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NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION

LABORATORY TEST PROCEDURE

FOR

FMVSS 305, ELECTRIC POWERED VEHICLES: ELECTROLYTE SPILLAGE AND ELECTRICAL SHOCK PROTECTION

ENFORCEMENT
Office of Vehicle Safety Compliance
Room 6111, NVS-224
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REVISION CONTROL LOG
FOR OVSC LABORATORY
TEST PROCEDURES

TP-305
ELECTRIC POWERED VEHICLES: ELECTROLYTE SPILLAGE AND ELECTRICAL SHOCK PROTECTION

TEST PROCEDURE		FMVSS 305		DESCRIPTION
REV. No.	DATE	AMENDMENT	EFFECTIVE DATE	
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01				
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OVSC LABORATORY TEST PROCEDURE NO. 305
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1. PURPOSE AND APPLICATION OF LABORATORY TEST PROCEDURE

The Office of Vehicle Safety Compliance (OVSC) provides contractor laboratories with Laboratory Test Procedures as guidelines for obtaining compliance test data. The data are used to determine if a specific vehicle or item of motor vehicle equipment meets the minimum performance requirements of the subject Federal Motor Vehicle Safety Standard (FMVSS). The purpose of the OVSC Laboratory Test Procedures is to present a uniform testing and data recording format, and provide suggestions for the use of specific equipment and procedures. These Laboratory Test Procedures do not constitute an endorsement or recommendation for use of any product or method. If any contractor views any part of an OVSC Laboratory Test Procedure to be in conflict with a Federal Motor Vehicle Safety Standard or observes deficiencies in a Laboratory Test Procedure, the contractor is required to advise the Contracting Officer's Technical Representative (COTR) and resolve the discrepancy prior to the start of compliance testing.

The purpose of FMVSS 305, ELECTRIC POWERED VEHICLES: ELECTROLYTE SPILLAGE AND ELECTRICAL SHOCK PROTECTION is to reduce deaths and injuries during a crash which occur because of electrolyte spillage from propulsion batteries, intrusion of propulsion battery system components into the occupant compartment, and electrical shock. This laboratory test procedure will test for electrical isolation, electrolyte leakage, and propulsion battery system movement during a test series that includes a frontal, side, or rear barrier impact, followed by a static rollover sequence.

NOTE: The OVSC Laboratory Test Procedures, prepared for the limited purpose of use by independent laboratories under contract to conduct compliance tests for the OVSC, are not rules, regulations or NHTSA interpretations regarding the meaning of a FMVSS. The Laboratory Test Procedures are not intended to limit the requirements of the applicable FMVSS(s). In some cases, the OVSC Laboratory Test Procedures do not include all of the various FMVSS minimum performance requirements. Recognizing applicable test tolerances, the Laboratory Test Procedures may specify test conditions that are less severe than the minimum requirements of the standard. In addition, the Laboratory Test Procedures may be modified by the OVSC at any time without notice, and the COTR may direct or authorize contractors to deviate from these procedures, as long as the tests are performed in a manner consistent with the standard itself and within the scope of the contract. Laboratory Test Procedures may not be relied upon to create any right or benefit in any person. Therefore, compliance of a vehicle or item of motor vehicle equipment is not necessarily guaranteed if the manufacturer limits its certification tests to those described in the OVSC Laboratory Test Procedures.

2. GENERAL REQUIREMENTS

FMVSS No. 305 specifies performance requirements for limitation of electrolyte spillage, retention of propulsion batteries, and electrical isolation of the chassis from the high-voltage system during the crash event. This standard applies to vehicles that use electricity as propulsion power.

APPLICABILITY

The standard is applicable to passenger cars, and to multipurpose passenger vehicles, trucks and buses with a GVWR of 4536 kg or less, that use more than 48 nominal volts of electricity as propulsion power and whose speed, attainable in 1.6 km on a paved level surface, is more than 40 km/h.

STANDARD REQUIREMENTS

When tested to the procedures contained herein, each vehicle to which the standard applies:

- shall not spill more than 5.0 liters of electrolyte from propulsion batteries outside the passenger compartment, and no visible trace of electrolyte shall spill into the passenger compartment. Spillage is measured from the time the vehicle ceases motion after a barrier impact test until 30 minutes thereafter, and throughout any static rollover after a barrier impact test.

- shall not have any propulsion battery system component located inside the passenger compartment move from the location in which they are installed

- shall not have any propulsion battery system component located outside the passenger compartment enter the passenger compartment

- shall maintain an electrical isolation between the propulsion battery system and the vehicle electricity-conducting structure of not less than 500 ohms/volt

METRIC SYSTEM OF MEASUREMENT

As a general rule, use of the metric system of weights and measures is preferred. Performance parameters and test conditions in FMVSS are specified in metric units. In this Laboratory Test Procedure, metric values may be followed by English units only for reference (not necessarily equal). If test equipment is not available for direct measurement in metric units, the test laboratory shall calculate the exact metric equivalent by means of a conversion factor carried out to at least five significant digits before rounding consistent with the specified metric requirement. Metric units shall be used in the Final Test Reports.

REFERENCES

The following sections are provided to the test laboratory as part of the contract documentation:

- Test Vehicles
- Measurement and Test Equipment

- Deviation from OVSC Test Procedures
- Storage of test vehicles, items, parts, components, and equipment
- Security
- Deliverables/Milestones
- Quality Assurance Quality Control (QA/QC) Management Plan
- Test Instrumentation/Equipment Calibration Procedures
- Contractor's In-House Laboratory Test Procedures
- Test Schedule
- Monthly Status Reports
- Test Failure Reports
- Draft and Final Test Reports
- Vehicle Condition Report Form
- Contracting Officer’s Technical Representation (COTR)
- Government Furnished Property (GFP)
- Invalid Tests/Retests
- Security of GFP
- Disposition of GFP
- GFP Involved in Test Failure
- Interpretation of Test Procedures
- Confidentiality of Test Reports
- Specifications for High Speed Video
- Specifications for Photographs
- Static Rollover Procedure

APPLICABLE BARRIER TESTS

Vehicles will be tested to the requirements of FMVSS 305 in conjunction with testing to either FMVSS 208, 214 Dynamic, and/or FMVSS 301 (frontal or rear impact).

Table 1 indicates the governing barrier tests that are utilized when testing to this standard. The vehicle must be able to meet the requirements of this standard for any of the governing barrier tests.

TABLE 1

Type of Test	**Applicable FMVSS**	**Description**	**Requirement**
Frontal Rigid Barrier	208	Any single rigid barrier crash at any speed up to and including 48 km/h, in a line of travel perpendicular to the barrier face or at any angle between +/- 30 degrees from the line of travel perpendicular to the barrier face	305 S5.1, S5.2, and S5.3
Side Deformable Barrier	214Dynamic	Any single moving deformable barrier crash at any speed up to and including 54km/h, side impact (passenger car)	
Side Deformable Barrier	214Dynamic	Any single moving deformable barrier crash at any speed up to and including 54km/h, side impact (MPV, truck, or bus)	
Rear Rigid Barrier	301	Any single moving rigid barrier crash at any speed up to and including 48km/hr, rear impact (passenger car, MPV, truck, or bus under 8500lb GVWR, or 5500lb UVW)	
Rear Deformable Barrier	301 (Optional)	Any single moving deformable barrier crash at any speed up to and including 80km/hr, rear impact with 70% overlap toward either side of the vehicle (passenger car, MPV, truck, or bus under 8500lb GVWR, or 5500lb UVW)	

FINAL TEST REPORT

All FMVSS 305 test data required by this test procedure shall be incorporated within the final test report of the governing barrier test.

3. TEST FACILITY

The test facility must be adequate to conduct the governing barrier tests prescribed in FMVSS 208, 214D, and 301(front and rear). The facility must meet the minimum requirements regarding weighing capability, speed measurement systems, test surface, tow road, abort system, barriers, and all other requirements.

4. RECOMMENDED TEST EQUIPMENT

4.1 Electrical Isolation Measurement

A. Voltage Measurement Device and Interface

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

Voltage measurements throughout this test must be made quickly and safely. To ensure these requirements are met, the testing lab must devise, for COTR approval, a test interface port or other device to facilitate these voltage measurements. All voltage measurements shall be immediate upon connection to the interface port. This test interface port equipment shall be easily accessible from the exterior of the vehicle and connected to the appropriate propulsion system and battery components via laboratory installed wires. The external mounting of this test interface port shall be configured such that no movement, interference, or damage will result to it from a barrier crash test. The test interface port shall incorporate a fusible link and any other necessary safety device or usage procedure to protect the data measurement and recording equipment from damage, and the test technicians from electrical shock.

A terminal block or circuitboard is recommended as a means to providing an external interface.

The following is an example quoted from Transport Canada document, “Test Procedures, Frontal Impact 208-212-301F-305F, No. 03-002”

“This kit is composed of a PVC box compliant with the electrical code and containing insulated banana connectors that allow the measuring equipment to be connected for the verification of the standard. A warning light indicates the presence of voltage inside the box. A shielded cable with three conductors, 20 feet in length and capable of supporting 600 volts, connects the box to the vehicle’s electrical system. This cable is covered with orange-coloured mechanical protection (similar to the Hybrid vehicle high-voltage identification code). The box is protected by a 0.5-amp fuse.”

4.2 STATIC ROLLOVER AND ELECTROLYTE COLLECTION

B. STATIC ROLLOVER MACHINE

The rollover machine must be capable of rotating, and holding in place, the barrier impacted test vehicle up to 5443 kg about its longitudinal axis with the axis kept horizontal, to each successive increment of 90^o, 180^o, and 270^o at a uniform rate, with 90^o of rotation taking place in any time interval from 1 to 3 minutes. Leakage will be collected for the 5-minute period from the beginning of rotation plus any additional 1-minute collection periods that are required. Voltage measurements shall be able to be made continuously throughout the rollover test.

C. STODDARD AND ELECTROLYTE COLLECTION CONTAINERS

Containers for the collection of Stoddard solvent and propulsion battery electrolyte and a stopwatch for timing the fluid collection intervals are required. Containers for each fluid collected must be labeled before they are photographed. For containers containing both Stoddard and electrolyte, the fluids should be allowed to separate by specific gravity then measured and photographed.

4.3 OTHER INSTRUMENTATION

The Contractor shall provide the necessary equipment to permanently record and display data. The data shall be included in the final test report and on the electronic data media.

5. DUMMY REQUIREMENTS

As required by the governing barrier test procedure. No dummy instrumentation is necessary unless required by additional contract obligations.

6. DEFINITIONS

A. *Propulsion Battery System Component*

Any part of a propulsion battery module, interconnect, venting system, battery restraint device, and battery box or container that holds the individual battery modules used for propulsion.

B. *Dummy*

A 50th percentile male test dummy as specified for use in 208, 214D, and/or 301.

C. *Governing Barrier Test Procedure*

The OVSC Test Procedures for FMVSS No. 208, 214D or 301 per Table 1. Each of these is available on the agency website: www.NHTSA.dot.gov

D. *Electrolyte Spillage*

The fall, flow, or run of propulsion battery electrolyte in, on, or from the vehicle, including wetness resulting from capillary action.

E. *Gross Vehicle Weight Rating or GVWR*

The value specified by the manufacturer as the loaded weight of a single vehicle. (571.3)

F. *Longitudinal or Longitudinally*

Parallel to the longitudinal centerline of the vehicle. (571.3)

G. *Outboard Designated Seating Position*

A designated seating position where a longitudinal vertical plane tangent to the outboard side of the seat cushion is less than 12 inches from the innermost point on the inside surface of the vehicle at a height between the design H-point and the shoulder reference point (as shown in fig. 1 of Federal Motor Vehicle Safety Standard No. 210) and longitudinally between the front and rear edges of the seat cushion. (571.3)

H. *Rated Cargo and Luggage Capacity Weight (RCLW)*

RCLW = vehicle capacity weight – (68 kg x designated seating capacity).
Maximum RCLW used in testing a truck, MPV, or bus is 136 kg.
RCLW for school buses will follow the calculation contained within the governing barrier test procedure.

I. *Telltale*

A display that indicates the actuation of a device, a correct or defective functioning or condition, or a failure to function. (571.101, S4)

J. *Unloaded Vehicle Weight (UVW)*

The weight of a vehicle with maximum capacity of all fluids necessary for operation of the vehicle, but without cargo, occupants, or accessories that are ordinarily removed from the vehicle when they are not in use. (571.3)

K. *Vehicle Capacity Weight (VCW)*

The rated cargo and luggage load plus 68 kilograms times the vehicle's designated seating capacity (571.110, S3).
VCW for school buses will follow the calculation contained within the governing barrier test procedure.

7. IMAGING DOCUMENTATION

7.1 CAMERA COVERAGE

1. High-speed photographic coverage:

   All High-speed photographic coverage required by the governing barrier test procedure may be included in this test.

2. Real-time photographic coverage:

   The contractor shall use a "real time" color digital and/or color motion picture camera with at least 24 frames per second (fps) to record the condition of the passenger compartment interior area of the vehicle, and locations of propulsion battery components, pre- and post-test. All Real-time photographic coverage required by the governing barrier test procedure shall be included in the final film submission.

7.2 PHOTOGRAPHIC COVERAGE OF PROPULSION BATTERY AND ELECTROLYTE SPILLAGE.

A real-time camera (24 fps) shall be used to record any propulsion battery electrolyte spillage from, or into the interior compartment of, the test vehicle after the impact event or during the static rollover test.

7.3 STILL PHOTOGRAPHS

Provide color digital still photographs of pretest and post-test condition of entire vehicle deformation and details that pertain to the tested standards. Photographs of all areas of the test vehicle that may be of importance to the governing barrier test, or FMVSS 305 test, should be taken in excess and included in the test report only if the need arises.

The following still photographic documentation shall be recorded and included in the final test report:

A. Propulsion battery module(s)

B. High voltage interconnect(s)

C. Propulsion battery venting system(s)

D. Battery box(s) or container(s) which holds the individual battery modules

E. Other visible electrical propulsion components.

F. Pretest view of the propulsion battery, if any part of it is visible. Do NOT disassemble any parts other than carpet, seats, and other interior pieces to take these photographs.

G. Pretest and post-test view of the electric propulsion drive. Take the best photographs possible without removing any parts. Use mirrors to view any hidden components where possible.

H. Pretest view of the installed Test Interface Port and other test devices.

I. Post-test propulsion battery electrolyte spillage location view, when leakage occurs.

J. Post-test indication of battery module movement, or retention loss. Apply paint or other highly visible finish, such as machinist blue, to all attachment fasteners or means (welds), pretest, to indicate component movement or retention loss.

K. Post-test battery component intrusion, when intrusion occurs. Disassembly and removal of parts may be necessary to take these photographs. Do Not Disassemble Without OVSC representative present.

L. Post-test views of test vehicle while vehicle is on static rollover machine at 90°, 180°, 270°, and 360°, highlighting propulsion battery location.

M. Photographs of propulsion battery system mounting and/or intrusion failures.

N. Pretest and post-test of the vehicle passenger compartment to show any vehicle areas at which intrusion/spillage may occur.

O. Post-test view of the propulsion battery box(s) or container(s) that hold the individual battery modules. Disassembly and removal of parts may be necessary to take these photographs. Do Not Disassemble Without OVSC Representative present.

P. Photographs of all labels on the vehicle related to the electrical propulsion system.

Q. Other photographs requested by COTR.

8. COMPLIANCE TEST PREPARATION

8.1 DATA COLLECTION SET-UP

1. Remove the key from the keylock and insure the vehicle is not powered.

2. Remove barriers to access the propulsion battery module (e.g. seat backs, carpet, covers).

3. Wear high-voltage protection gloves, nonconductive shoes, eye protection and any other safety equipment deemed necessary to safely prepare the vehicle and conduct the test.

4. Set the propulsion battery module switch, service plug, or otherwise to the "OFF" or de-powered, position (See examples below). Follow any Manufacturer instructions provided by the COTR.

5. Wait 5 Minutes.

6. Remove propulsion battery module service cover, or cover that closes the battery compartment.

7. Measure the voltage across the propulsion battery at the appropriate terminals, and verify 0 volts.

8. Measure the voltage between the positive terminal of the propulsion battery and the vehicle body, and verify 0 volts.

9. Measure the voltage between the negative terminal of the propulsion battery and the vehicle body, and verify 0 volts.

10. If any voltage measurements differ from 0 volts, **STOP**, quarantine vehicle, document incident and contact the COTR.

11. Attach test leads from the propulsion battery, propulsion system, automatic propulsion battery disconnect, ground points, and any other points necessary on the vehicle such that immediate retrieval of data is possible after an impact event and at all times during the static rollover test.

NOTE: IF VEHICLE IS EQUIPPED WITH AN AUTOMATIC DISCONNECT PHYSICALLY CONTAINED WITHIN THE BATTERY PACK SYSTEM, ALL VOLTAGE MEASUREMENTS **AFTER IMPACT** WILL BE TAKEN FROM THE TRACTION SIDE OF THE AUTOMATIC DISCONNECT TO THE VEHICLE CHASSIS.

IF THE VEHICLE UTILIZES AN AUTOMATIC DISCONNECT THAT IS NOT PHYSICALLY CONTAINED WITHIN THE BATTERY PACK SYSTEM, ALL POST-IMPACT VOLTAGE MEASUREMENTS ARE TO BE MADE FROM THE BATTERY SIDE OF THE AUTOMATIC DISCONNECT. AUTOMATIC DISCONNECT PRESENCE, LOCATION, AND SET-UP INSTRUCTION ARE VEHICLE SPECIFIC AND IS AVAILABLE FROM THE COTR.

12. Re-Install the propulsion battery module service cover, or otherwise close the battery compartment. Take great care to preserve the integrity of the connection wiring and propulsion battery holddowns.

8.2 TEST VEHICLE PREPARATION

1. Apply paint or other highly visible finish, such as machinist blue, to all *battery system component* attachment fasteners or attachment means (e.g., welds), to indicate component movement or separation, post-test.

2. If the vehicle is equipped with a liquid cooling system, assure that the coolant is a different color than the Stoddard solvent in use.

3. Reset the propulsion battery module switch, service plug, or otherwise to the "ON", or powered, position. Verify proper function of propulsion system.

4. Charge the propulsion battery system to:

    A. The maximum state of charge recommended by the manufacturer, as stated in the vehicles owner's manual or on a label that is permanently affixed to the vehicle;

    OR

    B. If the manufacturer has made no recommendation, at a state of charge of not less than 95 percent of the maximum capacity of the battery system. Maximum capacity can be verified by consulting the COTR.

    OR

    C. If the batteries are rechargeable only by an energy source on the vehicle, operate the vehicle such that the maximum practicable state of charge within the normal operating range, as specified by the manufacturer, is reached as indicated by the vehicle's instrumentation. Discuss with COTR.

5. Complete Data Sheet 1—Test Vehicle Specifications and Data Sheet 2– Pre-test Data.

6. Prepare the test vehicle per the test procedure of the applicable governing barrier test (e.g. FMVSS 208).

7. Document and photograph test vehicle per the FMVSS 305 test procedure, and record in Data Sheet 6.

8.3 ELECTRICAL ISOLATION BASELINE MEASUREMENT

NOTE: The following measurements are to be made immediately prior to barrier impact test, and should be completed within 15 minutes.

1. Check that the battery system is connected to the vehicle's propulsion system, and the vehicle is in the "ready-to-drive" (propulsion motor(s) activated) position. Start Data Sheet 3 – Pre-Impact Electrical Isolation Measurements & Calculations.

2. Measure the voltage of the propulsion battery as shown in Figure 1 below. Before any vehicle impact test, verify that V_b is equal to or greater than the nominal operating voltage as specified by the vehicle manufacturer, or as supplied by the COTR. If V_b is not equal to or greater than the nominal operating voltage as specified by the vehicle manufacturer, or as supplied by the COTR, repeat the propulsion battery charging step of Test Vehicle Preparation and promptly call COTR for guidance. The voltmeter used in this test measures direct current values and has an internal impedance of at least 10MΩ. Record the voltage measurement as V_b in Data Sheet 3. Make certain all voltages are DC. If there is AC voltage on the traction side connection, consult the COTR for additional guidance.

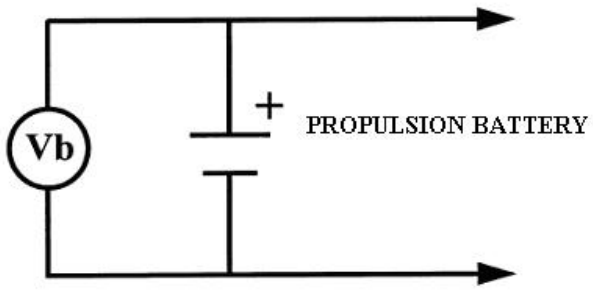

FIGURE 1

3. Measure the voltage (V_1) from the negative side of the propulsion battery to the vehicle chassis point(s) as shown in Figure 2 below. Record the voltage measurement as V_1, in Data Sheet 3.

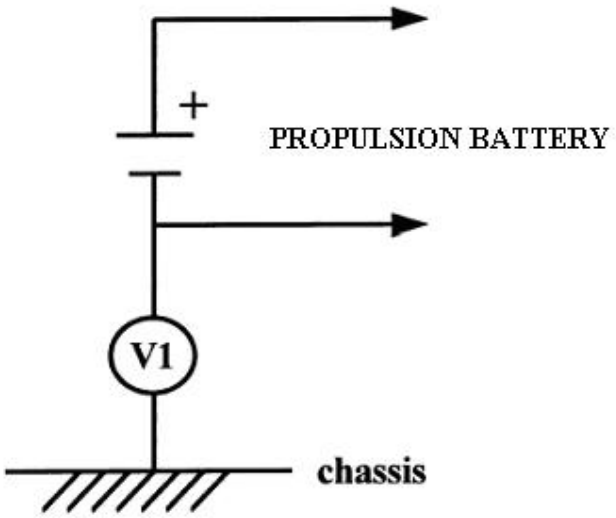

FIGURE 2

4. Measure the voltage (V_2) from the positive side of the propulsion battery to the vehicle chassis point(s) as shown in Figure 3 below. Record the voltage measurement as V_2, in Data Sheet 3.

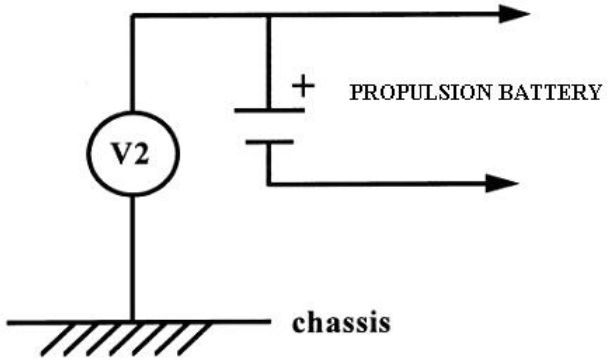

FIGURE 3

5. Insert a resistor ($\mathbf{R_o}$) of a known resistance (in ohms) approximately 500 times the nominal operating voltage of the vehicle (in volts) per SAE J1766, between the negative side of the propulsion battery and the vehicle chassis. With $\mathbf{R_o}$ installed, measure and record the voltage (V_1') as shown in Figure 4 between the negative side of the propulsion battery and the vehicle chassis point(s). Calculate the electrical isolation value (in ohms) as shown in Figure 4 below. Record electrical isolation value as $\mathbf{R_{i1}}$ in Data Sheet 3.

NOTE--R_o is not required to be precisely this value since the equations are valid for any R_o; however, an R_o value in this range should provide good resolution for the voltage measurements.[1]

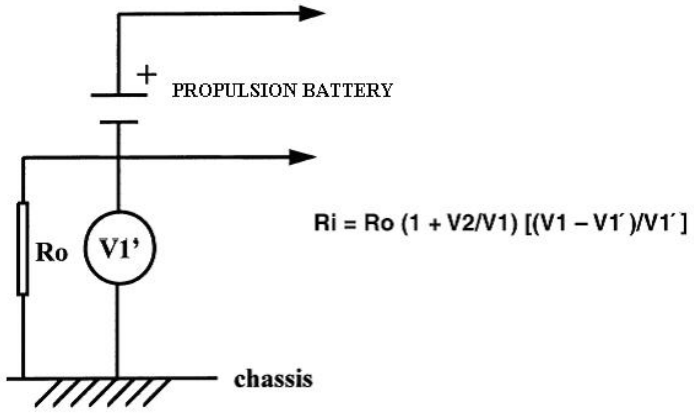

FIGURE 4

[1] SAE J1766-Rev. June 1998- RECOMMENDED PRACTICE FOR ELECTRIC AND HYBRID ELECTRIC VEHICLE BATTERY SYSTEMS CRASH INTEGRITY TESTING

6. With $\mathbf{R_o}$ installed, measure and record the voltage (V_2') as shown in Figure 5 between the positive side of the propulsion battery and the vehicle chassis point(s). Calculate the electrical isolation value (in ohms) as shown in Figure 5 below. Record electrical isolation value as $\mathbf{R_{i2}}$ in Data Sheet 3.

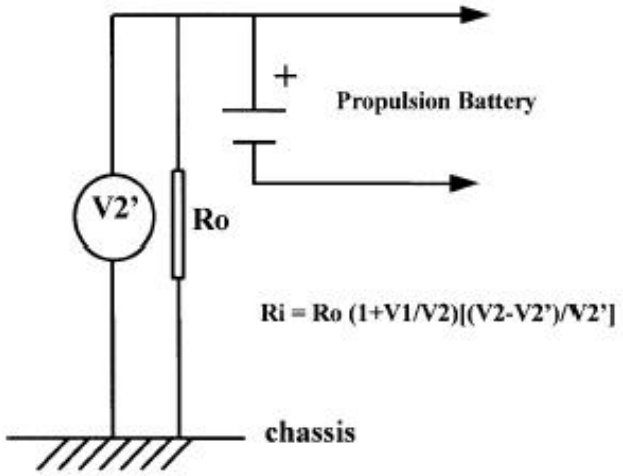

Figure 5

NOTE: Exact location of measurement will vary depending on the location of the disconnect(s) for the system.

7. If $\mathbf{R_{i1}}$ is less than $\mathbf{R_{i2}}$ then, divide $\mathbf{R_{i1}}$ by the nominal operating voltage of the propulsion battery (V_b) shown in Figure 4. Record this value as $\mathbf{R_i}$ / V_b, in Data Sheet 3. This value must be equal to or greater than 500. If this value is less than 500, a test failure has occurred.

8. If $\mathbf{R_{i2}}$ is less than $\mathbf{R_{i1}}$ then, divide $\mathbf{R_{i2}}$ by the nominal operating voltage of the propulsion battery (V_b) shown in Figure 4. Record this value as $\mathbf{R_i}$ / V_b, in Data Sheet 3. This value must be equal to or greater than 500. If this value is less than 500, a test failure has occurred.

9. Recheck that the battery system is connected to the vehicle's propulsion system, and the vehicle in the "ready-to-drive" (propulsion motor(s) activated) position.

10. Verify that the parking brake and transmission are set in accordance with the governing barrier test procedure.

9. COMPLIANCE TEST EXECUTION

9.1 GOVERNING BARRIER TEST

NOTE: IF VEHICLE IS EQUIPPED WITH AN AUTOMATIC DISCONNECT PHYSICALLY CONTAINED WITHIN THE BATTERY PACK SYSTEM, ALL VOLTAGE MEASUREMENTS **AFTER IMPACT** WILL BE TAKEN FROM THE TRACTION SIDE OF THE AUTOMATIC DISCONNECT TO THE VEHICLE CHASSIS.

IF THE VEHICLE UTILIZES AN AUTOMATIC DISCONNECT THAT IS NOT PHYSICALLY CONTAINED WITHIN THE BATTERY PACK SYSTEM, ALL POST-IMPACT VOLTAGE MEASUREMENTS ARE TO BE MADE FROM THE BATTERY SIDE OF THE AUTOMATIC DISCONNECT. AUTOMATIC DISCONNECT PRESENCE, LOCATION, AND SET-UP INSTRUCTION ARE VEHICLE SPECIFIC AND MUST BE OBTAINED FROM THE COTR.

1. Perform applicable governing barrier test (e.g. FMVSS 208).

9.2 ELECTRICAL ISOLATION COMPLIANCE MEASUREMENT

NOTE: All voltage measurements shall be recorded immediately after the barrier impact test, and at the start of each increment of 90º, 180º, 270º, and 360º of the FMVSS 301 static rollover test.

1. Immediately following the barrier impact test, measure V_1, V_2, V_1', and V_2' voltages per Figures 2-5 with $\mathbf{R_o}$ installed and record the values in Data Sheet 4, Post-Impact Data.

2. Calculate the electrical isolation value (in ohms) as shown in Figure 4. Record electrical isolation value as $\mathbf{R_{i1}}$ in Data Sheet 4..

3. Calculate the electrical isolation value (in ohms) as shown in Figure 5. Record electrical isolation value as $\mathbf{R_{i2}}$ in Data Sheet 4.

4. If $\mathbf{R_{i1}}$ is less than $\mathbf{R_{i2}}$ then, divide $\mathbf{R_{i1}}$ by the nominal operating voltage of the propulsion battery (V_b) shown in Figure 4. Record this value as $\mathbf{R_i}$ / V_b, in Data Sheet 4. This value must be equal to or greater than 500. If this value is less than 500, a test failure has occurred.

5. If $\mathbf{R_{i2}}$ is less than $\mathbf{R_{i1}}$ then, divide $\mathbf{R_{i2}}$ by the nominal operating voltage of the propulsion battery ($\boldsymbol{V_b}$) shown in Figure 4. Record this value as $\mathbf{R_i}$ / $\boldsymbol{V_b}$, in Data Sheet 4. This value must be equal to or greater than 500. If this value is less than 500, a test failure has occurred.

6. Visually inspect for electrolyte leakage in the passenger compartment and record and photograph findings in Data Sheet 4 & Data Sheet 6.

7. Visually inspect for external battery component entry into the occupant compartment and record and photograph findings in Data Sheet 4 & Data Sheet 6.

8. Visually inspect for internal battery component movement in the occupant compartment and record and photograph findings in Data Sheet 4 & Data Sheet 6.

9. Document and photograph test vehicle per prescribed governing barrier test procedure and FMVSS 305 test procedure deliverables and record findings in Data Sheet 6.

10. Prepare the vehicle for the Static Rollover Test using the FMVSS 301 Compliance Test Procedure.

9.3 STATIC ROLLOVER TEST

NOTE: When the test vehicle is rotated in a fixture on its longitudinal axis to each successive increment of 90°, following an impact crash, propulsion battery electrolyte shall not exceed 5 liters, and electrical isolation shall not be less than 500 ohms/volt throughout the complete barrier impact test and at each 90° increment of the static rollover test.

The passenger compartment must be visually checked directly after a barrier impact for evidence of electrolyte leakage, battery system component intrusion, and retention of interior mounted battery modules. Photographs of the propulsion battery system components should be taken before the vehicle is placed in the static rollover machine.

Do not proceed to the static rollover if there are apparent test failures of the governing barrier test. The Contractor must conduct a static rollover test within 45 minutes after the vehicle impact only after the "quick look" data provides assurance that the vehicle has met the performance requirements of FMVSS No. 208, 214D, and/or 301, and 305. The Contractor must keep the test vehicle under constant observation for propulsion battery electrolyte leakage during the transition between impact and static rollover testing.

After the vehicle impact, propulsion battery electrolyte leakage will be collected by hand and documented with a real-time (24 fps) digital motion picture camera. The "tea cup method" has been used in the past and involves simply placing a collection vessel(s) beneath the leakage source(s). The collected propulsion battery electrolyte samples can subsequently be measured and spillage volume calculated. Contractors are invited to suggest alternative methods for fluid collection. If the "tea cup method" is used, the test personnel must be in position to scramble to observation points around the test vehicle at the instant the vehicle comes to rest after the impact event. If possible, segregate the collections of Stoddard solvent, propulsion battery electrolyte, or any other fluid if leakage of fluid is evident. If it is not possible to collect leakage samples separately, provide a collection vessel adequately sized to collect the leakage mixture and separate by suitable means, post-test. Take adequate safeguards when collecting leakage, as it may be hazardous.

1. Reference Static Rollover preparation and procedure from the most current FMVSS 301 Test Procedure.

2. Mount the test vehicle on the static rollover fixture and position at 0° (wheels down)

3. Immediately following the rollover transition of each successive increment of 90 ^{o} (e.g. at 90 ^{o}, 180 ^{o}, 270 ^{o}, 360^{o}), perform the following:

   3.1 Measure V_1, V_2, V_1 ', and V_2 ' voltages per Figures 2-5 with $\mathbf{R_o}$ installed, and record the values in Data Sheet 5--Static Rollover Test Data.

   3.2 Calculate the electrical isolation value (in ohms) as shown in Figure 4. Record electrical isolation value as $\mathbf{R_{i1}}$ in Data Sheet 5.

   3.3 Calculate the electrical isolation value (in ohms) as shown in Figure 5. Record electrical isolation value as $\mathbf{R_{i2}}$ in Data Sheet 5.

   3.4 If $\mathbf{R_{i1}}$ is less than $\mathbf{R_{i2}}$ then, divide $\mathbf{R_{i1}}$ by the nominal operating voltage of the propulsion battery (V_b) shown in Figure 4. Record this value as $\mathbf{R_i}$ / V_b, in Data Sheet 5.This value must be equal to or greater than 500. If this value is less than 500, a test failure has occurred.

   3.5 If $\mathbf{R_{i2}}$ is less than $\mathbf{R_{i1}}$ then, divide $\mathbf{R_{i2}}$ by the nominal operating voltage of the propulsion battery (V_b) shown in Figure 4. Record this value as $\mathbf{R_i}$ / V_b, in Data Sheet 5.This value must be equal to or greater than 500. If this value is less than 500, a test failure has occurred.

4. Repeat Step 3 for increments of 180 ^{o} 270 ^{o} and 360 ^{o}

NOTE: If there is an indication of a test failure during an impact test, the static rollover test WILL NOT BE CONDUCTED!

10. DATA SHEETS

Data Sheet No. 1
Test Vehicle Specifications

TEST VEHICLE INFORMATION:
Year/Make/Model/Body Style _____
NHTSA No.: _____; Color: _____; Date Received: _____
Odometer Reading: _____ miles
Selling Dealer: _____
& Address:_____

DATA FROM VEHICLE'S CERTIFICATION LABEL:
Vehicle Manufactured By:_____
Date of Manufacture:_____
VIN:_____
GVWR: _____ kg. ; GAWR-Front: _____ kg. ; GAWR-Rear: _____kg.

DATA FROM VEHICLE'S TIRE PLACARD & SIDEWALL:
Location of Placard on Vehicle:_____
Recommended Tire Size: _____
Recommended Cold Tire Pressure: Front:_____ kPa; Rear: _____kPa
Size of Tires on Test Vehicle: _____
Type of Spare Tire: _____

VEHICLE CAPACITY DATA:
Type of Front Seat(s): _____
Number of Occupants: Front = ____ ;Rear = ____ ;Total = _____
A. VEHICLE CAPACITY WEIGHT (VCW) =_____ kg.
B. Number of Occupants x 68 kg. =_____ kg.
RATED CARGO AND LUGGAGE WEIGHT (RCLW) [A-B]:_____kg
Maximum RCLW used in testing a truck, MPV, or bus is 136 kg.
RCLW-School Bus (If Applicable)=_____kg

ELECTRIC VEHICLE PROPULSION SYSTEM
Type of Electric Vehicle (Electric/Hybrid): _____
Propulsion Battery Type: _____
Nominal Voltage: _____ V;
Physical Location of Automatic Propulsion Battery Disconnect:
_____
Auxiliary Battery Type:_____

RECORDED BY: _____DATE: _____
APPROVED BY: _____DATE: _____

Data Sheet No. 2
Pre-Test Data

Vehicle:_____ NHTSA No.: _____

CALCULATION OF TARGET TEST WEIGHT (TTW)

1. Unloaded Vehicle Weight (UVW) =_____kg.
2. Rated Cargo & Luggage Weight (RCLW) = _____ kg.
3. Weight of ____ Part 572 Dummies = _____kg.

TARGET TEST WEIGHT = 1 + 2 + 3 = _____ kg.

As Tested

Test Weight of Vehicle, _____ Dummies and _____ kg of Cargo Weight

TOTAL TEST WEIGHT = _____ kg

Measured Cold Tire Pressure @ Total Test Weight:
Front:_____ kPa; Rear: _____kPa

PROPULSION BATTERY SYSTEM DATA:
(COTR supplied data)
Electrolyte Fluid Type: _____
Electrolyte Fluid Specific Gravity: _____
Electrolyte Fluid Kinematic Viscosity: _____ centistokes
Electrolyte Fluid Color: _____
Propulsion Battery Coolant Type, Color, Specific Gravity (if applicable):
_____
Location of Battery Modules:

☐ Inside Passenger Compartment:

☐ Outside Passenger Compartment:

Propulsion Battery State of Charge:

☐ Maximum State of Charge: _____

Test Voltage
(No less than 95% of Maximum State of Charge): _____

OR

☐ Range of Normal Operating Voltage: _____

Test Voltage
(Within Normal Operative Voltage Range): _____

VEHICLE CHASSIS GROUND POINT(S) LOCATION(S):

Details of Vehicle Chassis Ground Point(s) & Location(s) [Supply photographs as appropriate]:

_____
_____
_____
_____
_____

PROPULSION BATTERY SYSTEM:

Details of Propulsion Battery Components [Supply photographs as appropriate]:

_____
_____
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_____

Comments:_____
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RECORDED BY: _____DATE: _____
APPROVED BY: _____DATE: _____

Data Sheet No. 3
Pre-Impact Electrical Isolation Measurements & Calculations

Vehicle:_____ NHTSA No.: _____

VOLTMETER INFORMATION:

- The voltmeter used in this test shall measure DC values and have an internal impedance of at least 10MΩ
- NOTE: An oscilloscope meeting the above requirements may need to be used to adequately measure voltage in some vehicles

Make: _____; Model: _____; S/N: _____
Internal Impedance Value: _____MΩ
Resolution: _____V Last Calibration Date:_____

PROPULSION BATTERY VOLTAGE:

- Measurement shall be made with propulsion battery connected to the vehicle propulsion system, and the vehicle in the "ready-to-drive" (propulsion motor(s) activated) position
- If voltage measurement is not at the voltage or within the normal operating voltage range specified by the manufacturer, the battery must be charged

Vb = _____ V

PROPULSION BATTERY TO VEHICLE CHASSIS

- Vehicle chassis point(s) determined and supplied to contractor by COTR

V1 = _____ V
V2 = _____ V

PROPULSION BATTERY TO VEHICLE CHASSIS ACROSS RESISTOR

- The known resistance Ro (in ohms) should be approximately 500 times the nominal operating voltage of the vehicle (in volts) per SAE J1766.

Ro = _____ Ω

Electrical Isolation Measurement

V1' = _____V
Ri1 = Ro (1 + V2/V1) [(V1-V1')/V1']
Ri1 = _____ Ω

V2' = _____V
Ri2 = Ro (1 + V1/V2) [(V2-V2')/V2']
Ri2 = _____ Ω

Ri = The lesser of Ri1 and Ri2

Ri = _____ Ω Pre-test

Ri/Vb = _____ Ω/ V (Electrical Isolation Value)
Minimum Electrical Isolation Value is 500 Ω/ V

- Is the measured Electrical Isolation Value ≥500 Ω/ V?

☐ YES ☐ NO (Fail)

Comments:_____
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RECORDED BY: _____DATE: _____
APPROVED BY: _____DATE: _____

Data Sheet No. 4
Post-Impact Data

Vehicle:_____ NHTSA No.: _____

ELECTICAL ISOLATION MEASUREMENTS & CALCULATIONS

VOLTMETER INFORMATION:

- The voltmeter used in this test shall measure DC values and have an internal impedance of at least 10MΩ
- NOTE: An oscilloscope meeting the above requirements may need to be used to adequately measure voltage in some vehicles

Make: _____; Model: _____; S/N: _____
Internal Impedance Value: _____MΩ
Nominal Propulsion Battery Voltage (Vb): _____V

- Record V1, V2, V1', V2' voltage measurements immediately after the impacted vehicle **comes to rest**.

V1 = _____ V Impact Time: _____minutes _____s
V2 = _____ V Impact Time: _____minutes _____s
V1' = _____V Impact Time: _____minutes _____s
V2' = _____V Impact Time: _____minutes _____s

- Attach complete data acquisition to final test report

Electrical Isolation Measurement

Ri1 = Ro (1 + V2/V1) [(V1-V1')/V1']

Ri1 = _____ Ω Impact Time: _____minutes _____s

Ri2 = Ro (1 + V1/V2) [(V2-V2')/V2']

Ri2 = _____ Ω Impact Time: _____minutes _____s

Ri = The lesser of Ri1 and Ri2

Ri = _____ Ω Impact Time: _____minutes _____s

Ri/Vb = Electrical Isolation Value/ Nominal Battery Voltage
Minimum Electrical Isolation Value is 500 Ω/ V
Ri/Vb = _____ Ω/V Impact Time: _____minutes _____s

- Is the measured Electrical Isolation Value ≥500 Ω/ V?

☐ YES ☐ NO (Fail)

PROPULSION BATTERY SYSTEM COMPONENTS

Describe Propulsion Battery Module movement within the passenger compartment [Supply photographs as appropriate]:

_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____

- Has the Propulsion Battery Module moved within the passenger compartment?

  ☐ YES (Fail) ☐ NO

Describe intrusion of an outside Propulsion Battery Component into the passenger compartment [Supply photographs as appropriate]:

_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____

- Has an outside Propulsion Battery Component intruded into the passenger compartment?

  ☐ YES (Fail) ☐ NO

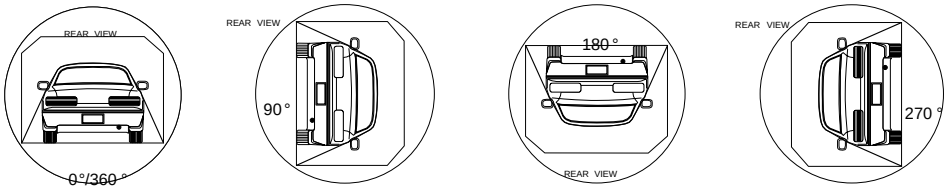
- Is propulsion battery electrolyte spillage visible in the passenger compartment?

  ☐ YES (Fail) ☐ NO

RECORDED BY: _____DATE: _____
APPROVED BY: _____DATE: _____

Data Sheet No. 5
STATIC ROLLOVER TEST DATA

Vehicle: _____ NHTSA No.:_____



I. **DETERMINATION OF PROPULSION BATTERY ELECTROLYTE COLLECTION TIME PERIOD:**

Rollover Stage	Rotation Time (spec. 1-3 min)				FMVSS 301 Hold Time		Total Time				Next Whole Minute Interval	
0º-90º		minutes		seconds		minutes		minutes		seconds		minutes
90º-180º		minutes		seconds		minutes		minutes		seconds		minutes
180º-270º		minutes		seconds		minutes		minutes		seconds		minutes
270º-360º		minutes		seconds		minutes		minutes		seconds		minutes

II. **ACTUAL TEST VEHICLE PROPULSION BATTERY ELECTROLYTE SPILLAGE:**

FMVSS 305 Requirements: Maximum allowable propulsion battery electrolyte spillage is **5.0 Liters**

Rollover Stage	Propulsion Battery Electrolyte Spillage (L)	Spillage Location
0º-90º		
90º-180º		
180º-270º		
270º-360º		

Total Spillage: _____ L

- Is the total spillage of propulsion battery electrolyte greater than 5.0 Liters?

  ☐ YES (Fail) ☐ NO

- Is propulsion battery electrolyte spillage visible in the passenger compartment?

  ☐ YES (Fail) ☐ NO

III. ELECTICAL ISOLATION MEASUREMENTS & CALCULATIONS

VOLTMETER INFORMATION:

- The voltmeter used in this test shall measure DC values and have an internal resistance of at least 10MΩ
- NOTE: An oscilloscope meeting the above requirements may need to be used to adequately measure voltage in some vehicles

Make: _____; Model: _____; S/N: _____
Internal Resistance Value (Ro): _____MΩ
Nominal Propulsion Battery Voltage (Vb): _____V

Record V1, V2, V1', V2' voltage measurements at the start of each successive increment of **90º**, **180º**, **270º**, and **360º** of the static rollover test.

Electrical Isolation Measurement

V1 = _____ V 0º Time: _____minutes _____s
V1 = _____ V 90º Time: _____minutes _____s
V1 = _____ V 180º Time: _____minutes _____s
V1 = _____ V 270º Time: _____minutes _____s

V2 = _____ V 0º Time: _____minutes _____s
V2 = _____ V 90º Time: _____minutes _____s
V2 = _____ V 180º Time: _____minutes _____s
V2 = _____ V 270º Time: _____minutes _____s

V1' = _____ V 0º Time: _____minutes _____s
V1' = _____ V 90º Time: _____minutes _____s
V1' = _____ V 180º Time: _____minutes _____s
V1' = _____ V 270º Time: _____minutes _____s

V2' = _____ V 0º Time: _____minutes _____s
V2' = _____ V 90º Time: _____minutes _____s
V2' = _____ V 180º Time: _____minutes _____s
V2' = _____ V 270º Time: _____minutes _____s

- Attach complete data acquisition to final test report of governing barrier test

Electrical Isolation Calculation

Ri1 = Ro (1 + V2/V1) [(V1-V1')/V1']

Ri1 = _____ Ω 90º Time: _____minutes _____s
Ri1 = _____ Ω 180º Time: _____minutes _____s
Ri1 = _____ Ω 270º Time: _____minutes _____s
Ri1 = _____ Ω 360º Time: _____minutes _____s

Ri2 = Ro (1 + V1/V2) [(V2-V2')/V2']

Ri2 = _____ Ω 90º Time: _____minutes _____s
Ri2 = _____ Ω 180º Time: _____minutes _____s
Ri2 = _____ Ω 270º Time: _____minutes _____s
Ri2 = _____ Ω 360º Time: _____minutes _____s

Ri = The lesser of Ri1 and Ri2

Ri = _____ Ω 90º Time: _____minutes _____s
Ri = _____ Ω 180º Time: _____minutes _____s
Ri = _____ Ω 270º Time: _____minutes _____s
Ri = _____ Ω 360º Time: _____minutes _____s

Ri/Vb = Electrical Isolation Value/ Nominal Battery Voltage
Minimum Electrical Isolation Value is 500 Ω/ V

Ri/Vb = _____ Ω/V 90º Time: _____minutes _____s
Ri/Vb = _____ Ω/V 180º Time: _____minutes _____s
Ri/Vb = _____ Ω/V 270º Time: _____minutes _____s
Ri/Vb = _____ Ω/V 360º Time: _____minutes _____s

- Is the measured Electrical Isolation Value ≥500 Ω/ V?

☐ YES ☐ NO (Fail)

COMMENTS:

_____
_____
_____
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_____

RECORDED BY: _____DATE: _____
APPROVED BY: _____DATE: _____

Data Sheet No. 6
Photograph Data Sheet

Vehicle:_____ NHTSA No.: _____

PHOTOGRAPH CHECKLIST

Pre-test	Post-test	
		A. View of the propulsion battery if any part of it is visible. Do NOT disassemble any parts other than carpet, seats and overlay to take these photographs
		B. View of the electric propulsion drive. Take the best photograph possible without removing any parts.
		C. View of the vehicle passenger compartment adjacent to propulsion battery.
		D. Post-test battery module movement, or retention loss, if applicable.
		E. Post-test battery component intrusion.
		F. Post-test view of test vehicle while vehicle is on static rollover machine.
		G. Photographs of propulsion battery system mounting and/or intrusion failures.
		H. Post-test propulsion battery electrolyte spillage location view.
		I. Labels and markings related to propulsion battery system.
		J. Other photographs requested by COTR.

COMMENTS:

_____

_____

RECORDED BY: _____DATE: _____
APPROVED BY: _____DATE: _____