positive side of the traction battery and the vehicle chassis (see Figure A3):

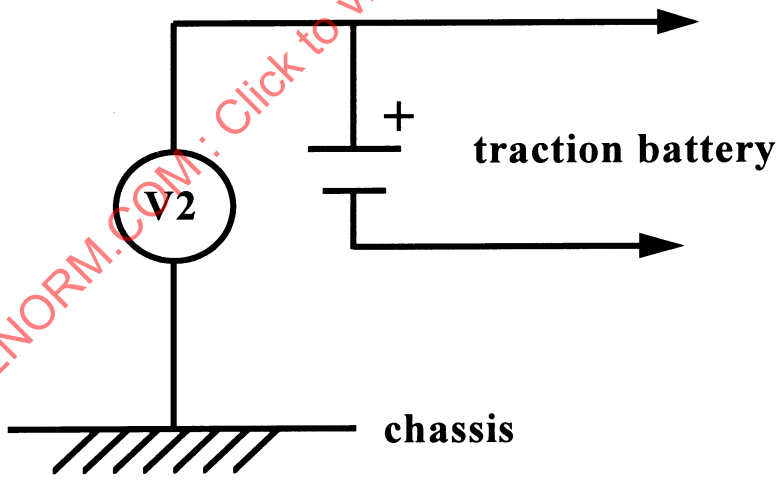

FIGURE A3—MEASURE OF THE VOLTAGE BETWEEN THE POSITIVE SIDE OF THE TRACTION BATTERY AND THE VEHICLE CHASSIS

NOTE—It is anticipated that the absolute value of V1 plus the absolute value of V2 will approximate the absolute value of Vb. If the sum of V1 and V2 is appreciably less than Vb, this indicates that the electrical isolation between the traction battery and the vehicle chassis is on the order of the internal resistance of the voltage meter (10 MΩ minimum), i.e., near perfect electrical isolation

If V1 is greater than or equal to V2, insert a standard known resistance (Ro) between the negative side of the traction battery and the vehicle chassis. With Ro installed, measure the voltage (V1') between the negative side of the traction battery and the vehicle chassis (see Figure A4). Calculate the electrical isolation (Ri) according to the formula shown. This electrical isolation value (in ohms) divided by the nominal operating voltage of the traction battery (in volts) must be equal to or greater than 500.

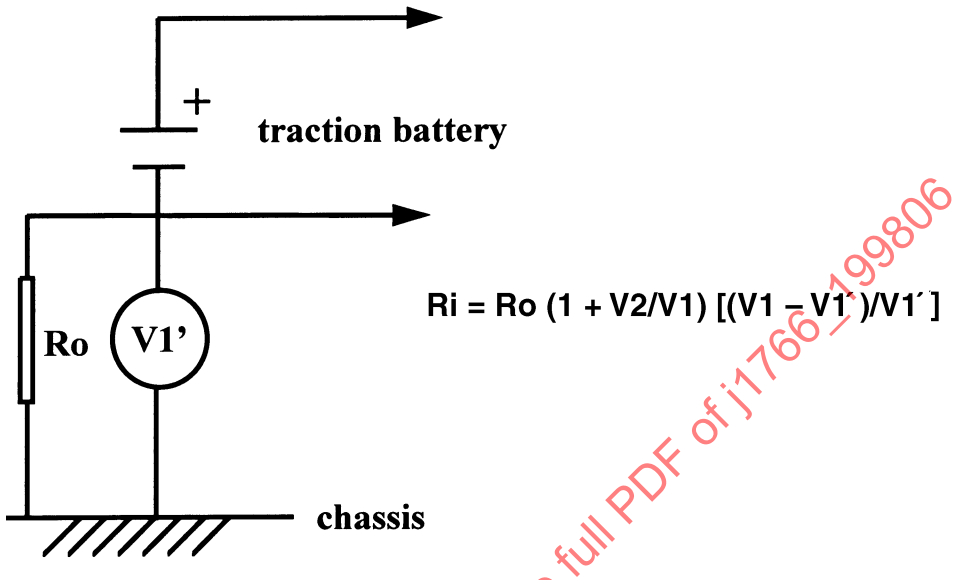

FIGURE A4—VOLTAGE ACROSS RESISTOR BETWEEN NEGATIVE SIDE OF TRACTION BATTERY AND VEHICLE CHASSIS

If V2 is greater than V1, insert a standard known resistance (Ro) between the positive side of the traction battery and the vehicle chassis. With Ro installed, measure the voltage (V2') between the positive side of the traction battery and the vehicle chassis. (See Figure A5.)

Calculate the electrical isolation (Ri) according to the formula shown. This electrical isolation value (in ohms) divided by the nominal operating voltage of the traction battery (in volts) must be equal to or greater than 500.