

## Battery Terminology

## RATIONALE

This document is being created to provide a reference standard for terminology relating to automotive energy storage systems and components. The document will focus on battery systems, subsystems, modules, cells, electrochemical elements and auxiliary components. Terminology for the testing, measurement, specification and use of battery systems is covered as they relate to automotive applications.

## FOREWORD

This document is an ongoing effort to provide the technical community with the terminology used most frequently in the automotive industry as they relate to energy storage and batteries for starting, lighting and ignition applications as well as for hybrid electric (HEV) and electric vehicles (EVs).

## 1. SCOPE

This SAE Information Report contains definitions for energy storage system and battery terminology. It is intended that this document be a resource for those writing other battery, HEV and EV documents, specifications, standards, or recommended practices.

## 1.1 Purpose

The purpose of this document is to provide a record of commonly used terminology established by the technical community involved with writing practices and information reports in reference to energy storage systems, batteries and their use and application.

## 1.2 Field of Application

This SAE Information Report pertains to batteries and energy storage systems.

## 1.3 Product Classification

Information Report.

## 1.4 Product Description

Information Report containing commonly used terminology in the automotive battery industry.

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## 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 NFPA Publication

Available from the National Fluid Power Association, 3333 N. Mayfair Road, Suite 211, Milwaukee, WI 53222-3219, Tel: 414-778-3344, [www.nfpa.com](http://www.nfpa.com). NFPA 30 Flammable and Combustible Liquids Code

### 2.2 Related 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.

#### 2.2.1 SAE Publication

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

SAE J670 Vehicle Dynamics Terminology

#### 2.2.2 Institute of Electrical and Electronic Engineers Publication

Available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, Piscataway, NJ 08854-1331, Tel: 732-981-0060, [www.ieee.org](http://www.ieee.org).

ANSI/IEEE 100 Standard Dictionary of Electrical and Electronic Terms, latest revision

#### 2.2.3 Japanese Electric Vehicle Society Publication

Available from Japanese Electric Vehicle Association, [evinfo@gw.jeva.or.jp](mailto:evinfo@gw.jeva.or.jp). JEVS Z 805 Glossary of Terms Relating to Electric Vehicles, latest revision

#### 2.2.4 National Institute of Science and Technology (NIST) Publication

Available from National Institute of Standards and Technology, 100 Bureau Drive, Stop 1070, Gaithersburg, MD 20899 1070, Tel: 301-975-6478, [www.nist.gov](http://www.nist.gov). For definitions of SI units of measurement - mass, EMF, current, power, etc.

#### 2.2.5 National Highway Traffic Safety Administration Publication

Available from The Government Printing Office, <http://www.fmcsa.dot.gov/rules-regulations/administration/fmcsr/fmcsrguidedetails.aspx?menukey=571>.

49 CFR Ch V, Section 571 Federal Motor Vehicle Safety Standards

#### 2.2.6 SAND Publication

Available from Sandia National Laboratories, P.O. Box 5800, Albuquerque, NM 87185, [www.sandia.gov](http://www.sandia.gov). SAND88-2852 \*

UC-212 Glossary of Testing Terminology for Rechargeable Batteries, latest revision

### 2.2.7 USABC Publication

Available from USCAR, 1000 Town Center Drive, Suite 300, Southfield, MI 48075, Tel: 248-223-9000, [www.uscar.org](http://www.uscar.org).  
USABC Test Procedures Manual, latest revision

## 3. BATTERY TERMINOLOGY

### 3.1 AC Recharge Energy

The AC energy, measured in AC W•h, from the power outlet required to return the energy storage system to full charge after a test. This measurement must include energy needed to power charging equipment (e.g., EVSE)

### 3.2 Active Material

The constituents of a cell that participate in electrochemical charge and/or discharge reactions. This does not include separators, current collectors, catalysts or supports.

### 3.3 Aqueous Electrolyte Batteries

Electrochemical cells that contain water-based electrolytes.

### 3.4 Available or Deliverable Capacity

The total A•h that can be withdrawn from a fully charged electrochemical cell or energy storage system under specified operating conditions such as discharge rate, temperature, age and stand time.

### 3.5 Average Power

Total energy withdrawn (or returned) from (or to) a electrochemical cell divided by the time of discharge (or charge).

### 3.6 Average Voltage

The ratio of the watt-hours to A•h for a given discharge or charge. Also known as current weighted voltage.

### 3.7 Battery

A battery is a general term that inclusively refers to electrochemical cells, modules, packs and energy storage systems. More specific terminology should be used to describe the level of functionality where appropriate.

### 3.8 Battery Auxiliaries

The components required to support the operation of a battery module, such as a tray, watering subsystem, pumps or control electronics.

### 3.9 Battery Cell

See Electrochemical Cell

### 3.10 Battery Management System

The top level controller and subsystem control, communication and sensing components for the energy storage system. The system may provide communications, safety, cell balancing and supervisory control.

### 3.11 Battery Module

Refers to the multiple connections of electrochemical or electrostatic cells. Battery modules may or may not include sensors such as voltage and temperature sensors, safety components, and a cooling structure so that each module can be controlled and managed independently.

### 3.12 Battery Pack

A battery pack may consist of only one module or multiple modules. The pack includes sensors, interlocks, contactors, battery management controller, safety devices, thermal management and structural components.

### 3.13 Battery System

See Energy Storage System

### 3.14 Battery System Components

Refers to the components contained within an HEV or EV traction energy storage system. These include the modules, interconnects, venting systems, restraint devices, electronic controls, and the battery box or container that holds the individual electrochemical cells.

### 3.15 Battery System Density

Energy storage system mass divided by energy storage system volume.

### 3.16 Battery System Mass Fraction

Ratio of energy storage system weight to gross vehicle weight.

### 3.17 Battery Volume

Cell, module, pack, or system should be specified, and should include the usable exterior volume displaced.

### 3.18 Battery Mass

The mass of the cell, module, pack, or system.

### 3.19 CN

The Capacity (C) in A·h obtained from a battery discharged at a constant current to an end-of-discharge condition (discharge cutoff voltage) in N hours. CN is established once and is not adjusted through the battery's life.

### 3.20 CN Hour Rate

The constant current rate at which a fully charged battery can be discharged to its discharge cut-off voltage in N hours, see C/N Rate.

### 3.21 C/N Rate

The Capacity (C) of a battery divided by the discharge time in hours that yields that capacity.

### 3.22 Calendar Life (years)

Calendar life refers to the total time elapsed to EOL (End of Life) of a cell, module, pack or system measured in hours/days/years.

### 3.23 Capacitor

An electrostatic device capable of accumulating and holding a charge of electrons that consisting of two opposing electrodes separated by a dielectric material.

### 3.24 Capacity (C)

The total number of A•h that can be withdrawn from a fully charged electrochemical cell under specified conditions.

### 3.25 Charge

Conversion of electrical energy into chemical potential energy within an electrochemical cell achieved by the application of direct current.

### 3.26 Charge Profile

Schedule used for charging a battery, usually defined by voltage, current or power versus time.

### 3.27 Charge Rate

Refers to the charge current. General term that may be expressed as an average or a singular point.

### 3.28 Charge Segment

A contiguous subsection of a charge regime.

### 3.29 Charge Step

A change from one power level to another in a charge regime.

### 3.30 Charge Voltage Limit

The maximum voltage permitted under load during specified conditions.

### 3.31 CI

See Constant Current Charging.

### 3.32 CI/CV

A constant current charge followed by a constant-voltage charge.

### 3.33 Constant Current Charging or Discharging (CI)

The charging or discharging of a battery at a constant rate of current flow.

### 3.34 Constant Voltage Charging (CV)

The charging of a battery by applying a constant voltage while allowing the current to vary.

### 3.35 Coulombic (A•h) Efficiency

The A•h removed from a battery during a discharge divided by the A•h required to restore the initial capacity.

### 3.36 Current Collector

The part of an electrode that is designed to conduct current from the active material to the electrochemical cell terminal.

### 3.37 Cutoff Voltage

The battery voltage at which charge or discharge is terminated.

### 3.38 CV

See Constant Voltage Charging.

### 3.39 Cycle

From the start of one charge/discharge to the start of the next charge/discharge where the period includes discharge time, open-circuit time, charge time and stabilization time. The depth of discharge (or percentage of capacity) associated with each cycle must be specified for cycle life measurements.

### 3.40 Cycle Life

Cycle life is the total energy throughput to EOL (End of Life) of an electrochemical cell, module, pack or energy storage system measured in kWh.

### 3.41 DC Recharge Energy

The net DC energy output of the battery in DC Wh measured over a cycle.

### 3.42 Deep Discharge

A qualitative term for the discharge of a significant percentage of capacity from a fully charged state (typically, 80% of available capacity or more).

### 3.43 Depth of Discharge (DOD)

The number of A·h withdrawn from a battery divided by its rated capacity at the test current and temperature and expressed as a percentage.

### 3.44 Derived Peak Power

An estimate of the maximum power capability of a cell or battery calculated from the results of power profile tests specified by the Dynamic Capacity Test (SAE), the Dynamic Stress Test or Hybrid Pulse Power Characterization Test (USABC).

### 3.45 Diffusion

Diffusion is the movement of ions in response to a gradient. Movement occurs from an area of high concentration to areas of low concentration. The rate of diffusion is proportional to the diffusivity of the species and the magnitude of the gradient. Pertains to solid, liquid, and gas phases in electrochemical systems. Can be described by Fick's Law.

### 3.46 Discharge

Conversion of chemical energy into electrical energy within a battery by the passage of direct current.

### 3.47 Discharge Profile

Schedule used for battery discharge that follows a particular current, voltage or power versus time sequence.

### 3.48 Discharge Rate

The current during discharge of a battery.

### 3.49 Discharge Segment

A contiguous subsection of a discharge regime.

### 3.50 Discharge Step

A change from one power level to another in a discharge regime.

### 3.51 Discharge Voltage Limit

The minimum voltage permitted under load during specified conditions.

### 3.52 DOD

See Depth-of-Discharge.

### 3.53 Driving Profile

See Energy Storage Driving Profile and Vehicle Driving Profile

### 3.54 Dynamic Capacity Test (DCT)

A variable-power discharge test to simulate the expected duty cycle of a battery over a specified state of charge range.

### 3.55 Dynamic Stress Test (DST)

A variable-power discharge test to simulate the expected duty cycle of a battery during vehicle driving conditions.

### 3.56 Electrochemical Cell

An electrochemical cell is a device that converts chemical energy into electrical energy or vice versa when a chemical reaction is occurring in the cell. Typically, it consists of two electrodes immersed into a solution (electrolyte) with electrode reactions occurring at the electrode-solution surfaces.

### 3.57 Electrode

The conducting body that contains active materials and through which current enters or leaves a cell.

### 3.58 Electrolyte

The medium that provides ion transport between the positive and negative electrodes of a cell. Electrolytes may also participate directly in the charge and/or discharge reactions.

### 3.59 End of Life (EOL)

When an electrochemical cell fails to meet specified capacity or power performance criteria under controlled conditions. When an energy storage system fails to meet specified capacity, power or function in specified use conditions.

### 3.60 Energy Capacity

See Energy Output.

### 3.61 Energy Density

The rated energy of a battery (Wh) divided by the total cell, module, pack, or system volume (L). Also known as volumetric energy density.

### 3.62 Energy (Watt-Hour, Round Trip) Efficiency

The rated energy of cell, module, pack or system (Wh) divided by the respective volume (L).

### 3.63 Energy Output

The total Wh that can be withdrawn from a fully charged battery under specified operating conditions (such as temperature, rate, age, stand time, and discharge cutoff criteria).

### 3.64 Energy Storage System (Battery System)

One or more packs connected in parallel and/or series configuration and associated electronics.

### 3.65 Energy Storage System Driving Profile

A vehicle speed-versus-time schedule represented as power versus time that is used to test energy storage system characteristics.

### 3.66 Equalization

The process of restoring all cells in a module, pack or energy storage system to approximately the same state-of-charge.

### 3.67 Failure Criteria

Specific cell or battery performance characteristics that indicate the cell or battery can no longer perform its intended function.

### 3.68 Finishing Charge Rate

The current specified for completing the charging of a cell, module, pack, or system that is nearing the fully charged condition.

### 3.69 Flame Arrestor

Device located at the outlet of a venting system designed to prevent an external spark or flame from propagating into the pack or energy storage system.

### 3.70 Float Charge

Charging a cell or battery at a fixed voltage for extended periods of time to obtain or maintain the fully charged condition.

### 3.71 Formation

The initial charging process during which electrochemical cell active material are transformed into the constituents required for proper electrochemical operation.

### 3.72 Gassing

The evolution of gas from one or both of the electrodes in a cell.

### 3.73 Hybrid Pulse Power Characterization (HPPC) Test

A test procedure whose results are used to calculate pulse power and energy capability under specified operating conditions.

### 3.74 High Voltage

Any wiring system which contains one or more circuits operating above 60 V DC or AC RMS.

### 3.75 Internal Impedance

A measure of the opposition to alternating current flow under specified conditions including phase and frequency.

### 3.76 Internal Resistance

A measure of the opposition to direct current flow.

### 3.77 Minimum Discharge Voltage

See Discharge Voltage Limit.

### 3.78 Module

See Battery Module

### 3.79 Negative Electrode

Of the two electrodes composing a cell, the electrode at which the associated half-cell reaction has the lower potential. It is negative in voltage compared to the other electrode of the cell. It is the electrode at which oxidation occurs during discharge of the cell.

### 3.80 Net A•h

For a discharge test including both negative (discharge) and positive (charge) current or power steps, the difference between the A•h removed from the electrochemical cell during discharge steps and the A•h returned to the electrochemical cell during charge steps, regardless of charge acceptance.

### 3.81 Nominal Conditions (or Nominal Standard Conditions)

Nominal conditions may refer to standard test conditions. In general, nominal conditions refer to the range of conditions which allow a battery to function to the rated capability.

### 3.82 Nominal Operating Voltage

The voltage of an energy storage system, pack, module or electrochemical cell, discharging at a rate and temperature that is specified by the manufacturer.

### 3.83 Nonaqueous Electrolyte Batteries

Cells or batteries with electrolytes that are not water based, such as those with molten salts or organic electrolytes.

### 3.84 Nonvented Batteries

A hermetically sealed battery comprised of one or more rechargeable cells that has no provision for venting, or the addition of water or electrolyte, or for the external measurement of specific gravity.

### 3.85 Open Circuit After Charge (OCAC)

The period during which the energy storage system, pack, module or electrochemical cell is placed on open-circuit following a charge.

### 3.86 Open Circuit After Discharge (OCAD)

The period during which the energy storage system, pack, module or electrochemical cell is placed on open-circuit following a discharge.

### 3.87 Open-Circuit Voltage (OCV)

The voltage of an energy storage system, pack, module or electrochemical cell at a specified state-of-charge and temperature in the absence of charge or discharge current and after a specified rest period.

### 3.88 Operating Conditions (or Operating Test Conditions)

Operating conditions refer to but is not limited to the voltage, current, temperature, humidity, elevation or duty cycle at which battery is designed to operate. Typically a component of reliability metrics.

### 3.89 Operating Temperature Range

The temperature range in which the energy storage system, pack, module or electrochemical cell is designed to operate under nominal conditions.

### 3.90 Overcharge

The amount by which the charge in A•h exceeds a full charge.

### 3.91 Pack

See Battery Pack

### 3.92 Peak Power

The maximum power obtainable from an energy storage system, pack, module or electrochemical cell for a specified period of time when discharged at constant current (or voltage), generally determined as a function of depth of discharge.

### 3.93 Peak Power Density

The peak power available from an energy storage system, pack, module or electrochemical cell divided by its volume.

### 3.94 Performance Degradation

The extent to which the energy storage system, pack, module or electrochemical cell is decreased from the original performance specification or rating.

### 3.95 Peukert Curve

A plot of the logarithm of discharge current versus the logarithm of discharge time, or discharge current versus discharge time, to a specified end-of-discharge voltage. The curve is constructed to show the effect of discharge rate on capacity. A Peukert equation is an empirical formula that shows how the available capacity of a battery changes according to the rate of discharge.

### 3.96 Polarization

The electrical potential deviation from equilibrium open-circuit voltage caused by the passage of current in an electrochemical cell. It includes the effect of IR potential drop, activation polarization, and concentration polarization. Since an electrochemical cell under load is not in equilibrium, the measured voltage and capacity may differ significantly from their respective equilibrium values. The further from equilibrium these values are (for example the larger the charge or discharge current) the larger the deviation from the cell voltage and capacity.

### 3.96.1 Polarization - IR Polarization

Voltage drop caused by Ohmic loss in the electrolyte. May include voltage drop caused by the electrical conductivity of the discrete (hardware) components.

### 3.96.2 Polarization - Activation Polarization

Potential difference required to initiate the transfer of electric charge.

### 3.96.3 Polarization - Concentration Polarization

Potential difference caused by diffusion rate of the active species at the electrode surface.

### 3.97 Positive Electrode

Of the two electrodes comprising a cell, the electrode at which the associated half-cell reaction has the higher potential. It is positive in voltage relative to the other electrode of the cell. It is the electrode at which reduction occurs during discharge of the cell.

### 3.98 Power Continuous (i.e., Continuous Power)

A power level characteristic of an energy storage system, pack, module or electrochemical cell providing constant power for a specified time.

### 3.99 Power Density

The rated power (W) of the energy storage system, pack, module or electrochemical cell divided by the total volume of the energy storage system, pack, module or electrochemical cell (L). Also known as volumetric power density.

### 3.100 Power-to-Energy Ratio (P/E)

Ratio of the power obtained under specified conditions and time, such as depth-of-discharge, to the energy output obtained under specified discharge conditions.

### 3.101 Ragone Curve

A plot of specific energy as a function of the continuous specific power at which the energy storage system, pack, module or electrochemical cell is discharged. Alternatively, the plot may depict energy density versus continuous discharge power density. Originally defined as the set of curves ranging between the high-power design and the high-energy design for a particular technology.

### 3.102 Rated Capacity

The manufacturer's specification of the total number of A·h that can be withdrawn from a fully charged energy storage system, pack, module or electrochemical cell for a specified set of test conditions such as discharge rate, temperature, discharge cutoff voltage, etc.

### 3.103 Rated Current

Current level (or levels) in amperes at which a device is designed to operate for a specified duty cycle.

### 3.104 Rated Open-Circuit Voltage

The manufacturer's specification for the open-circuit voltage of a fully charged energy storage system, pack, module or electrochemical cell at a defined condition.

### 3.105 Rated Power

The manufacturer's specification of power capability for an energy storage system, pack, module or electrochemical cell under specified conditions.

### 3.106 Rated Voltage

Voltage range at which a device is designed to operate.

### 3.107 Recharge Factor

The inverse of the coulombic efficiency, expressed as a ratio, for a cycle.

### 3.108 Reference Performance Tests (RPT)

A set of tests to be performed periodically to monitor performance degradation during life-cycle testing.

### 3.109 Regenerative Energy Capture

A conversion of vehicle kinetic energy into energy stored in the RESS. Also known as "regen" braking.

### 3.110 Residual Capacity

The number of A•h that can be discharged from an energy storage system, pack, module or electrochemical cell at a specified discharge rate and temperature after it has been exposed to specified conditions such as driving-profile or open-circuit stand tests.

### 3.111 Rechargeable Energy Storage System (RESS)

Any energy storage system that has the capability to be charged and discharged. (Examples: batteries, capacitors, and electro-mechanical flywheels).

### 3.112 RESS Available Energy

Energy available at the connection point of the RESS to the system under specified conditions.

### 3.113 Reversal

Forced discharge of a cell or battery to the point that the cell's electrical terminals change polarity.

### 3.114 Sealed Battery

See Valve Regulated Battery

### 3.115 Secondary Cell or Battery

A cell or battery capable of being charged and discharged repeatedly. Also known as a rechargeable cell or battery.

### 3.116 Self-Discharge

The process by which the available capacity of an energy storage system, pack, module or electrochemical cell is spontaneously reduced over time.

### 3.117 Separator

A cell component placed between the negative and positive electrodes, which acts as an electrical insulator and an ionic conductor.