

ETA-TP012

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Evaluation of Electric Vehicle On-Board Battery Energy Management System(s) [BEMS]

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1.0 Objective

This procedure provides a consistent protocol for the evaluation of the performance of an electric vehicle's Battery Energy Management System (BEMS), and that system's ability to satisfactorily maintain the main propulsion battery(s) in the condition required by EV America's Minimum Performance Requirements.

2.0 Purpose

The purpose of this procedure is to provide a traceable, quantifiable methodology for the collection and evaluation of BEMS data. This activity is meant to quantify results obtained from the operation of the BEMS when operating an electric vehicle on a day-to-day basis through varying conditions. Although it is necessary to test and monitor the performance of these systems to ensure the successful operation of the BEMS, tests of other subsystems or portions of individual subsystems are addressed by other Test Procedures. This testing and data acquisition meets the requirements specified in the EV America Technical Requirements specific to the BEMS.

3.0 Documentation

Documentation addressed by this procedure shall be consistent, easy to understand, easy to read, and readily reproducible. This documentation shall contain enough information to "stand alone"; that is, be self-contained to the extent that all individuals qualified to review it could be reasonably expected to reach a common conclusion, without the need to review additional documentation. Review and approval of test documentation shall be in accordance with ETA-AC004, "Review of Test Results." Storage and retention of records during and following testing activities shall be completed as described in Procedure ETA-AC001, "Control, Close-out and Storage of Documentation."

4.0 Prerequisites

- 4.1 Personnel conducting testing under this procedure shall be familiar with the requirements of this procedure as evidenced by Certification by the Program Manager or Test Manager, any applicable SAE Test Instructions, and the Administrative Control Procedures, prior to commencing any testing activities.
- 4.2 Overall error in recording or indicating instruments shall not exceed $\pm 2\%$ of the maximum value of the variable being measured, unless otherwise excepted. Periodic calibration shall be performed and documented to ensure compliance with this requirement. [This error value does not apply to instrumentation permanently installed by the manufacturer that is required by the RFP.]
- 4.3 A list of all instrumentation used in the test shall be identified on Appendix A, and attached to the test results. It shall include the following information:
 - 4.3.1 Manufacturer
 - 4.3.2 Model Number
 - 4.3.3 Serial Number
 - 4.3.4 Last Calibration date
 - 4.3.5 Next Calibration date
- 4.4 Any deviation from the test procedure and the reason for the deviation shall be approved in advance by the Program Manager or Test Manager in accordance with ETA-AC002, "Control of Test Conduct," and so noted on the appropriate data sheet(s).
- 4.5 Necessary recording equipment shall be installed in a manner that does not hinder vehicle operation or alter the operating characteristics of the vehicle.

5.0 Measurement of Battery Energy Monitoring System (BEMS) Performance

This procedure is designed as a non-intrusive, qualitative evaluation tool to assist the Test Manager in determining if the BEMS is operating correctly. Based upon the manufacturer's submittal, the vehicle will be assumed to contain a BEMS unless otherwise stipulated.¹ The BEMS shall be evaluated to ensure it is capable of properly maintaining the battery.

EV America Shall Statement #33 states:

“The vehicle shall be equipped with a Battery Management System (BMS). This system should control propulsion battery pack and module voltages, temperatures and state of charge. Further, the BMS shall automatically limit battery discharge below a pre-determined minimum level. The charger system should include equipment to maintain each module in the battery pack at equal temperature and within the allowed temperature range of the battery throughout each charge-discharge cycle.”

There are several methods of verifying the BEMS is operating correctly. Record all comments made on a copy of Appendix A, and include in the Test Report.

5.1 Evaluation of Battery Temperature(s)

Battery temperature affects battery capacity and life. Unequal module temperatures within the propulsion pack can result in uneven charging and discharging and even premature failure. Indications of erratic or inconsistent battery temperatures may be a sign the BEMS is not operating correctly. This condition warrants further discussion with the vehicle manufacturer.

5.2 Evaluation of Battery Performance on Charge

The ability of a battery to recharge in a consistent manner (based upon temperature, SOC, etc.) can be used to identify problems with the battery or the BEMS. Batteries which are charged in a consistent manner following similar discharges indicate the BEMS and the battery are operating appropriately. Inconsistent recharge times, relatively short or long charge times, or erratic performance during or following a charge, are indications the battery or BEMS may not be operating properly. This condition warrants further discussion with the vehicle manufacturer.

¹EV America requires all production level vehicles to have a BEMS (Shall Statement #33). Vehicles without a BEMS may be tested as “prototype” vehicles; however, in that case, this procedure would not apply.

5.3 Evaluation of Battery Performance on Discharge

The ability of a battery to discharge in a consistent manner (based upon temperature, SOC, etc.) can be used to identify problems with the battery or the BEMS. Batteries which discharge in a consistent manner following full charges indicate the BEMS and the battery are operating appropriately. Inconsistent discharge capabilities (as measured by kWh or Ah out), high or low battery temperatures or erratic charge performance following a discharge are indications the battery or BEMS may not be operating properly. This condition warrants further discussion with the vehicle manufacturer. [Note that a faulty or disabled charged may also cause improper charging.]

5.4 Evaluation of Battery System Voltages

The BEMS should control propulsion battery pack and module voltages to preclude conditions which may be detrimental to the battery. Voltages which change rapidly on discharge are an indication that one or more modules may have failed. A sudden decrease in battery voltage should trigger the BEMS to control discharge rates. This may be evidenced by a premature loss of power or tell-tales illuminating out of sequence, or not at all. These conditions warrant further discussion with the vehicle manufacturer.

5.5 Evaluation of Tell-Tales

Tell-tales are normally provided to alert the operator/driver that battery limits are being approached. There is usually a specific sequence of illumination, starting with the illumination of an information tell-tale and culminating with the illumination of a final telltale concurrent with a power restriction or limiting feature (initiated by the BEMS). Illuminate of these tell-tales out of sequence or not at all may indicate the BEMS is operating incorrectly, or the battery is operating erratically. Either of these conditions warrant further discussion with the vehicle manufacturer.

7.0 Glossary

- 8.1 **BEMS** - Battery Energy Management System.
- 8.2 **Effective Date** - The date, after which the procedure has been reviewed and approved, that the procedure can be utilized in the field for official testing.
- 8.3 **Program Manager** - As used in this procedure, the individual within Electric Transportation Applications responsible for oversight of the EV America Performance Test Program. [Subcontract organizations may have similarly titled individuals, but they are not addressed by this procedure.]
- 8.4 **Shall** - Items which require adherence without deviation. Shall statements identify binding requirements. A go, no-go criterion.
- 8.5 **Should** - Items which require adherence if at all possible. Should statements identify preferred conditions.
- 8.6 **Test Director** - The individual within Electric Transportation Applications responsible for all testing activities associated with the EV America Performance Test Program.
- 8.7 **Test Director's Log** - A daily diary kept by the Test Director, Program Manager, Test Manager or Test Engineer to document major activities and decisions that occur during the conduct of a Performance Test Evaluation Program. This log is normally a running commentary, utilizing timed and dated entries to document the days activities. This log is edited to develop the Daily Test Log published with the final report for each vehicle.
- 8.8 **Test Engineer** - The individual(s) assigned responsibility for the conduct of any given test. [Each contractor/subcontractor should have at least one individual filling this position. If so, they shall be responsible for adhering to the requirements of this procedure.]
- 8.9 **Test Manager** - The individual within Electric Transportation Applications responsible for the implementation of the test program for any given vehicle(s) being evaluated to the requirements of the EV America Performance Test Program. [Subcontract organizations may have similarly titled individuals, but they are not addressed by this procedure.]

9.0 References

- 9.1 EV America Technical Requirements
- 9.2 ETA-AC001, Revision 2 - “Control, Close-out and Storage of Documentation”
- 9.3 ETA-AC002, Revision 2 - “Control of Test Conduct”
- 9.4 ETA-AC004, Revision 2 - “Review of Test Results”
- 9.5 ETA-AC005, Revision 2 - “Training and Certification Requirements for Personnel Utilizing ETA Procedures”
- 9.6 ETA-AC006, Revision 2 - “Vehicle Verification”
- 9.7 ETA-TP011, Revision 1 - “Receipt Inspection Procedure”

