

ETA-HITP03

Revision 0

Effective November 1, 2004

Implementation of SAE J1634 May93 Fuel Economy Testing

Prepared by

Electric Transportation Applications

Prepared by: _____ Date: _____
Garrett Beauregard

Approved by: _____ Date: _____
Donald Karner

TABLE OF CONTENTS

1. Objectives	1
2. Purpose	1
3. Documentation Support	1
4. Initial Conditions and Prerequisites	1
5. Testing Activity Requirements	4
6. Road Load Simulation (Without Air Conditioning)	5
7. Road Load Simulation (With Air Conditioning)	8
8. Data Reduction and Acceptability Criteria	11
9. Glossary	11
10. References	12

Appendices

Appendix A - Metrology Usage Sheet	13
Appendix B - J1634 Data Sheet	14
Appendix C - J1634 Road Test Data Sheet	17
Appendix D - Sample Fuel Use Spreadsheet	19

1. Objective

The objective of this procedure is to provide methods for testing the fuel economy of vehicles participating in HICEV America. Testing is conducted in accordance with SAE Standard J1634, "Electric Vehicle Energy Consumption and Range Test Procedure" and includes tests both with and without air conditioning loads. These methods are not meant to supersede those of the testing facility, those specifically addressed by SAE Test Standards (except as noted) nor of any regulatory agency which may have or exercise control over the covered activities.

2. Purpose

The purpose of this procedure is to identify acceptable methods for the implementation of the test requirements of SAE-J1634. SAE-J1634 establishes uniform procedures for testing battery-powered electric vehicles through the Urban Driving Schedule (UDS) and Highway Fuel Efficiency Tests (HWFET). This procedure (ETA-HTP03, "Implementation of SAE J1634 May 93 - Electric Vehicle Energy Consumption and Range Test Procedure") establishes some requirements that are outside of the guidance of that SAE J1634. Additionally, this procedure authorizes deviations from some of the test requirements of the SAE J1634. These deviations are necessary to accomplish this test for hydrogen internal combustion engine vehicles and to assure that relative performance between vehicle types can be assessed. Deviations from SAE J1634 are clearly noted where they occur.

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-HIAC04, "Review of Test Results." Storage and retention of records during and following testing activities shall be completed as described in Procedure ETA-HIAC01, "Control, Close-out and Storage of Documentation."

4. Initial Conditions and Prerequisites

Prior to conduct of any portion of the testing, the following initial conditions and prerequisites should be met. Satisfactory completion of these items should be verified as complete and recorded on the 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 or the Test Manager/Engineer prior to commencing any testing activities.
- 4.2 Ambient temperatures during testing shall be $77^{\circ}\text{F} \pm 9^{\circ}\text{F}$ ($25^{\circ}\text{C} \pm 5^{\circ}\text{C}$).
- 4.3 Dynamometer Testing
 - 4.3.1 The load shall be programmable at various vehicle speeds to simulate vehicle road load versus speed characteristics.

- 4.3.2 Road load power settings shall be made based on SAE J1263 as described in ETA-HITP01 and this procedure.
- 4.3.3 The Dynamometer flywheel shall be engaged with the nearest available dynamometer inertia weight which equals or exceeds Gross Vehicle Weight Rating (GVWR). Weights which exceed the GVWR by more than 2% will be approved by the Program Manager or Test Director, as appropriate.
- 4.3.4 During dynamometer operation, a fixed speed cooling fan shall be positioned so as to direct cooling air to the front of the vehicle. The fan capacity in general shall not exceed 2.5 m³/s (5300 ft³/min). Auxiliary fans may be employed if needed to more closely duplicate on-road cooling conditions.
- 4.4 Vehicle shall be tested in its normal configuration with normal appendages (mirrors, bumpers, hubcaps, etc.). Certain items (hub caps, etc.) may be removed where necessary for safety on the dynamometer.
- 4.5 During dynamometer testing, vehicles may use tires which have had the tread “shaved” off. This reduces tire heating, tire squirm and prevents absorption of road load by the tires. **This is a departure from the requirements of SAE J1634.**
- 4.6 Dynamometer tire pressure shall be set as required to achieve consistent testing results and repeatability through the coastdown cycles. This will nominally be 50 psig (cold inflation pressure). This is different than the pressure used to establish the dynamometer road load power setting in ETA-HITP01. **This is a departure from the requirements of SAE J1634.**
- 4.7 Normal Supplier's recommended lubricants shall be employed.
- 4.8 Prior to dynamometer testing, vehicles shall have accumulated a minimum of 100 miles (300 miles recommended) by completing the requirements of procedures ETA-HITP004 and ETA-HITP005. **This is a departure from the requirements of SAE J1634.**
- 4.9 The following data shall be collected during conduct of the various tests specified by this procedure. Overall error in recording or indicating instruments shall not exceed $\pm 2\%$ of the maximum value of the variable being measured, or as specifically excepted elsewhere. Periodic calibration shall be performed and documented to ensure compliance with this requirement.
 - 4.9.1 Vehicle speed versus time
 - 4.9.2 Distance versus time
 - 4.9.3 Fuel consumption
- 4.10 The range of ambient temperature during the testing shall be recorded.
- 4.11 A description of the dynamometer load program shall be recorded.
- 4.12 The date, starting and ending times shall be recorded.
- 4.13 The beginning and ending vehicle odometer readings shall be recorded.

- 4.14 All instrumentation used in the test shall be listed on Appendix A and attached to the test data sheets/results and shall include the following information:
 - 4.14.1 Manufacturer
 - 4.14.2 Model Number
 - 4.14.3 Serial Number
 - 4.14.4 Last Calibration date
 - 4.14.5 Next Calibration date
- 4.15 Any deviation from the test procedure and the reason for the deviation shall be recorded in accordance with ETA-HIAC02, "Control of Test Conduct."
- 4.16 The speed-time measuring device and other necessary equipment shall be installed so they do not hinder vehicle operation or alter the operating characteristics of the vehicle.
- 4.17 A description of the dynamometer shall be recorded, including:
 - 4.17.1 Drum or roll diameter and number of tire contact points
 - 4.17.2 Road load power set points
 - 4.17.3 Dynamometer inertia weight
 - 4.17.4 Vehicle speed from dynamometer roll
- 4.18 No accessories, with the exception of air conditioning when required by the specific test procedure, shall be used during testing activities.
- 4.19 All documentation required to complete the testing shall be completed, approved and issued prior to commencing the testing it addresses.
- 4.20 A copy of test documentation and methodologies/instructions used for testing shall be included in the final test documentation program. This is in accordance with ETA-HIAC02, "Control of Test Conduct."
- 4.21 Verify that procedures ETA-HIAC06, "Vehicle Verification," and ETA-HITP11, "Receipt Inspection," have been, or are being, completed.
- 4.22 Portions of procedure ETA-HITP09, "Measurement and Evaluation of Magnetic Fields Generated by Electric Vehicles" shall be completed in conjunction with this procedure.
- 4.23 The volume of hydrogen consumed when testing vehicles shall be determined by measuring the pressure change in the fuel storage tank during testing. The test vehicle fuel storage tank shall be instrumented with a calibrated pressure gauge having an accuracy in the range of measurement of at least 2%.

5. Dynamometer Setup

The purpose of this section is to prepare the dynamometer for use in testing electric vehicles to the requirements of SAE J1634 as required in Section 6.

CAUTION

In this procedure, the dynamometer is started and run. ALL personnel shall exercise appropriate cautions while in the vicinity of both the Power Absorption Unit and the Roller Section.

NOTE

Activities necessary to complete the test are identified in the following sections. All items shall be completed, whether they are required by J1634 or not. Any section which cannot be completed shall be so annotated, along with the appropriate justification in accordance with ETA-HIAC02, "Control of Test Conduct."

NOTE

For this test, vehicles shall be loaded at curb weight plus 332 pounds.

- 5.1 Start up the vibration monitor and control computer.
- 5.2 Conduct an initial warm-up of the dynamometer.
- 5.3 Conduct and complete the speed calibration of the dynamometer.
- 5.4 Conduct the Torque Calibration process for the dynamometer system.
- 5.5 Calibrate the Data Acquisition System (DAS) used in conjunction with the Dynamometer system.
- 5.6 Prepare the vehicle to be tested as follows:
 - 5.6.1 Verify the vehicle is ballasted to curb weight plus 332 pounds (including the driver and test equipment).
 - 5.6.2 Install or verify that there are shaved tires installed on the test vehicle, as appropriate.
 - 5.6.3 Inflate the tires to a cold inflation pressure of 50 psig ± 0.5 psig. Record on Appendix B.
 - 5.6.4 Place the test vehicle on the dynamometer rollers, and center it on the rollers by slowly running it or turning the dynamometer rollers with the motor.
 - 5.6.5 If the vehicle will not center on the rollers, repeat step 5.6.4 until the vehicle is centered.
 - 5.6.6 Place fan(s) in front of the vehicle and turn them on. Fans should be placed to simulate road air flow, not to exceed 2.5 m³/s (5300 ft³/min).
 - 5.6.7 Attach tie-down straps to the vehicle.
 - 5.6.8 Place wheel chocks at the non-driving wheels.
 - 5.6.9 Hook up vehicle instrumentation leads to the DAS.

- 5.7 Determination of Dynamometer and Tire Parasitic Losses
 - 5.7.1 Place the vehicle in neutral.
 - 5.7.2 Set the inertial weight to the lowest appropriate weight. Record the weight on Appendix B.
 - 5.7.3 Using the motor on the dynamometer, run the vehicle for a minimum of ten minutes for tire warm-up.
 - 5.7.4 Record the tire temperatures on Appendix B.
 - 5.7.5 Using the dynamometer motor, accelerate the vehicle to 63 mph.
 - 5.7.6 Shift to neutral and coast to 9 mph.
 - 5.7.7 Record the tire temperatures and parasitic loss coefficients on Appendix B.
 - 5.7.8 Save the data on the DAS.
 - 5.7.9 Repeat this test at each applicable inertial weight. Record the inertial weights used and the results of each run on Appendix B.
- 5.8 Set up the dynamometer to achieve the desired coast-down times.
 - 5.8.1 Determine the coastdown time in the 55-45 mph speed range using an initial estimate of the A and C coefficients.
 - 5.8.2 If measured coastdown times are not within 1.5% of the desired coastdown times, adjust A and C as necessary until three consecutive coastdown times fall into the allowable 3% ($\pm 1.5\%$) range. Record the numerical results on Appendix B.
- 5.9 If the adjustment to A and C are greater than 3% from the initial calibration (the first time this procedure was conducted for the vehicle), an attempt to determine the cause of the “drift” should be undertaken. This evaluation should include both the vehicle and the dynamometer. It may be necessary to shave the tread off drive axle tires to achieve coastdown accuracy. If shaved tires are required, record such requirement in Appendix B.

6. Road Load Simulation (Without Air Conditioning Loads)

The purpose of this section is to determine the efficiency of an HICEV vehicle when subjected to the test schedules identified in SAE J1634 (May, 1993) and operated without air conditioning loads. This section selectively implements portions of SAE J1634 in support of this purpose. The actual dynamometer instructions are developed by the entity operating the dynamometer and shall be used in conjunction with this procedure. As such, this procedure may be used at any facility utilizing a Clayton IM-240 Electric Dynamometer.

This procedure performs SAE Standard J1634 testing at an ambient temperature of $77^{\circ}\text{F} \pm 9^{\circ}\text{F}$. The load cycles shall follow the combined UDS/HWFET road load schedule contained in SAE Standard J1634, May, 1993. Test room temperatures shall be controlled in accordance with existing facility instructions.

- 6.1 Conduct a warm-up of the dynamometer as follows:
 - 6.1.1 Verify that the proper inertia weight for the vehicle to be tested has been selected. Record this weight on Appendix C.
 - 6.1.2 Check the roller area and inform other people in the area that dynamometer operation is about to start.
 - 6.1.3 Verify that the rollers are clear of personnel and debris, cables, etc.
 - 6.1.4 Set the run time to at least 15 minutes and turn on the dynamometer motor. Monitor vibration levels for anomalies. Terminate operation if vibration levels exceed the manufacturer's/operator's recommended maximum or alert levels. Record the maximum allowable and achieved vibration levels on Appendix C.
- 6.2 Conduct a speed calibration of the dynamometer unit.
- 6.3 Conduct a torque calibration of the dynamometer and control system.
- 6.4 Conduct a calibration of the Data Acquisition System (DAS).
- 6.5 Conduct the SAE J1634 Road Load Simulation (without air conditioning) test as follows:
 - 6.5.1 Verify that the required ambient temperature in the test chamber has existed for at least 12 hours and that the vehicle has been in the test chamber for that entire period.
 - 6.5.2 Verify that the DAS instrumentation is connected.
 - 6.5.3 Verify that shaved tires are installed on the drive axle, if they are required to achieve coastdown accuracy in Section 5.9. Verify the test vehicle tires have a cold inflation pressure of 50 psig $\pm$ 0.5 psig. Record pressures on Appendix C.
 - 6.5.4 Turn on the cooling fan(s).
 - 6.5.5 Complete an initial tire warm-up for at least 15 minutes.
 - 6.5.6 Enter the final A and C coefficients into the dynamometer control system. These were obtained in Step 5.8 of this procedure.
 - 6.5.7 Record tire temperature on Appendix C.
 - 6.5.8 Record fuel pressure and temperature of the fuel tank to be used for dynamometer testing after soaking the vehicle for 4 hours in a constant temperature area. Tank temperature shall be measured by a thermocouple attached to the tank exterior approximately mid tank (long dimension). The temperature of the tank shall be within 1°C of the air temperature in the immediate vicinity of the tank and the air temperature approximately four (4) feet from the tank.
 - 6.5.9 Record ambient temperature of test room on Appendix C.
 - 6.5.10 Notify test vehicle driver that the test is about to begin.
 - 6.5.11 Verify that all accessories, including air conditioning are off.
 - 6.5.12 Begin the test sequence of the SAE J1634 May, 1993 Combined UDS/HWFET Road Load Cycle.

- 6.5.13 Monitor the driver's performance and note the time, odometer reading, speed and distance at which an excursion from the drive cycle occurs, as well as the reason(s) for any such excursions on Appendix C.
- 6.5.14 Operate the dynamometer through two Urban Drive Cycles (UDS) and two Highway Drive Cycles (HWFET).
- 6.5.15 Between the 1st and 2nd HWFET sections (~15 seconds), the vehicle key shall remain on and the brakes applied.
- 6.5.16 If the vehicle finishes the combined UDS and HWFET cycles without meeting the test termination criteria of Section 6.5.22, complete the following:
 - 6.5.16.1 Turn off the fan(s)
 - 6.5.16.2 Turn off the ignition key
 - 6.5.16.3 Wait ten (10) minutes. Record the times on Appendix C.
 - 6.5.16.4 Take tire temperatures. Record on Appendix C.
- 6.5.17 Restart the Dynamometer Road Load Test ten minutes after completing Section 6.5.19 and complete two UDS followed by two HWFET in accordance with Sections 6.5.13 through 6.5.19.
- 6.5.18 Upon completion of the test, record the following on Appendix C:
 - 6.5.18.1 Time of day
 - 6.5.18.2 Test elapsed time
 - 6.5.18.3 Odometer reading
 - 6.5.18.4 Dynamometer distance
 - 6.5.18.5 Total distance
 - 6.5.18.6 Distance to SAE J1634 Cutoff criteria
 - 6.5.18.9 Final tire temperatures.
- 6.6 Record fuel pressure and temperature of the fuel tank to be used for constant speed fuel economy testing after soaking the vehicle for 6 hours in the test chamber. Tank temperature shall be measured by a thermocouple attached to the tank exterior approximately mid tank (long dimension). The temperature of the tank shall be within 1°C of the air temperature in the immediate vicinity of the tank and the air temperature approximately four (4) feet from the tank.

Calculate the quantity (moles) of fuel consumed using the following formula.

$$\Delta n = (P_{initial} * V_{initial}) / (\zeta * R * T_{initial}) - (P_{final} * V_{final} / \zeta * R * T_{final})$$

where;

 - R = Universal Gas Constant
 - ζ = Compressability Factor
- 6.6.1 Calculate the quantity (gge) of fuel consumed using the following formula.

$$Q = \Delta n * EMW / ACC$$

where;

EMW = Effective Molecular Weight of the fuel

ACC = Average Conversion Constant for the fuel

select the appropriate EMW as follows;

- 6.6.2 Calculate the constant speed fuel economy (miles/gge) using the following formula.

$$FE = (ODOMETER_{initial} - ODOMETER_{final}) / Q$$

- 6.6.3 For convenience and accuracy, the equations used in Section 6.6 have been incorporated into a MicroSoft Excel® spreadsheet. The file name for this spreadsheet is "ETA-YTP002 (Fuel Use Calculator)" and is marked as Revision 0. A sample print from this spreadsheet is attached as Appendix E.

7. Road Load Simulation (With Air Conditioning Loads)

The purpose of this section is to determine the efficiency of an HEV vehicle when subjected to the test schedules identified in SAE J1634 (May 93) and operated with air conditioning loads. This section selectively implements portions of SAE J1634 in support of this purpose. The actual dynamometer instructions are developed by the entity operating the dynamometer and shall be used in conjunction with this procedure. As such, this procedure may be used at any facility utilizing a Clayton IM-240 Electric Dynamometer.

This procedure performs SAE Standard J1634 testing at an ambient temperature of 77°F ± 9°F. The load cycles shall follow the combined UDS/HWFET road load schedule contained in SAE Standard J1634, May93. Test room temperatures shall be controlled in accordance with existing facility instructions.

- 7.1 Conduct a warm-up of the dynamometer as follows:
 - 7.1.1 Verify that the proper inertia weight for the vehicle to be tested has been selected. Record this weight on Appendix C.
 - 7.1.2 Check the roller area and inform other people in the area that dynamometer operation is about to start.
 - 7.1.3 Verify that the rollers are clear of personnel and debris, cables, etc.
 - 7.1.4 Set the run time to at least 15 minutes and turn on the dynamometer motor. Monitor vibration levels for anomalies. Terminate operation if vibration levels exceed the manufacturer's/operator's recommended maximum or alert levels. Record the maximum allowable and achieved vibration levels on Appendix C.
- 7.2 Conduct a speed calibration of the dynamometer unit.
- 7.3 Conduct a torque calibration of the dynamometer and control system.
- 7.4 Conduct a calibration of the Data Acquisition System (DAS).

7.5 Conduct the SAE J1634 Road Load Simulation (with air conditioning) test as follows:

- 7.5.1 Verify that the required ambient temperature in the test chamber has existed for at least 12 hours and that the vehicle has been in the test chamber for that entire period.
- 7.5.2 Verify that the DAS instrumentation is connected.
- 7.5.3 Verify that shaved tires are installed on the drive axle, if they are required to achieve coastdown accuracy in Section 5.9. Verify the test vehicle tires have a cold inflation pressure of 50 psig ± 0.5 psig. Record pressures on Appendix C.
- 7.5.4 Turn on the cooling fan(s).
- 7.5.5 Complete an initial tire warm-up for at least 15 minutes.
- 7.5.6 Enter the final A and C coefficients into the dynamometer control system. These were obtained in Step 5.8 of this procedure.
- 7.5.7 Record tire temperature on Appendix C.
- 7.5.8 Record fuel pressure and temperature of the fuel tank to be used for constant speed fuel economy testing after soaking the vehicle for 4 hours in a constant temperature area. Tank temperature shall be measured by a thermocouple attached to the tank exterior approximately mid tank (long dimension). The temperature of the tank shall be within 1°C of the air temperature in the immediate vicinity of the tank and the air temperature approximately four (4) feet from the tank.
- 7.5.9 Record ambient temperature of test room on Appendix C.
- 7.5.10 Notify test vehicle driver that the test is about to begin.
- 7.5.11 Verify that all accessories, except air conditioning are off. Turn the air conditioning to maximum and open all windows in the vehicle and as many doors as can safely be opened.
- 7.5.12 Begin the test sequence of the SAE J1634 May93 Combined UDS/HWFET Road Load Cycle.
- 7.5.13 Monitor the driver's performance and note the time, odometer reading, speed and distance at which an excursion from the drive cycle occurs, as well as the reason(s) for any such excursions on Appendix C.
- 7.5.14 Operate the dynamometer through two Urban Drive Cycles (UDS) and two Highway Drive Cycles (HWFET).
- 7.5.15 Between the 1st and 2nd HWFET sections (~15 seconds), the vehicle key shall remain on with the air conditioning operating and the brakes applied.
- 7.5.16 If the vehicle finishes the combined UDS and HWFET cycles without meeting the test termination criteria of Section 7.5.22, complete the following:
 - 7.5.16.1 Turn off the fan(s)

- 7.5.16.2 Turn off the ignition key and the air conditioning
- 7.5.16.3 Wait ten (10) minutes. Record the times on Appendix C.
- 7.5.16.4 Take tire temperatures. Record on Appendix C.
- 7.5.17 Restart the Dynamometer Road Load Test ten minutes after completing Section 7.5.19 and complete two UDS followed by two HWFET in accordance with Sections 7.5.13 through 7.5.19.
- 7.5.18 Upon completion of the test, record the following on Appendix C:
 - 7.5.18.1 Time of day
 - 7.5.18.2 Test elapsed time
 - 7.5.18.3 Odometer reading
 - 7.5.18.4 Dynamometer distance
 - 7.5.18.5 Total distance
 - 7.5.18.6 Distance to SAE J1634 Cutoff criteria
 - 7.5.18.7 Final tire temperatures
 - 7.5.18.8 The weight of fuel consumed
- 7.6 Record fuel pressure and temperature of the fuel tank to be used for constant speed fuel economy testing after soaking the vehicle for 6 hours in the test chamber. Tank temperature shall be measured by a thermocouple attached to the tank exterior approximately mid tank (long dimension). The temperature of the tank shall be within 1°C of the air temperature in the immediate vicinity of the tank and the air temperature approximately four (4) feet from the tank.

Calculate the quantity (moles) of fuel consumed using the following formula.

$$\Delta n = (P_{initial} * V_{initial}) / (\zeta * R * T_{initial}) - (P_{final} * V_{final} / \zeta * R * T_{final})$$

where;

 - R = Universal Gas Constant
 - ζ = Compressability Factor
- 7.6.1 Calculate the quantity (gge) of fuel consumed using the following formula.

$$Q = \Delta n * EMW / ACC$$

where;

 - EMW = Effective Molecular Weight of the fuel
 - ACC = Average Conversion Constant for the fuel

select the appropriate EMW as follows;

- 7.6.2 Calculate the constant speed fuel economy (miles/gge) using the following formula.

$$FE = (ODOMETER_{initial} - ODOMETER_{final}) / Q$$

- 7.6.3 For convenience and accuracy, the equations used in Section 6.6 have been incorporated into a MicroSoft Excel® spreadsheet. The file name for this spreadsheet is "ETA-YTP002 Revision 0 (Fuel Use Calculator)". A sample print from this spreadsheet is attached as Appendix E.

8. Data Reduction and Acceptability Criteria

- 8.1 The requirements for data reduction are specifically addressed in Section 9 of SAE J1263. Refer to that standard when clarification for utilizing these techniques is required.
- 8.2 Acceptability requirements are presented in Section 9.4 of SAE J1634.
- 8.3 Distribution, Retention and destruction of all test documents shall be in accordance with the requirements identified in Procedure ETA-HIAC01, "Control, Close-out and Storage of Documentation."

9. Glossary

- 9.1 Data Reduction - The techniques for analyzing a set of coastdown data and the correction factors employed in the determination of the coefficients of the road load equation. These corrected coefficients are used to set up the dynamometer to match the 55-45 mph coastdown time targets.
- 9.2 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.
- 9.3 Effective Mass - The sum of the test mass and the effective inertia's of the driven and non-driven axles.
- 9.4 Gross Vehicle Weight Rating (GVWR) - The maximum design loaded weight of the vehicle specified by the Supplier.
- 9.5 HICEV America - Hydrogen Internal Combustion Engine Vehicle America Performance Test Program, the DOE sponsored test program for independently assessing the performance of vehicles submitted for testing.
- 9.6 Initial Conditions - Conditions that must exist prior to an event occurring.
- 9.7 Prerequisites - Requirements that must be met or resolved prior to an event occurring.
- 9.8 Program Manager - As used in this procedure, the individual within Electric Transportation Applications responsible for oversight of HICEV America.
- 9.9 Shall - Items which require adherence without deviation. Shall statements identify binding requirements. A go, no-go criterion.
- 9.10 Should - Items which require adherence if at all possible. Should statements identify preferred conditions.
- 9.11 Test Director - The individual within Electric Transportation Applications responsible for all testing activities associated with HEV America.

- 9.12 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.
- 9.13 Test Engineer - The individual(s) assigned responsibility for the conduct of any given test.
- 9.14 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.
- 9.15 Test Mass/Weight - The mass/weight of the vehicle as tested; including driver, operator (if necessary) and all instrumentation.

10. References

- 10.1 SAE Recommended Practice - "Road Load Measurement and Dynamometer Simulation Using Coastdown Techniques." - SAE J1263, Jun91
- 10.2 SAE Recommended Practice - "Electric Vehicle Energy Consumption and Range Test Procedure." SAE J1634, May93
- 10.3 HICEV America Vehicle Specification
- 10.4 ETA-HIAC01 - "Control, Close-out and Storage of Documentation"
- 10.5 ETA-HIAC02 - "Control of Test Conduct"
- 10.6 ETA-HIAC04 - "Review of Test Results"
- 10.7 ETA-HIAC05 - "Training and Certification Requirements For Personnel Utilizing ETA Procedures"
- 10.8 ETA-HIAC06 - "Receipt Inspection"
- 10.9 ETA-HITP04 - "HICE Vehicle Constant Speed Fuel Economy Test"
- 10.10 ETA-HITP11 - "Vehicle Verification"

APPENDIX-A
Vehicle Metrology Setup Sheets
(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		
Tire Pressure Gauge S/N:		
Fuel Pressure Gauge S/N:		
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)		

APPENDIX-B
SAE J1634 Test Data Sheet
(Page 1 of 3)

VIN Number: _____ A/C On ☐ AC Off ☐

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

Vehicle Setup

VEHICLE WEIGHT AS TESTED (Curb weight plus 332 pounds)			
Left Front:	Right Front:	Total Front:	Percent Front: %
(lbs or kg)	(lbs or kg)	(lbs or kg)	
Left Rear:	Right Rear:	Total Rear:	Percent Rear: %
(lbs or kg)	(lbs or kg)	(lbs or kg)	
Shaved Tires Required ☐ yes ☐ no		Total Weight:	
		(lbs or kg)	
COLD TIRE PRESSURE (50 psig $\pm$ 0.5 psig)			
Left Front:		Right Front	
(psig or kPa)		(psig or kPa)	
Left Rear		Right Rear	
(psig or kPa)		psig or kPa) (	

Determination of Dynamometer and Tire Parasitic Losses

Inertial Weight Setting:				
TIRE WARM-UP TEMPERATURES				
Left Front:		Right Front:		
(°F or °C)		(°F or °C)		
Left Rear:		Right Rear:		
(°F or °C)		(°F or °C)		
Parasitic Loss -V _____				
	Base			
C1				
C2				
C3				
C4				
Tire Temperatures [°F]				
	Base			
Left				
Right				

APPENDIX-B
SAE J1634 Test Data Sheet
(Page 2 of 3)

VIN Number: _____ A/C On ☐ AC Off ☐

Repeatability: _____

Parasitic Loss -V _____				
	Base			
C1				
C2				
C3				
C4				
Tire Temperatures [°F]				
	Base			
Left				
Right				
Parasitic Loss -V _____				
	Base			
C1				
C2				
C3				
C4				
Tire Temperatures [°F]				
	Base			
Left				
Right				
Parasitic Loss -V _____				
	Base			
C1				
C2				
C3				
C4				
Tire Temperatures [°F]				
	Base			
Left				
Right				

VIN Number: _____ A/C On ☐ AC Off ☐

This image shows a single sheet of white paper with horizontal blue or grey ruling lines. The lines are evenly spaced and run across the width of the page. There is no handwriting or other markings on the paper.

(Date)

(Date) _____

(Date) _____

APPENDIX-C
SAE J1634 Road Test
Data Sheet (Page 1 of 2)

VIN Number: _____ **A/C On** ☐ **AC Off** ☐

Inertial Weight Setting: (lb)	Maximum Allowable Vibration:
TIRE PRESSURES (50 psig $\pm$ 0.5 psig)	
Left Front: (psig or kPa)	Right Front (psig or kPa)
Left Rear (psig or kPa)	Right Rear (psig or kPa)
TIRE TEMPERATURES	
Left Front: (°F or °C)	Right Front: (°F or °C)
Left Rear: (°F or °C)	Right Rear: (°F or °C)
Test Room Ambient Temperature: (°F or °C)	
TIRE TEMPERATURES	
Left Front: (°F or °C)	Right Front: (°F or °C)
Left Rear: (°F or °C)	Right Rear: (°F or °C)
Time of Day:	Test Time:
Odometer Reading:	Total Distance:
FINAL TIRE TEMPERATURES	
Left Front: (°F or °C)	Right Front: (°F or °C)
Left Rear: (°F or °C)	Right Rear: (°F or °C)

Fuel Pressure: (after 4 hour constant temperature soak)

Time:	Distance:	Weight (lbs):	Comments:	Initials:
			Initial Fuel Pressure	
			Final Fuel Pressure	

Excursions from Drive Cycle

[illegible]

APPENDIX D

Sample Fuel Use Spreadsheet (Page 1 of 1)

SAMPLE

File Name: ETA-YTP002 (Fuel Use Calculator)
Calculations for Fuel Economy

Revision: 0

Assumptions	
Assumed LHV for H2	51,608 Btu/lb (LHV)
Assumed LHV for CH4	21,480 Btu/lb (LHV)
Assumed curve fit of Z for H2 (pressure in psi)	$Z=2E-12P^3+2E-8P^2+1E-5P+.9974$
Assumed curve fit of Z for CH4 (pressure in psi)	$Z=3E-8P^2-1E-4P+.9914$

Test Number	ETA-06-002
Test Date	6/3/03
Test Engineer	B.S.

Input Parameters

Input Gasoline Energy per Gallon	122,000	Btu/gallon (LHV)
Input Molar Percentage H2	0.3	%
Input Tank Volume	85	liters
Input Initial Pressure	3220	psig
Input Initial Temperature	81.0	°F
Input Final Pressure	1520	psig
Input Final Temperature	74.1	°F
Input Distance Traveled	60	Miles

Output Parameters

Initial Gasoline Gallons Equivalent	3.92	GGE
Final Gasoline Gallons Equivalent	1.65	GGE
Gasoline Gallons Equivalent Used	2.27	GGE
Miles Per Gasoline Gallon Equivalent	26.48	Miles per GGE

Calculations

H2 Mass Percentage	0.050847	%	
Initial Pressure	3220	psig	465796.8 psf
Z for H2	1.021526		
Z for CH4	0.918415		
Molar Ratio (H2/CH4)	0.428571		
Pressure Ratio (H2/CH4)	0.476687		
Partial Pressure of H2	1044.189	psi	150363.2 psf
Partial Pressure of CH4	2190.511	psi	315433.6 psf
Total Initial Pound Moles	1.760966		
Initial H2 Weight	1.05658	lbs	
Initial CH4 Weight	19.72282	lbs	
Initial Energy of H2	54527.97	Btu	
Initial Energy of CH4	423646.2	Btu	
Initial Total Energy	478174.2	Btu	
Final Pressure	1520	psig	220996.8 psf
Z for H2	1.006308		
Z for CH4	0.885032		
Molar Ratio (H2/CH4)	0.428571		
Pressure Ratio (H2/CH4)	0.487299		
Partial Pressure of H2	502.8294	psi	72407.43 psf
Partial Pressure of CH4	1031.871	psi	148589.4 psf
Total Final Pound Moles	0.742973		
Initial H2 Weight	0.445784	lbs	
Final CH4 Weight	8.321302	lbs	
Final Energy of H2	23006.02	Btu	
Final Energy of CH4	178741.6	Btu	
Final Total Energy	201747.6	Btu	

966 Perfect gas partial pressure (used for calculating Z)
2254 Perfect gas partial pressure (used for calculating Z)

456 Perfect gas partial pressure (used for calculating Z)
1064 Perfect gas partial pressure (used for calculating Z)