

ETA-GTP005

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Battery Charger Performance

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1 Objective

This procedure provides a consistent protocol for evaluation of the performance of a battery charger and that charger's ability to satisfactorily recharge a vehicle's battery from any state of discharge. This procedure does not apply to equipment that is sold without a battery charger.

2 Purpose

The purpose of this procedure is to provide a traceable, quantifiable methodology for the collection and evaluation of electric vehicle charger data. This activity is meant to quantify results obtained from operation of the battery charger when charging the battery from a complete discharge and when operating in the float mode. 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 eGSEV America Vehicle Technical 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-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 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 accepted. 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 and required by the contract.]

- 4.3 A list of all instrumentation used in the test shall be identified in Appendix B, 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-GAC002, "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.
- 4.6 The performance of Total Harmonic Distortion (THD) testing is not required for Level I chargers.

5 Measurement of Battery Charger Parameters

The battery chargers shall be evaluated for their ability to recharge the main propulsion battery as required by the operations of the tractor, their power factor, their effect on supply line power quality, and the THD introduced by the charger. Several of these evaluations are completed concurrently and are described in the following sections.

- 5.1 Measuring the Charger Evaluation Parameters
 - Measurements of the following parameters shall be performed to complete the charger evaluations:
 - 5.1.1 AC input voltage
 - 5.1.2 AC input current
 - 5.1.3 Battery voltage
 - 5.1.4 DC current
 - 5.1.5 Ground current.

5.2 Measuring System Components

The measuring system shall have the following three main components:

- 5.2.1 Sensors, including potential transformers and AC and DC current transformers
- 5.2.2 Signal conditioners, including isolation amplifier and attenuator
- 5.2.3 Data acquisition system.

5.3 AC Input Parameters

The input AC parameters shall be measured using a potential transformer and current transformer for each phase as required by the charging equipment. The voltage signal shall be further reduced using attenuation through an isolation amplifier. The output of the amplifier shall then be fed to the acquisition system. The AC line current shall be measured using a clamp-on current transformer (CT) for each phase as required by the charging equipment, with a frequency response of at least DC to 400Hz.

5.4 DC Output Parameters

The DC voltage of the battery shall be measured using the proper attenuation in the isolation amplifier. The DC current shall be measured using an AC/DC CT with a frequency response of at least 0 to 2 kHz.

The signals are first passed through a signal conditioning and amplifier unit that provides the necessary signal levels for compatibility with the A/D converter. The program shall sample at a frequency of at least 21.6 kHz, acquiring at least 720 points per channel, and covering at least two cycles of the 60Hz waveform. This sampling frequency will ensure adequate resolution for the power quality measurements.

5.5 Calculated Parameters

Using the collected samples, the required parameters shall be calculated periodically and stored in a data file. The following parameters shall be calculated and logged in Appendix A:

- 5.5.1 V_{RMS} of the AC input voltage
- 5.5.2 I_{RMS} of the AC input voltage
- 5.5.3 THD of the AC input current
- 5.5.4 AC active power
- 5.5.5 True power factor
- 5.5.6 Battery voltage

- 5.5.7 DC value of the charging current
 - 5.5.8 Ampere-hours
 - 5.5.9 Watt-hours
 - 5.5.10 Charger efficiency (DC power out / AC power in).
- 5.6 Determination of the End-of-Charge Point for Vehicle Batteries
- The battery charger is considered to have charged the battery to 100% when all 3 of the following criteria are met:
- 5.6.1 The battery pack charging voltage has stopped increasing and has been stable to within one volt for a minimum of 1 hour, determined by a minimum of 7 consecutive readings taken a minimum of 10 minutes apart, AND
 - 5.6.2 The battery pack charging current has stopped decreasing and has been stable to within one ampere for a minimum of 1 hour, determined by a minimum of 7 consecutive readings taken a minimum of 10 minutes apart, AND
 - 5.6.3 The charger indicator shows that the charge is complete. This may be a meter reading, a light, a beeper, or the charger turning off, as specified by the vehicle supplier.
- 5.7 Charger Ground Leakage Current
- Within 15 minutes of initiating charge, the ground current shall be measured using a clamp-on CT, with a frequency response of at least DC to 400 Hz. This will require using a charge cord with the ground conductor separated to allow use of the clamp on the CT. The current shall be less than 20 mA.

6 Battery Charger Evaluation

This section provides detail on conducting the evaluation of the charger capability. Perform the following:

- 6.1 Discharge the main propulsion battery using onboard instrumentation to the minimum SOC allowed by the vehicle supplier. This may be accomplished by conducting the procedures in ETA-GTP003, “Battery Capacity and Depth of Discharge Test”, Section 5.3.
- 6.2 Within two hours of completing Step 6.1, place the vehicle on charge in accordance with the manufacturer’s instructions. Record the time the charger supply disconnect is closed.
- 6.3 Monitor the AC and DC parameters during the entire charge period per Section 5.1 through 5.5 of this procedure.

- 6.4 Determine the end of charge per Section 5.6 of this procedure and note the time.
- 6.5 Note the time the vehicle indication of full charge (if this time is different from the method specified in Section 5.6) shows the batteries fully charged—if equipped with a battery state of charge indicating device.
- 6.6 Plot the parameters listed in Section 5.5 of this procedure as a function of time.

7 Glossary

- 7.1 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.
- 7.2 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.]
- 7.3 Shall - Items that require adherence without deviation. Shall statements identify binding requirements. A go, no-go criterion.
- 7.4 Should - Items that require adherence if at all possible. Should statements identify preferred conditions.
- 7.5 Snapshot - A term given to the timeframe that normally accompanies a single event or a number of concurrent events. Usually indicates a repetitive series of events is occurring or is meant to occur.
- 7.6 State of Charge (SOC) - For this testing, the SOC of a battery is defined as the expected residual battery capacity, expressed in amperes-hours, 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-NTP004.
- 7.7 Test Director - The individual within Electric Transportation Applications responsible for all testing activities associated with the NEV America Performance Test Program.
- 7.8 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 that is published with the final report for each vehicle.

- 7.9 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.]
- 7.10 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.]
- 7.11 Time Stamp - The arbitrary time zero (t_0) denoting the beginning of an event.

8 References

eGSEV America Technical Specification

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

ETA-GAC002, "Control of Test Conduct"

ETA-GAC004, "Review of Test Results"

ETA-GTP003, "Battery Capacity and Depth of Discharge Test"

Appendix A, Charging Data Sheet

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Vehicle Number: _____

Project No:		Test Date:	
Root File Name:			
Test Engineer:			
(Initials)		(Date)	
Test Location:			
Ambient Temperature (initial):		Ambient Temperature (final):	
Battery Temperature (initial):		Battery Temperature (final):	
AC Voltage (RMS):	AC Current (RMS):	AC Power (RMS):	
Power Factor (%):		THD I (%):	
Max DC Current:	Max DC Voltage:	Max DC Power:	
Ampere-hours Delivered:		Watt-hours Delivered:	
Total Charge Time:			

