

# ETA-UTP008

Revision 0

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## Battery Charging

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## **1.0 Objective**

This procedure identifies the proper method for the conduct of charging the main propulsion batteries installed in an electric vehicle while it is being tested during the UEV 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 charging traction batteries during the time the vehicle is being subjected to the UEV America Performance Test Program. This procedure shall also be used to calculate charging efficiencies during the performance of the ETA-UTP005, "Rough Road Test," as well as other procedures which support the UEV America Technical Requirements.

## **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-UAC004, "Review of Test Results." Storage and retention of records during and following testing activities shall be completed as described in Procedure ETA-UAC001, "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 Charging of vehicle batteries shall be in accordance with the requirements of the vehicle/battery supplier as stated in the Owner/Operators manual.
- 4.3 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.
- 4.4 All personnel conducting charging of batteries shall observe proper safety precautions at all times.
- 4.5 Charging rates shall not exceed the maximum recommended by the manufacturer.
- 4.6 Charging of on-board battery systems should normally be accomplished at 208 VAC, or as specified by the manufacturer.
- 4.7 Charging at 120 VAC should only be used when specifically required to meet the requirements of a test procedure or a specific vehicle, as the time required to charge at 120V is much longer than if completed at 208V.
- 4.8 All documentation required to complete the charging activities shall be completed, approved and issued prior to commencing any charging activities.
- 4.9 Record the required data for all metrology used on Appendix B.

## 5.0 Charging Requirements

The UEV 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.

### CAUTION

Vehicles shall not be charged from any outlet except the outlet specifically designated for that vehicle.

The following steps assume the vehicle has been parked at the charging facility, and is capable of being charged from its dedicated charging feed.

### 5.1 Level I or Level II Charging

- 5.1.1 Verify by physical inspection that there is no damage to the battery or charging system.
- 5.1.2 Determine and select the proper cable and connector type for the specific vehicle being charged. This shall be determined by visual inspection of the charger connector.
- 5.1.3 Read and record the onboard State of Charge (SOC) indicator reading prior to commencing the charge on Appendix A.
- 5.1.4 If a kilowatt-hour meter or reading is available, this should also be recorded on Appendix A.
- 5.1.5 Select the appropriate charging station location.
- 5.1.6 If so equipped, open the charging station disconnect supplying the vehicle.
- 5.1.7 Read and record on Appendix A the watt-hour meter reading at the charging station.
- 5.1.8 Connect the charging cable to the vehicle.
- 5.1.9 Connect the charging cable to the vehicle charging station.
- 5.1.10 If so equipped, 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 If available, read and record the initial DC charging current and voltage.
- 5.1.13 Verify the kilowatt-hour meter or the data logger is operating.
- 5.1.14 When the charge has completed (as determined by the manufacturer's algorithm), 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 Kilowatt-hour 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 charging station.
- 5.1.17 Disconnect the charging cable from the vehicle.

**5.2 Charging Efficiencies**

This section provides guidance on the calculation of charging efficiencies. Charging efficiencies shall be calculated based upon conduct of Endurance Course Testing per ETA-UTP005.

5.2.1 Daily charging efficiency

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

5.2.2 Weekly charging efficiency

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

5.2.3 Charging efficiency

- 5.2.3.1 Ensure the vehicle is fully charged.
- 5.2.3.2 Record vehicle mileage prior to conduct of Endurance Course Procedure ETA-UTP005.
- 5.2.3.3 Record charger kWh prior to conduct of Endurance Course Procedure ETA-UTP005.
- 5.2.3.4 Conduct procedure ETA-UTP005. Ensure that the vehicle is charged only on its designated charger and is operated only for conduct of the test procedure.
- 5.2.3.5 Upon completion of testing, ensure the vehicle is fully charged.
- 5.2.3.6 Determine the miles traveled during the entire test program
- 5.2.3.7 Determine the kWh consumed during the entire test program
- 5.2.3.8 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, that the procedure can be utilized in the field for official testing.
- 6.4 Program Manager - As used in this procedure, the individual within Electric Transportation Applications responsible for oversight of the UEV America Performance Test Program. [Subcontract organizations may have similarly titled individuals, but they are not addressed by this procedure.]
- 6.5 Shall - Items which require adherence without deviation. Shall statements identify binding requirements. A go, no-go criterion.
- 6.6 Should - Items which require adherence if at all possible. Should statements identify preferred conditions.
- 6.7 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 35 mph Constant Speed Range Test portion of procedure ETA-UTP004, "Constant Speed Range Test."
- 6.8 Test Director - The individual within Electric Transportation Applications responsible for all testing activities associated with the UEV America Performance Test Program.
- 6.9 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.
- 6.10 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 UEV America Performance Test Program. [Subcontract organizations may have similarly titled individuals, but they are not addressed by this procedure.]

## 7.0 References

- 7.1 UEV America Technical Requirements
- 7.2 ETA-UAC001, Revision 0 - "Control, Close-out and Storage of Documentation."
- 7.3 ETA-UAC002, Revision 0 - "Control of Test Conduct."
- 7.4 ETA-UAC004, Revision 0 - "Review of Test Results"
- 7.5 ETA-UAC005, Revision 0 - "Certification and Training of Personnel Utilizing ETA Procedures."
- 7.6 ETA-UAC006, Revision 0 - "Vehicle Verification"
- 7.7 ETA-UAC007, Revision 0 - "Receipt Inspection"
- 7.8 ETA-UQP001, Revision 0 - "Quality Program"
- 7.9 ETA-UTP002, Revision 0 - "Electric Vehicle Acceleration, Gradeability and Maximum Speed Test"
- 7.10 ETA-UTP003, Revision 0 - "Electric Vehicle Energy Consumption and Range Test"
- 7.11 ETA-UTP004, Revision 0 - "Constant Speed Range Test"
- 7.12 ETA-UTP005, Revision 0 - "Endurance Course Course Test"
- 7.13 ETA-UTP006, Revision 0 - "Braking Test"
- 7.14 ETA-UTP007, Revision 0 - "Road Course Handling Test"
- 7.15 ETA-UTP010, Revision 0 - "Measurement and Evaluation of Electric Vehicle Battery Charger Performance"
- 7.16 ETA-UTP011, Revision 0 - "Receipt Inspection"
- 7.17 ETA-UTP012, Revision 0 - "Evaluation of Electric Vehicle Battery Energy Management System(s)"

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