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A valve regulated lead-acid (VRLA) battery, commonly known as a sealed lead-acid (SLA) battery,[1] is a type of lead-acid battery characterized by a limited amount of electrolyte ("starved" electrolyte) absorbed in a plate separator or formed into a gel; proportioning of the negative and positive plates so that oxygen recombination is facilitated within the cell; and the presence of a relief valve that retains the battery contents independent of the position of the cells.[2]

There are two primary types of VRLA batteries, absorbent glass mat (AGM) and gel cell (gel battery).[3] Gel cells add silica dust to the electrolyte, forming a thick putty-like gel. AGM (absorbent glass mat) batteries feature fiberglass mesh between the battery plates which serves to contain the electrolyte and separate the plates. Both types of VRLA batteries offer advantages and disadvantages compared to flooded vented lead-acid (VLA) batteries or each other.[4]

Due to their construction, the gel cell and AGM types of VRLA can be mounted in any orientation, and do not require constant maintenance. The term "maintenance free" is a misnomer as VRLA batteries still require cleaning and regular functional testing. They are widely used in large portable electrical devices, off-grid power systems and similar roles, where large amounts of storage are needed at a lower cost than other low-maintenance technologies like lithium ion.

The first lead-acid gel battery was invented by Elektrotechnische Fabrik Sonneberg in 1934.[5] The modern gel or VRLA battery was invented by Otto Jache of Sonnenschein in 1957.[6][7]

The Cyclon was a spiral wound cell with thin lead foil electrodes. A number of manufacturers adopted the technology to implement it in cells with conventional flat plates. In the mid 1980s, two UK companies, Chloride Group and Tungstone Products, simultaneously introduced "ten year life" AGM batteries in capacities up to 400 Ah, stimulated by a British Telecom specification for backup batteries to support new digital exchanges.

In the same period, Gates acquired another UK company, Varley, specializing in aircraft and military batteries. Varley adapted the Cyclon lead foil technology to produce flat plate batteries with exceptional high rate output. These gained approval for a variety of aircraft including the BAE 125 and 146 business jets, the Harrier jump jet and its derivative the AV-8B, and some F16 variants as the first alternatives to then standard nickel-cadmium (Ni-Cd) batteries.[6]

Lead-acid cells consist of two plates of lead, which serve as electrodes, suspended in an electrolyte consisting of diluted sulfuric acid. VRLA cells have the same chemistry, except the electrolyte is immobilized. In AGM this is accomplished with a fiberglass mat; in gel batteries or "gel cells", the electrolyte is in the form of a

paste like gel created by adding silica and other gelling agents to the electrolyte.[9]

Each cell in a VRLA battery has a pressure relief valve which will activate when the battery starts building pressure of hydrogen gas, generally a result of being recharged.[12]

The cell covers typically have gas diffusers built into them that allow safe dispersal of any excess hydrogen that may be formed during overcharge. They are not permanently sealed, but are designated to be maintenance free. They can be oriented in any manner, unlike normal lead-acid batteries, which must be kept upright to avoid acid spills and to keep the plates" orientation vertical. Cells may be operated with the plates horizontal (pancake style), which may improve cycle life.[13]

AGM batteries differ from flooded lead-acid batteries in that the electrolyte is held in the glass mats, as opposed to freely flooding the plates. Very thin glass fibers are woven into a mat to increase the surface area enough to hold a sufficient amount of electrolyte on the cells for their lifetime. The fibers that compose the fine glass mat do not absorb and are not affected by the acidic electrolyte. These mats are wrung out 2-5% after being soaked in acids just prior to finish manufacturing.

The plates in an AGM battery may be of any shape. Some are flat, whereas others are bent or rolled. Both deep cycle and starting type of AGM batteries, are built into a rectangular case according to Battery Council International (BCI) battery code specifications.

As with lead-acid batteries, in order to maximize the life of an AGM battery, it is important to follow the manufacturer"s charging specifications. The use of a voltage regulated charger is recommended.[15] There is a direct correlation between the depth of discharge (DOD) and the cycle life of the battery,[16] with differences between 500 and 1300 cycles depending on DOD.

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