



# SURFACE VEHICLE RECOMMENDED PRACTICE

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## Lithium-Ion Cell Performance Testing

### RATIONALE

Lithium-ion chemistry is commonly used in the batteries of vehicles with electrified propulsion systems. To develop a battery for a specific propulsion application, various battery designs are typically compared in order to decide on an optimized design. Part of deciding on an optimized design is to consider performance of the battery's cells. A common set of cell performance tests can enable consistent tests to be conducted. This SAE Recommended Practice was created to provide a common set of tests for lithium-ion battery cells.

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## 1. SCOPE

This SAE Recommended Practice defines performance and life cycle tests for lithium-ion cells used primarily for propulsion of electric vehicles including battery electric vehicles (BEVs), hybrid electric vehicles (HEVs), and other similar propulsion applications (for example, forklift trucks).

The objective of this document is to define common performance test procedures for lithium-ion cells. Results from these procedures can be used for comparative purposes. Performance requirements are not defined in this document, but are to be defined by the users of the document.

## 2. REFERENCES

### 2.1 Applicable Documents

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 International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), [www.sae.org/](http://www.sae.org/).

SAE J1715                Hybrid Electric Vehicle (HEV) and Electric Vehicle (EV) Terminology

SAE J1715/2            Battery Terminology

#### 2.1.2 IEC Publications

Available from IEC Central Office, 3, rue de Varembe, P.O. Box 131, CH-1211 Geneva 20, Switzerland, Tel: +41 22 919 02 11, [www.iec.ch](http://www.iec.ch).

IEC 62660-1:2018      Secondary lithium-ion cells for the propulsion of electric road vehicles - Part 1: Performance testing

#### 2.1.3 ISO Publications

Copies of these documents are available online at <https://webstore.ansi.org/>.

ISO/TR 8713:2019      Electrically Propelled Road Vehicles - Vocabulary

ISO 17025:2017        General Requirements For The Competence Of Testing And Calibration Laboratories

## 3. DEFINITIONS

### 3.1 BATTERY CELL

An electrochemical device that is capable of producing electrical energy from chemical reactions or storing electrical energy through chemical reactions.

#### NOTES:

1. This definition is taken from SAE J1715/2.
2. This definition also applies to the term ELECTROCHEMICAL CELL in SAE J1715/2.

### 3.2 BATTERY ELECTRIC VEHICLE (BEV)

A vehicle that receives its on-board propulsion power solely from batteries, unlike a hybrid vehicle that may receive a portion of its power from a separately fueled power source, such as an internal combustion engine.

NOTE: This definition is taken from SAE J1715.

### 3.3 BATTERY PACK

A battery assembly that consists of one or more modules.

NOTES:

1. This definition also applies to the term BATTERY PACK in SAE J1715/2.
2. A pack may include sensors, interlocks, contactors, battery management controller, safety devices, thermal management, and structural components.

### 3.4 $C_n$

The capacity (C) obtained from a battery discharged at a constant current to an end-of-discharge condition (discharge cutoff voltage) in n hours at 25 °C.

NOTES:

1. This definition is taken from SAE J1715/2.
2.  $C_n$  is established once and is not adjusted through the battery's life.

### 3.5 $C_n$ HOUR RATE

The constant current rate at which a fully charged battery can be discharged to its discharge cut-off voltage in n hours at 25 °C. See  $C_n/n$  RATE (3.6).

NOTE: This definition is taken from SAE J1715/2.

### 3.6 $C_n/n$ RATE

The constant current rate at which a fully charged battery can be discharged to its discharge cut-off voltage in n hours at 25 °C. For example:

- a.  $C_1/1$ —The constant current required to discharge modules in 1 hour at 25 °C
- b.  $C_2/2$ —The constant current required to discharge modules in 2 hours at 25 °C
- c.  $C_3/3$ —The constant current required to discharge modules in 3 hours at 25 °C

NOTES:

1. This definition is taken from SAE J1715/2.
2. If the rating is not supplied by the manufacturer, then the constant current rate may be calculated based on a fraction of the rated capacity. For example, if a module is rated at 100 Ah, then the  $C_1/1$  discharge rate is 100 A, the  $C_2/2$  is 50 A, and  $C_3/3$  is 33 A. It is expected that using the method will results in discharge times less than 1, 2, and 3 hours for  $C_1/1$ ,  $C_2/2$ , and  $C_3/3$ , respectively.
3.  $C_n/n$  is also commonly written with or without subscript notation (for example: C/n, C/2;  $C_n$ ,  $C_{20}$ ;  $C_n$  or  $C_{20}$ ).

### 3.7 CUTOFF VOLTAGE

Specified voltage of a battery at which the battery discharge or charge is terminated.

#### NOTES:

1. This definition is taken from SAE J1715/2.
2. In practical usage, the cutoff voltage most often refers to discharge cutoff voltage.

### 3.8 ENERGY DENSITY (VOLUMETRIC ENERGY DENSITY)

The rated energy of a battery divided by its volume.

NOTE: This definition is taken from SAE J1715/2.

### 3.9 HYBRID ELECTRIC VEHICLE

A vehicle that can draw propulsion energy from both of the following sources of stored energy: (1) a consumable fuel, and (2) an RESS that is recharged by an electric motor-generator system, an external electric energy source, or both.

NOTE: This definition is taken from SAE J1715.

### 3.10 INITIAL CAPACITY

The first value reference point of battery rated capacity right after testing is initiated.

NOTE: This definition is taken from SAE J1715/2.

### 3.11 MEASUREMENT UNCERTAINTY

The range over which a measured value is expected to lie in, within a given probability.

NOTE: Measurement uncertainty includes all random and systematic uncertainties of calibration operation and environmental conditions and is calculated/estimated per ISO 17025 requirements. Range is typically defined as percent of full scale (FS), which is the range of a given measurement instrument used or per reading for each measurement value, independent of the range of the instrument used.

### 3.12 RATED CAPACITY

The manufacturer's specification of the total coulometric charge that can be withdrawn from a fully charged battery for a specified set of test conditions such as discharge rate, temperature, discharge cutoff voltage, etc.

NOTE: This definition is taken from SAE J1715/2.

### 3.13 RATED ENERGY

The manufacturer's specification of the total energy that can be withdrawn from a fully charged battery for a specified set of test conditions such as discharge rate, temperature, discharge cutoff voltage, etc.

NOTE: This definition is taken from SAE J1715/2.