COMING TO TERMS WITH BATTERIES

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ABSTRACT

It started when I observed that six IEEE standards had four different definitions for the same term. On closer examination I found several other contradictory terms as well. The Stationary Battery Committee created a Glossary Working Group to look into what terms were in conflict. We found about a hundred terms defined among the various standards. "That shouldn't take long," we thought. Then we decided that maybe we should look at what other definitions were in use throughout industry. Two years, two dozen meetings, and over 1500 line items later, the group has been reduced to a few glassy-eyed, mumbling disbelievers. This paper explains the work of the committee, its goals and guidelines, and provides several examples of words, the meaning of which maybe you *thought* you knew… but maybe not!

FORWARD

> "Up you two get, and off we go!" said Thorin.
>
> "I'm awfully sorry," said Bilbo, "but I have come without my hat, and I have left my pocket-handkerchief behind, and I haven't got any money. I didn't get your note until after 10:45, to be precise."
>
> "Don't be precise," Said Dwalin, "and don't worry!. You will have to manage without pocket-handkerchiefs, and a good many other things, before you get to the journey's end."
>
> -- *The Hobbit* [B1]

BACKGROUND

The IEEE Stationary Battery Committee is *the* definitive repository of battery knowledge. It is responsible for authoring at least fourteen Standards (with more in the works) and for sponsoring or correlating a few more. It also sponsors technical papers at conferences such as the IEEE Power Engineering Society, and its members are frequent speakers at educational conferences such as Battcon.® With such responsibility, one would naturally look to this engineering committee as the ultimate authority for precise communications on battery topics.

That is why I was a bit befuddled one day as I saw a term being used in a manner that caused me to pause. I whipped out IEEE 100, *The Authoritative Dictionary of IEEE Standards Terms*[B1]. Lo and behold, there turned out to be more than one definition, both from Standards authored by the previously-mentioned committee. "How can this be?" I asked myself. Receiving no answer, I started to look through the *Definitions* chapters of all the standards (usually Chapter 3). I was again surprised that I found the word defined in six different standards, with four variations. The rule is: "Working Groups are strongly encouraged to use definitions that already exist in IEEE 100 instead of creating new definitions or slightly modifying existing definitions." I saw no such unique usage.

So again I asked myself, "If the IEEE Stationary Battery Committee cannot agree on what commonly-used terms mean, how can we expect anybody else to use them correctly?" Receiving the same response as to my previous question, I posed the question to the Committee. They also yielded the same results. As is so often the nature of committees, if you are so bold as to pose an imponderable question, then you are assigned to chair a task group to find the answer. And so I set out like Bilbo Baggins the Hobbit, innocently anticipating a rewarding trip and totally unaware of the goblins and trolls who waited.

GOALS AND RULES

In short order a group of equally naive enthusiasts was formed. Our first task was to identify our objectives and establish a few guidelines, which were as follows:

- This would be a task group, not a Standards Working Group, so no PAR would be required
- Initial membership would be limited to the Executive Committee (chairs of Standards Working Groups) in order to stay within a manageable size. Too many discussions are the bane of progress.
- The final document would be presented to the members at large for further refinement. It would be a "living" document, adapting to new information and adding terms as technology advances.
- The final document would be for internal use; it would not be treated as a "standard."
- We would default to IEEE 100 definitions when they exist, unless we found compelling reason to change.
- Where more than one definition is required, or where proper use of a term is in question, or where multiple terms seem to exist for the same concept, we would provide "guidance" in addition to the definition.

The first task was to look at chapter 3 in each of the standards to identify where multiple definitions exist. We would then pick the one that seemed best, and move on. This actually was easily accomplished by the next meeting. There were only about 70 terms, and most were fairly easy to reconcile.

But then, as is always the case, project creep set in. "What about definitions that exist in other standards?" someone asked. "What about terms that are used and not defined in our standards?" asked another. We all nodded wisely. "Yes," we agreed, "We should examine those as well."

So we set out to scour all the terms that are in use. We looked at standards from other organizations. We looked at definitions in text books. We looked at presentations from battery maintenance organizations. We surfed the Internet. By our third meeting we had compiled close to 1,500 terms and definitions!

This was an epiphany. Formerly enthusiastic contributors suddenly developed higher work-related priorities and dropped out of sight. A handful of us dug in. We created a few more rules.

- We would only focus on user-oriented terms. Terms applicable only to the battery manufacturing process would not be included (this eliminated several dozen terms).
- We would stay focused on stationary batteries. Terms applicable only to motive, portable or primary batteries would not be included.
- Generic, commonly used terms (such as amps and volts) do not require our definitions.
- We would keep definitions short (one sentence whenever possible). Explanatory notes on the application would be left off or added in the guidance.

Deliberations began in earnest, starting at "A" and working toward "Z". Two years and more than 25 sessions later we are homing in our first complete draft. Some of the simplest and most common terms (or so we thought) turned out to be the ones that created the most debate, with up to half an hour on a single term. At that rate, it could have taken thousands of hours.

SOME TERMS

Following is a representative sampling. It is a mere handful out of the hundreds of terms addressed by the working group. Some terms are combined into logical groups, so what follows is not necessarily in alphabetical order.

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absorbed electrolyte: See: absorbed glass mat (AGM) or absorbed electrolyte cell
Guidance: *Do not use this term. When people use this term, they usually are referring to the type of battery, not the electrolyte itself. Electrolyte can be absorbed into plates, separators, etc.*

absorbed electrolyte cell: A cell in which the liquid electrolyte is immobilized in fiberglass or polymeric fiber separators
Guidance: *This definition is preferred over the definition in IEEE Std 100 as it does not limit the application to VRLA batteries*

glass mat: See: absorbed glass mat
retainer mat

absorbed glass mat (AGM): Porous separator material comprised of non-woven glass fibers.
See also: *absorbed electrolyte cell.*

retainer mat: Glass or polymeric fiber sheet for use as a retainer

AC impedance test: See internal ohmic measurement
AC conductance: "
AC conductance (cell): "
AC conductance test: "

internal ohmic measurement: A measurement of the electronic and ionic conduction path within a cell or unit, using techniques commonly known as impedance, conductance, or resistance tests.

internal resistance: The resistance to the flow of an electric current within a cell or battery.
Guidance: *Used for calculating short-circuit current and sizing conductors. When applied to measurements, "internal ohmic measurement" is preferred*

aging factor: A quantitative factor expressing the ratio between expected service life and design life of a battery.
See also: *aging margin*

aging margin: The quantitative factor included during battery sizing in order to calculate the end-of-life capacity.

ampere-hour capacity: See: capacity, battery

capacity, battery: A quantity of electrical energy , typically measured in ampere-hours or watt-hours

available energy: The total watt-hours that can be withdrawn from a cell based upon a specific set of operating conditions (including initial state-of-charge, discharge rate, initial cell temperature, and end voltage) and the age of the cell,

available capacity: The total ampere-hours or watt-hours that can be withdrawn from a cell based upon a specific set of operating conditions (including initial state-of-charge, discharge rate, initial cell temperature, and end voltage) and the age of the cell.
See also: *available energy*

battery: Two or more cells connected together electrically. Cells may be connected in series or parallel, or both, to provide the required operating voltage and current levels.
Guidance: *common usage permits this designation to be applied to a single cell used independently.*

battery case: See: battery container

jar: See: battery container

battery container: A receptacle or vessel that holds the plates, electrolyte, and other elements of a single unit in a battery. A battery container can be a single cell or multi-cell unit (also called a "monoblock").
Guidance: *This is the preferred term versus "jar" or "case"*

catalyst, VRLA: A catalyst introduced into the headspace of a VRLA cell to compensate for self discharge of the negative electrode

catalytic vent: A vent cap that incorporates a catalyst that recombines hydrogen and oxygen gas and returns the resulting water to the cell

charge retention: The ability of a cell to retain some portion of its charge after it has been stored for a period of time under specified conditions without being charged (normally expressed as a percentage of full charge).

shelf life: See: storage time

storage time: The period of time that a cell can be stored at a specified temperature, as shipped, without intervention

Guidance: *Intervention could be a freshening charge, addition of electrolyte for dry-charged batteries, or similar actions.*

connector: See: intercell connector
Inter-step connector
Inter-tier connector
Inter-rack connector
Terminal connection detail

coulombic efficiency (battery): The ratio of the ampere-hour output of the battery to the ampere-hour input required to restore the initial state of charge

Guidance: *The term "coulombic efficiency" is preferred over "ampere-hour efficiency"*

efficiency: See: coulombic efficiency (Oxygen recombination efficiency)

coup de fouet: Initial voltage drop and recovery experienced when discharging a fully charged lead-acid battery. [Note: French term literally translated as "whiplash."]

deep cycle: A deep discharge followed by a recharge

deep discharge: The removal of a significant portion (generally 50% or greater) of the battery's design capacity

depth of discharge: The ampere hours removed from a fully charged battery, expressed as a percentage of its rated ampere-hour capacity.

depolarization: A reduction in the polarization on a cell or electrode

Guidance: *See: polarization*

polarization: The shift in the potential of an electrode, or the voltage of a cell/battery, from the open-circuit value, brought about by the flow of current

polarization voltage: see: polarization

Guidance: *Do not use this term*

discharge rate: The rate, in amperes (or watts), at which current (or power) is delivered by a battery.

edge-to-edge: The configuration of cells in which the plate edges of adjacent cells in the series string are next to each other.

See also: *face-to-face*

end-to-end: See: Face-to- face or edge-to-edge

Guidance: *Do not use this term*

face-to-face: The configuration of cells in which the flat surfaces of plates of adjacent cells in the series string face each other. (See also edge-to-edge)

Guidance: *Normally applied to transparent containers to optimize visual inspection of positive plate edges*

plates parallel to the stand: See: edge-to-edge

plates perpendicular to the stand: See: face-to-face

equalization: The application of a higher-than-float voltage with the intent of restoring all cells within the battery to an equal state of charge

See also: *equalizing charge*

fan curve(s): A graph that contains a set of curves used to describe a cell's discharge characteristics

See also: *"S curve*

final voltage: See: cutoff voltage

Guidance: *The terms "final voltage" and "cutoff voltage" typically refer to the battery system; the terms "end voltage" and "end-of-discharge voltage" usually refer to cell level.*

float: See: float charge
float operation

float charge: The process by which a constant potential is applied to a battery in order to maintain it in a fully charged condition, while minimizing side reactions such as aging or water consumption.

See also: *"float operation"*

float charging: See: float charge

float current: The current flowing into a battery once it is charged in order to maintain it in a fully charged condition.

float service: See: float operation

float operation The operation of a dc system with the battery, the battery charger, and the load all connected in parallel and with the battery charger supplying the normal dc load including charging current

Guidance: *The term "float operation" is preferred over:*

- *"float,"*
- *"floating,"*
- *"float charge,"*
- *"float charging,"*
- *"full float operation,"*
- *"float service,"*
- *"trickle charge," or*
- *"constant potential charging"*

flooded cell: See: vented cell

vented cell A cell in which the products of electrolysis and evaporation are allowed to escape to the atmosphere as they are generated.

Guidance: *This is the preferred term that should be used in place of*

- *"wet cell" or*
- *"flooded cell"*

freshening charge: A charge given to a battery following its nonuse or storage in order to return it to a near maximum state of charge and to minimize sulfation.

Guidance: *Freshening charges are usually performed using the manufacturer's recommended equalization or cycle-service charging voltage*

full cycle: A battery discharge (where 80% or more of the cell's design capacity is removed) followed by a complete recharge

gelled electrolyte: Electrolyte that has been immobilized by the addition of a gelling agent

gel cell: See: gelled electrolyte cell

gelled electrolyte cell: One type of valve-regulated lead-acid cell, which utilizes gelled electrolyte.
See also: *valve-regulated lead-acid cell*
gelled electrolyte

high-rate charge: The application of a high current charge, typically accomplished by applying a potential higher than the float charge.
See also: *activation charge*
boost charge
commissioning charge
equalizing charge
finishing charge
initial charge
quick charge

hourly rate: See "hour rate"

hour rate: The discharge rate of a battery expressed in terms of the length of time a fully-charged battery can be discharged at a specific current before reaching a specified end-of-discharge voltage:

hydration: See: hydration short

hydration short: A condition, caused by over-discharging a lead-acid cell, typically at a low rate, that leads to creation of multiple lead-sulfate shorts, thereby rendering the cell useless.
Guidance: *not to be confused with "rehydration"*

immobilized electrolyte: Electrolyte in a cell that is prevented from flowing by use of either gelled or absorbed electrolyte technology

initial closed-circuit voltage, battery: The battery closed-circuit voltage at the beginning of a discharge, measured after coup de fouet.

initial open-circuit voltage: The battery voltage after installation and before any external connections are made to the battery.
Guidance: *Post-installation voltage test to ensure that battery has been connected correctly.*

intercell connection resistance: The electrical resistance of the connection between the terminals of two series-connected cells. It includes the resistance of the intercell connector(s) and the contact resistance at the points of connection to the cell terminals.

lead-acid cell: A secondary cell in which the active material of the positive electrode is lead dioxide, the active material of the negative electrode is lead, and the electrolyte is dilute sulfuric acid.

lead-antimony cell: A type of lead-acid cell in which the principal strengthening agent in the lead plate grids is antimony in concentrations greater than 4%

low-antimony cell: A type of lead-acid cell in which the principal strengthening agent in the lead plate grids is antimony in concentrations less than 2%, and in which other materials are added as grain refiners to reduce the brittleness of the alloy.
See also: *lead selenium*

lead-calcium cell: A lead-acid cell in which the principal strengthening agent in the lead plate grids is calcium.

lead-selenium cell: A lead-acid cell with plate grids made from a low-antimony alloy (typically less than 2% antimony) with selenium as a grain refiner.

lead-tin cell: A lead-acid cell in which the principal strengthening agent in the lead plate grids is tin

life: The period during which a fully charged battery is capable of delivering at least a specified percentage of its capacity, generally 80%.

service life: The period of useful service under specified conditions, usually expressed as the time period or number of cycles that elapse before the ampere-hour capacity falls to a specified percentage of the rated capacity.

load profile: See: duty cycle

duty cycle: The sequence of loads a battery is expected to supply for specified time periods while maintaining a minimum specified voltage.

maintenance-free battery: A battery that does not require (nor usually accept) water additions during its useful lifetime (this term may refer to flooded cells which are designed with an initial overfill of water, or to VRLA batteries, lithium batteries, and nickel-metal hydride batteries).
Guidance: *This is not an accepted term as all battery systems require periodic inspection and cleaning.*

modified constant-voltage charge: A charge in which the first stage is at a limited constant current and the second stage is at constant voltage. Syn: IU charge
Guidance: *In practice, almost all charging is modified constant-voltage charging*

modified performance test: A test, in the "as found" condition, of battery capacity and the ability of the battery to satisfy the duty cycle.

module: Multiple cells/units in a single assembly.

monoblock: See: multicell unit
Guidance: *slang term*

multicell unit: Multiple cells in a single container

nickel-cadmium (Ni-Cd) cell: A secondary cell in which the active material of the positive active material is nickel oxyhydroxide, the active material of the negative electrode is cadmium, and the electrolyte is dilute potassium hydroxide.

nominal battery voltage: The value assigned to a battery of a given voltage class for the purpose of convenient designation. The operating voltage of the system may vary above or below this value

open circuit: The state of a cell or battery when no current is flowing in an external circuit

oxygen recombination: The process by which oxygen is generated at the positive plates and ultimately recombined with hydrogen ions at the negative plates and converted back to water. In this process, hydrogen gas formation and evolution are suppressed.

oxygen recombination cell: See: valve-regulated lead-acid cell
Guidance: *Do not use this term*

oxygen recombination efficiency: The amount of oxygen ultimately converted to water at the negative plates expressed as a percentage of the total amount of oxygen produced at the positive plates.

parallel assembly: The arrangement of cells within a battery in which individual cells or groups of series-connected cells are connected in parallel.

See also: *parallel cell connection*
parallel strings

Guidance: *Use with respect to physical battery arrangement; does not refer to assembly of plates within a cell.*

parallel cell connection: The arrangement of cells in a battery group made by connecting all positive terminals together and all negative terminals together, the voltage of the group being that of one cell and the capacity being the sum of the individual cell capacities

parallel strings: The interconnection of two or more strings in which the like terminals of each battery string are connected together.

plate: An assembly of active materials on a supporting and conducting framework

plate growth: See: positive plate growth

positive plate growth The physical growth of the positive plates of a lead acid cell as the cell ages, caused by intergranular oxidation of metallic lead grids forming lead dioxide, which increases the plate size.

polarity: The characteristic of poles in a cell or battery which determines the direction of current flow as expressed as positive or negative.

polarization: The shift in the potential of an electrode, or the voltage of a cell/battery, from the open-circuit value, brought about by the flow of current.

pole: See: terminal
positive terminal
negative terminal

post: One type of "terminal", commonly used on large cells.

See also: *terminal*
positive terminal
negative terminal

terminal: That part of a cell, module, or battery to which an external connection is made.

Also called: *post*
pillar
pole
terminal post

post corrosion: Formation of compounds on a post that can affect connection quality, and in extreme cases can result in failure of a post seal and cracking of a cover or container.

Guidance: *Specific to lead-acid technology*

rated capacity: The capacity assigned to a cell by its manufacturer for a given discharge rate, at a specified electrolyte temperature, to a given end-of-discharge voltage.

recombinant cell: A cell characterized by the recombination of internally generated oxygen and suppression of hydrogen gas evolution to limit water consumption.

reference electrode: A non-polarizable test electrode that has a reproducible potential against which other electrode potentials can be referenced.

reserve time: The time that a fully charged battery can satisfy the load with no contribution from the charging source

See also: *Autonomy*

reversal: A changing of the normal polarity of a cell caused by over-discharge or incorrect connection

ripple current:: See : ripple
ripple voltage: " "
percent ripple " "

ripple: A type of electrical noise characterized by a uniform waveform riding in the dc circuit, normally expressed as peak, peak-to-peak, or root-mean square (rms) voltage or current.

Guidance: *Do not use the term "ac ripple"*

sealed cell: A cell that is designed not to allow release of gas to the atmosphere during normal operation.

Guidance: *A valve-regulated lead-acid cell does not comply with this definition. A nickel-metal-hydride cell would be sealed under conditions of normal operation.*

sealed lead-acid battery: An incorrect term often used to refer to VRLA batteries

secondary cell: An electrochemical cell that is capable of being discharged and then recharged.

Also called: *"storage cell"*
"storage battery;"
"accumulator."

seismic rack: A battery rack that is designed to restrain the cells during a seismic event.

Guidance: *Use this term vs.*
"earthquake rack",
"earthquake stand," or
"seismic stand."

self discharge: The process by which the available capacity of a battery is reduced by local action and parasitic currents

shipping vent: The vent placed in a cell containing liquid electrolyte during transportation

Guidance: *May also be referred to as a "transit plug" or shipping plug.*

specific energy: The ratio of the available energy of a battery to its mass, based on defined discharge conditions.

See also: *energy density*
Guidance: *Use this term instead of gravimetric energy density*

specific power: The ratio of the available power of a battery to its mass, based on defined discharge conditions.

See also: *power density*
Guidance: *Use this term instead of gravimetric power density*

power density: The ratio of the available power from a cell or battery to its volume, based on specific discharge conditions.

stationary battery: A battery designed for service in a permanent location

storage battery: see: secondary battery

secondary battery [or cell]: An electrochemical battery [or cell] that is capable of being discharged and then recharged.

Tafel curve: A semi-logarithmic graph showing the relationship between electrode and/or cell polarization and charging current.

temperature coefficient of capacity: See: temperature correction factor
temperature coefficient of electromotive force: "

temperature correction factor: A factor applied in battery sizing or testing to adjust for variation in available capacity as a function of temperature.

thermal runaway: A condition that is caused by a battery charging current or other process which produces more internal heat than the battery can dissipate.

trickle charge: A continuous, low rate, constant current charge given to a cell or battery to maintain the unit in a fully charged condition.
See also: *float operation*

unit (battery): Multiple cells in a single container.

valve-regulated lead-acid (VRLA)cell: A lead-acid cell that is sealed with the exception of a valve that opens to the atmosphere when the internal pressure in the cell exceeds atmospheric pressure by a pre-selected amount. VRLA cells provide a means for recombination of internally generated oxygen and the suppression of hydrogen gas evolution to limit water consumption.

SUMMARY AND CONCLUSION

Extracts from a draft glossary of battery terms have been previewed. The Glossary is not a released document, and it will not be published as a standard. It is intended for use by members of the IEEE Stationary Battery Committee for consistency in the development of stationary battery standards. The Working Group expects that changes will be made once it is reviewed by the entire IEEE Stationary Battery Committee, and that changes will continue to be made to it.

BIBLIOGRAPHY

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B2 *IEEE 100: The Authoritative Dictionary of IEEE Standards Terms,* 7th Edition, Institute of Electrical and Electronics Engineers, www.ieee.org