

ETA-UTP007

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Road Course Handling Test

Prepared by

Electric Transportation Applications

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1.0 Objective

The objective of this procedure is to identify the proper method for the conduct of a Road Handling Course Test conducted as part of the UEV 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 determine the minimum time required for a vehicle to safely negotiate a SCCA-style Road Handling Course (gymkhana-style course). This procedure also tests the handling and maneuverability of an electric vehicle at different States of Charge (SOC) over a consistent course. This test is not intended to determine the range or speed capabilities of any vehicle. No inferences concerning the speed, range or gradeability characteristics of any vehicle 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 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

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 Road Course Handling Test Data Sheet.

- 4.1 Personnel conducting testing 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 testing activities.
- 4.2 Ambient temperature during road testing should be within the range of 40°F to 120°F (5°C to 53°C).
- 4.3 The recorded average wind speed at the test site during the test should not exceed 10 mph (16 km/h).
- 4.4 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.
- 4.5 The vehicle shall be tested at curb weight plus 332 pounds.
- 4.6 Manufacturer's recommended tires shall be used.
- 4.7 Manufacturer's recommended lubricants shall be employed.
- 4.8 For tests requiring a battery at X% State of Charge (SOC) at the start of testing, the required initial SOC will be established as follows:
 - 4.8.1 The battery shall be fully charged to the requirements of the battery manufacturer until the battery is at 100% SOC.
 - 4.8.2 The battery kilowatt-hour capacity (mileage based) shall be obtained from the 35 mph Constant Speed Range Test completed as part of ETA-UTP004.
 - 4.8.3 To achieve X% SOC, the battery will be discharged, by driving the vehicle on a test track at a constant speed of 35 mph until 1-X% capacity, measured in ampere-hours, kilowatt-hours or miles, have been removed from the battery.
 - 4.8.4 Tests conducted with the battery partially discharged at the test start should be initiated no more than 10 minutes after the desired initial state-of-discharge is reached.
- 4.9 Overall error in recording or indicating instruments shall not exceed $\pm 2\%$ 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.

- 4.10 Complete or verify completed procedures ETA-UAC006, “Vehicle Verification,” and ETA-UTP011, “Receipt Inspection.”
- 4.11 The road surface type and condition identified and the course route shall be noted. Grade shall be less than 1%.
- 4.12 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), in accordance with ETA-UAC002, “Control of Test Conduct.”
- 4.13 Accessories shall not be used during this test.
- 4.14 The driver of the vehicle being tested shall have driven at least fifteen practice laps on the specific course to become familiar with the layout of the course and to clean the track of debris. These practice laps may have been completed in an internal combustion vehicle or an electric vehicle.
- 4.15 The course shall be laid out in accordance with Appendix C.
- 4.16 The course shall be “swept” prior to commencement of testing for each vehicle. This sweeping may be completed mechanically, by picking up debris by hand, or by repetitive driving of the course. If repetitive driving of the course is used, then a visual inspection of the course shall be completed prior to any testing.
- 4.17 All documentation required to complete the testing identified in the UEV America Technical Requirements shall be completed, approved and issued prior to commencing the testing it addresses. In all cases, official testing and data collection shall not be commenced prior to the effective date of the procedures.
- 4.18 Any metrology used in the conduct of this test procedure shall be recorded on Appendix B.

5.0 Road Course Test

This test will determine the time in which a vehicle can safely negotiate a modified "road course." A single driver should be used for all test cycles over a common course. The course shall be set up and maintained throughout the UEV America Test Program. There are no pass or fail criteria for this test; only time datum.

This testing shall be conducted at three (3) different State of Charges (SOCs): 90% \pm 10%; 50% \pm 10% and 20% \pm 10%. The test at each SOC should be started at 100%, 60% and 30%, the high end of the tolerance. Starting at the higher SOC helps ensure sufficient battery capacity is available to conduct two runs at each level. Two runs will help ensure the driver is familiar with the vehicle characteristics at that SOC. The times of the two runs at each SOC shall be averaged to obtain the official speed at that SOC.

NOTE

All steps shall be completed in the order written. Deviations from any step or requirement shall have the prior written approval of the Test Manager or Test Engineer in accordance with Procedure ETA-UAC002, "Control of Test Conduct."

NOTE

During this testing, if the vehicle fails electrically or mechanically for any reason other than a propulsion battery reaching its design Depth of Discharge (DOD) limit, the vehicle shall be removed from this test area (and the test schedule) until the manufacturer can effect the necessary repairs. See ETA-UAC002, "Control of Test Conduct" for additional details.

- 5.1 The road course, including elapsed time counters-recorders, shall be set up on a rolled asphalt area. It shall be constructed using traffic cones or similar non-damaging devices. The course shall be constructed as shown in Appendix C.
- 5.2 Place/verify placement of the elapsed time counters as depicted on Appendix C.
- 5.3 Record the following environmental conditions.
 - 5.3.1 Range of ambient temperature during the test;
 - 5.3.2 Range of wind velocity during the test;
 - 5.3.3 Range of wind direction during the test;
- 5.4 Move the vehicle to the starting point on the track.
- 5.5 Verify the traction battery is at the manufacturer's established 100% SOC (90% \pm 10% SOC). If not, charge the battery to achieve this SOC.

- 5.6 When the driver is ready to commence the first run, the driver shall start the test by accelerating into the test course from the start line.
- 5.7 Maneuver the vehicle through the test course at the highest safe speed achievable.
- 5.8 After completion of the run, the vehicle shall be rapidly decelerated to a stop. Record or verify the recording of the elapsed time of the run on Appendix A.
- 5.9 The vehicle shall be returned to the starting area for the second run.
- 5.10 Verify the traction battery is at 90% \pm 10% SOC. If not, proceed to step 5.15. Otherwise continue to step 5.11.
- 5.11 Allow at least five minutes to pass prior to proceeding to the next run. This will allow time for the tires to cool down. Record the elapsed time and driver comments on Appendix A.
- 5.12 When the driver is ready to commence the next run, the driver shall start the test by accelerating into the test course from the start line.
- 5.13 Maneuver the vehicle through the test course at the highest safe speed achievable.
- 5.14 After completion of the run, the vehicle shall be decelerated to a stop. Record the elapsed time and any driver comments on Appendix A.
- 5.15 Move the vehicle to the staging area. Discharge the battery to 60% SOC by driving the vehicle on the test track at a constant speed of 35 mph. During this drive-off, no auxiliary loads (radio, heater, air conditioner, etc.) shall be operated.
- 5.16 Verify the traction battery is at the 60% SOC (50% \pm 10% SOC).
- 5.17 Allow at least five minutes to pass prior to proceeding to the next run. This will allow time for the tires to cool down. Record the elapsed wait time on Appendix A.
- 5.18 When the driver is ready to commence the next run, the driver shall start the test by accelerating into the test course.
- 5.19 Maneuver the vehicle through the test course at the highest safe speed achievable.
- 5.20 After completion of the run, the vehicle shall be decelerated to a stop. The driver shall record the elapsed time and any comments on Appendix A.
- 5.21 The vehicle shall be returned to the starting area for the next run.
- 5.22 Verify the traction battery is at 50% \pm 10% SOC. If not, proceed to step 5.27. Otherwise continue to step 5.23.

- 5.23 Allow at least five minutes to pass prior to proceeding to the next run. This will allow time for the tires to cool down. Record the elapsed wait time on Appendix A.
- 5.24 When the driver is ready to commence the next run, the driver will start the test by accelerating into the test course.
- 5.25 Maneuver the vehicle through the test course at the highest safe speed achievable.
- 5.26 After completion of the run, the vehicle shall be decelerated to stop. Record the elapsed time and any driver comments on Appendix A.
- 5.27 Move the vehicle to the staging area. Discharge the battery to 30% SOC by driving the vehicle on the test track at a constant speed of 35 mph. During this drive-off, no auxiliary loads (radio, heater, air conditioner, etc.) shall be operated.
- 5.28 Verify the traction battery is at the 30% SOC (20% \pm 10% SOC).
- 5.29 Allow at least five minutes to pass prior to proceeding to the next run. This will allow time for the tires to cool down. Record elapsed wait time on Appendix A.
- 5.30 When the driver is ready to commence the next run, the driver shall start the test by accelerating into the test course.
- 5.31 Maneuver the vehicle through the test course at the highest safe speed achievable.
- 5.32 After completion of the run, the vehicle shall be rapidly decelerated to a stop. Record the elapsed time and any driver comments on Appendix A.
- 5.33 The vehicle shall be returned to the starting area for the next run.
- 5.34 Verify the traction battery is at 20% \pm 10% SOC. If not, proceed to step 5.39. Otherwise continue to step 5.35.
- 5.35 Allow at least five minutes to pass prior to proceeding to the next run. This will allow time for the tires to cool down. Record the elapsed wait time on Appendix A.
- 5.36 When the driver is ready to commence the next run, the driver will start the test by accelerating into the test course.
- 5.37 Maneuver the vehicle through the test course at the highest safe speed achievable.
- 5.38 After completion of the run, the vehicle shall be rapidly decelerated to a stop. Record the elapsed time and any driver comments on Appendix A.
- 5.39 When the vehicle has completed running the course at all three SOCs, this test is complete. Record the following data on Appendix A:

- 5.39.1 Date and time of test phase completion
- 5.39.2 Kilowatt-hour indicator reading, in kilowatt-hours
- 5.39.3 Elapsed time for each run
- 5.39.4 Cones hit/dislodged during each run
- 5.39.5 Equipment failures, if any;
- 5.39.6 Equipment abnormalities, if any;
- 5.39.7 Driver Notes, if any

6.0 Glossary

- 6.1 Curb Weight - The total weight of the vehicle including batteries, lubricants, and other expendable supplies but excluding the driver, passengers, and other payloads.
- 6.2 Depth of Discharge (DOD) - As used in this procedure, the energy removed from the main propulsion battery expressed as miles, amp-hours or kilowatt-hours which represents a state of charge of the battery as a percentage of the total battery capacity.
- 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 Gross Vehicle Weight Rating (GVWR) - The maximum design loaded weight of the vehicle specified by the manufacturer.
- 6.5 Initial Conditions - Conditions that must exist prior to an event occurring.
- 6.6 Initial State of Charge (SOC) - The SOC at the beginning of a test.
- 6.7 Prerequisites - Requirements that must 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 UEV 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 35 mph Constant Speed Range Test portion of procedure ETA-UTP004, "Constant Speed Range Test."
- 6.12 Test Director - The individual within Electric Transportation Applications responsible for all testing activities associated with the UEV America Performance Test Program.

6.0 Glossary (continued)

- 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 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 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-UAC006, Revision 0 - "Vehicle Verification"
- 7.6 ETA-UAC007, Revision 0 - "Control of Measuring and Test Equipment"
- 7.7 ETA-UTP004, Revision 0 - "Electric Vehicle Constant Speed Range Test"
- 7.8 ETA-UTP005, Revision 0 - "Electric Vehicle Endurance Course Test"
- 7.9 ETA-UTP008, Revision 0 - "Battery Charging"
- 7.10 ETA-UTP011, Revision 0 - "Receipt Inspection"
- 7.11 SAE J1441, "Subjective Rating Scale for Vehicle Handling"

**APPENDIX-A
Road Course Handling Test
Data Sheet (Page 1 of 5)**

VIN 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: <small>(lbs or kg)</small>	Right Front: <small>(lbs or kg)</small>	Total Front: <small>(lbs or kg)</small>	Percent Front: %
Left Rear: <small>(lbs or kg)</small>	Right Rear: <small>(lbs or kg)</small>	Total Rear: <small>(lbs or kg)</small>	Percent Rear: %
		Total Weight: <small>(lbs or kg)</small>	
INSTALLED TIRES (Placard or sidewall whichever is less)			
Left Front		Right Front	
Pressure: <small>(psi or kPa)</small>		Pressure: <small>(psi or kPa)</small>	
Left Rear		Right Rear	
Pressure: <small>(psi or kPa)</small>		Pressure: <small>(psi or kPa)</small>	

Track/Weather Conditions

Test Track Location:	Track Grade: % <small>(<1%)</small>
Ambient Temperature (initial): <small>(40-120°F or 5-53°C)</small>	Ambient Temperature (final): <small>(40-120°F or 5-53°C)</small>
Wind Velocity (initial): <small>(<10 mph or 16 km/h)</small>	Wind Velocity (final): <small>(<10 mph or 16 km/h)</small>
Wind Direction (initial): °	Wind Direction (completion): °

**APPENDIX-A
Road Course Handling
Test Data Sheet (Page 2 of 5)**

VIN Number: _____ **Test Data Sheet (Traction Battery at 90%±10% SOC)**

Sequence No: 1	File No.:	Direction of Travel:
Time (initial):	Time (final):	
Odometer (initial): <small>(miles or kilometers)</small>	Odometer (final): <small>(miles or kilometers)</small>	
Status of Charge (initial): <small>(SOC,kWh,Ah)</small>	Status of Charge (final): <small>(SOC,kWh,Ah)</small>	
Battery Temp (initial): <small>(°F or °C)</small>	Battery Temp (final): <small>(°F or °C)</small>	
Comments (initials/date):		
Number of cones hit/dislodged: _____		
Elapsed Time: _____		
<i>Note: Allow at least 5 minutes to pass prior to proceeding to the next run.</i>		

(Traction Battery at 90% ±10% SOC)

Sequence No: 2	File No.:	Direction of Travel:
Time (initial):	Time (final):	
Odometer (initial): <small>(miles or kilometers)</small>	Odometer (final): <small>(miles or kilometers)</small>	
Status of Charge (initial): <small>(SOC,kWh,Ah)</small>	Status of Charge (final): <small>(SOC,kWh,Ah)</small>	
Battery Temp (initial): <small>(°F or °C)</small>	Battery Temp (final): <small>(°F or °C)</small>	
Comments (initials/date):		
Number of cones hit/dislodged: _____		
Elapsed Time: _____		
<i>Note: Allow at least 5 minutes to pass prior to proceeding to the next run.</i>		

**APPENDIX-A
Road Course Handling Test
Data Sheet (Page 3 of 5)**

VIN Number: _____ **(Traction Battery at 50% ±10% SOC)**

Sequence No: 3	File No.:	Direction of Travel:
Time (initial):	Time (final):	
Odometer (initial): <small>(miles or kilometers)</small>	Odometer (final): <small>(miles or kilometers)</small>	
Status of Charge (initial): <small>(SOC,kWh,Ah)</small>	Status of Charge (final): <small>(SOC,kWh,Ah)</small>	
Battery Temp (initial): <small>(°F or °C)</small>	Battery Temp (final): <small>(°F or °C)</small>	
Comments (initials/date):		
Number of cones hit/dislodged: _____		
Elapsed Time: _____		
<i>Note: Allow at least 5 minutes to pass prior to proceeding to the next run.</i>		

(Traction Battery at 50% ±10% SOC)

Sequence No: 4	File No.:	Direction of Travel:
Time (initial):	Time (final):	
Odometer (initial): <small>(miles or kilometers)</small>	Odometer (final): <small>(miles or kilometers)</small>	
Status of Charge (initial): <small>(SOC,kWh,Ah)</small>	Status of Charge (final): <small>(SOC,kWh,Ah)</small>	
Battery Temp (initial): <small>(°F or °C)</small>	Battery Temp (final): <small>(°F or °C)</small>	
Comments (initials/date):		
Number of cones hit/dislodged: _____		
Elapsed Time: _____		
<i>Note: Allow at least 5 minutes to pass prior to proceeding to the next run.</i>		

**APPENDIX-A
Road Course Handling Test
Data Sheet (Page 4 of 5)**

VIN Number: _____ **(Traction Battery at 20% ±10% SOC)**

Sequence No: 5	File No.:	Direction of Travel:
Time (initial):	Time (final):	
Odometer (initial): <small>(miles or kilometers)</small>	Odometer (final): <small>(miles or kilometers)</small>	
Status of Charge (initial): <small>(SOC,kWh,Ah)</small>	Status of Charge (final): <small>(SOC,kWh,Ah)</small>	
Battery Temp (initial): <small>(°F or °C)</small>	Battery Temp (final): <small>(°F or °C)</small>	
Comments (initials/date):		
Number of cones hit/dislodged: _____		
Elapsed Time: _____		
<i>Note: Allow at least 5 minutes to pass prior to proceeding to the next run.</i>		

(Traction Battery at 20% ±10% SOC)

Sequence No: 6	File No.:	Direction of Travel:
Time (initial):	Time (final):	
Odometer (initial): <small>(miles or kilometers)</small>	Odometer (final): <small>(miles or kilometers)</small>	
Status of Charge (initial): <small>(SOC,kWh,Ah)</small>	Status of Charge (final): <small>(SOC,kWh,Ah)</small>	
Battery Temp (initial): <small>(°F or °C)</small>	Battery Temp (final): <small>(°F or °C)</small>	
Comments (initials/date):		
Number of cones hit/dislodged: _____		
Elapsed Time: _____		
<i>Note: Allow at least 5 minutes to pass prior to proceeding to the next run.</i>		

**APPENDIX-B
Vehicle Metrology Setup Sheet
(Page 1 of 1)**

VIN Number: _____

Instrument/Device:	Calibration Due Date:	Initials / Date:
Fifth Wheel S/N:		
Fifth Wheel Calibrator S/N:		
DAS S/N:		
DAS Set-up Sheet S/N		
kWh Meter S/N:		
Shunt S/N:		
Tire Pressure Gauge S/N:		
Misc:		
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>

APPENDIX-C
Handling Course Layout
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