ETA-NTP005

Revision 2
Effective December 1, 2004

Electric Vehicle Rough Road Course Test

Prepared by

Electric Transportation Applications

Prepared by: _____ **Date:**_____
Ryan Harkins

Approved by: _____ **Date:** _____
Donald B. Karner

©2004 *Electric Transportation Applications* All Rights Reserved

TABLE OF CONTENTS

1.0	Objectives	3
2.0	Purpose	3
3.0	Documentation	3
4.0	Initial Conditions and Prerequisites	4
5.0	Testing Activity Requirements	6
6.0	Glossary	12
7.0	References	14

Appendices

Appendix A - Electric Vehicle Rough Road Test Data Sheet	15
Appendix B - Vehicle Metrology Setup Sheet	17

©2004 Electric Transportation Applications All Rights Reserved

1.0 Objective

The objective of this procedure is to identify the proper method for the control of Rough Road Course Testing being conducted as part of the NEV America Performance Test Program. These methods are not meant to supersede those of the testing facility, 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 test is to (1) accumulate standardized test-mileage on each vehicle over a test track that includes both rough road, water hazard and smooth track; (2) test the vehicles ability to endure extreme conditions in a short time frame; and (3) to collect energy use data for the determination of charging efficiency in accordance with ETA-NTP-008. This test is not intended to determine range or speed capabilities of any vehicle. No inferences concerning a vehicle's speed, range or gradeability characteristics should be drawn from this test. 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. This testing and data acquisition meets the requirements specified in the NEV 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, to be self-contained to the extent that all individuals qualified to review it could reasonably be 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-NAC004, "Review of Test Results." Storage and retention of records during and following testing activities shall be completed as described in Procedure ETA-NAC001, "Control, Close-out and Storage of Documentation."

4.0 Initial Conditions and Prerequisites

Prior to conduct of 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 Test Data Sheet.

©2004 Electric Transportation Applications All Rights Reserved

4.1 Personnel conducting testing under this procedure shall be familiar with the requirements of this procedure, and when applicable, any and all appropriate SAE Standards, Test Instructions and Administrative Control Procedures. They shall also be certified by the Program Manager or Test Director prior to commencing any testing activities.

4.2 Ambient temperature during road testing shall be >68˚F (>20˚C).

4.3 Battery temperature shall be >60˚F and ≤120˚F

4.4 The recorded wind speed at the test site during the test should not exceed 10 mph (16 km/h).

4.5 Testing shall be completed over a "rough road" course defined by Electric Transportation Applications which contains smooth asphalt, potholes, cobblestones, washboard and standing water. The test facility at Failure Analysis Associates (E^{x}ponent FaAA) in Phoenix has such features.

4.6 Speeds identified for each hazard have been determined to be the optimum speed for testing the vehicle at that hazard. Attempting to negotiate a hazard at a speed different than that identified should be avoided.

4.7 Vehicles shall be tested in their normal configuration with normal appendages (mirrors, bumpers, hubcaps, etc.). Certain items (hub caps, etc.) may be removed where necessary for safety.

4.8 Vehicles shall be loaded at curb weight plus 332 pounds.

4.9 Tires provided with the vehicle shall be the standard tire offered by the Electric Vehicle's manufacture. Tires shall be inflated to the manufacturer's recommended (placard) cold inflation pressure.

4.10 Manufacturer's recommended lubricants shall be employed.

4.11 The main propulsion battery shall be fully charged in accordance with the manufacturer's recommended charging procedure and equipment in accordance with ETA-NTP008, "Battery Charging."

4.12 Should the batteries require cycling, they shall be charged and discharged in accordance with the requirements of procedures ETA-NTP008, "Battery Charging," and ETA-NTP004, "Electric Vehicle Range at Steady Speed Test."

4.13 Overall error in recording or indicating instruments shall not exceed ±2% of the maximum value of the variable being measured unless otherwise excepted. Periodic calibration shall be performed and documented to ensure compliance with this requirement.

4.14 Complete or verify completed Procedures ETA-NAC006, "Verification Procedure," and ETA-NTP011, "Receipt Inspection."

©2004 Electric Transportation Applications All Rights Reserved

4.15 The road surface type and condition (SAE J688), and lengths and grades of test route shall be noted.

4.16 Instrumentation used in the test shall be identified on Appendix B, and attached to the test results. It shall include the following information:

4.16.1 Manufacturer
4.16.2 Model Number
4.16.3 Serial Number
4.16.4 Last Calibration date
4.16.5 Next Calibration date

4.17 Any deviation from the test procedure and the reason for the deviation shall be approved in advance and so noted on the appropriate data sheet(s).

4.18 Any necessary equipment shall be installed in a manner that does not hinder vehicle operation or alter the operating characteristics of the vehicle.

4.19 Accessories shall not be used during the rough road testing.

4.20 Speeds for each hazard or groups of hazards shall be posted on the test track in a manner which allows the driver(s) to achieve the required speed prior to encountering the hazard.

4.21 Prior to the initial test sequence, the vehicle's underside shall have been inspected to identify pre-existing damage. Any damage shall have been recorded in writing. Photographs may be taken to document the conditions.

4.22 Subsequent to each completed test cycle, the vehicle's underside shall again be inspected to ascertain any additional damage resulting from conduct of the test. Any additional damage shall be recorded in the Comments Section.

5.0 Rough Road Testing

CAUTION

Deviations from these prescribed speeds can present a safety issue for vehicles. All vehicles should maintain posted speed. If any vehicle cannot maintain or achieve speed, it shall be removed from the course.

©2004 Electric Transportation Applications All Rights Reserved

CAUTION

Should any vehicle be unable to complete the requirements of the hazards or attain the required speed through the hazards, the driver of that vehicle shall move the test vehicle out of the test path.

NOTE

This procedure was written specifically for implementation at the Test Track at E^{x}ponent - Failure Analysis Associates in Phoenix, AZ. As such, hazards and appropriate speeds for negotiation of those hazards are specific, and must be adhered to. All steps shall be completed in the order written. These hazards and their appropriate speeds are listed here:

FRONT SIDE

3" Deep Random Chuck Holes	5 mph (8 km/h)
Sine Wave	10 mph (16 km/h)
Railroad Crossing	15 mph (24 km/h)
Perpendicular Dip	15 mph (24 km/h)
Diagonal Dip	15 mph (24 km/h)
Single Wheel Dip	15 mph (24 km/h)
1" Deep Random Chuck Holes	20 mph (32 km/h)
Adjustable Irregularities (tar strips)	25 mph (40 km/h)
Road Crown	25 mph (40 km/h)

BACK SIDE

1" Deep Random Chuck Holes	25 mph (40 km/h)
Belgian Blocks (cobblestone)	25 mph (40 km/h)
Railroad crossing	25 mph (40 km/h)
2” Standing Water	20 mph (32 km/h)

Note; If test speed exceeds maximum vehicle speed, use maximum vehicle speed

5.1 Record the VIN/Test number of the vehicle being tested on Appendix A.

5.2 Record the vehicle cold inflation tire pressure. Adjust the cold inflation tire pressure to the meet the requirements of the manufacturer’s placard, if necessary.

©2004 Electric Transportation Applications All Rights Reserved

5.3 Verify the traction battery is at the manufacturer's established 100% SOC. If not, charge the battery in accordance with the requirements of ETA-NTP008, "Battery Charging Procedure." Record the kWh reading of the charging meter.

NOTE

Care should be taken to ensure that the battery is at 100% SOC as the subsequent testing will be the basis of the charging efficiency calculation.

5.4 Record the following environmental conditions:

5.4.1 Ambient temperature;

5.4.2 Battery temperature (at the discretion of the Test Manager);

5.4.4 Wind velocity;

5.4.5 Wind direction;

5.4.6 Record vehicle mileage;

NOTE

If more than one vehicle is being tested, test vehicles shall maintain a nominal safe distance between themselves and the vehicle in front of them, in accordance with accepted standards.

NOTE

During this testing, if a vehicle fails electrically or mechanically for any reason other than a propulsion battery reaching its end of charge (as determined in Section 5.1 of procedure ETA-NTP004), that vehicle shall be removed from testing until such time as the manufacturer/builder can repair it. See procedure ETA-NAC002, "Control of Test Conduct" for additional details. Both days of testing shall be completed consecutively to allow charging efficiency to be properly calculated

NOTE

The test sequence for this procedure will be to complete a 6-hour soak; complete six stop/start evolutions; complete five laps through the rough road course, and then complete 2 laps at maximum speed. Specific direction is provided as follows.

©2004 Electric Transportation Applications All Rights Reserved

NOTE

When instructed to decelerate in Steps 5.4 through 5.18, the driver shall begin the deceleration approximately 45 feet prior to the stop sign. These deceleration points shall be marked on the test track.

NOTE

Vehicle odometer readings shall be recorded on Appendix A upon initiation and completion of testing.

5.5 Move the vehicle to the handling pad (E^{x}ponent FaAA) or similar area. If equipped with windows or window curtains, they shall be completely closed, except for the driver's and front passenger's windows, which may each be left open no more than one-half ($^{1}/_{2}$) inch. Vehicle shall be parked with the windshield facing South.

5.6 The vehicle shall be soaked for at least six hours, during which time it shall have been exposed to a minimum ambient temperature of at least 100°F for at least one hour of the six-hour soak. If ambient temperatures will not reach 100°F, the vehicle may be soaked in a suitable soak chamber at a minimum of 100°F for two hours before being moved to the handling pad in lieu of performing a soak on the handling pad. At the completion of this soak period, move the vehicle to the test track starting point.

5.7 From the starting point, smoothly accelerate the vehicle at maximum achievable acceleration to maximum speed, and continue approximately one (1) mile to the stop sign.

5.8 Decelerate the vehicle and bring it to a complete stop at the stop sign.

5.9 From the stop sign, rapidly accelerate the vehicle to maximum speed and continue approximately one (1) mile to the next stop sign.

5.10 Decelerate the vehicle and bring it to a complete stop at the stop sign. The first lap is complete.

5.11 From the stop sign, rapidly accelerate the vehicle to maximum speed and continue approximately one (1) mile to the next stop sign

5.12 Decelerate the vehicle and bring it to a complete stop at the stop sign.

5.13 From the stop sign, rapidly accelerate the vehicle to maximum speed and continue approximately one (1) mile to the next stop sign.

5.14 Decelerate the vehicle and bring it to a complete stop at the stop sign. The second lap is complete.

5.15 From the stop sign, rapidly accelerate the vehicle to maximum speed and continue approximately one (1) mile to the next stop sign

5.16 Decelerate the vehicle and bring it to a complete stop at the stop sign.

©2004 Electric Transportation Applications All Rights Reserved

5.17 From the stop sign, rapidly accelerate the vehicle to maximum speed and continue approximately one (1) mile to the next stop sign.

5.18 Decelerate the vehicle and bring it to a complete stop at the stop sign. The third lap is complete.

5.19 Stop-Start Portion of the test is complete.

5.20 From the Stop sign, accelerate the vehicle to 5 mph and negotiate the 3" deep random Chuck Holes.

5.21 After completing negotiation of the 3" Random Chuck Holes, smoothly accelerate the vehicle so as to enter the Sine Wave at 10 mph.

5.22 After completing negotiation of the sine wave, smoothly accelerate the vehicle so as to enter the Railroad Crossing at 15 mph.

5.23 After completing negotiation of the Railroad Crossing, maintain the vehicle speed so as to enter the Perpendicular Dip at 15 mph.

5.24 After completing negotiation of the Perpendicular Dip, maintain the vehicle speed so as to enter the Diagonal Dip at 15 mph.

5.25 After completing negotiation of the Diagonal Dip, maintain the vehicle speed so as to enter the Single Wheel Dip at 15 mph.

5.26 After completing negotiation of the Single Wheel Dip, smoothly accelerate the vehicle speed so as to enter the 1" Random Chuck Holes at 20 mph.

5.27 After completing negotiation of the 1" Random Chuck Holes, smoothly accelerate the vehicle speed so as to enter the Tie Down Area (simulated Tar Strips) at maximum speed.

5.28 After completing negotiation of the Tie Down Area (simulated Tar Strips), smoothly accelerate the vehicle speed so as to enter the High Crown Intersection at maximum speed.

5.29 After completing negotiation of the High Crown Intersection, maintain speed at maximum speed and negotiate the transition to the back side of the track.

5.30 Smoothly decelerate the vehicle so as to enter the 1" Random Chuck Holes at maximum speed.

5.31 Maintain speed so as to negotiate the Belgian Block section at maximum speed.

5.32 Maintain this vehicle speed so as to negotiate the Railroad Crossing section at maximum speed.

5.33 Smoothly decelerate the vehicle to a achieve a speed of 20 mph through the Shallow (≈2 inches) Water Bath.

©2004 Electric Transportation Applications All Rights Reserved

5.34 After completing negotiation of the Shallow Water Bath, smoothly accelerate the vehicle to maximum speed. Maintain this speed through the back turn.

5.35 Repeat steps 5.20 through 5.34, IN ORDER, until the vehicle has traveled five (5) laps (approximately 10 miles).

5.36 Following the Accelerate the vehicle to maximum speed, or its maximum attainable speed.

5.37 Drive the vehicle at maximum speed for 2 Laps (approximately 4 miles) or until the vehicle will not maintain 19 mph.

5.38 When the vehicle has completed 2 Laps at maximum speed, the first phase of this test is complete. Within 30 minutes of completing Section 5.37, move the vehicle to the charging area, place the vehicle on charge and record the following:

5.38.1 Within 15 minutes of placing the vehicle on charge, read and record the battery leakage current (battery-to-chassis). Current shall be less than 0.5 MIU.

5.38.1.1 Connect a test circuit as described in UL 2231-1 between the most positive propulsion circuit cable and chassis.

5.38.1.2 Using a voltmeter capable of accurately measuring low voltages (millivolts) measure the voltage across the circuit.

5.38.1.3 If the AC or DC readings are 0.5 MIU or greater, record the value and the non-compliance on a comment sheet.

5.38.1.4 Repeat Sections 5.38.1 through 5.38.3 with the test circuit connected between the most negative propulsion circuit cable and chassis.

5.38.2 Within 15 minutes of placing the vehicle on charge, read and record the charger AC ground current using the method described in ETA-NTP010 Section 5.7. Current shall be less than 5 mA. Record the results Appendix A.

©2004 Electric Transportation Applications All Rights Reserved

5.39 Following current checks, move the vehicle to the garage or similar area for inspection of the vehicle. Record or verify recorded the following data on Appendix A:

- 5.39.1 Date and time of test phase completion
- 5.39.2 SOC reading (energy consumed and percent)
- 5.39.3 Miles traveled / laps completed
- 5.39.4 Equipment failures, if any;
- 5.39.5 Equipment abnormalities, if any;
- 5.39.6 Damage to vehicle underside
- 5.39.7 Damage to any vehicle components
- 5.39.8 Battery leakage current
- 5.39.9 Driver Notes, if any

5.40 Subsequent to this inspection, move the vehicle to the charging station and recharge the vehicle's main propulsion batteries to 100% SOC in accordance with ETA-NTP008, "Battery Charging."

5.41 Following satisfactory recharge of the main propulsion batteries, repeat steps 5.2 through 5.39. If this is the second evolution of this procedure, the test is complete.

5.42 Return the vehicle to the charging area and place the vehicle on charge.

5.43 After the charge cycle has been completed, but in no instance sooner than the beginning of the next normal workday, record the total AC kWh of energy consumed by the vehicle from the start of charging following completion of the first cycle to completion of charging following the second test cycle. This energy will be used with ETA-NTP010 Section 8.0 to determine the energy consumption values for the vehicle identified on the Summary Data Sheet as "Charging Efficiency."

6.0 Glossary

©2004 Electric Transportation Applications All Rights Reserved

6.1 Battery Kilowatt-Hour Capacity - The capacity of a battery in ampere-hours determined as a function of the total distance traveled by the vehicle during performance of the Constant Speed Range Test portion of ETA-NTP004.

6.2 Curb Weight - The total weight of the vehicle including batteries, lubricants, and other expendable supplies but excluding the driver, passengers, and other payloads.

6.3 Effective Date - The date, after which a procedure has been reviewed and approved, that the procedure can be utilized in the field for official testing.

6.4 Gross Vehicle Weight Rating (GVWR) - The maximum design loaded weight of the vehicle specified by the manufacturer.

6.5 Initial Conditions - Conditions that shall exist prior to an event occurring.

6.6 Initial State of Charge (SOC) - The residual capacity in amperes-hours of a battery after a discharge (full or partial) expressed as a percent of the total battery ampere-hour capacity. Initial State of Charge is the SOC at the beginning of a test.

6.7 Prerequisites - Requirements that shall be met or resolved prior to an event occurring.

6.8 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.]

6.9 Shall - Items which require adherence without deviation. Shall statements identify binding requirements. A go, no-go criterion.

6.10 Should - Items which require adherence if at all possible. Should statements identify preferred conditions.

6.11 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 Constant Speed Range Test portion of procedure ETA-NTP004.

6.12 Test Director - The individual within Electric Transportation Applications responsible for all testing activities associated with the NEV America Performance Test Program.

6.13 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

©2004 Electric Transportation Applications All Rights Reserved

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.

6.14 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.]

6.15 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 NEV America Performance Test Program. [Subcontract organizations may have similarly titled individuals, but they are not addressed by this procedure.]

6.16 Test Weight - The weight of the vehicle as tested including driver, operator (if necessary), and all instrumentation.

7.0 References

7.1 NEV America Technical Requirements
Revision 1, April 15, 2002

©2004 Electric Transportation Applications All Rights Reserved

7.2 ETA-NAC001 - "Control, Close-out and Storage of Documentation"

7.3 ETA-NAC002 - "Control of Test Conduct"

7.4 ETA-NAC004 - "Review of Test Results"

7.5 ETA-NAC005 - “Training and Certification Requirements for Individuals Utilizing ETA Procedures”

7.6 ETA-NAC006 - "Vehicle Verification"

7.7 ETA-NAC007 - “Control of Measuring and Test Equipment”

7.8 ETA-NTP004 - "Electric Vehicle Range at Steady Speed"

7.7 ETA-NTP008 - “Battery Charging”

7.8 ETA-NTP011 - “Receipt Inspection”

7.9 SAE Standard J688

©2004 *Electric Transportation Applications* All Rights Reserved

APPENDIX-A
Electric Vehicle Rough Road
Test Data Sheet
(Page 1 of 2)

Vehicle Number: _____

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

Vehicle Setup

VEHICLE WEIGHTS AS TESTED WITH DRIVER & INSTRUMENTATION (Curb weight plus 332 pounds)			
Left Front: (lbs or kg)	Right Front: (lbs or kg)	Total Front: (lbs or kg)	Percent Front: %
Left Rear: (lbs or kg)	Right Rear: (lbs or kg)	Total Rear: (lbs or kg)	Percent Rear: %
		Total Weight: (lbs or kg)	

INSTALLED TIRES (Placard or sidewall whichever is less)			
Left Front		Right Front	
Pressure: (psi or kPa)	)	Pressure: (psi or kPa)	
Left Rear		Right Rear	
Pressure: (psi or kPa)		Pressure: (psi or kPa)	

Track/Weather Conditions

Test Track Location:	Track Grade: %
Ambient Temperature (initial): (≥90°F or 32°C)	Ambient Temperature (final): (≥90°F or 32°C)
Track Temperature (initial): (°F or °C)	Track Temperature (final): (°F or °C)
Wind Velocity (initial): (<10 mph or 16 km/h)	Wind Velocity (final): (<10 mph or 16 km/h)
Wind Direction (initial): °	Wind Direction (completion): °

©2004 Electric Transportation Applications All Rights Reserved

APPENDIX-A
Electric Vehicle Rough Road
Test Data Sheet
(Page 2 of 2)

Test Data Sheet

Sequence No: 1	File No.:	Direction of Travel:
Soak Time (initial): Chamber ☐ Pad ☐	Soak Time (final): Chamber ☐ Pad ☐	
Range Time (initial):	Range Time (final):	
Odometer (initial): (miles or kilometers)	Odometer (final): (miles or kilometers)	
Status of Charge (initial): (SOC,kWh,Ah)	Status of Charge (final): (SOC,kWh,Ah)	
Battery Temp (initial): (°F or °C)	Battery Temp (final): (°F or °C)	
Battery Leakage Current: + to Chassis: - to Chassis: (MIU AC/ MIU DC)	AC Ground Current: (mA)	
Comments (initials/date):		
Completed By: (Printed Name)	(Signature)	(Date)
Reviewed By: (Printed Name)	(Signature)	(Date)
Approved By: (Printed Name)	(Signature)	(Date)

©2004 Electric Transportation Applications All Rights Reserved

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: (Printed Name)	(Signature)	(Date)
Reviewed By (QA): (Printed Name)	(Signature)	(Date)
Approved By: (Printed Name)	(Signature)	(Date)

©2004 Electric Transportation Applications All Rights Reserved