

ETA-HTP01

Revision 2

Effective February 1, 2008

Implementation of SAE Standard J2263

"Road Load Measurement Using Onboard Anemometry and Coastdown Techniques"

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 | 1 |
| 4. | Initial Conditions and Prerequisites | 1 |
| 5. | Testing Activity Requirements | 4 |
| 6. | Data Reduction and Acceptability Criteria | 6 |
| 7. | Glossary | 7 |
| 8. | References | 8 |

Appendices

| | |
|---|-----------|
| Appendix A - Vehicle Road Load Test Data Sheet | 9 |
| Appendix B - Metrology Usage Sheet | 15 |

1. Objective

The objective of this procedure is to provide methods for obtaining road load coefficients of vehicles participating in HEV America. Testing is conducted in accordance with recommended practice SAE J2263, "Road Load Measurement Using Onboard Anemometry and Coastdown Techniques." These methods are not meant to supersede those of the testing facility, those specifically addressed by SAE Test Standards, 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 J2263, and to provide a common format for the collection and retention of data for further use with SAE J1711, "Recommended Practice for Measuring Fuel Economy and Emissions of Hybrid-Electric and Conventional Heavy-Duty Vehicles." This procedure collects and retains this data to complete testing as specified in the "HEV America Vehicle Specification."

3. Documentation

Documentation addressed by this procedure shall be consistent, easy to understand, easy to read, and readily reproducible. This documentation contains enough information to "stand alone;" in other words, it is self-contained to the extent that all individuals qualified to review it could reasonably be expected to reach a common conclusion, without the need to review additional documentation. If review of outside documents is required, then it is reasonable to expect that all individuals would need to review those documents. Review and approval of test documents shall be in accordance with ETA-HAC04, "Review of Test Results." Close-out and storage 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 Vehicle Road Load Test Data Sheet (Appendix A).

- 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 and/or Test Manager prior to commencing any testing activities.
- 4.2 Tests should be conducted at ambient temperatures between 41°F (5°C) and 95°F (35°C).

- 4.3 Tests shall not be run during foggy conditions.
- 4.4 Tests shall not be conducted when wind speeds average more than 10 mph (16 km/h) (or when peak wind speeds are more than 12.3 mph (20 km/h). The average of the component of the wind velocity parallel to the test road shall not exceed 5 mph (8 km/h).
- 4.5 Roads shall be dry, clean, smooth, and must not exceed 0.5% grade. In addition, the grade should be constant and the road should be straight since variations in grade or straightness can significantly affect results. [The road surface should be concrete or rolled asphalt (or equivalent) in good condition since rough roads can significantly affect rolling resistance.]
- 4.6 The range of speeds over which the vehicle is coasted should be as wide as possible considering the length of the straightaway. The speed interval shall include 65 MPH (80 km/h) and should include the range of 75-5 MPH
- 4.7 Vehicles should have accumulated a minimum of 300 miles (500 km) prior to this testing. Actual mileage shall be recorded prior to starting testing.
- 4.8 Tires should have accumulated a minimum of 100miles (160km) and should have at least 75% of the original tread depth remaining. **This is a deviation from SAE Standard J2263.** All tire break-in shall be performed on the test vehicle. Tread depth will be recorded in 1/32 inch increments prior to start of test.
- 4.9 Vehicle tires shall be inflated to the Supplier's recommended cold inflation pressure as specified on the tire placard, corrected for the difference between ambient temperature and tire temperature. Record the actual inflation pressure and preparation area temperature on Appendix A. [Tire pressures will be increased 1 psi for each 13°F the preparation area is higher than the test area (or 1 kPa for each 1°C).]

NOTE

Tire sizes and inflation pressures shall be in accordance with the requirements of the placard. At no time shall the tire's cold inflation pressure exceed the maximum pressure imprinted upon the tire's sidewall.

4.10 Instrumentation

4.10.1 All instrumentation used during testing shall be calibrated. Information for all instrumentation used and their calibration dates shall be recorded on the Metrology Usage Sheet(s) contained in Appendix B.

4.10.2 All instrumentation shall have the accuracies and resolutions noted. Unless specifically excepted, at a minimum the following instrumentation shall be installed and employed during the testing:

4.10.2.1 Speed-time

- a) Accuracy $\pm 0.1\%$ of total coast down time
- b) Resolution of 0.1s
- c) Accuracy of ± 0.25 mph (0.4 km/h)
- d) Resolution of 0.1 mph (0.2 km/h)

4.10.2.2 Temperature

- a) The temperature indicating devices must have a resolution of 2°F (or 1°C) and an accuracy of $\pm 2^{\circ}\text{F}$ (or $\pm 1^{\circ}\text{C}$). The sensing element shall be shielded from radiant heat sources.

4.10.2.3 Atmospheric Pressure

- a) A barometer with an accuracy of ± 0.2 inches Hg or ± 0.7 kPa is necessary.

4.10.2.4 Wind

- a) Wind measurements should permit the determination of average longitudinal and cross wind components to within ± 1 mph (± 1.6 km/h).

4.10.2.5 Vehicle weight

- a) Accuracy requirement is ± 10 lb (± 5 kg) per axle

4.10.2.6 Tire Pressure

- a) Accuracy requirement is ± 0.5 psi (± 4 kPa).

4.11 Upon receipt of the vehicle for coast down testing, it should be "checked in". The following items shall be compared to Supplier's recommendations prior to the test:

4.11.1 Tire type, size, and cold inflation pressure as specified on the tire placard.

4.11.2 Wheel size, conditions, and presence of wheel covers.

- 4.11.3 Vehicle suspension heights (rocker panel to ground, front and rear). This is measured as detailed in Reference 8.2, SAE J1100, "Motor Vehicle Dimensions,". [The body height measurement needed for frontal area calculations shall be the curb weight plus 332 pound measurement obtained during the completion of procedure ETA-HAC06, "Receipt Inspection."]
- 4.12 The speed-time measuring device and other necessary equipment must be installed so that they do not hinder vehicle operation or alter the operating characteristics of the vehicle. Mounting shall be accomplished so as to not interfere with the tow vehicle, if used. Nominally, the device is mounted at the rear of the vehicle).
- 4.13 Vehicles shall be tested at delivered curb weight plus 332 pounds. Consideration should be given to how adding instrumentation will affect the test weight and balance of the vehicle. **This is a deviation from SAE Standard J2263.**
- 4.14 The vehicle frontal area must be estimated, using the formula provided in Appendix A. The suspension height used for this calculation shall be the height obtained in Step 4.11.3.
- 4.15 During the coast down portion of the test, lane changes shall be avoided. If a lane change occurs, it should be achieved over at least one-half mile, and should be noted in the comments section of the test record.
- 4.16 If the vehicle is equipped with regenerative braking, it should be disengaged from service for the duration of the testing. The manner in which it is disengaged should be noted on Appendix A.
- 4.17 All protocols, procedures and attendant documentation required to conduct this testing shall be completed, approved and issued prior to commencing the testing it addresses.

5. Test Activity Requirements

Activities necessary to complete the test are identified in the following sections. All items should be completed, whether they are required by J2263 or not. Any section which cannot be completed should be so annotated as required by ETA-HAC02, "Control of Test Conduct," along with the appropriate justification, on Appendix A. Data collection may be via a Data Acquisition System (DAS), in lieu of hand-written entries. Such data shall be transcribed in accordance with the requirements of procedures ETA-HAC02, "Control of Test Conduct," and ETA-HAC04, "Review of Test Results."

NOTE

A minimum of twelve runs shall be completed in alternating directions. The runs shall be paired in order to reduce error during data reduction. A pair consists of two consecutive runs in opposite directions.

NOTE

Unless otherwise noted, the following steps may be completed in any order.

- 5.1 Estimate the vehicle's frontal area, using the formula in Attachment A. Use the body height measurement for "Curb Weight plus 332 pounds" obtained during completion of procedure ETA-HAC06, "Receipt Inspection." Record on Appendix A. This step may be completed any time prior to data reduction.
- 5.2 Record the mileage from the odometer in Appendix A.
- 5.3 Verify the vehicle windows are closed. Record in Appendix A.
- 5.4 Verify that regenerative braking has been disengaged. Note the method by which this was done and record on Appendix A.

NOTE

If the vehicle's regenerative braking cannot be disengaged, obtain the concurrence of the Program or Test Manager prior to continuing. This shall be noted as a Test Exception.

- 5.5 Verify that the vehicle's drive train has been disengaged from the drive axle during the coast down. Note method of disengagement (clutch, electrical or mechanical neutral, etc.) Record on Appendix A.

NOTE

If the drive train cannot be disengaged from the drive axle, obtain the concurrence of the Program or Test Manager prior to continuing. This shall be noted as a Test Exception.

- 5.6 Verify vehicle tires are inflated to the Supplier's recommended cold inflation pressure as specified on the tire placard, corrected for the difference between ambient temperature and tire temperature. Record the actual inflation pressure and preparation area temperature on Appendix A. [Tire pressures shall be increased 1 psi for each 13°F the preparation area is higher than the test area (or 1 kPa for each Celsius degree).]

CAUTION

Tire sizes and inflation pressures shall be in accordance with the requirements of the placard. At no time shall the tire's

inflation pressure exceed the maximum pressure imprinted upon that tire's sidewall.

- 5.7 Verify and record the speed the DAS will be engaged at. This speed should be 5 mph (8 km/h) higher than the maximum desired coast down speed. At a minimum, record the following data on Appendix A:
 - 5.7.1 Sequence (run) number/computer file number of each run.
 - 5.7.2 Direction of each run.
 - 5.7.3 Vehicle speed as a function of time.
 - 5.7.4 Total wind, and either the wind direction or the cross-wind component of the total wind. Wind quantities shall be recorded, screened for gusts exceeding the ambient condition limits in section 4.4, and averaged.
- 5.8 Prior to the start of testing, the vehicle shall be operated on a warm-up cycle for a minimum of 30 minutes at 50 mph. Testing shall begin within 15 minutes of completing this operation. Should testing be suspended for a period greater than 30 minutes, the warm-up cycle shall be repeated.
- 5.9 At the start of each run, accelerate the test vehicle to 80 mph (128 km/h) or a speed of 5 mph (8 km/h) above the high point of the coast down speed range. Record on Appendix A.
- 5.10 Each run may be considered complete after the vehicle has decelerated to a speed of less than 5 mph (8 km/h). If the vehicle's speed will not decrease to less than this point, contact the Test Manager for assistance.
- 5.11 After completion of all of the test runs, collect the following data:
 - 5.10.1 The ambient temperature at the end of the test.
 - 5.10.2 Verify the vehicle weight package is still in place, and equal to 332 pounds including the driver and instrumentation.
- 5.12 After completing the final run, record the odometer reading in Appendix A.
- 5.13 Calculate vehicle Force vs. Velocity coefficients for the vehicle based on at least 3 pairs of separate runs.
- 5.14 Obtain the EPA coefficients if available for this make and model of vehicle. If the overall RMS of the data is less than .8 then an inquiry must be made in order to determine the reason for the deviation.

6. Data Reduction and Acceptability Criteria

- 6.1 The requirements for data reduction are specifically addressed in Section 10 of SAE J2263. Refer to this standard when clarification utilizing these techniques is required.

- 6.2 The acceptability requirements presented in Section 10.4 of SAE J2263 shall be used.
- 6.3 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."

7. Glossary

- 7.1 Curb Weight - The total weight of the vehicle as delivered including batteries, lubricants, and other expendable supplies but excluding the driver, passengers, and other payloads.
- 7.2 Data Reduction - The techniques for analyzing a set of coast down data and the correction factors employed in the determination of the coefficients of the road load equation. These corrected coefficients are used to calculate the time required to freely decelerate from 55 to 45 mph (88 to 72 km/h) on a chassis dynamometer.
- 7.3 Effective Date - The date, after which a procedure has been reviewed and approved, that the procedure can be utilized in the field for official testing.
- 7.4 Effective Mass - The sum of the test mass and the effective inertias of the driven and non-driven axles.
- 7.5 Fifth Wheel - A calibrated mechanical instrument used to measure a vehicle's speed and distance independent of the vehicles on-board systems.
- 7.6 Frontal Area - The area of the orthogonal projection of the vehicle including tires and suspension components onto the plane perpendicular to the longitudinal axis of the vehicle.
- 7.7 HEV America – Hybrid Electric Vehicle America Performance Test Program, the DOE sponsored test program for independently assessing the performance of vehicles submitted for testing.
- 7.8 Initial Conditions - Conditions that must exist prior to an event occurring.
- 7.9 Prerequisites - Requirements that must be met or resolved prior to an event occurring.
- 7.10 Program Manager - As used in this procedure, the individual responsible for oversight of HEV America.
- 7.11 Shall – Items which require adherence without deviation. Shall statements identify binding requirements. A go, no-go criterion.
- 7.12 Should - Items which require adherence if at all possible. Should statements identify preferred conditions.
- 7.13 Test Director - The individual responsible for all testing activities associated with HEV America.

- 7.14 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.
- 7.15 Test Engineer - The individual(s) assigned responsibility for the conduct of any given test. [Each contractor/subcontractor should have at least one individual filling this position. If so, they shall be responsible for adhering to the requirements of this procedure.]
- 7.16 Test Manager - The individual responsible for the implementation of the test program for any given vehicle(s) being evaluated to the requirements of HEV America.
- 7.17 Test Mass/Weight - The mass/weight of the vehicle as tested; including driver, operator (if necessary) and all instrumentation.

8. References

- 8.1 SAE Recommended Practice - "Road Load Measurement Using Onboard Anemometry and Coastdown Techniques." - SAE J2263, Issued October 1996."
- 8.2 SAE Recommended Practice - "Motor Vehicle Dimensions" SAE J1100a, Jun93
- 8.3 SAE Recommended Practice - "Recommended Practice for Measuring Fuel Economy and Emissions of Hybrid-Electric and Conventional Heavy-Duty Vehicles" SAE J1711, Issued September 2002.
- 8.4 HEV America Vehicle Specification
- 8.5 ETA-HAC01, "Control, Close-out and Storage of Documentation"
- 8.6 ETA-HAC02, "Control of Test Conduct"
- 8.7 ETA-HAC04, "Review of Test Results"
- 8.8 ETA-HAC06, "Receipt Inspection"
- 8.9 ETA-HTP11, "Vehicle Verification"

APPENDIX-A

Hybrid Vehicle Road Load Test Data Sheet (Page 1 of 6)

VIN Number: _____

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

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> | | |
| VEHICLE FRONTAL AREA ESTIMATION: | | | | |
| Suspension Heights: | Left Front: | Left Rear: | Right Front: | Right Rear: |
| $A=(0.8)(H101)(W103) \div 144$ Where as: H101 = Body Height (inches) measured according to J1100a W103 = Body Width (inches) measured according to J1100a | | | | |
| Vehicle Frontal Area = _____ | | | | |
| Preparation Area Temperature: _____ <small>(°F or °C)</small> | | | Warm-up Cycle Completed: ___ <small>(Yes) (No)</small> | |
| Left Front | | Right Front | | |
| Pressure: <small>(psi or kPa)</small> | Tread Depth: <small>(>75% of original depth (in or mm))</small> | Pressure: <small>(psi or kPa)</small> | Tread Depth: <small>(>75% of original depth (in or mm))</small> | |
| Left Rear | | Right Rear | | |
| Pressure: <small>(psi or kPa)</small> | Tread Depth: <small>(>75% of original depth (in or mm))</small> | Pressure: <small>(psi or kPa)</small> | Tread Depth: <small>(>75% of original depth (in or mm))</small> | |

**APPENDIX-A
Hybrid Vehicle Road Load Test Data Sheet (Page 2 of 6)**

VIN Number: _____

Track/Weather Conditions

| | | |
|---|---|--|
| Test Track Location: | | Track Grade: _____ % <small>(< 0.5%)</small> |
| Ambient Temperature (initial): <small>(30-90°F or -1-32°C)</small> | Ambient Temperature (final): <small>(30-90°F or -1-32°C)</small> | |
| Track Temperature (initial): <small>(°F or °C)</small> | Track Temperature (final): <small>(°F or °C)</small> | |
| Wind Velocity (initial): <small>(Average: <10 mph or 16 km/h)</small> | Wind Velocity (final): <small>(Average: <10 mph or 16 km/h)</small> | |
| Cross Wind Component: <small>(Average: <5 mph or 8 km/h)</small> | Cross Wind Component: <small>(Average: <5 mph or 8 km/h)</small> | |
| Wind Direction (initial): _____ ° | Wind Direction (completion): _____ ° | |
| Barometric Pressure (initial): <small>(inHg)</small> | Barometric Pressure (completion): <small>(inHg)</small> | |

Test Data “Coast Down Characteristics from 65-10 MPH (100-16 km/h)”

| | | | |
|---|------------------------|---|----------------------|
| Odometer (initial): <small>(miles or kilometers)</small> | | Odometer (final): <small>(miles or kilometers)</small> | |
| Vehicle windows closed: | (Yes) _____ (No) _____ | | |
| Regenerative breaking disabled: | (Yes) _____ (No) _____ | | |
| Drive train is disengaged: | (Yes) _____ (No) _____ | | |
| Sequence No: 1 | File No.: | Time: | Direction of Travel: |
| Comments (initials/date): | | | |
| Sequence No: 2 | File No.: | Time: | Direction of Travel: |
| Comments (initials/date): | | | |
| Sequence No: 3 | File No.: | Time: | Direction of Travel: |
| Comments (initials/date): | | | |
| Sequence No: 4 | File No.: | Time: | Direction of Travel: |
| Comments (initials/date): | | | |

APPENDIX-A
Hybrid Vehicle Road Load
Test Data Sheet (Page 3 of 6)

VIN Number: _____

Test Data (continued)

| | | | |
|---------------------------|-----------|-------|----------------------|
| Sequence No: 5 | File No.: | Time: | Direction of Travel: |
| Comments (initials/date): | | | |
| Sequence No: 6 | File No.: | Time: | Direction of Travel: |
| Comments (initials/date): | | | |
| Sequence No: 7 | File No.: | Time: | Direction of Travel: |
| Comments (initials/date): | | | |
| Sequence No: 8 | File No.: | Time: | Direction of Travel: |
| Comments (initials/date): | | | |
| Sequence No: 9 | File No.: | Time: | Direction of Travel: |
| Comments (initials/date): | | | |
| Sequence No: 10 | File No.: | Time: | Direction of Travel: |
| Comments (initials/date): | | | |
| Sequence No: 11 | File No.: | Time: | Direction of Travel: |
| Comments (initials/date): | | | |

APPENDIX-A
Hybrid Vehicle Road Load
Test Data Sheet (Page 4 of 6)

VIN Number: _____

Test Data (continued)

| | | | |
|---------------------------|-----------|-------|----------------------|
| Sequence No: 12 | File No.: | Time: | Direction of Travel: |
| Comments (initials/date): | | | |
| Sequence No: 13 | File No.: | Time: | Direction of Travel: |
| Comments (initials/date): | | | |
| Sequence No: 14 | File No.: | Time: | Direction of Travel: |
| Comments (initials/date): | | | |
| Sequence No: 15 | File No.: | Time: | Direction of Travel: |
| Comments (initials/date): | | | |
| Sequence No: 16 | File No.: | Time: | Direction of Travel: |
| Comments (initials/date): | | | |
| Sequence No: 17 | File No.: | Time: | Direction of Travel: |
| Comments (initials/date): | | | |
| Sequence No: 18 | File No.: | Time: | Direction of Travel: |
| Comments (initials/date): | | | |

APPENDIX-A
Hybrid Vehicle Road Load
Test Data Sheet (Page 5 of 6)

VIN Number: _____

Test Data (continued)

| | | | |
|---------------------------|-----------|-------|----------------------|
| Sequence No: 19 | File No.: | Time: | Direction of Travel: |
| Comments (initials/date): | | | |
| Sequence No: 20 | File No.: | Time: | Direction of Travel: |
| Comments (initials/date): | | | |
| Sequence No: 21 | File No.: | Time: | Direction of Travel: |
| Comments (initials/date): | | | |
| Sequence No: 22 | File No.: | Time: | Direction of Travel: |
| Comments (initials/date): | | | |
| Sequence No: 23 | File No.: | Time: | Direction of Travel: |
| Comments (initials/date): | | | |
| Sequence No: 24 | File No.: | Time: | Direction of Travel: |
| Comments (initials/date): | | | |
| Sequence No: 25 | File No.: | Time: | Direction of Travel: |
| Comments (initials/date): | | | |

APPENDIX-B
Hybrid 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: | | |
| Misc: | | |
| Comments (initials/date): | | |
| | | |
| Completed By: | | |
| <small>(Printed Name)</small> | <small>(Signature)</small> | <small>(Date)</small> |
| Reviewed By: | | |
| <small>(Printed Name)</small> | <small>(Signature)</small> | <small>(Date)</small> |
| Approved By: | | |
| <small>(Printed Name)</small> | <small>(Signature)</small> | <small>(Date)</small> |