

ETA-TP013

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Level III Charging Of Electric Vehicles

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1.0 Objective

This procedure identifies the proper method for the conduct of Level III charging of the main propulsion batteries installed in an electric vehicle while it is being tested during the EV America Performance Test Program. It shall not supersede the charging protocols of the vehicle's manufacturer, nor is it meant to supersede those specifically addressed by SAE Test Standards, nor of any regulatory agency who may have or exercise control over the covered activities.

2.0 Purpose

The purpose of this procedure is to provide guidance on Level III charging of propulsion batteries during the time the vehicle is being subjected to the EV America Performance Test Program. This procedure shall also be used to calculate charging efficiencies during the performance of the ETA-TP005, "Rough Road Test," as well as other procedures which support the EV America Technical Requirements. Different charging strategies shall not be mixed during a single test program unless the manufacturer details that as the normal method of charge operation for the end user.

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 Initial Conditions and Prerequisites

- 4.1 Personnel conducting charging of vehicle batteries under this procedure shall be familiar with the requirements of this procedure, any applicable SAE Test Instructions, the Administrative Control Procedures, and certified by the Program Manager or Test Manager prior to commencing any charging activities.
- 4.2 All personnel conducting charging of batteries shall observe proper safety precautions at all times.
- 4.3 Charging of vehicle batteries shall be in accordance with the requirements of the vehicle/battery supplier as stated in the Owner/Operators manual.
- 4.4 Charging rates shall not exceed the maximum recommended by the manufacturer.
- 4.5 The only charging used during Testing will be Level III (Fast) Charging unless otherwise specifically required by the Manufacturer in the Owner's Manual.
- 4.6 Should charging at other than Level III be required, it will be instituted on the schedule mandated by the owner's manual.
- 4.8 Level II charging, if required, will be performed at the completion of the 8-hour test period immediately prior to the scheduled requirement.
- 4.9 Should a combination of Level II and Level III charging be required, the sequences shall be as mandated by the owner's manual.
- 4.10 Vehicles shall not be left on the Level III charger if not actively charging. [When a Level III charge is complete, the vehicle shall be removed from the charger, whether it is to be driven or not.]
- 4.11 Ambient temperature should not be in excess of 120°F at the commencement of charging, or the maximum allowed by the manufacturer, whichever is less.
- 4.12 AC supply voltages for chargers shall be as specified by the manufacturer.
- 4.13 Charging of on-board battery systems should be accomplished at a charger current rating specified by the manufacturer.
- 4.14 Charging at 120 VAC should only be used if specifically required to meet the requirements of the manufacturer, as the time required to charge at 120V is much longer.
- 4.15 All documentation required to complete the charging activities should be completed, approved and issued prior to commencing any charging activities.
- 4.16 Record the required data for all metrology used on Appendix B.

5.0 Charging Requirements

The EV America Technical Requirements require that manufacturers provide a charger, which can fully recharge the main propulsion batteries from any state of discharge in less than 12 hours. It also states that the vehicle manufacturer should have the battery manufacturer review and approve the charging algorithm for the main propulsion batteries. This procedure does not verify these items, but does utilize the concepts as developmental bases. The following instructions apply to the generic activity of charging. They shall not replace or supersede the requirements of any specific manufacturer. Should a conflict arise, the requirements of the Vehicle/Battery manufacturer shall take precedence.

For vehicles designed by their manufacturers for Level III Charging, the EV America Test Program may be conducted using Level III Charging. Because of the differences in the chargers and their potential effect on the batteries, if the manufacturer's Level III charge methodology is to be used, a separate EV America Test Program utilizing only the Level III methodology should be conducted. This testing should be in addition to a full EV America Test Program conducted using the manufacturer's Level II charge methodology and equipment.

5.1 Level III Charging Requirements

Once it has been established that Level III charging will be employed, the following activities shall be completed.

CAUTION

All personnel from ETA and its subcontractors who will conduct charging operations shall be specifically trained in all aspects of the charger, including its automatic shutdowns and safety procedures.

NOTE

If necessary to transition from Level II charging to Level III charging, the vehicle shall receive at least five (5) full charge cycles and five (5) partial charge cycles in any order prior to the conduct of any EV America Test Program procedures for Level III charging. If battery performance variations are noticeable at the end of this conditioning, the conditioning cycle shall be repeated prior to testing.

NOTE

During the conduct of the test program, it may be necessary to conduct leveling or equalizing charges using a Level I or Level II Charger. If this is required, then the equalizing charge shall be conducted in accordance with Section 5.2 of this procedure.

5.1.1 Verify by physical inspection that there is no damage to the battery charging system.

- 5.1.2 Record the specific charger type being used (Norvik, Hughes, etc.) and its nominal rating.

NOTE

If this procedure is being used in conjunction with ETA-TP014, charge data shall be recorded on the applicable Appendix of that procedure, and transcribed to the permanent charging record within 24 hours.

- 5.1.3 Identify and record the appropriate charging rates, including:
- 5.1.3.1 Initial Maximum Charging Rate (in Amperes).
 - 5.1.3.2 Charging Rate (in Amperes) at which the charge will be terminated, if termination is not automatic.
- 5.1.4 Read and record the vehicle's onboard SOC indicator reading prior to commencing the charge on Appendix A.
- 5.1.5 If a kilowatt-hour meter or reading is available, this should also be recorded on Appendix A.
- 5.1.6 Ensure the charger-to-vehicle disconnect is Open.

NOTE

Monitoring and recording the charge and discharge cycles will provide a tertiary method to determine when the conditioning cycles have been completed. If the Level III charger is equipped with a computer data port (e.g., RS-232) and a computer with the corresponding software is available, the computer may be connected to the charger at this time. See the charger manufacturer's instructions for information on this.

- 5.1.7 Read and record the charger's initial totalizer value (Ah or kWh)
- 5.1.8 Connect the charging cable to the vehicle.
- 5.1.9 If required, start the Level III charger's independent power supply (e.g., diesel engine, etc.).
- 5.1.10 Close the charging station disconnect supplying the vehicle.
- 5.1.11 Read and record on Appendix A the time that charging is starting.
- 5.1.12 Read and record the initial DC charging current and voltage.
- 5.1.13 Verify the totalizer meter or the data logger is operating.

- 5.1.14 When the charge has completed (or the charge rate has decreased to the level determined in Step 5.1.3.2), record the following information as appropriate:
 - 5.1.14.1 Time
 - 5.1.14.2 Final voltage (if available)
 - 5.1.14.3 Final charging current (if available)
 - 5.1.14.4 Charging station location energy meter reading
 - 5.1.14.5 Vehicle SOC reading
 - 5.1.14.6 Vehicle Kilowatt-hour reading (if equipped)
 - 5.1.14.7 Totalizer meter or data logger information
 - 5.1.14.8 Vehicle odometer reading
- 5.1.15 If so equipped, open the charging station disconnect supplying the vehicle.
- 5.1.16 Disconnect the charging cable from the vehicle.

5.2 Use of Equalizing/Leveling Charges

Level III Charging provides a way to return large amounts of energy to the propulsion batteries in a short period of time. However, the battery may still require periodic equalizing charges. The Battery and/or vehicle manufacturer is responsible for determining the frequency of equalizing the propulsion batteries.

To ensure that equalizing is done within the period specified by the manufacturer, equalizing charges shall be conducted by EV America at the intervals required by the manufacturer. To this end, the following method of conducting equalizing charges shall be followed whole completing ETA-TP014.

- 5.2.1 If the manufacturer requires that an equalizing charge be conducted every X charge, when X charge is due, an equalizing charge shall be completed. If this is scheduled to occur between a days scheduled drive segments, the equalizing charge shall be considered as part of the day's normal charging regime, and shall supercede the requirements for additional drive segments until the equalizing charge has been completed. Any wait time subsequent to the equalizing charge required to occur prior to driving shall be observed.
- 5.2.2 If the manufacturer requires that an equalizing charge be completed no more often than x charges, then the equalizing charge shall be completed the night before the day in which the equalizing charge cycle would fall. [Example: if an equalizing charge is required to be completed at least every 10 cycles, and less than 10 cycles were completed during the day's drive-charge activities, the equalizing charge would be conducted at the end of that day's testing, and prior to the beginning of the next day's drive-charge activities.]
- 5.2.3 If the manufacturer requires that an equalizing charge be completed after at least N fast charges had occurred but before N+X fast charges had occurred, then the equalizing charge shall be completed the night before the day that N+X charges would be expected to occur. [Example: if an equalizing charge is required to be completed after 10 cycles but before 16 cycles, and more than 10 cycles were completed during the day's drive-charge activities, and it was expected to exceed 15 charge cycles the following day, the equalizing charge would be conducted at the end of that day's testing, and prior to the beginning of the next day's drive-charge activities.]

5.3 Charging Efficiencies

This section provides guidance on the calculation of charging efficiencies. Charging efficiencies shall be calculated based upon conduct of Rough Road Testing per ETA-TP005.

5.3.1 Daily charging efficiency

$$\text{Daily Charging Efficiency} = \frac{\text{Miles Traveled Since Last Charge}}{\text{Kilowatt-hours Returned in Last Charge}}$$

5.3.2 Weekly charging efficiency

$$\text{Weekly Charging Efficiency} = \frac{\text{Miles Traveled During Previous 7 Days}}{\text{Kilowatt-hours Returned in Previous 7 Days}}$$

5.3.3 Charging efficiency

- 5.3.3.1 Ensure the vehicle is fully charged.
- 5.3.3.2 Record vehicle mileage prior to conduct of Rough Road Procedure ETA-TP005.
- 5.3.3.3 Record charger kWh prior to conduct of Rough Road Procedure ETA-TP005.
- 5.3.3.4 Conduct procedure ETA-TP005. Ensure that the vehicle is charged only on its designated charger and is operated only for conduct of the test procedure.
- 5.3.3.5 Upon completion of testing, ensure the vehicle is fully charged.
- 5.3.3.6 Determine the miles traveled during the entire test program
- 5.3.3.7 Determine the kWh consumed during the entire test program
- 5.3.3.8 Calculate the program charging efficiency as follows:

$$\text{Program Charging Efficiency} = \frac{\text{Miles Traveled During the Test Program}}{\text{Kilowatt-hours Returned During Test Program}}$$

6.0 Glossary

- 6.1 Charging Algorithm - The circuitry/mathematical controls used by a charger to automatically control the charging profile of current versus voltage versus time during the battery charge.
- 6.2 Charging Station Location - As used in this procedure, refers to the specific plug-in location assigned to each specific vehicle.
- 6.3 Effective Date - The date, after which the procedure has been reviewed and approved, a procedure can be utilized in the field for official testing.
- 6.4 Fast Charge - Charging conducted using a Level III Charger.
- 6.5 Level III Charger - A charger capable of returning 40% SOC to a battery in less than 20 minutes.
- 6.6 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.]
- 6.7 Shall - Items which require adherence without deviation. Shall statements identify binding requirements. A go, no-go criterion.
- 6.8 Should - Items which require adherence if at all possible. Should statements identify preferred conditions.
- 6.9 State of Charge (SOC) - For this testing, the SOC of a battery is defined as the expected residual battery capacity, expressed in amperes-hours or watt-hours or miles, as a percentage of the total available. The 100% SOC basis (available ampere-hours, kilowatt hours or miles) is determined by the actual discharge capability of the main propulsion battery when discharged to the requirements of the 45 mph Constant Speed Range Test portion of procedure ETA-TP004, "Constant Speed Range Test."
- 6.10 Test Director - The individual within Electric Transportation Applications responsible for all testing activities associated with the EV America Performance Test Program.
- 6.11 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 day's activities. This log is edited to develop the Daily Test Log published with the final report for each vehicle.
- 6.12 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.]

6.0 Glossary (continued)

- 6.11 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.]

- 7.10 ETA-TP003, Revision 2 - “Electric Vehicle Energy Consumption and Range Test”
- 7.11 ETA-TP004, Revision 3 - “Constant Speed Range Test”
- 7.12 ETA-TP005, Revision 2 - “Rough Road Course Test”
- 7.13 ETA-TP006, Revision 2 - “Braking Test”
- 7.14 ETA-TP007, Revision 2 - “Road Course Handlin
- 7.15 ETA-TP010, Revision 2 - “Measurement and Evaluation of Electric Vehicle Battery Charger Performance”
- 7.16 ETA-TP011, Revision 2 - “Receipt Inspection”
- 7.17 ETA-TP012, Revision 0 - “Evaluation of Electric Vehicle Battery Energy
- 7.18 ETA-TP014, Revision 0 – “Electric Vehicle Range Testing Using Level III

APPENDIX-A
Charging Data Sheet
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