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Electric Vehicle Test Procedure—SAE J227a

SAE Recommended Practice
Last Revised February 1976

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APPEAR IN THE NEXT EDITION
OF THE SAE HANDBOOK

Society of Automotive Engineers, Inc.
400 COMMONWEALTH DRIVE, WARRENDALE, PA. 15096



PREPRINT

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Report of Electric Vehicle Technical Committee approved March 1, 2011 and last revised February 2016

1. Purpose and Scope—This SAE recommended practice establishes uniform procedures for testing electric battery powered vehicles which are capable of being operated on public and private roads. It is the intent of these recommended practices to provide standard tests which will allow various performance characteristics of electric vehicles to be cross-compared on a common basis in specifications, technical papers, and engineering discussions. The tests concern attributes of the total vehicle system rather than those of its subsystems and components. Tests of components such as batteries are the subject of separate procedures.

The road tests specified in this standard practice are recommended for use whenever possible particularly to establish vehicle performance specifications. The dynamometer procedures are included primarily to facilitate development testing.

Section 2 provides definitions of terminology used in this document. Section 3 specifies test conditions and instrumentation which are to be used for all the tests specified in this recommended practice while Section 4 identifies the data which are to be recorded for all tests. The specific tests covered by this document are:

- Range at Steady Speed (Section 5)
- Vehicle Range When Operated In A Selected Driving Pattern (Section 6)
- Acceleration Characteristics On A Level Road (Section 7)
- Gradeability Limit (Section 8)
- Gradeability at Speed (Section 9)
- Vehicle Road Energy Consumption (Section 10)
- Vehicle Energy Economy (Section 11)
- Deceleration (Section 12)

2. Terminology

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

2.2 Drive Line Ratio—The motor shaft rpm divided by the rpm of the traction wheels of the vehicle.

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

2.4 Initial State of Charge (of Battery)—The amount of energy stored in the battery. When practical, the initial state of charge should be expressed as a percent of the capacity obtainable from a fully charged battery when discharged at a rate equivalent to the vehicle maximum cruise speed discharge rate.

2.5 Projected Frontal Area—The total frontal area of the vehicle obtained by projecting its image on a vertical plane normal to its direction of travel.

2.6 Tractive Force—The force available from the driving wheels at the driving wheel ground interface.

2.7 Tire Rolling Radius—The effective radius of a tire when it is deformed by the weight of the vehicle ballasted to its rated gross vehicle weight (SAE J670c).

2.8 Maximum Cruise Speed—The highest vehicle speed sustainable for at least one hour under specified environmental road test conditions starting with a fully charged battery; or such other maximum cruise speed as may be recommended by the vehicle manufacturer.

3. Test Conditions and Instrumentation Common To All Tests—The following conditions shall apply to all tests defined in this recommended practice unless otherwise stated in specific test procedures.

3.1 Condition of Vehicle

3.1.1 Vehicle shall be tested in its normal configuration with normal appendages (mirrors, bumpers, hub caps, etc.).

3.1.2 The vehicle shall be tested at manufacturer's rated gross vehicle weight.

3.1.3 Manufacturer's recommended tires shall be used. Tire pressures shall not exceed pressures recommended by Tire and Rim Association (TRA). Tire tread shall not be worn to the point where the tread wear indicators are exposed.

3.1.4 Normal manufacturer's recommended lubricants shall be employed.

3.1.5 The vehicle shall be stored for a minimum 8 h soak at ambient temperature (Section 3.3.1.1) before tests which start with a fully charged battery.

3.2 Condition of Battery

3.2.1 If batteries are new or have been subject to extended storage, batteries shall be cycled per manufacturer's recommendation before starting test.

3.2.2 A minimum 8 h soak period at ambient temperature (Section 3.3.1.1) shall be allowed after completion of charging and before starting tests initiated with fully charged battery.

3.2.3 Full charge is to be established using manufacturer's recommended charging procedure and equipment.

3.2.4 For tests requiring an X% discharged battery at the start (for example, gradeability tests), the required initial state-of-charge will be established as follows. A Range at Steady Speed test (Section 5) shall be performed at recommended maximum cruise speed, and the end-point time and watt-hours consumed to the end-point of range determined. To achieve X% discharge of a fully charged battery, the battery will be discharged for X% of the end-point time either by driving the vehicle at recommended maximum cruise speed or by discharging the battery through a load at an equivalent constant power. Tests conducted with the battery partially discharged at the start must be initiated no longer than 10 min after the desired initial state-of-discharge is reached.

3.2.5 For tests in which the effects of battery initial state-of-charge are to be investigated, tests should be conducted with the propulsion batteries 0%, 40%, and 80% discharged.

3.3 Environmental Conditions

3.3.1 GENERAL

3.3.1.1 Temperature during vehicle and battery ambient soak period shall be within the range of 16°–32°C (60°–90°F). Ambient temperature during road testing shall be in the range of 5°–32°C (40°–90°F).

3.3.2 ROAD TESTS

3.3.2.1 Road tests are to be performed on a road which is level to within $\pm 1\%$ and having a hard, dry surface. Tests shall be run in opposite direction when they are performed on a road test route. The direction of travel need not be reversed when operating on a closed test track.

3.3.2.2 The recorded wind speed at the test site during test shall not exceed 16 km/h (10 mph).

3.3.3 DYNAMOMETER TESTS

3.3.3.1 Dynamometer load must be programmable at various vehicle speeds to simulate vehicle road load versus speed characteristics.

3.3.3.2 Dynamometer road load power settings shall be made using either of the following procedures. Data from the coast-down tests described in Section 10 which establish the power required at various vehicle speeds to overcome aerodynamic drag and rolling resistance may be directly used to program the power absorbed by the dynamometer. Alternatively the dynamometer road load points can be set to require the same power output from the battery as is required to propel the vehicle at constant speed on a level roadway. Battery power required to maintain various steady road speeds shall be measured using the vehicle testing procedures described in Section 5 of this document.

3.3.3.3 Dynamometer flywheel shall be engaged with the nearest available inertial weight which equals or exceeds the rated gross vehicle weight.

3.4 Test Instrumentation—This section provides a list of instruments which are required to perform the tests specified in this recommended practice. The overall error in recording or indicating instruments shall be no worse than $\pm 2\%$ of the maximum value of the variable to be measured (not including reading errors). Periodic calibration shall be performed and documented to insure compliance with this requirement.

3.4.1 GENERAL INSTRUMENTATION—The following classes of instruments are required for the purpose of tests outlined in this procedure.

- DC watt-hour meter or watt-time recorder
- Vehicle speed versus time recorder
- Distance versus time recorder
- Tire pressure gauge
- Ambient temperature versus time indicator
- DC watt meter
- Battery temperature indicator
- Electrolyte hydrometer (for vehicles with lead-acid batteries)
- AC kilowatt-hour meter

3.4.2 ROAD TESTS

- Wind speed and direction measurement versus time
- Means for determining grades of test-route segments
- Fifth wheel for measuring vehicle speed and distance

4. Data to be Recorded for all Tests

4.1 General

4.1.1 Vehicle Identification.

4.1.2 Overall maximum dimensions (including projected frontal area).

4.1.3 Weight: curb weight and test weight to within $\pm 2\%$.

4.1.4 BATTERY

- Manufacturer.
- Type and nominal rating at specified discharge rate.
- Previous history of the battery including chronological age, number and nature of charge-discharge cycles, description of the test, discharge and recharge processes, and a brief description of known adverse usage conditions.