

ETA-GTP003

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Battery Capacity and Depth of Discharge Test

Prepared by

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1 Objective

This procedure identifies the proper method for conducting tests and evaluation of the battery capacity and depth of discharge limiting function for a tractor being tested during the eGSEV America Performance Test Program. It shall not supersede the testing protocols of the vehicle's manufacturer, nor is it meant to supersede those specifically addressed by SAE Test Standards, nor of any regulatory agency that may have or exercise control over the covered activities.

2 Purpose

The purpose of this procedure is to provide guidance on testing and evaluating the battery capacity and depth of discharge limiting system during the time the electric pushback tractor is being subjected to the eGSEV America Performance Test Program. This activity is meant to test the vehicle as a total system. Tests of specific subsystems or portions of individual subsystems are addressed by other test procedures, as appropriate. This testing and data acquisition meets the requirements specified in the eGSEV America Technical Requirements.

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-GAC004, "Review of Test Results." Storage and retention of records during and following testing activities shall be completed as described in ETA-GAC001, "Control, Close-out, and Storage of Documentation."

4 Initial Conditions and Prerequisites

Prior to conducting any portion of the testing, the following initial conditions and prerequisites shall be met. Satisfactory completion of these items shall be verified as complete and recorded on the appropriate Test Data Sheet.

- 4.1 Personnel conducting testing under this procedure shall be familiar with the requirements of this procedure, and when applicable, the appropriate SAE test instructions, administrative control procedures, and be certified by the Program Manager, Test Director, or Test Manager prior to commencing any testing activities.
- 4.2 Ambient temperature during testing shall be $>40^{\circ}\text{F}$ ($>5^{\circ}\text{C}$).

- 4.3 Battery temperatures at the beginning of testing shall be within a range of 60°F to 120°F (16°C to 49°C). Record in Appendix A.
- 4.4 Testing requiring a full charge at the start of the test shall be conducted after the battery has been charged with the manufacturer's recommended charging equipment and after that equipment has indicated a complete charge (GTP-005, Section 5.6).
- 4.5 Vehicles shall be tested in their normal configuration with normal standard equipment, appendages, and accessories.
- 4.6 Supplier's recommended lubricants shall be employed.
- 4.7 Accessories not required for safe operation shall not be used or operated during testing.
- 4.8 The overall error of recording or indicating instruments shall not exceed $\pm 2\%$ of the maximum value of the attribute being measured. Periodic calibration shall be performed and documented to ensure compliance with this requirement.
- 4.9 Complete or verify completed procedures ETA-GTP001, "Vehicle Verification," and ETA-GAC006, "Receipt Inspection," for the vehicle being tested.
- 4.10 The test surface type and condition (SAE J688), and lengths of test route shall be recorded in Appendix A.
- 4.11 For instrumentation used in the test, at a minimum, record the following information for each instrument in Appendix B:
 - 4.11.1 Supplier
 - 4.11.2 Model number
 - 4.11.3 Serial number
 - 4.11.4 Last calibration date
 - 4.11.5 Next calibration date.
- 4.12 Any deviation from the test procedure and the reason for the deviation shall be recorded in accordance with ETA-GAC002, "Control of Test Conduct."

- 4.13 Speed-time measuring devices and other necessary equipment shall be installed in a manner that does not hinder vehicle operation or alter the operating characteristics of the vehicle.
- 4.14 All steps shall be completed in the order written. Deviations from any step or requirement must have the prior written approval of the Program Manager, Test Director, or Test Manager in accordance with ETA-GAC002.
- 4.15 All documentation required to complete the testing identified in the contract/proposal/technical guidelines shall be completed, approved, and issued prior to the effective date of the procedure. In no case shall the procedure be utilized for official testing or data collection prior to its effective date.
- 4.16 Testing may take place over the course of several days. Page 1 of Appendix A shall be completed for each day testing is commenced.

5 Testing Activity

These tests evaluate and verify the tractor battery capacity and depth of discharge limiting system as required by the eGSEV America Technical Specification.

NOTE:

During this testing, if a vehicle fails electrically or mechanically for any reason other than a propulsion battery reaching its design depth of discharge (DOD) limit, testing of the vehicle shall be halted and the vehicle removed from the test program until the supplier has affected repairs. See ETA-GAC002 for additional details.

5.1 Test Preparation

Instrument the vehicle to obtain the following data:

- 5.1.1 Speed versus time
- 5.1.2 Distance versus time
- 5.1.3 Battery current
- 5.1.4 Battery voltage
- 5.1.5 Battery temperature.

5.2 Ambient Conditions

Record the following environmental conditions in Appendix A:

- 5.2.1 Range of ambient temperature during the test
- 5.2.2 Precipitation.

5.3 Battery Capacity Tests

- 5.3.1 The electrical system shall consist of an appropriate size and type traction battery pack. Verify this requirement by performing the following:
 - 5.3.1.1 With the battery pack at 100% state of charge, conduct the Static Drawbar Test as directed in ETA-GTP002, Section 5.4.2.
 - 5.3.1.2 Operate the tractor at maximum static drawbar until the traction system controller begins to cut or limit power or until the battery reaches the depth of discharge (SOC) specified by the tractor manufacturer.
 - 5.3.1.3 If an SOC indicator is supplied with the vehicle, record indicated SOC and Ahr discharged periodically during the discharge. At least ten data points shall be recorded to allow evaluation of the SOC indicator accuracy.
 - 5.3.1.4 The Ahr discharged during this test represents the capacity of the battery for all test conducted for the eGSEV America program.
- 5.3.2 The battery provided shall be of size and capacity to satisfy performance and accessory requirements.
 - 5.3.2.1 Conduct the tests as prescribed in ETA-GTP002, “Traction System Test”.
 - 5.3.2.2 If any requirement is determined to have not been met due to premature discharge of the battery pack or an undervoltage condition, then this requirement has not been met.

6 Glossary

- 6.1 Effective Date - After a procedure has been reviewed and approved, the first date the procedure can be utilized for official data collection and testing.
- 6.2 Fifth Wheel - A calibrated mechanical instrument used to measure a vehicle's speed and distance independent of the vehicles onboard systems.
- 6.3 Initial Conditions - Conditions that must exist prior to an event occurring.
- 6.4 Initial State of Charge (SOC) - The residual capacity of a battery after a discharge (full or partial) expressed as a percent of the total battery energy

capacity. This may be portrayed in ampere-hours, miles, or kilowatt-hours. Initial State of Charge is the SOC at the beginning of a test.

- 6.5 Prerequisites - Requirements that must be met or resolved prior to an event occurring.
- 6.6 Program Manager - As used in this procedure, the individual within Electric Transportation Applications responsible for oversight of the NEV America Performance Test Program. [Subcontract organizations may have similarly titled individuals, but they are not addressed by this procedure.]
- 6.7 Shall - This word is used to indicate an item that requires adherence without deviation. Shall statements identify binding requirements. A go, no-go criterion.
- 6.8 Should - This word is used to identify an item that requires adherence if at all possible. Should statements identify preferred conditions.
- 6.9 Summary Data Sheet - A stylized presentation of test results in the form shown in Appendix A.
- 6.10 Test Director - The individual within Electric Transportation Applications responsible for all testing activities associated with the NEV 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 that is 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.]
- 6.13 Test Manager - The individual within Electric Transportation Applications responsible for implementation of the test program for any given vehicle(s) being evaluated to the requirements of the NEV America Performance Test Program. [Subcontract organizations may have similarly titled individuals, but they are not addressed by this procedure.]

7 References

eGSEV America Vehicle Technical Specification Revision 0, December 1, 2005

ETA-GAC001, "Control, Close-out and Storage of Documentation"

ETA-GAC002, "Control of Test Conduct"

ETA-GAC004, "Review of Test Results"

ETA-GAC006, "Receipt Inspection"

ETA-GTP001, "Vehicle Verification"

ETA-GTP002, "Traction System Test"

Appendix A, Battery Capacity Test Data Sheet (Page 1 of 3)

Vehicle Number: _____

Project No.:	Test Date(s):
Root File No.:	
Test Engineer:	
(Initials)	(Date)

Track/Weather Conditions

Test Location:	Surface Type:
Ambient Temperature (initial): (≥40°F or 5°C)	Ambient Temperature (final): (≥40°F or 5°C)
Battery Temperature (initial): (°F or °C)	Battery Temperature (final): (°F or °C)
Battery Voltage (initial):	Battery Voltage (final): (<10 mph or 16 km/h)

Appendix B, Vehicle Metrology Setup Sheets

(Page 1 of 1)

Vehicle Number _____

Instrument/Device:	Calibration Due Date:	Initials / Date:
Fifth Wheel S/N:		
Fifth Wheel Calibrator S/N:		
DAQ S/N:		
DAQ Set-up Sheet S/N:		
kWh Meter S/N:		
Shunt S/N:		
Tire Pressure Gauge S/N:		
Accelerometer:		
Misc:		
Misc:		
Misc:		
Comments (initials/date):		
Completed By:		
<small>(Printed Name)</small>	<small>(Signature)</small>	<small>(Date)</small>
Reviewed By (QA):		
<small>(Printed Name)</small>	<small>(Signature)</small>	<small>(Date)</small>
Approved By:		
<small>(Printed Name)</small>	<small>(Signature)</small>	<small>(Date)</small>