

ETA-HTP08

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Rechargeable Energy Storage System (RESS) Charging

Prepared by

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TABLE OF CONTENTS

1.	Objectives	1
2.	Purpose	1
3.	Documentation	1
4.	Initial Conditions and Prerequisites	1
5.	Charging Activities	
5.1	Vehicles Operable In "Normal Mode Only"	2
5.2	Vehicles Operable In "RESS Mode Only"	2
5.3	Grid Connected Vehicles (Level I or Level II Charging)	2
5.4	Charging Efficiency	4
6.	Glossary	6
7.	References	7

Appendices

Appendix A - Charging Data Sheet	8
Appendix B - Metrology Usage Sheet	9

1. Objective

This procedure identifies the method for charging the Rechargeable Energy Storage System (RESS) installed in hybrid electric vehicles participating in HEV America. It shall not supersede the charging protocols of the vehicle's Supplier, nor is it meant to supersede those specifically addressed by SAE Test Standards, nor of any regulatory agency which may have or exercise control over the covered activities.

2. Purpose

The purpose of this procedure is to provide specific and repeatable guidance for charging the RESS of vehicles participating in HEV America. This guidance includes vehicles operable in "RESS only mode," vehicles operable in "normal only mode," and vehicles capable of grid connection. This procedure is also used to calculate charging efficiencies during the performance of the ETA-HTP05, "Rough Road Test," as well as other procedures which support the HEV America Vehicle Specification.

3. 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-HAC04, "Review of Test Results." Storage and retention of records during and following testing activities shall be completed as described in Procedure ETA-HAC01, "Control, Close-out and Storage of Documentation."

4. Initial Conditions and Prerequisites

- 4.1 Personnel conducting charging of vehicle Rechargeable Energy Storage Systems (RESS) 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 RESS 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 Supplier, whichever is less.
- 4.4 All personnel conducting charging of RESS shall observe proper safety precautions at all times.

- 4.5 Charging rates shall not exceed the maximum recommended by the Supplier.
- 4.6 Charging of a grid connected RESS should normally be accomplished at 208 VAC (Level II), unless specified differently by the Supplier.
- 4.7 Charging of a grid connected RESS at 120 VAC (Level I) should only be used when specifically required to meet the requirements of a test procedure or a specific vehicle..
- 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. Charging Requirements

5.1 Vehicles Operable In "Normal Only Mode"

Test vehicles that are not capable of grid connection and are not capable of selecting an "RESS only mode" shall only be charged in their "normal operating mode". All "normal operating mode" tests shall be conducted only at a beginning State of Charge (SOC) achieved by operating the vehicle for at least 5 miles (8 kilometers) at a constant speed of 35 mph (56 kph).

5.2 Vehicles Operable In "RESS Only Mode"

Test vehicles that are not capable of grid connection and are capable of being driven in an operator selectable mode that uses only the Rechargeable Energy Storage System (RESS) shall be tested in that "RESS only mode." All "RESS only mode" tests shall be conducted only at an Initial State of Charge (SOC) achieved by operating the vehicle in "normal operating mode" for at least 5 miles (8 kilometers) at a constant speed of 35 mph (56 kph).

5.3 Grid Connected Vehicles (Level I or Level II Charging)

The HEV America Vehicle Specification requires that Suppliers provide a charger for HEVs capable of grid connection. This charger shall fully recharge the Rechargeable Energy Storage System (RESS) from any state of discharge in less than 12 hours.

The following instructions apply to charging activities for all hybrid vehicles capable of grid connection. They shall not replace or supersede the requirements of any specific Supplier. Should a conflict arise, the requirements of the Vehicle/RESS Supplier shall take precedence.

CAUTION

Vehicles shall not be charged from any outlet except the outlet specifically designated for that vehicle at its designated Charge Station Location. The following steps assume the vehicle has been parked in the charging area, and is capable of being charged from its dedicated Charge Station Location.

- 5.3.1 Verify by physical inspection that there is no damage to the RESS or charging system.
- 5.3.2 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.
- 5.3.3 Read and record on Appendix A the RESS State of Charge (SOC) indicator reading prior to commencing the charge.
- 5.3.4 If an onboard kilowatt-hour meter reading is available, this should also be recorded on Appendix A.
- 5.3.5 Select the appropriate charging station location.
- 5.3.6 Read and record on Appendix A the watt-hour meter reading at the charging station.
- 5.3.7 Verify that the electrical disconnect supplying power to the charger is closed.
- 5.3.8 Connect the charging cable to the vehicle.
- 5.3.9 Read and record on Appendix A the time that charging is starting.
- 5.3.10 If available, read and record the initial DC charging current and voltage.
- 5.3.11 Verify the kilowatt-hour meter or the data logger is operating.
- 5.3.12 Allow the charger to continue charging until the charge is automatically terminated by the Charge Algorithm.
- 5.3.13 When the charge has completed (as determined by automatic termination of the Suppliers Charge Algorithm), verify the charger is not indicating a charging fault. If a faulty has occurred, the reason for the fault shall be recorded in accordance with ETA-HAC02, "Control of Test Conduct" and the Supplier notified to perform necessary repairs.
- 5.3.14 If the charger has automatically terminated, without fault, record the following information:
 - 5.3.14.1 Time
 - 5.3.14.2 Final voltage (if available)

- 5.3.14.3 Final charging current (if available)
- 5.3.14.4 Charging station location energy meter reading
- 5.3.14.5 Vehicle SOC reading
- 5.3.14.6 Vehicle Kilowatt-hour reading (if equipped)
- 5.3.14.7 Kilowatt-hour meter or data logger information
- 5.3.14.8 Vehicle odometer reading
- 5.3.15 If so equipped, depress the "STOP" button on the charger.
- 5.3.16 Disconnect the charging cable from the vehicle.

NOTE

Completion of charge by automatic termination of the Charge Algorithm, without fault, shall be considered 100% SOC for the RESS.

5.4 Charging Efficiency

This section provides guidance on the calculation of charging efficiencies for hybrid vehicles capable of grid connection. Charging efficiencies shall be calculated based upon conduct of rough road testing conducted in accordance with ETA-HTP05, "Hybrid Electric Vehicle Rough Road Course Test." The charging efficiency test shall be conducted over a two-day period. One complete rough road test shall be completed each day in accordance with ETA-HTP05, "Hybrid Electric Vehicle Rough Road Course Test."

5.4.1 Day One Testing

- 5.4.1.1 Ensure the vehicle is fully charged in accordance with Section 5.3.
- 5.4.1.2 Record vehicle mileage prior to conduct of ETA-HTP05, "Hybrid Electric Vehicle Rough Road Course Test."
- 5.4.1.3 Record charger kWh prior to conduct of ETA-HTP05, "Hybrid Electric Vehicle Rough Road Course Test."
- 5.4.1.4 Conduct ETA-HTP05, "Hybrid Electric Vehicle Rough Road Course Test."
- 5.4.1.5 Upon completion of testing, return the vehicle promptly to its designated Charge Station Location and place it on charge in accordance with Section 5.3.

5.4.2 Day Two Testing

- 5.4.2.1 Ensure the vehicle is fully charged in accordance with Section 5.3.
- 5.4.2.2 Record vehicle mileage prior to conduct of ETA-HTP05, "Hybrid Electric Vehicle Rough Road Course Test."

5.4.2.3 Record charger kWh prior to conduct of ETA-HTP05, "Hybrid Electric Vehicle Rough Road Course Test."

5.4.2.4 Conduct ETA-HTP05, "Hybrid Electric Vehicle Rough Road Course Test."

5.4.2.5 Upon completion of testing, return the vehicle promptly to its designated Charge Station Location and place it on charge in accordance with Section 5.3.

NOTE

The Kilowatt-hour meter reading taken in accordance with Section 5.4.3 is taken on day three and should be taken as near as practical to the time that the vehicle was taken off the charger on day one for conduct of rough road testing.

5.4.3 Charging Efficiency Calculation

5.4.3.1 Verify the vehicle is fully charged in accordance with Section 5.3.

5.4.3.2 Record vehicle mileage on Appendix A.

5.4.3.3 Record charger kWh on Appendix A.

5.4.3.4 Calculate the miles traveled during the two rough road tests.

5.4.3.5 Calculate the kWh consumed during the two rough road tests.

5.4.3.6 Calculate the vehicle charging efficiency as follows:

$$\text{Vehicle Charging Efficiency} = \frac{\text{Miles Traveled (5.4.3.4)}}{\text{Kilowatt-hours Consumed (5.4.3.5)}}$$

5.4.3.7 Using the Miles per kWh-AC calculated in Step 5.4.3.6, and a given rate of 10¢ per kWh-AC (an average daily rate sans demand charges), calculate the cost per mile to charge as follows:

$$\text{Cost per Mile} = (10¢ \text{ per kWh-AC} / \text{Miles per kWh-AC})$$

6. 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 HEV America – Hybrid Electric Vehicle America Performance Test Program, the DOE sponsored test program for independently assessing the performance of vehicles submitted for testing.
- 6.5 Initial State of Charge (SOC) - RESS SOC at the beginning of a test.
- 6.6 Program Manager - As used in this procedure, the individual within Electric Transportation Applications responsible for oversight of HEV America. [Subcontract organizations may have similarly titled individuals, but they are not addressed by this procedure.]
- 6.7 Rechargeable Energy Storage System (RESS) – A component or system of components that stores energy and for which its supply of energy is rechargeable by an electric motor-generator system, an off-vehicle energy source, or both. Examples of RESS's for HEVs include batteries, capacitors and electromechanical flywheels.
- 6.8 Shall - Items which require adherence without deviation. Shall statements identify binding requirements. A go, no-go criterion.
- 6.9 Should - Items which require adherence if at all possible. Should statements identify preferred conditions.
- 6.10 State of Charge (SOC) - State of Charge (SOC) - For vehicles operable in "RESS only mode," the SOC of the RESS is defined as the present capacity, (amperes-hours or watt-hours or miles), expressed 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 RESS when discharged to the requirements of the 45 mph Constant Speed Range Test portion of procedure ETA-HTP04.
- 6.11 Test Director - The individual within Electric Transportation Applications responsible for all testing activities associated with HEV America.
- 6.12 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.

- 6.13 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.]
- 6.14 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 HEV America. [Subcontract organizations may have similarly titled individuals, but they are not addressed by this procedure.]

7. References

- 7.1 HEV America Vehicle Specification
- 7.2 ETA-HAC01 - "Control, Close-out and Storage of Documentation."
- 7.3 ETA-HAC02 - "Control of Test Conduct."
- 7.4 ETA-HAC04 - "Review of Test Results"
- 7.5 ETA-HAC05 - "Certification and Training of Personnel Utilizing ETA Procedures."
- 7.6 ETA-HAC06 - "Receipt Inspection"
- 7.7 ETA-HTP05 - "Hybrid Electric Vehicle Rough Road Course Test"
- 7.8 ETA-HTP11 - "Vehicle Verification"

APPENDIX-A
Battery Charging Log
(Page 1 of ____)

Charging Station No.				Vehicle:			VIN:	
Date	Time	Connect/ Disconnect	Onboard SOC Indicator Status	Vehicle Odometer Reading	Battery Temp (°F)	Charger kWh Meter Reading	Comments	Initials

APPENDIX-B

Hybrid Vehicle Metrology Setup Sheets (Page 1 of 1)

VIN Number: _____

Instrument/Device:	Calibration Due Date:	Initials / Date:
Off-board kWh Meter:		
Volt Meter:		
DAS S/N:		
DAS Set-up Sheet S/N		
kWh Meter S/N:		
Shunt S/N:		
Misc:		
Misc:		
Misc:		
Misc:		
Misc:		
Comments (initials/date):		
Completed By:		
(Printed Name)	(Signature)	(Date)
Reviewed By (QA):		
(Printed Name)	(Signature)	(Date)
Approved By:		
(Printed Name)	(Signature)	(Date)