



Cell Capacity vs. C-Rate and Cell Energy vs. Power for Rechargeable Energy Storage Systems

1 Introduction

Note: Nothing in this standard supercedes applicable laws and regulations.

Note: In the event of conflict between the English and domestic language, the English language shall take precedence.

Note: General Motors (GM) shall approve all changes to the format and/or content of this test standard.

Note: Samples of components or material released to this standard shall be tested for conformity with the requirements of this standard and approved by the responsible GM department prior to the start of delivery of production level components or materials.

Note: Any change to the component or material, e.g., design, function, properties, manufacturing process and/or location of manufacture, requires a new release of the product. It is the sole responsibility of the supplier to provide the customer, unsolicited, with documentation of any change or modification to the product/process, and to apply for a new release.

Note: If not otherwise agreed to, the entire verification test shall be repeated and documented by the supplier prior to start of delivery of the modified or changed product. In some cases, a deviation based on a limited subset of tests can be agreed to between the responsible GM department and the supplier.

1.1 Purpose. This standard specifies the test procedure for evaluating the performance for Hybrid Electric Vehicle (HEV), Plug-in Hybrid Electric Vehicle (PHEV), Extended Range Electric Vehicle (EREV) and Electric Vehicle (EV) batteries that are used in a vehicle environment.

1.1.1 Cell Capacity vs. C-Rate and Energy vs. Power for Rechargeable Energy Storage Systems (RESS). This test shall be used to evaluate the ability to meet vehicle RESS performance metrics. The Cell Capacity vs. C-Rate test evaluates cell charge/discharge capacities at various charge/discharge rates. The Cell Energy vs. Power test evaluates cell charge/discharge energy at various charge/discharge power levels.

1.2 Applicability. This standard applies to all RESS for passenger or commercial vehicles and trucks.

This standard does not apply to Hybrid controllers, Battery Disconnect Units (BDU), and other internal electrical/electronic components which are required to meet GMW3172.

1.3 Remarks.

1.3.1 This document provides the test procedure for evaluating standard technical requirements for HEV, PHEV, EREV, and EV batteries. A program-specific technical specification that is used in conjunction with this document may include additional program-specific requirements that are not referenced in this document and may supercede any requirements included in this document. In the case of any conflicts between this document and the program-specific technical specification, the program-specific technical specification takes precedence.

2 References

Note: Only the latest approved standards are applicable unless otherwise specified.

2.1 External Standards/Specifications.

None

2.2 GM Standards/Specifications.

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2.3 Additional References.

CG2762 Default Test Parameters.

3 Resources

3.1 Facilities.

3.1.1 Calibration. The test facilities and equipment shall be in good working order and shall have a valid calibration label.

3.1.2 Alternatives. Alternative test facilities and equipment may also be used. However, all measuring variables as specified in this standard shall be determined correctly with respect to their physical definition.

3.2 Equipment.

3.2.1 Equipment Parameters. Unless stated otherwise, the information in Table 1: Equipment Parameters and Tolerances defines the minimum test equipment parameters and tolerances to be used for all testing.

Table 1: Equipment Parameters and Tolerances

Parameter	Range	Tolerance
Direct Current (DC) Voltage – Cell-Level: Generate and Measure	0.25 V above maximum specified Device Under Test (DUT) voltage 0.25 V below minimum specified Device Under Test (DUT) voltage	± 20 mV
DC Current: Cell-Level: Generate and Measure	0 A to 5 A 5 A to 500 A	± 50 mA $\pm 1\%$ of reading

3.3 Test Vehicle/Test Piece. All cell-level RESS.

3.4 Test Time. Refer to CG2762.

3.5 Test Required Information. All limits imposed by the battery manufacturer shall be observed over the course of testing. Power, current, voltage, and temperature restrictions provided in written documentation by the manufacturer take precedence over any instructions given in this document.

3.6 Personnel/Skills. All personnel performing tests must have up to date training records in a high voltage training program.

3.7 Personal Protection Equipment (PPE). PPE, such as high-voltage gloves, face shields, fire extinguishers, etc., shall be in good working order and available in the immediate area used in the execution of the testing.

4 Procedure

4.1 Preparation.

4.1.1 Additional customer requests or requirements must be provided in writing prior to start of test.

4.1.2 All Devices Under Test (DUT) should be subjected to an initial inspection as defined by the requestor.

4.2 Conditions.

4.2.1 Environmental Conditions. Deviations from the requirements of this standard shall have been agreed upon. Such requirements shall be specified on component drawings, test certificates, reports, etc.

Unless stated otherwise, the information in Table 2: Environmental Parameters and Tolerances defines the minimum test environment parameters and tolerances to be used for all testing.

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Table 2: Environmental Parameters and Tolerances

Parameter	Range	Tolerance
Temperature Sensor: Measure	-40 °C to 85 °C	± 3 °C
Chamber Temperature: Generate and Measure	-40 °C to 60 °C	± 3 °C
Chamber Humidity: Generate and Measure	20% to 80% Non-Condensing – Arc Free Relative Humidity (RH)	± 5% RH
Lab Environment Temperature: Generate	25 °C	± 10 °C
Lab Environment Temperature: Measure	Not applicable	± 3 °C
Lab Environment Humidity: Measure	10% to 85% RH	± 5% RH

4.2.1.1 Unless otherwise specified by the test requestor, all testing should be conducted using environmental chambers and the humidity level should be set according to the requirements specified in Table 2: Environmental Parameters and Tolerances. The ambient temperature for the DUT should be maintained in accordance with manufacturer specifications.

4.2.1.2 Unless otherwise specified by the manufacturer, for cell-level testing, if the temperature of the DUT is > 20 °C with respect to the ambient temperature, the test must immediately enter a safety rest mode until the difference in temperature is < 5 °C, and then continue. If the rest mode exceeds one (1) h, halt test.

4.2.1.3 For cell-level testing, a thermocouple must be placed in the center of the largest exposed area of the cell as in Figure 1: Examples of Thermocouple Locations on a Cell. If the cell is constrained in a compression fixture, the thermocouple should not be compressed within the fixture. In this case, a thermocouple must be placed near the positive terminal and if the terminals are side by side, the thermocouple must be placed between the terminals. Another thermocouple must be placed nearby the cell to monitor ambient temperature.

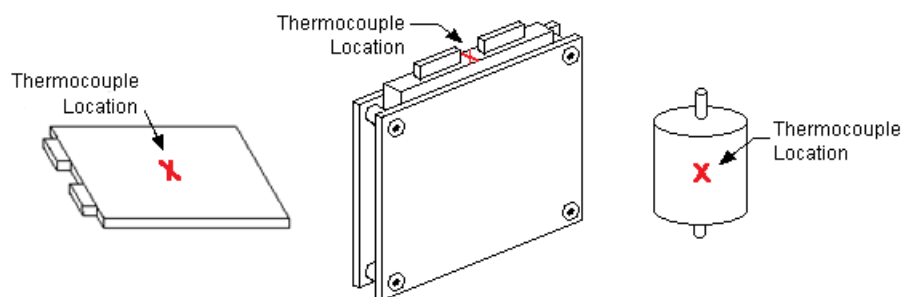


Figure 1: Examples of Thermocouple Locations on a Cell

4.2.1.4 When tested in a new required temperature, i.e., a new test starts or a temperature change within the test, the DUT is required to have environmental conditioning according to 4.2.1.4.1, unless otherwise specified by the manufacturer or requestor.

4.2.1.4.1 Cell-Level DUTs.

- **Temperature:** If the previous test temperature is not equal to the desired test temperature, set the chamber temperature such that the cell surface temperature reaches the test temperature and then soak for at least six (6) h. If previous test temperature is equal to the desired test temperature and the cell surface temperature is equal to the desired test temperature, continue immediately.
- **Humidity:** Uncontrolled, monitored.

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4.2.2 Test Conditions. Deviations from the requirements of this standard shall have been agreed upon. Such requirements shall be specified on component drawings, test certificates, reports, etc.

4.3 Instructions.

4.3.1 Cell Capacity vs. C-Rate and Cell Energy vs. Power. This test will be conducted with a cell-level RESS connected to equipment being used to perform the test and record data. A detailed flowchart of the instructions can be seen in Appendices A and B, Figure A1 through Figure A3: Cell Capacity vs. C-Rate Test Flowcharts, Figure B1 through Figure B3: Cell Energy vs. Power Test Flowcharts. Default testing conditions and other information can be found in CG2762.

5 Data

5.1 Calculations. Refer to CG2762.

5.2 Interpretation of Results. To be provided in a laboratory test request document.

5.3 Test Documentation.

5.3.1 Test Data Documentation. All raw/unprocessed data will be archived. If the test cannot be run properly, the deficiency will be determined and corrected. The test will be rerun if possible. If the test cannot be rerun, then a report will be generated based on the available data. A reason will be given why the test cannot be completed.

Unless specified in the test request, the required and recommended data acquisition rate is listed in CG2762. For the recommended items, the test engineer shall decide the appropriate data acquisition rate while taking into account the following:

- The acquisition rate shall support the data analysis needs in each specific test
- The test data accumulated shall be in an appropriate size to handle
- For cell-level testing, in addition to sampling rate, recommend using absolute change (Δ) V = 0.02 V as data acquisition trigger in test steps

5.4 Data Analysis. Refer to CG2762.

6 Safety

This standard may involve hazardous materials, operations, and equipment. This standard does not propose to address all the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

The test must monitor and act upon, i.e., pause or terminate test, the manufacturer specified safety limits for voltage, current, charge time, ampere hour count and temperature. The maximum cell temperature is 55 °C, unless otherwise specified.

7 Notes

7.1 Glossary.

C-Rate: An electrical current corresponding to the manufacturer's rated capacity (in ampere hours) for a specified discharge duration. For example, if the battery's rated one (1) h capacity is 10 A·h, then 1C rate is 10 A, 2C rate is 20 A, C/2 rate is 5 A, and 1C, 2C, C/2 represent the currents under which this rated one (1) h capacities can be discharged in 1 h, 0.5 h, 2 h, respectively.

7.2 Acronyms, Abbreviations, and Symbols.

Δ	Absolute Change
BDU	Battery Disconnect Unit
DC	Direct Current
DUT	Device Under Test
EREV	Extended Range Electric Vehicle
EV	Electric Vehicle

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