Battery Terms & Definitions

Technical terms associated with Batteries and their definitions.

Accumulator A fairly old term for a lead-acid battery, with a number of cells in series to 'accumulate' a higher voltage.

Alkaline-Manganese Dioxide Cell A type of primary cell which uses an anode of powdered zinc, a cathode of manganese dioxide and a potassium hydroxide electrolyte. Offers up to 8 times the capacity of carbon-zinc cells. Commonly called the 'alkaline' battery.

Ampere-hour (Ah) The unit used in specifying the storage capacity of a battery. A battery with 1Ah capacity can supply a current of one ampere for one hour or 0.5A for two hours, etc. 1Ah is the equivalent of 3600 coulombs of electrical charge.

Battery An electrochemical energy storage system packaged as a physical component. Strictly speaking the term means an array of multiple interconnected cells (generally in series), by analogy to a gun battery (or a battery of hens), but in the popular vernacular it is often used to mean a single cell.

C Rate The charging or discharging rate of a cell or battery, expressed in terms of its total storage capacity in Ah or mAh. So a rate of 1C means transfer of all of the stored energy in one hour; 0.1C means 10% transfer in one hour, or full transfer in 10 hours; 5C means full transfer in 12 minutes, and so on.

Capacity The electrical charge effectively stored in a primary or secondary battery and available for transfer during discharge. Usually expressed in ampere-hours (Ah) or milliampere-hours (mAh), also can be expressed as Watt/hours, although this is harder to measure.

Carbon-Zinc Battery The first type of primary cell safe for general use, developed by Georges Leclanché in 1868 and still very widely used. Earlier battery designs used dangerously strong acids; the Leclanché cell uses much less corrosive ammonium chloride. Current designs use carbon and manganese dioxide as the positive electrode and zinc as the negative electrode, with an aqueous mixture of ammonium and zinc chloride as the electrolyte.

Cell A single electrochemical system, consisting of positive and negative electrodes and an electrolyte to transport ions between them — all housed in a protective enclosure. Strictly speaking, a "battery" properly consists of an array of such cells.

Cell Reversal With rechargeable batteries with a number of cells in series, excessive discharge can cause the cells with least capacity to be partly recharged in the reverse direction. This generally shortens the service life of the cell.

Charge Rate The rate at which a secondary cell or battery is recharged, expressed in terms of the battery capacity. In other words the C rate, but as applied to recharging. (For example a 1Ah battery charged at 2 Amps is being charged at the "2C" rate).

Charge Retention The degree to which a charged cell or battery maintains its charge when not supplying load current. (Similar to "Shelf Life" of a primary battery).

Charging With secondary batteries, the process of supplying electric power to the battery in order to restore its stored energy.

CC Charging ("Constant Current") Restoring charge to a secondary battery in a mode where the charging current level is kept substantially constant. Ideally, an automatic circuit switches the current off (or reduces it) when full charge is detected. Mostly used for Nickel Cadmium and Nickel Metal-Hydride cells.

CV Charging ("Constant Voltage") Restoring charge to a secondary battery in a mode where the battery's terminal voltage is kept substantially constant, or not allowed to rise above a certain level. Automotive battery charging systems are a common example. Also part of Lithium-Ion charging sequence.

Cutoff A voltage level or other indication (eg cell temperature) where either the charging or discharging of a battery is ended, (or should be ended) for optimum battery life.

Cycle For secondary cells or batteries, a single discharge- and recharge sequence.

Cycle Depth The degree to which the charge of a secondary battery is drawn from it during discharge, expressed as a percentage of the total battery capacity.

Cycle Life How many cycles a secondary battery can typically perform before its capacity falls significantly. Varies with the type of battery and the type of cycling it is made to perform.

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Deep Cycling Repeated subjection of a secondary battery to deep discharging and recharging; i.e., frequent withdrawal of most of the battery's total storage capacity – running it to "almost flat". Batteries must be specifically designed for this type of service, otherwise their service life may be short.

Discharge Rate The rate at which charge is withdrawn from a cell or battery during discharge; i.e., the discharge current, expressed in terms of the battery's capacity. In other words the C rate, as applied to discharging.

Discharging Withdrawing the stored energy from a cell or battery.

Dry Cell/Battery The most common type of disposable cell or battery nowadays, where the electrolyte is either in non-liquid form (i.e., a paste or gel) or absorbed in a porous separator material. This allows the cell or battery to be sealed. Usually Carbon-Zinc or Alkaline.

Electrode (battery) One of the two conducting elements in an electrochemical cell where part of the chemical reaction occurs, and electrons are either released to or withdrawn from the external electrical circuit.

Electrolyte The element in an electrochemical cell which provides the medium through which ions are transported between the two electrodes, to allow internal current flow. Generally either a liquid, paste or gel.

Energy loss All batteries waste energy due to internal resistance and other losses. This term describes the proportion of a secondary battery's nominal capacity which is lost during charging, and not returned using discharge. A typical figure is 40% of capacity, usually wasted heating up the battery.

Eneloop A special type of Nickel Metal Hydride cell (see **NiMH**), with very low-self discharge. Eneloops can be sold pre-charged and essentially used off-the-shelf like Alkaline cells, but then can be recharged in a standard NiMH charger.

EOC Voltage "End Of Charge" The terminal voltage of a secondary cell or battery which is specified as indicating the end of safe charging.

EOD Voltage "End Of Discharge" The terminal voltage of a cell or battery which is specified as indicating the end of safe discharge.

Energy Density A measure of the energy storage efficiency of a battery, usually expressed in watt-hours per kilogram (Wh/kg). Generally Lead-Acid cells have the lowest energy density, Lithium have the highest.

Fast Charging A term used to describe charging a secondary battery at a rate of 0.5C or higher - i.e., in less than 2 hours. Generally this requires sophisticated control electronics to avoid damage to the battery..

Float Charging A term used to describe charging a secondary battery at a rate only sufficient to neutralize its self-discharge - i.e., maintain it at full capacity. Mostly applicable to lead-acid batteries.

Flooded cell A type of wet cell where the active electrodes are submerged in liquid electrolyte. The common car Lead Acid battery uses this type of cell.

Gel Cell A type of sealed lead-acid battery where the sulphuric acid is contained in a colloid ("gel") of silicic acid.

Galvanic or Voltaic cell Any electrochemical cell which employs a chemical reaction to generate electrical energy. The first such cell is attributed to Luigi Galvani in 1792 — although Alessandro Volta was the first to explain how it worked, in 1800.

Internal Resistance The phenomenon where a battery behaves as though it is being used wired in series with a resistor. All cells and batteries exhibit internal resistance to some extent, which limits discharging and charging current levels and produces heat within the battery. Generally the resistance tends to increase with age.

Lead-Acid Cell A type of secondary cell which uses a positive electrode of lead oxide, a negative electrode of metallic lead and an electrolyte of sulphuric acid (in either liquid or gel form). First developed in 1859 by French physician Gaston Planté.

Li-ion Cell (Lithium-Ion) A type of secondary cell which uses a negative electrode of lithium-cobalt dioxide and a positive electrode of carbon with an electrolyte of a lithium salt dissolved in an organic solvent. Because of their light weight and high terminal voltage per cell (typically 3.7V) these are now almost universally used in portable equipment and seem likely to eventually replace all other types of secondary cell, despite their need for complex charging systems (See below)..

LiFePO4 (Lithium Iron Phosphate) Similar to Li-Ion except it uses Lithium Iron Phosphate for the negative terminal. LIFEP04 generally have lower capacity then Li-Ion but have much lower-self-discharge and are far less prone to explosion if mishandled.

Lithium-Manganese Cell A type of primary cell which uses manganese dioxide and carbon as the positive electrode, lithium metal foil as the negative electrode and lithium perchlorate dissolved in propylene carbonate as the electrolyte. Often called simply "lithium cells", they offer very high energy storage density plus a high terminal voltage per cell (3V). These are most often supplied as "Button" or "Coin" cells.

Memory Effect If NiCad cells or batteries are subjected to repeated shallow cycling, their internal structure changes and they lose storage capacity, popularly known as the memory effect. That is, they tend to "remember" the shortened cycle length, rather like an athlete getting "out of condition".

Mercuric Oxide Cell Commonly called the "mercury cell", a type of alkaline primary cell with a positive electrode of mercuric oxide, a negative electrode of metallic zinc and either potassium or sodium hydroxide as electrolyte. Once widely used in photographic light meters because of their extremely stable terminal voltage (1.35V). However due to environmental concerns about Mercury, they are no longer sold in most countries.

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Milliamp-hours (mAh) The unit generally used to specify the storage capacity of smaller batteries. A battery with a capacity of 100mAh can supply 100mA for one hour, or 10mA for 10 hours etc. One mAh is the equivalent of 3.6 coulombs of charge

Negative Electrode The electrode of a cell or battery which develops an excess of electrons as a result of the internal chemical reaction.

NiCad Battery ("Nickel Cadmium") A now almost obsolete type of secondary cell, with a terminal voltage of 1.2V and which uses nickel hydroxide as the positive electrode, cadmium/cadmium hydroxide as the negative electrode and potassium hydroxide as the electrolyte. Since the 1970s these were widely used consumer appliances, but by the early 2000s they began to be replaced by Nickel Metal Hydride batteries, which have higher capacity, no memory effect, and are more environmentally benign. Currently NiCads are mostly used in "maintenance" applications such as cordless phones, where only that type of battery will work.

NiMH Battery (Nickel Metal Hydride) A type of secondary cell with a terminal voltage of 1.2V, broadly similar to NiCad but having higher capacity, and not being subject to the Memory effect. In place of cadmium it uses a complex nickel alloy which is able to absorb a large amount of hydrogen gas, which acts as the negative electrode. Special chargers are normally required for NiMH cells. Most products requiring AA NiCads will also accept AA NiMH cells and such "legacy" applications account for the bulk of current NiMH sales. Except where cost is an issue, NiMH has largely been replaced by Lithium-Ion in new applications.

Nominal Voltage The average terminal voltage of a cell or battery during its discharge. (eg 2V for lead-acid, 1.4V for carbon-zinc etc)

OC Voltage The terminal voltage of a cell or battery when open circuited — i.e., not supplying any significant load current. (eg 2.2 V for lead-acid, 1.5V for carbon-zinc etc).

Overcharging Attempting to store more charge into a secondary cell or battery than its electrochemical system can safely absorb — i.e., beyond its capacity. Can cause overheating and irreversible structural damage, including explosion, particularly with Lithium-Ion cells.

Overdischarging Withdrawing too much energy from a cell or battery, which can shorten its working life or in extreme cases cause irreparable damage, particularly with Lithium-Ion cells.

Plates Alternative term for "electrodes".

Positive Electrode The electrode of a cell or battery, which normally has a deficiency of electrons due to the internal chemical reaction.

PrimaryCell/ Battery An electrochemical cell or battery which contains a fixed amount of stored energy when manufactured, and cannot be recharged after that energy is withdrawn. Most commonly Carbon-Zinc and Alkaline cells.

Recharging With secondary cells or batteries, the process of restoring electrical energy after the battery is discharged — by driving a current back into it from an external source.

Rechargeable Alkaline A variety of manganese-zinc alkaline cell designed to absorb the hydrogen gas released during recharging, and allow re-use as a secondary battery. They generally have a very limited cycle lifetime and little cost advantage over proper rechargeable cells.

Rechargeable Battery Any electrochemical cell or battery which can be recharged — i.e., a secondary cell or battery.

Sealed Dry Battery A cell or battery where the case can be effectively sealed to allow operation in any position without leakage of the chemical electrolyte.

Secondary Battery Any electrochemical cell or battery which can be recharged.

Self-Discharge Rate All batteries tend to discharge themselves even when not supplying energy. The self discharge rate describes this effect in terms of a percentage of the battery capacity, over a specified period. Also known as "shelf life".

Shallow cycling Repeatedly discharging a secondary battery by only a small proportion of its capacity before recharging again. Some types of battery prefer this, others do not. (See Memory Effect).

Shelf Life The period during which a battery will retain a certain proportion of its rated capacity, when not in use.

Silver Oxide Cell An alkaline primary cell using silver oxide as the positive electrode and zinc as the negative electrode, with an electrolyte of either sodium or potassium hydroxide. Mainly used in low-drain applications, for a long time being virtually the only "watch battery" available.

SLA Battery ("Sealed Lead Acid") A type of secondary battery derived from the original flooded lead-acid type. It is designed to absorb a certain amount of oxygen and hydrogen gasses produced during charging, but this has to be strictly controlled by using a proper regulated charging system. This means the battery can be sealed to prevent the sulphuric acid from escaping, but the seals are designed to rupture if there is any significant gas buildup.

Slow or Trickle Charging Recharging a secondary battery at a rate of between 0.05C and 0.2C — i.e., over a period between 7 and 28 hours (charging 140% of nominal capacity).

Wet Cell/Battery Any electrochemical cell or battery in which the electrolyte is in the liquid form.

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Zinc-Air Cell A recently developed type of primary cell which has a very high energy density, but a relatively short working life. It uses a negative electrode of powdered zinc mixed with potassium hydroxide and a negative electrode of moist air.

Zinc Chloride Battery An enhanced version of the standard zinc-carbon primary battery, with about 50% higher capacity. The main difference is the use of zinc chloride as the electrolyte. Generally marketed as "Heavy Duty" somewhere between standard Carbon-Zinc and Alkaline.

SPECIAL NOTES ON LITHIUM-ION BATTERIES

While Lithium-Ion batteries have revolutionized many areas of electronics with their light weight, high terminal voltage, and high capacity, in larger sizes they are potentially very dangerous devices and require great care in the design of their charging and discharging circuitry.

Generally, their charging characteristic is similar to Lead Acid cells, except that their recommended "Float" voltage is 4.3 Volts per cell instead of 2.3V. However the required accuracy of this voltage is much greater than for Lead Acid cells, and Lithium Cells also contain highly inflammable organic solvents.

A properly designed Lithium Battery management system will contain all these components:

- Electronic (MOSFET) over discharge/over current protection
- Electronic (MOSFET) over charge protection
- Proper Lithium charge cycle controller
- Battery temperature sensor
- PTC or Fuse

For high power portable devices, the first two items should be duplicated, to give a backup if one MOSFET fails. The entire system (redundant over charge/discharge) is often mounted on a miniature circuit board inside the batteries themselves.

However, many low-cost devices designed to charge from a USB socket use a very basic charge circuit, consisting of little more than a silicon diode to drop the 5 Volts down to 4.3 Volts, and a current limiting resistor. If the lithium cell has an over charge/discharge board and it is less than 500mAh in capacity, this setup is acceptable (just). However in many cases the protection boards are not fitted and this highlights a serious flaw in the system: The battery will only be charged correctly if the USB socket is delivering exactly 5.0 Volts.

Unfortunately, the "legal" voltage range for USB is actually 4.75V to 5.25V, which means that depending on the device, the battery may be over-charged, or barely charge at all. What is worse, it is far from unusual for car cigarette lighter type USB adaptors or USB sockets on car stereos to have blown-up voltage regulators, and so deliver 12 Volts to the USB socket. Apart from possibly wrecking any 5V devices plugged into them, they can cause battery explosions.

Further, while most dashboard-mount devices use Mini USB sockets for their power input, many of these can actually work with any voltage between 5V and 15V. As a consequence, a lot of the "12V to USB" adaptors supplied with such devices are a "straight-through" 12V connection to the USB socket, *NOT* a regulated 5V supply!

A USB voltmeter such as the Jaycar XC5074 would be a wise investment for such situations.

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