



Center for Evaluation of Clean Energy Technology

# Test Specification – Coastdown Testing

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(CECET)**

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## Revision History Log

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## 1 Objective

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The objective of this Test Specification is to outline the method method for obtaining road load coefficients of vehicles participating in Advanced Vehicle Testing and Evaluation (AVTE) program or in other advanced vehicle testing activities. Testing is conducted in partial accordance with recommended practice SAE J1263, “Road Load Measurement and Dynamometer Simulation using Coastdown Techniques”. This Test Specification is to identify acceptable methods for the implementation of the test requirements of SAE J1263 and to provide a common format for the collection and retention of data for further use with SAE J1711, “Recommended Practice for Measuring the Exhaust Emissions and Fuel Economy of Hybrid-Electric Vehicles”. This Test Specification outlines the requirements for experimental conduct. The actual specific steps for the test conduct are listed and described in the associated Center for Evaluation of Clean Energy Technology (CECET) internal Work Instruction document.

## 2 Test Conduct

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Documentation resulting from usage of this Test Specification shall be consistent, easy to understand, easy to read and readily reproducible; all documentation required to complete testing shall be completed, approved and ready for issue prior to commencing the testing it addresses. The following will abide by company policy:

- Review and approval of test results
- Storage and retention of records during and following testing activities
- Recording of any deviation from the outlined procedures and the reason for the deviation

### 3 Initial Conditions & Prerequisites

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Prior to conduct of any portion of the testing, the following initial conditions and prerequisites shall be met. Satisfactory completion of these items should be verified.

#### 3.1 Personnel

Personnel conducting testing under this Test Specification, i.e., the Test or Project Engineer(s), shall be familiar with the requirements of this Test Specification, shall be trained in accordance with company policy, and shall be certified by a mandated reviewer prior to commencing any testing activities. This requirement includes training in all aspects of the Coastdown Testing, including its automatic shutdowns and safety procedures.

#### 3.2 Conditions and Prerequisites

- 3.2.1 During the data-collection 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.
- 3.2.2 There should be an even number of runs in the two track directions. If there is an unequal number, runs from the direction with the most runs will be discarded from the analysis in sufficient number to arrive at an equal number of runs in each direction.
- 3.2.3 At least 10 runs (5 in each direction) shall be included in the analysis.
- 3.2.4 The drivetrain shall be disengaged by placing the gear selector into neutral. If the drivetrain cannot be disengaged, the dynamometer mode shall be enabled, if possible. This may require special service settings for the vehicle controller. If the drivetrain cannot be disengaged and a dynamometer mode cannot be enabled, the torque and speed of the electric motor in an EV, PHEV, or HEV shall be monitored. If the torque and speed of the electric motor cannot be monitored, the current into/out of the battery and battery voltage shall be monitored.
- 3.2.5 Depending on the length of the straightaway, it may be necessary to perform two coastdown runs that are combined to cover the entire range of desired speeds. For example, if the vehicle has not reached the lowest speed by the end of the first run, a second run should be performed with a lower initial speed to ensure that the lowest speed can be achieved.

#### 3.3 Vehicle Conditions

- 3.3.1 Vehicles should have accumulated a minimum of 4,000 miles (6,450 km) prior to this testing. Actual mileage shall be recorded prior to starting testing.
- 3.3.2 Vehicles shall be tested in its normal configuration with normal appendages (mirrors, bumpers, hubcaps, etc.)
  - 3.3.2.1 The testing instrumentation shall be installed so it does not hinder vehicle operation or alter the operating characteristics of the vehicle. Mounting shall be accomplished so as to not interfere with a tow vehicle if required (nominally at the rear of the vehicle).

- 3.3.3 Vehicles shall be tested at delivered curb weight plus  $332 \pm 10$  lb (including driver and test equipment), distributed in a manner similar to the original curb loading of the vehicle.
- 3.3.4 Vehicle Manufacturer's recommended tires and lubricants shall be used. Tires should have accumulated a minimum of 100 miles (160 km) and shall have at least 75% of the original tread depth remaining. All tire break-ins shall be performed on the test vehicle. Tread depth should be recorded (in mm) prior to start of test.
- 3.3.5 Vehicle tires shall be inflated to the Vehicle Manufacturer's recommended cold inflation pressure as specified on the tire placard, corrected for the difference between ambient temperature and soak temperature. Tire pressures will be increased 1 psi for every 13 °F difference between the two temperatures.
- 3.3.6 ESS temperatures throughout the testing shall be within Vehicle Manufacturer specifications, where available.
- 3.3.7 Accessories shall not be used during testing.

### 3.4 Environmental Conditions

- 3.4.1 Road tests shall be performed on a road or test track and the roads shall be dry, clean, and smooth.
- 3.4.2 Ambient temperature during road testing shall be within the range of 41 °F (5 °C) to 100 °F (38 °C).
- 3.4.3 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 (20km/h). Test should always be conducted during periods of minimum wind velocity.

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**NOTE:** This is a deviation from SAE Standard J1263.

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- 3.4.4 Tests shall not be run during foggy conditions for safety reasons.

### 3.5 Instrumentation

- 3.5.1 All instrumentation used during testing shall be calibrated. The calibration shall be performed and documented in accordance with company policy.
- 3.5.2 All instrumentation shall have the accuracies and resolutions noted. Unless specific exceptions have been made by the Mandated Reviewer, the following identifies the minimum instrumentation specification that shall be installed and employed during the testing. Note that not all of the instrumentation applies to the testing conducted for this Test Specification.
  - 3.5.2.1 Time
    - a) Accuracy of  $\pm 0.05$  s
    - b) Resolution of 0.1s
  - 3.5.2.2 Speed
    - a) Accuracy of  $\pm 0.15$  km/h (0.25 mph)
    - b) Resolution of 0.06 km/h (0.1 mph)

### 3.5.2.3 Temperature

- a) Accuracy of  $\pm 1$  °C ( $\pm 2$  °F)
- b) Resolution of 1 °C (2 °F)
- c) The sensing element shall be shielded from heat sources

### 3.5.2.4 Atmospheric Pressure

- a) Accuracy of  $\pm 0.5$  mbar ( $\pm 0.015$  InHg) at 0 to 30 °C (32 to 86 °F)
- b) Resolution of 0.1 mbar (0.01 InHg)

### 3.5.2.5 Wind Speed

- a) Accuracy:  $\pm 3\%$  at 10 m/s
- b) Resolution: 1 mph (1 m/s)

### 3.5.2.6 Wind Direction

- a) Accuracy:  $\pm 2^\circ$
- b) Resolution:  $1^\circ$

### 3.5.2.7 Relative Humidity

- a) Accuracy:  $\pm 2^\circ$
- b) Resolution:  $1^\circ$

### 3.5.2.8 Tire Pressure

- a) Accuracy of  $\pm 4$  kPa ( $\pm 0.5$  psi)
- b) Resolution of 1 psi

### 3.5.2.9 ESS Current

- a) Accuracy of  $\pm 0.1$  A
- b) Resolution of 0.1 A

### 3.5.2.10 ESS Voltage

- a) Accuracy of  $\pm 0.1$  V
- b) Resolution of 0.1 V

3.5.3 The minimum instrumentation required for this Test Specification is a speed sensor. The ESS current and voltage may be obtained through digital vehicle signals if the accuracy has been validated. Wherever possible, analog signals should be included. The Mandated Reviewer shall determine what level of instrumentation and data acquisition rates are deemed acceptable. The default acquisition rates for Intertek Testing Services, North America are 100 Hz for non-temperature-based data and 1 Hz for temperature-based data.

3.5.4 Where applicable, the data logger used for fleet testing purposes shall remain in the vehicle as a backup for track test data logging. Additionally, every attempt shall be made to record the track data on the datalogger used during fleet testing.

## 4 Test Activity Requirements

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This section addresses all test types required to meet the stated purpose and objectives of this Test Specification. To this end, it selectively implements portions of SAE J1263.

### 4.1 Collected Test Data

The following data shall be collected during conduct of the various tests specified by this procedure.

- 4.1.1 Time
- 4.1.2 Vehicle speed
- 4.1.3 Vehicle distance traveled

Where possible and applicable, the following data should be collected in addition to the previous data.

- 4.1.4 ESS temperature
- 4.1.5 DC battery voltage
- 4.1.6 DC battery current
- 4.1.7 Electric motor current
- 4.1.8 Electric motor voltage
- 4.1.9 Electric motor torque
- 4.1.10 Electric motor speed

### 4.2 Collected Environmental Conditions Data

The following environmental conditions data shall be collected during conduct of the various tests specified by this procedure.

- 4.2.1 Ambient temperature at the beginning and end of test
- 4.2.2 Track temperature at the beginning and end of test
- 4.2.3 Wind velocity at beginning and end of test
- 4.2.4 Wind direction at beginning and end of test
- 4.2.5 Barometric pressure at beginning and end of test

### 4.3 Coastdown Test

The purpose of the coastdown test is to measure the speed profile and distance traveled while the vehicle coasts down from 75 to 5 mph. This testing is to be completed subject to the initial conditions and prerequisites stated in Section 4 of this Test Specification.

### 4.4 Data Analysis and Calculations

- 4.4.1 If the data from two runs are being combined because of an insufficiently long straightaway, perform the data combination so that a single run from 75 to 5 mph is obtained.



- 4.4.2 Calculate the vehicle's deceleration functions (in  $\text{m/s}^2$ ) for the coastdown runs.
- 4.4.3 Multiply each deceleration function by the vehicle test mass (including the additional  $332 \pm 10$  lb, but convert the total to kg) to obtain the force over the vehicle coastdown ( $F_{\text{coastdown}}$ , in N) as a function of velocity (in m/s).

4.4.3.1 If the vehicle being tested is an EV, HEV, or PHEV in which the electric motor cannot be disengaged for the coastdown test but the motor torque ( $T_{\text{motor}}$ , in Nm) and rotational speed ( $\omega_{\text{motor}}$ , in rad/s) can be monitored during the test, determine the force at each vehicle velocity point ( $V_{\text{vehicle}}$ , in m/s) from back-EMF of the motor that must be deducted from the overall coastdown force ( $F_{\text{coastdown}}$ ) from the previous step for each data point:

$$F_{\text{back-EMF}} = \frac{T_{\text{motor}} \cdot \omega_{\text{motor}}}{V_{\text{vehicle}}} \quad (1)$$

Deduct the back-EMF from each data point to obtain the force over the vehicle coastdown ( $F_{\text{coastdown}}$ , in N) as a function of velocity (in m/s). Note that the back-EMF has been deducted on the data sheet of Appendix A.

4.4.3.2 If the vehicle being tested is an EV, HEV, or PHEV in which the electric motor cannot be disengaged for the coastdown test and the motor torque ( $T_{\text{motor}}$ , in Nm) and rotational speed ( $\omega_{\text{motor}}$ , in rad/s) cannot be monitored during the test, but the battery current and voltage are being monitored (and the engine is off such that any current flowing into the battery is coming from the electric motor and not the engine), approximate the force at each vehicle velocity point ( $V_{\text{vehicle}}$ , in m/s) from back-EMF of the motor that must be deducted from the overall coastdown force ( $F_{\text{coastdown}}$ ) from the previous step for each data point:

$$F_{\text{back-EMF}} = \frac{P_{\text{batt}}}{V_{\text{vehicle}}} \quad (1)$$

Deduct the back-EMF from each data point to obtain the force over the vehicle coastdown ( $F_{\text{coastdown}}$ , in N) as a function of velocity (in m/s). Note that the back-EMF has been deducted on the data sheet of Appendix A.

- 4.4.4 Graph the vehicle coastdown force vs. velocity and apply a quadratic curve fit to the data. Obtain the coefficients from the fitted line in the form  $A+Bv+Cv^2$ .
- 4.4.5 Calculate the average, standard deviation, and coefficient of variation (CoV) for each set of coefficients. If the CoV is less than 100%, this is an indication that the collected run data are sufficiently consistent. Using the average value and standard deviation for each coefficient, examine the coefficients calculated for each run and discard any runs with coefficients that are more than two standard deviations away from the average value. Once a set of coefficients has been determined, enter this set on the data sheet of Appendix A.
- 4.4.6 Obtain the EPA coefficients (if available) for this make and model of vehicle and graph the EPA coefficients and the calculated coefficients from the coastdown together. If an excessive amount of deviation is present, an inquiry as to the cause of this deviation shall be undertaken and tests shall be re-run, if necessary. Enter the EPA coefficients on the data sheet of Appendix A.

- 4.4.7 Provide the calculated and EPA coefficients to the dynamometer facility that will conduct the dynamometer testing.

## 6 Glossary

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**AVTE:** Advanced Vehicle Testing and Evaluation

**CECET:** Center for Evaluation of Clean Energy Technology

**Blended Mode:** A vehicle operating mode within CD mode in which propulsion power is drawn from the ESS and also supplemented by either continuous or intermittent use of the CEFC.

**Charge-Depleting (CD) Mode:** An operating mode in which the ESS SOC is depleted (not continuously, but the trend is depletion) while the vehicle is driven. May be ESS-Only or Blended.

**Charge-Sustaining (CS) Mode:** An operating mode in which the ESS SOC is maintained within a prescribed range by operation of a CFEC.

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

**Effective Date:** After a document has been reviewed and approved, the first date the procedure can be utilized in an official capacity.

**Energy Storage System (ESS):** 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 ESSs include batteries, capacitors, and electromechanical flywheels.

**ESS-Only Mode:** A vehicle operating mode within CD mode in which the CEFC is disabled and the vehicle operates solely on energy from the ESS.

**Initial Conditions:** Conditions that must exist prior to an event occurring.

**Mandated Reviewer:** The individual(s) responsible for the implementation of the AVTE program and of other advanced vehicle testing activities.

**Prerequisites:** Requirements that shall be met or resolved prior to an event occurring.

**SAE:** Society of Automotive Engineers

**Shall:** This word is used to indicate an item which requires adherence without deviation. 'Shall' is used to identify the binding requirements in a statement. A go or no-go criterion.

**Should:** This word is used to identify an item, which requires adherence if at all possible. 'Should' statements identify preferred conditions.

**State of Charge (SOC):** The ESS SOC is defined as the present capacity, (ampere-hours or watt-hours or miles), expressed as a percentage of the total available.

**Test Mass (Weight):** The mass [weight] of the vehicle as tested; including driver and all instrumentation.

**Vehicle Manufacturer:** Entity that manufactured the test vehicle.

## 7 References

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SAE J1263 (2010). "Road Load Measurement and Dynamometer Simulation using Coastdown Techniques"

## Appendix A – Test Data Sheet for Dynamometer Facility

Year: \_\_\_\_\_  
 Make: \_\_\_\_\_  
 Model: \_\_\_\_\_  
 Last 4 VIN: \_\_\_\_\_  
 Date: \_\_\_\_\_

True Neutral Achieved (Y/N): \_\_\_\_\_  
 If 'N', back-EMF deducted (Y/N): \_\_\_\_\_

Test Weight (lb):		
Mandated Reviewer:	(Signature )	(Date)
<small>(Printed Name)</small>		

### AVTE Coefficients and EPA Coefficients

Coefficients	AVTE	EPA
<b>A</b>		
<b>B</b>		
<b>C</b>		