

# ETA-HTP03

Revision 0

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## Implementation of SAE J1634 May93 - “Electric Vehicle Energy Consumption and Range Test Procedure”

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## 1. Objective

The objective of this procedure is to provide methods for the testing of fuel economy of vehicles participating in HEV 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 hybrid electric 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-HAC04, "Review of Test Results." Storage and retention of records during and following testing activities shall be completed as described in Procedure ETA-HAC01, "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 HEV Test Modes
  - 4.2.1 Test vehicles that are capable of being driven in an operator selectable mode that uses only the Rechargeable Energy Storage System (RESS) shall be tested in that "RESS only mode."
  - 4.2.2 Test vehicles that are capable of being driven in an operator selectable mode that uses only the RESS, shall additionally be tested in their Supplier specified "normal operating mode". All "normal operating mode" tests will be conducted only at an Initial State of Charge (SOC) achieved by operating the vehicle for at least 5 miles (8 kilometers) at a constant speed of 35 mph (56 kph).
  - 4.2.3 Test vehicles that are not capable of selecting an "RESS only mode" shall only be tested in their "normal operating mode". All "normal operating mode" tests will be conducted only at an Initial State of Charge (SOC) achieved by operating the vehicle for at least 5 miles (8 kilometers) at a constant speed of 35 mph (56 kph).
- 4.3 Ambient temperatures during testing shall be  $77^{\circ}\text{F} \pm 9^{\circ}\text{F}$  ( $25^{\circ}\text{C} \pm 5^{\circ}\text{C}$ ).
- 4.4 RESS and engine temperatures at the beginning of testing shall be less than  $120^{\circ}\text{F}$ , and should be less than  $100^{\circ}\text{F}$ .
- 4.5 Dynamometer Testing
  - 4.4.1 The load shall be programmable at various vehicle speeds to simulate vehicle road load versus speed characteristics.
  - 4.4.2 Road load power settings shall be made based on SAE J1263 as described in ETA-HTP01 and this procedure.
  - 4.4.3 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.
  - 4.4.4 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  $2.5 \text{ m}^3/\text{s}$  ( $5300 \text{ ft}^3/\text{min}$ ).

Auxiliary fans may be employed if needed to more closely duplicate on-road cooling conditions.

- 4.5 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.
- 4.6 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.**
- 4.7 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-HTP01. **This is a departure from the requirements of SAE J1634.**
- 4.8 Normal Supplier's recommended lubricants shall be employed.
- 4.9 Prior to dynamometer testing, vehicles shall have accumulated a minimum of 100 miles (300 miles recommended) by completing the requirements of procedures ETA-HTP004 and ETA-HTP005. **This is a departure from the requirements of SAE J1634.**
- 4.10 For vehicles operable in "RESS only mode," full RESS charge should be established using the Supplier's recommended charging procedure and equipment in accordance with ETA-HTP08, “RESS Charging.”
- 4.11 For testing of vehicles in a "normal operating mode," the required 100% SOC shall be established by operating the vehicle at a constant speed of 35 (56 kph) mph for at least 5 miles (6 kilometers).
- 4.12 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.
  - 4.12.1 RESS voltage versus time
  - 4.12.2 RESS current versus time
  - 4.12.3 Vehicle speed versus time
  - 4.12.4 Distance versus time
  - 4.12.5 RESS temperature versus time

- 4.12.6 RESS power versus time
- 4.12.7 Fuel consumption
- 4.13 The range of ambient temperature during the testing shall be recorded.
- 4.14 A description of the dynamometer load program shall be recorded.
- 4.15 The date, starting and ending times shall be recorded.
- 4.16 The beginning and ending vehicle odometer readings shall be recorded.
- 4.17 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:
  - 4.17.1 Manufacturer
  - 4.17.2 Model Number
  - 4.17.3 Serial Number
  - 4.17.4 Last Calibration date
  - 4.17.5 Next Calibration date
- 4.18 Any deviation from the test procedure and the reason for the deviation shall be recorded in accordance with ETA-HAC02, "Control of Test Conduct."
- 4.19 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.
- 4.20 A description of the dynamometer shall be recorded, including:
  - 4.20.1 Drum or roll diameter and number of tire contact points
  - 4.20.2 Road load power set points
  - 4.20.3 Dynamometer inertia weight
  - 4.20.4 Vehicle speed from dynamometer roll
- 4.21 No accessories, with the exception of air conditioning when required by the specific test procedure, shall not be used during testing activities.
- 4.22 All documentation required to complete the testing shall be completed, approved and issued prior to commencing the testing it addresses.
- 4.23 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-HAC02, "Control of Test Conduct."

- 4.24 Verify that procedures ETA-HAC06, "Receipt Inspection," and ETA-HTP11, "Vehicle Verification," have been, or are being, completed.
- 4.25 Portions of procedure ETA-HTP09, "Measurement and Evaluation of Magnetic Fields Generated by Electric Vehicles" shall be completed in conjunction with this procedure.
- 4.26 The volume of liquid fuels consumed when testing vehicles in "normal operating mode" shall be determined by a weight method. The test vehicle shall be supplied from an external fuel tank. The tank shall be weighed before and immediately after testing. The quantity of fuel consumed shall be calculated using the density of the fuel and the weight of the fuel consumed during testing. The scale used for this measurement shall have an accuracy of at least 2% of the weight of the fuel tank after testing.

## 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-HAC02, "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  $\pm$ 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 m<sup>3</sup>/s (5300 ft<sup>3</sup>/min).
  - 5.6.7 Attach tie-down straps to the vehicle.
  - 5.6.8 Place wheel chocks at the non-driving wheels.

#### CAUTION

**High Voltage may be present. To prevent personnel injury or equipment damage, use extreme caution when hooking up instrumentation leads.**

- 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 3% ( $\pm 1.5\%$ ). 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.

## 6. Road Load Simulation (Without 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 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, May93. Test room temperatures shall be controlled in accordance with existing facility instructions.

### NOTE

Vehicles operable in "RESS only mode" will be tested in accordance with this Section 6 both in "RESS only mode" and in "normal operating mode." Vehicles not capable of operating in "RESS only mode" will only be tested in "normal operating mode."

- 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 the test vehicle has shaved tires installed with cold inflation tire pressures of 50 psig  $\pm$ 0.5 psig. Record 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 For vehicles operable in "RESS only mode," full RESS charge should be verified using the Supplier's recommended charging procedure and equipment in accordance with ETA-HTP08, "RESS Charging."
  - 6.5.9 For testing of vehicles in a "normal operating mode," verify that the required 100% SOC has been established by operating the vehicle at a constant speed of 35 (56 kph) mph for at least 5 miles (6 kilometers) either before the vehicle was placed in the test chamber or while operating on the dynamometer.

**NOTE**

The SOC indicator reading shall be recorded at each significant datum (F, 1/2, 1/4, E, etc.).

- 6.5.10 Record RESS SOC indicator reading on Appendix C.
- 6.5.11 The minimum RESS SOC to be allowed during the test shall be obtained from ETA-HAC06, "Receipt Inspection." Record this value on Appendix C.
- 6.5.12 Record ambient temperature of test room on Appendix C.
- 6.5.13 Notify test vehicle driver that the test is about to begin.
- 6.5.14 Verify that all accessories, including air conditioning are off.
- 6.5.15 Begin the test sequence of the SAE J1634 May93 Combined UDS/HWFET Road Load Cycle.
- 6.5.16 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.
- 6.5.17 Operate the dynamometer through two Urban Drive Cycles (UDS) and two Highway Drive Cycles (HWFET).
- 6.5.18 Between the 1<sup>st</sup> and 2<sup>nd</sup> HWFET sections (~15 seconds), the vehicle key shall remain on and the brakes applied.
- 6.5.19 If the vehicle finishes the combined UDS and HWFET cycles without meeting the test termination criteria of Section 6.5.22, complete the following:
  - 6.5.19.1 Turn off the fan(s)
  - 6.5.19.2 Turn off the ignition key
  - 6.5.19.3 Wait ten (10) minutes. Record the times on Appendix C.
  - 6.5.19.4 Take tire temperatures. Record on Appendix C.
- 6.5.20 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.

**NOTE**

For vehicles operating in "normal operating mode," testing is now complete, go to Section 6.5.23 of this procedure. For vehicles operating in "RESS only mode," continue testing at Section 6.5.21 of this procedure.

6.5.21 For vehicles operating in "RESS only mode," repeat Section 6.5.18 through 6.5.20 until the test termination criteria are met.

6.5.22 Testing shall terminate upon occurrence of the following:

- Sustained inability of the vehicle to attain or maintain speed; and
- Depletion of the vehicle RESS based on the Supplier's specification of minimum voltage identified in ETA-HAC06, "Receipt Inspection," or by the Test Director or Test Manager.

**This is a deviation from the requirements of SAE J1634.**

6.5.23 Upon completion of the test, record the following on Appendix C:

6.5.20.1 Time of day

6.5.20.2 Test time

6.5.20.3 Odometer reading

6.5.20.4 Dynamometer distance

6.5.20.5 Total distance

6.5.20.6 Distance to SAE J1634 Cutoff criteria

6.5.20.7 Distance to RESS depletion

6.5.20.8 Final SOC indicator reading

6.5.20.9 Final tire temperatures.

6.5.20.10 The weight of fuel consumed (for testing of vehicles in "normal operating mode")

6.5.24 Remove the vehicle from the dynamometer and secure the test chamber.

**NOTE**

RESS energy consumption may be calculated for the combined UDS-HWFET, a UDS cycle or a HWFET cycle. The equation is the same, but only the energy withdrawn during the test being evaluated should be used.

**NOTE**

Heat Engine energy consumption may be calculated for the combined UDS-HWFET, a UDS cycle or a HWFET cycle. The equation is the same, but only the energy withdrawn during the test being evaluated should be used.

- 6.6 Calculate the DC energy consumption in Wh/mi delivered by the RESS up to the point of test termination (where the test is officially terminated to the requirements of SAE J1634), using the following equation:
- 6.6.1 Using the official mileage from the test cycle, complete the following calculation:

$$\text{Vehicle DC Energy Consumption} = \frac{\text{DC Energy from RESS During Cycle (Wh)}}{\text{Distance Traveled (miles)}}$$

(with units of DC Wh/mile)

- 6.7 Calculate the AC energy consumption in Wh/mile in accordance with procedure ETA-HTP08, "RESS Charging."

**This is a departure from the requirements of SAE J1634, May93.**

- 6.8 Calculate the heat engine fuel consumption in mi/gal for the test mileage completed using the following equation:

- 6.8.1 Calculate the gallons of fuel consumed using the following calculation:

$$\text{Vehicle Fuel Consumption} = \frac{\text{Initial Fuel Weight - Final Fuel Weight (lbs)}}{\text{Fuel Density (lbs/gal)}}$$

(with units of gallons)

Fuel density shall be corrected to the average temperature of the test chamber for the twelve hours prior to testing.

- 6.8.2 Using the official mileage from the test cycle and the fuel consumption from Section 6.8.1, complete the following calculation:

$$\text{Vehicle Fuel Energy Consumption} = \frac{\text{Distance traveled (miles)}}{\text{Fuel consumed during test cycles (gal)}}$$

(with units of miles per gallon)

**NOTE**

Both RESS and heat engine energy consumption shall be calculated for tests conducted in "normal operating mode" and both values shall be reported, unless the RESS energy is less than 2% of the heat engine energy

**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  $77^{\circ}\text{F} \pm 9^{\circ}\text{F}$ . The load cycles shall follow the combined UDS/HWFET road load schedule contained in SAE Standard J1634, May93. Test room temperatures shall be controlled in accordance with existing facility instructions.

**NOTE**

Vehicles operable in "RESS only mode" will be tested in accordance with this Section 6 both in "RESS only mode" and in "normal operating mode." Vehicles not capable of operating in "RESS only mode" will only be tested in "normal operating mode."

- 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 the test vehicle has shaved tires installed with cold inflation tire pressures of 50 psig  $\pm$ 0.5 psig. Record 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 For vehicles operable in "RESS only mode," full RESS charge should be verified using the Supplier's recommended charging procedure and equipment in accordance with ETA-HTP08, "RESS Charging."
  - 7.5.9 For testing of vehicles in a "normal operating mode," verify that the required 100% SOC has been established by operating the vehicle at a constant speed of 35 (56 kph) mph for at least 5 miles (6 kilometers) either before the vehicle was placed in the test chamber or while operating on the dynamometer.

**NOTE**

The SOC indicator reading shall be recorded at each significant datum (F, 1/2, 1/4, E, etc.).

- 7.5.10 Record RESS SOC indicator reading on Appendix C.
- 7.5.11 The minimum RESS SOC to be allowed during the test shall be obtained from ETA-HAC06, "Receipt Inspection." Record this value on Appendix C.
- 7.5.12 Record ambient temperature of test room on Appendix C.
- 7.5.13 Notify test vehicle driver that the test is about to begin.

- 7.5.14 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.
- 7.5.15 Begin the test sequence of the SAE J1634 May93 Combined UDS/HWFET Road Load Cycle.
- 7.5.16 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.
- 7.5.17 Operate the dynamometer through two Urban Drive Cycles (UDS) and two Highway Drive Cycles (HWFET).
- 7.5.18 Between the 1<sup>st</sup> and 2<sup>nd</sup> HWFET sections (~15 seconds), the vehicle key shall remain on with the air conditioning operating and the brakes applied.
- 7.5.19 If the vehicle finishes the combined UDS and HWFET cycles without meeting the test termination criteria of Section 7.5.22, complete the following:
- 7.5.19.1 Turn off the fan(s)
- 7.5.19.2 Turn off the ignition key and the air conditioning
- 7.5.19.3 Wait ten (10) minutes. Record the times on Appendix C.
- 7.5.19.4 Take tire temperatures. Record on Appendix C.
- 7.5.20 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.

#### NOTE

For vehicles operating in "normal operating mode," testing is now complete, go to Section 7.5.23 of this procedure. For vehicles operating in "RESS only mode," continue testing at Section 7.5.21 of this procedure.

- 7.5.21 For vehicles operating in "RESS only mode," repeat Section 7.5.18 through 7.5.20 until the test termination criteria are met.
- 7.5.22 Testing shall terminate upon occurrence of the following:
- Sustained inability of the vehicle to attain or maintain speed; and



- Depletion of the vehicle RESS based on the Supplier's specification of minimum voltage identified in ETA-HAC06, "Receipt Inspection," or by the Test Director or Test Manager.

**This is a deviation from the requirements of SAE J1634.**

- 7.5.23 Upon completion of the test, record the following on Appendix C:
- 7.5.20.1 Time of day
  - 7.5.20.2 Test time
  - 7.5.20.3 Odometer reading
  - 7.5.20.4 Dynamometer distance
  - 7.5.20.5 Total distance
  - 7.5.20.6 Distance to SAE J1634 Cutoff criteria
  - 7.5.20.7 Distance to RESS depletion
  - 7.5.20.8 Final SOC indicator reading
  - 7.5.20.9 Final tire temperatures.
  - 7.5.20.10 The weight of fuel consumed (for testing of vehicles in "normal operating mode")
- 7.5.24 Remove the vehicle from the dynamometer and secure the test chamber.

**NOTE**

RESS energy consumption may be calculated for the combined UDS-HWFET, a UDS cycle or a HWFET cycle. The equation is the same, but only the energy withdrawn during the test being evaluated should be used.

**NOTE**

Heat Engine energy consumption may be calculated for the combined UDS-HWFET, a UDS cycle or a HWFET cycle. The equation is the same, but only the energy withdrawn during the test being evaluated should be used.

- 7.6 Calculate the DC energy consumption in Wh/mi delivered by the RESS up to the point of test termination (where the test is officially terminated to the requirements of SAE J1634), using the following equation:
- 7.6.1 Using the official mileage from the test cycle, complete the following calculation:

$$\text{Vehicle DC Energy Consumption} = \frac{\text{DC Energy from RESS During Cycle (Wh)}}{\text{Distance Traveled (miles)}}$$

(with units of DC Wh/mile)

- 7.7 Calculate the AC energy consumption in Wh/mile in accordance with procedure ETA-HTP08, "RESS Charging."

**This is a departure from the requirements of SAE J1634, May93.**

- 7.8 Calculate the heat engine fuel consumption in mi/gal for the test mileage completed using the following equation:

- 7.8.1 Calculate the gallons of fuel consumed using the following calculation:

$$\text{Vehicle Fuel Consumption} = \frac{\text{Initial Fuel Weight - Final Fuel Weight (lbs)}}{\text{Fuel Density (lbs/gal)}}$$

(with units of gallons)

Fuel density shall be corrected to the average temperature of the test chamber for the twelve hours prior to testing.

- 7.8.2 Using the official mileage from the test cycle and the fuel consumption from Section 7.8.1, complete the following calculation:

$$\text{Vehicle Fuel Energy Consumption} = \frac{\text{Distance traveled (miles)}}{\text{Fuel consumed during test cycles (gal)}}$$

(with units of miles per gallon)

#### NOTE

Both RESS and heat engine energy consumption shall be calculated for tests conducted in "normal operating mode" and both values shall be reported, unless the RESS energy is less than 2% of the heat engine energy

## 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-HAC01, "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 HEV America – Hybrid Electric 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 Initial State of Charge (SOC) - RESS SOC at the beginning of a test.
- 9.8 Prerequisites - Requirements that must be met or resolved prior to an event occurring.
- 9.9 Program Manager - As used in this procedure, the individual within Electric Transportation Applications responsible for oversight of HEV America. [Subcontract organizations may have similarly titled individuals, but they are not addressed by this procedure.]
- 9.10 Rechargeable Energy Storage System (RESS) – A component or system of components that stores energy and for which its supply of energy is rechargeable by an electric motor-generator system, an off-vehicle energy source, or both. Examples of RESS's for HEVs include batteries, capacitors and electromechanical flywheels.
- 9.11 Shall - Items which require adherence without deviation. Shall statements identify binding requirements. A go, no-go criterion.
- 9.12 Should - Items which require adherence if at all possible. Should statements identify preferred conditions.

- 9.13 State of Charge (SOC) - For vehicles operable in "RESS only mode," the SOC of the RESS is defined as the present capacity, (amperes-hours or watt-hours or miles), expressed 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 RESS when discharged to the requirements of the 45 mph Constant Speed Range Test portion of procedure ETA-HTP04.
- 9.14 Test Director - The individual within Electric Transportation Applications responsible for all testing activities associated with HEV America.
- 9.15 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.
- 9.16 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.]
- 9.17 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. [Subcontract organizations may have similarly titled individuals, but they are not addressed by this procedure.]
- 9.18 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 HEV America Vehicle Specification
- 10.4 ETA-HAC01 - "Control, Close-out and Storage of Documentation"
- 10.5 ETA-HAC02 - "Control of Test Conduct"
- 10.6 ETA-HAC04 - "Review of Test Results"

- 10.7 ETA-HAC05 - "Training and Certification Requirements For Personnel Utilizing ETA Procedures"
- 10.8 ETA-HAC06 - "Receipt Inspection"
- 10.10 ETA-HTP04 - "Electric Vehicle Range at Steady Speed Test"
- 10.12 ETA-HTP08 - "RESS Charging"
- 10.13 ETA-HTP09 - "Measurement and Evaluation of Magnetic Fields Generated by Electric Vehicles",
- 10.15 ETA-HTP11 - "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		
kWh Meter S/N:		
Shunt S/N:		
Tire Pressure Gauge S/N:		
Fuel Scale 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  RESS Only  Normal

Project No.:	Test Date(s):
Root File No.:	
Test Driver: <small>(Initials) (Date)</small>	
Test Engineer: <small>(Initials) (Date)</small>	

**Vehicle Setup**

VEHICLE WEIGHT AS TESTED (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>	
COLD (SHAVED) TIRE PRESSURE (50 psig ±0.5 psig)			
Left Front: <small>(psig or kPa)</small>	Right Front <small>(psig or kPa)</small>		
Left Rear <small>(psig or kPa)</small>	Right Rear <small>psig or kPa (</small>		

**Determination of Dynamometer and Tire Parasitic Losses**

Inertial Weight Setting:			
TIRE WARM-UP TEMPERATURES			
Left Front: <small>(°F or °C)</small>	Right Front: <small>(°F or °C)</small>		
Left Rear: <small>(°F or °C)</small>	Right Rear: <small>(°F or °C)</small>		
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  RESS Only  Normal

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				





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

VIN Number: \_\_\_\_\_ A/C On  AC Off  RESS Only  Normal

Inertial Weight Setting: <small>(lb)</small>	Maximum Allowable Vibration:
<b>TIRE PRESSURES</b> (50 psig ±0.5 psig)	
Left Front: <small>(psig or kPa)</small>	Right Front <small>(psig or kPa)</small>
Left Rear <small>(psig or kPa)</small>	Right Rear <small>(psig or kPa)</small>
<b>TIRE TEMPERATURES</b>	
Left Front: <small>(°F or °C)</small>	Right Front: <small>(°F or °C)</small>
Left Rear: <small>(°F or °C)</small>	Right Rear: <small>(°F or °C)</small>
RESS State of Charge:	
Minimum Allowable RESS Voltage:	
Test Room Ambient Temperature: <small>(°F or °C)</small>	
<b>TIRE TEMPERATURES</b>	
Left Front: <small>(°F or °C)</small>	Right Front: <small>(°F or °C)</small>
Left Rear: <small>(°F or °C)</small>	Right Rear: <small>(°F or °C)</small>
Time of Day:	Test Time:
Odometer Reading:	Total Distance:
<b>FINAL TIRE TEMPERATURES</b>	
Left Front: <small>(°F or °C)</small>	Right Front: <small>(°F or °C)</small>
Left Rear: <small>(°F or °C)</small>	Right Rear: <small>(°F or °C)</small>

**Fuel Weight:**

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

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

**Excursions from Drive Cycle**

VIN Number: \_\_\_\_\_ A/C On  AC Off  RESS Only  Normal

<b>Time:</b>	<b>Speed:</b>	<b>Distance:</b>	<b>Comments:</b>	<b>Initials:</b>

**APPENDIX-D**  
**SAE J1634 Energy Efficiency Calculation**  
**Data Sheet**  
**(Page 1 of 1)**

VIN Number: \_\_\_\_\_ A/C On  AC Off  RESS Only  Normal

AC into the Charger: <small>(kWh)</small>	DC into the RESS: <small>(kWh)</small>
<p>Calculations (initials/date):</p> <p>System DC Energy Consumption = <math>\frac{\text{DC Energy from RESS While Driving}}{\text{Distance Traveled}}</math>                  (with units of DC Wh/mile)</p> <p>System DC Energy Consumption = _____ =                  (with units of DC Wh/mile)</p>	
<p>Completed By: _____  <small>(Printed Name) (Signature) (Date)</small></p>	
<p>Reviewed By: _____  <small>(Printed Name) (Signature) (Date)</small></p>	
<p>Approved By: _____  <small>(Printed Name) (Signature) (Date)</small></p>	