Intertek

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Center for Evaluation of Clean Energy Technology

Test Specification – Acceleration and Deceleration Testing

Center for Evaluation of Clean Energy Technology (CECET)

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Revision History Log

Revision No.	Revisions Description	Effective Date	Revised/Reviewed By	Approved By
0	Initial release	11/23/2015	Jeffrey Wishart	Jeremy Diez

Table of Contents

1 Objective

The objective of this Test Specification is to methods for testing acceleration and deceleration of vehicles participating in the Advanced Vehicle Testing and Evaluation (AVTE) program or in other advanced vehicle testing activities Testing is conducted in partial accordance with Society of Automotive Engineers (SAE) J1666, “Electric Vehicle Acceleration, Gradeability and Deceleration Test Procedure”. This Test Specification outlines the methods for experimental conduct and data analysis. 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

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

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 Test Specification, including its automatic shutdowns and safety procedures.

3.2 Vehicle Modes

Depending on the vehicle type, the vehicle to be tested may be capable of operating in more than one mode. The specific modes shall be determined by an Mandated Reviewer prior to testing. The available mode is applicable to testing only if full functionality is possible in this mode. It should be noted that while a mode may apply to a type of vehicle, not all vehicles in the type will have the required functionality. All testing shall be done in "NORMAL" mode, and not, where applicable, in modes such as "ECO", and "SPORT"; these latter modes are not materially different from the "NORMAL" mode. The modes and applicable vehicles are:

3.2.1 Charge-depleting (CD) mode is applicable to electric vehicles (EVs), some plug-in hybrid electric vehicles (PHEVs), and neighborhood electric vehicles (NEVs). This mode is applicable to a PHEV only if the vehicle is capable of full capabilities in CD mode with ESS power alone.

3.2.2 Blended CD mode is applicable to some PHEVs in which the ESS power is supplemented by another source (i.e., the power is "blended) during CD driving.

3.2.3 Charge-sustaining (CS) mode is applicable to HEVs and PHEVs.

3.2.4 Engine-Only mode is applicable to conventional spark ignition (SI) and compression ignition (CI) internal combustion engine vehicles (ICEVs), natural gas vehicles (NGVs) and hydrogen ICEVs (HICEVs).

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 a test weight that is the delivered curb weight plus 332 ± 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 will be recorded in 1/32 inch increments 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 supplier specifications.

3.3.7 Accessories shall not be used during testing.

3.4 Vehicle Charging

The following instructions apply to charging activities for all PHEVs, EVs and NEVs. They shall not replace or supersede the requirements of any specific Vehicle Manufacturer. Should a conflict arise, the requirements of the Vehicle Manufacturer shall take precedence.

3.4.1 ESSs shall always be charged by using electric vehicle supply equipment (EVSE) that allows for charging at level(s) that are recommended by the Vehicle Manufacturer.

3.4.2 When a charge event is terminated by the vehicle, without an indicated fault on either the vehicle or the EVSE, the ESS SOC shall be considered to be 100%. For both the pre- and post-test charge events, every attempt shall be made to ensure that the SOC at the charge event termination is 100%.

3.4.3 If a fault is indicated on either the vehicle or EVSE during the post-test charge event, testing shall be stopped until the cause of the fault can be determined and corrected. Once the fault cause is found, testing can only resume if negligible ESS power was used and if the fault does not indicate a possibility of introducing invalid test data. If the effect on testing is not definitive, testing shall be restarted.

3.5 Environmental Conditions

3.5.1 Road tests shall be performed on a road or test track and the roads shall be dry, clean, and smooth.

3.5.2 Ambient temperature during road testing shall be within the range of 41 °F (5 °C) to 100 °F (38 °C).

3.5.3 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.

3.5.4 Tests shall not be run during foggy conditions.

3.6 Instrumentation

3.6.1 All instrumentation used during testing shall be calibrated. The calibration shall be performed and documented in accordance with company policy.

3.6.2 All instrumentation shall have the accuracies and resolutions noted. Unless specific exceptions have been made by a Mandated Reviewer, the following identifies the minimum instrumentation specification that shall be installed and employed during the testing.

3.6.2.1 Time

a) Accuracy of ± 0.1 s
b) Resolution of 0.1 s

3.6.2.2 Speed

a) Accuracy of ± 0.35 mph
b) Resolution of 0.1 mph

3.6.2.3 Temperature

a) Accuracy of ± 1 °C
b) Resolution of 1 °C

3.6.2.4 Atmospheric Pressure

a) Accuracy of ± 1.0 mm Hg
b) Resolution of 1.0 mm Hg

3.6.2.5 Wind Speed

a) Accuracy: ± 3% at 10 m/s
b) Resolution: 1 mph (1 m/s)

3.6.2.6 Wind Direction

a) Accuracy: ± 2 °
b) Resolution: 1 °

3.6.2.7 Relative Humidity

a) Accuracy: ± 2 %
b) Resolution: 1 %

3.6.2.8 Tire Pressure

a) Accuracy of ± 0.5 psi
b) Resolution of 0.5 psi

3.6.2.9 Current

a) Accuracy of ± 1 A
b) Resolution of 0.1 A

3.6.2.10 Voltage

a) Accuracy of ± 1.0 V
b) Resolution of 0.1 V

3.6.3 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. An 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.

3.6.4 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

This section addresses the activities required to meet the stated purpose and objectives of this Test Specification. To this end, it selectively implements portions of SAE J1666.

4.1 Collected Test Data

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

4.1.1 Time of day (HH:MM)

4.1.2 Vehicle speed (mph)

4.1.3 Vehicle distance traveled (miles)

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

4.1.4 ESS temperature (°C) (if available)

4.1.5 DC voltage (V, voltage at which current is output from the ESS during acceleration/deceleration runs)

4.1.6 DC current (A, output from ESS during acceleration/deceleration runs)

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 (from track control center)

4.2.2 Track temperature at the beginning and end of test (from track control center)

4.2.3 Wind velocity at beginning and end of test (from track control center)

4.2.4 Wind direction at beginning and end of test (from track control center)

4.2.5 Barometric pressure at beginning and end of test (from track control center)

4.3 Test Requirements

4.3.1 An equal number of runs for both acceleration and deceleration that are included in the analysis (i.e., acceleration and deceleration pairs) must be in opposite track directions to remove wind as a factor.

4.3.2 Acceleration and deceleration runs may be conducted consecutively, i.e., an acceleration run may be immediately followed by a deceleration run, if the conditions permit. For CS mode, where a lap around the test track at a constant speed of 50 mph is included after acceleration pairs (see Section 4.4.4), the lap may be completed after the four runs are completed, i.e., after pairs of both acceleration and deceleration runs.

4.4 Acceleration and Maximum Speed Test

The purpose of the acceleration and maximum speed test is to measure the vehicle acceleration from 0-60 mph (0-20 mph for NEVs) and to determine the maximum speed the vehicle can achieve within one mile. This testing is to be completed subject to the initial conditions and prerequisites stated in Section **Error! Reference source not found.** of this Test Specification and using the associated CECET internal Work Instruction document.

4.4.1 If the maximum speed is reached before the one-mile mark, this speed should be maintained until the one-mile mark is reached. Note that some vehicles will exceed the maximum speed a test track allows. An Mandated Reviewer shall determine whether the vehicle or test track speed must be reached; if the test track speed is the limiting factor, any reporting of results should make note of this test exception.

4.4.2 The acceleration test must be conducted for each of the modes from Section 3.2 in which the vehicle is capable of operating unless specified differently by an Mandated Reviewer.

4.4.3 If applicable, the testing in CD mode will continue from 100% SOC until the SOC at which CD mode is exited is reached, or until 12 acceleration runs have taken place, whichever occurs first.

4.4.4 If applicable, the testing in CS mode will continue from the SOC at which the vehicle enters CS mode until 12 acceleration runs have taken place. For CS mode testing, each pair of accelerations are followed by a full lap around the test track at 50 mph in order to allow the ESS to be recharged.

4.4.5 If applicable, the testing in Engine-Only mode will be repeated until 12 acceleration runs have taken place.

4.5 Deceleration Test

The purpose of the Deceleration Test is to measure the vehicle deceleration from 60 mph (20 mph for NEVs) while the vehicle is in gear. The objective is to determine the deceleration time and distance and, where applicable, the amount of “lift-throttle” regenerative energy that is directed to the ESS during the deceleration. This testing is to be completed, subject to the initial conditions and prerequisites stated in Section **Error! Reference source not found.** of this Test Specification and the associated CECET internal Work Instruction document.

4.5.1 The deceleration test must be conducted for each of the modes from Section 3.2 in which the vehicle is capable of operating unless specified differently by an Mandated Reviewer.

4.5.2 If applicable, the testing in CD mode will continue from 100% SOC until the SOC at which CD mode is exited is reached, or until 12 deceleration runs have taken place, whichever occurs first.

4.5.3 If applicable, the testing in CS mode will continue from the SOC at which the vehicle enters CS mode 12 deceleration runs have taken place.

4.5.4 If applicable, the testing in Engine-Only mode will be repeated until 12 deceleration runs have taken place.

4.6 Test Data Analysis

4.6.1 The start of the acceleration run is judged to occur at one data point prior to the first data point in which the distance counter of the speed sensor changes from '0'. The end of the acceleration run occurs at the one-mile mark. The maximum speed may be obtained prior to the one-mile mark.

4.6.2 The start of the deceleration run is judged to occur at the data point in which the speed measurement of the speed sensor reaches the desired starting speed (60 mph for all vehicles except for NEVs, for which the starting speed is 20 mph) and the next speed measurement is below the starting speed and decreasing continuously. The end of the deceleration run is judged to occur when the speed sensor measurement first reaches 10 mph since most vehicle creep speeds are below this value.

5 Glossary

AVTE: Advanced Vehicle Testing and Evaluation

Blended CD 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 of an engine or other power source.

CAN: Controller area network

CECET: Center for Evaluation of Clean Energy Technology (CECET)

Charge-Depleting (CD) Mode: An operating mode in which the energy storage system (ESS) state of charge (SOC) is depleted (not continuously, but the trend is depletion) while the vehicle is driven. May be ESS-Only (i.e., the vehicle operates solely on energy from the ESS) or Blended CD (i.e., the vehicle operates on energy from both the ESS and the consumable fuel energy converter (CFEC)).

Charge-Sustaining (CS) Mode: An operating mode in which the energy storage system (ESS) state of charge (SOC) is maintained within a prescribed range by operation of a consumable fuel energy converter (CFEC).

Consumable Fuel Energy Converter (CFEC): An engine which consumes fuel to produce work (either electrical or mechanical).

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: An operator selectable vehicle operating mode in which the CEFC is disabled and the vehicle operates solely on energy from the ESS.

Gradeability: The maximum percent grade which the vehicle can traverse for a specified time at a specified speed. The gradeability limit is the grade upon which the vehicle can just move forward.

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

Initial State of Charge (SOC): ESS SOC at the beginning of a test.

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 or Project Engineer: The individual(s) assigned responsibility for the conduct of any given test.

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

Tractive Force: The force available from the driving wheels at the driving wheel/ground interface.

Vehicle Manufacturer: Entity that manufactured the test vehicle.

6 References

SAE J1666 (OCT., 2002). "Electric Vehicle Acceleration, Gradeability, and Deceleration Test Procedure"