



SURFACE VEHICLE RECOMMENDED PRACTICE

J1798™

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Recommended Practice for Performance Rating of Electric Vehicle Battery Modules

RATIONALE

The Battery Standards Testing Committee recommends stabilizing this document at this time. The committee is currently evaluating separate documents for lithium and non-lithium battery modules. This Recommended Practice remains applicable for electric vehicle battery modules as currently written.

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Foreword—With the rapid development and deployment of Electric Vehicles, it is important to develop performance standards and guidelines to ensure components utilized in the manufacturing of Electric Vehicles meet requirements needed for vehicle operations.

The mission of this document as an SAE Recommended Practice is to provide direction for standardization of methods and techniques to verify and determine performance characteristics of the standard Electric Vehicle battery modules, as described in SAE J1797 or manufacturer's specifications. This document will provide industry the opportunity to establish and maintain performance standards to meet vehicle requirements. It is intended that the test procedures provide guidance for battery manufacturers, test facilities, and vehicle manufacturers to assess module performance with the same testing platform. This document is a menu for recommended tests that may be run as required for comparative measurements. It is understood that all module chemistries may not be used at the temperatures specified in any given procedure.

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1. Scope—This SAE Recommended Practice provides for common test and verification methods to determine Electric Vehicle battery module performance. The document creates the necessary performance standards to determine (a) what the basic performance of EV battery modules is; and (b) whether battery modules meet minimum performance specification established by vehicle manufacturers or other purchasers. Specific values for these minimum performance specifications are not a part of this document.

1.1 Field of Application—Electric Vehicles.

1.2 Product Classification—Electrochemical Storage Devices.

1.3 Form—An Electric Vehicle propulsion battery will consist of a battery configuration of several (typically 12 V) modules interconnected in one or more series strings. This document provides test methods to determine performance of such modules, including but not limited to modules built in accordance with SAE J1797. Use of this document is intended for independently packaged modules operating at ambient temperature. Testing of a fully configured propulsion battery system, or battery subsystems designed to operate at elevated temperatures, is expected to require additional testing methods beyond those included in this document.

2. References

2.1 Applicable Publications—The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

2.1.1 SAE PUBLICATIONS—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J1715—Electric Vehicle Terminology

SAE J1797—Recommended Practice for Packaging of Electric Vehicle Battery Modules

2.1.2 OTHER PUBLICATIONS

United States Advanced Battery Consortium Electric Vehicle Battery Test Procedures Manual, Revision 2,
Published January 1996

2.2 Related Publications—The following publications are provided for information purposes only and are not a required part of this document.

SAE TSB 001—SAE Technical Standards Board Rules and Regulations
SAE TSB 002—SAE Preparation of SAE Technical Reports
SAE J1115—Guidelines for Developing and Revising SAE Nomenclature and Definitions
SAE Report—Format Guidelines for Electronic Capture of SAE Documents
SAE Committee Guidelines Manuals

3. Definitions—See SAE J1715 for most definitions. The following are not currently in SAE J1715 but may be added to a later date:

3.1 C₁/1—The constant current required to discharge modules in 1 h at 25 °C.

3.2 C₂/2—The constant current required to discharge modules in 2 h at 25 °C.

3.3 C₃/3—The constant current required to discharge modules in 3 h at 25 °C.

3.4 P₁/1—The constant power required to discharge modules in 1 h at 25 °C.

3.5 P₂/2—The constant power required to discharge modules in 2 h at 25 °C.

3.6 P₃/3—The constant power required to discharge modules in 3 h at 25 °C.

4. Battery Module Selection—If battery modules are constructed to SAE J1797 or other requirements as defined by vehicle manufacturer, they should first be determined to comply with the physical requirements of SAE J1797 or other vehicle specification, including dimensions, open circuit voltage, mass, and terminations. If the measured performance is to be used to establish or verify battery ratings, modules selected for testing should be representative of those to be manufactured and delivered to the market.

5. Test Conditions

5.1 Test Samples—The number of test samples required to be subjected to each test condition for each test in this document will be determined by the vehicle manufacturer or other entity requesting tests. A single battery tested does not assure that any production quantity of modules will meet the tested values obtained. Reporting –1.28 standard deviation values from a statistical sample size of 23 modules will give assurance of 90% conformance, but it is not the intention to propose that any or all variations of the tests in this document be run on such a large sample size.

5.2 Test Temperature—Testing shall be performed at a controlled ambient temperature of 25 °C unless otherwise specified within this document. Measured module temperatures shall fall within this range at the start of discharge except for tests specifically required to be performed at other temperatures. This may require cooling to be applied to reduce the time between the end of a charge or discharge and the beginning of the next charge or discharge. If required, cooling shall be applied using the manufacturer's recommended temperature control means, which shall specify the required coolant flow rates, heat transfer properties, etc. All temperatures have a ±2 °C tolerance. Designation of both the cooling method and soak time are to be reported in Appendix A.

- 5.3 Temperature Sensing Locations**—A minimum of one ambient temperature measurement and one temperature measurement per module, insulated from ambient environment, is recommended. Different battery manufacturers may recommend specific locations for temperature sensing such as the center of the case side wall, one of the terminals, or the center of the end wall. As a default, use the center of the side wall. Placement in any of these locations should not affect the results as long as the device is not exposed to external conditions that may skew the readings. The terminal location on a module may require precautions to ensure there is no shock hazard. Designation of the temperature sense location should be reported in Appendix A.
- 5.4 Data Recording**—Data recording should include time, temperature, voltage, current, visual observations, and profiles of any data generated by vibration or shock. Data should include a record of any maintenance performed on module during test sequence.
- 5.5 Sampling Frequency**—All parameters should be measured and stored at a sample rate adequate to ensure that all relevant changes in the parameters are recorded for later data analysis. Additionally, for tests involving short-term transient conditions (e.g., peak power measurement) both the sampling frequency (typically once per second) and the time skew between corresponding current and voltage measurements (typically 0.1 s or less) are important during the critical test periods.
- 5.6 Measurement Accuracy**—The equipment should be able to meet the requirements in Table 1:

TABLE 1—MEASUREMENT ACCURACY

Parameter	Accuracy
Voltage	<1% of Reading
Current	<1% of Reading
Temperature	±1.0 °C

Additionally, the combination of accuracy and sampling rate should be adequate to assure that important derived parameters, including accumulated ampere-hours and kilowatt-hours, can be determined within ±3%.

NOTE—Voltage sense leads should be located as close to the terminals as possible to avoid any ambiguous readings due to resistance, noise, or other sources for error.

- 5.7 Module Inspection**—All modules should be visually inspected to ensure that no damage has occurred to test modules during shipping or other handling. The individual weight and volume of each module should be measured and recorded prior to testing for a baseline. These measurements may be used to calculate power levels or other criteria in test procedures defined later in this document.
- 5.8 Module Conditioning**—Module(s) should be conditioned in accordance with manufacturer's specifications prior to performing the following tests. However, this is not intended to cycle the module a significant portion of its life so a maximum of 10 cycles is recommended. Peak values for a given test may require a significant number of cycles to be run prior to running a given test. This is to be done per the battery manufacturer's recommendations and is to be recorded in Appendix A as PEAK performance.
- 5.9 Data Reporting**—Appendix A is a report template of the expected output from the tests performed. This is to be used as a guide from which vehicle manufacturers may choose specific tests and derive information.

6. Module Performance

6.1 Static Capacity Test (Constant Current Method)

- 6.1.1 PURPOSE—The purpose of this test is to establish the ampere hour and energy capacity provided at various discharge rates and temperatures as appropriate to establish vehicle application usage. This may be used as an application screening test to establish a need for sizing thermal management systems and energy performance. These tests may also verify performance as stated by the manufacturer, therefore 100% discharge is run to a voltage cutoff for these tests not just to rated capacity.

The capacity and energy at $C_3/3$ at 25 °C are the recommended values for ratings of battery types. In the industry, terms such as specific energy and energy density should use this test procedure to validate the values derived. These tests correspond to the USABC test procedures (see 2.1.2 for reference).

6.1.2 TEST SEQUENCE

- 6.1.2.1 The battery manufacturer is to define the $C_1/1$, $C_2/2$, and $C_3/3$ rates at 25 °C. Since these tests are comparative, the discharge rates are not changed for other discharge temperatures. For example, if $C_1/1$ is defined at 70 A at 25 °C then this rate is to be run at any temperature.
- 6.1.2.2 Module(s) should be discharged at the $C_3/3$ rate until a voltage, temperature, or other discharge limit (cutoff) is reached as specified by module manufacturer. The beginning of discharge must be at the test temperature, for initial testing the test temperature is 25 °C. The discharge temperature may be changed as described later in this procedure.
- 6.1.2.3 Since the discharge portion of this test may be run at temperatures other than 25 °C, place the discharged module(s) in a controlled temperature of 25 °C and allow module(s) temperature to stabilize to this value for three consecutive 1 h readings. For test temperatures at 25°C, the 3 h wait is not necessary.
- 6.1.2.4 When module(s) temperature has stabilized in accordance with 6.1.2.3, module(s) shall be fully charged in accordance with manufacturer's specification requirements.
- 6.1.2.5 Open circuit time periods between charge and discharge will be determined by module and vehicle manufacturers. This time may be dictated by the designation that the beginning of discharge temperature is defined for these tests. At 25 °C, the open circuit time may be short while at other temperatures a minimum soak of 16 h is recommended.
- 6.1.2.6 Repeat test sequence (6.1.2.2 through 6.1.2.5) for a minimum number of cycles determined by vehicle manufacturer, or until the measured capacity is repeatable to within 2% for three consecutive cycles.
- 6.1.2.7 Repeat test sequence (6.1.2.2 through 6.1.2.6), using discharge rates of $C_1/1$ and $C_2/2$.

NOTE—The discharge limits specified by the manufacturer may be different for different discharge rates.

- 6.1.2.8 This section may be required at the discretion of the vehicle manufacturer since the temperatures chosen may not be appropriate for a given module chemistry or vehicle system that is managed thermally. Repeat test sequence (6.1.2.2 through 6.1.2.7) using the test discharge temperatures of 45 °C, 0 °C and –20 °C. To ensure the module is at temperature, the module should be soaked at the test temperature at least 16 h prior to discharge.