

# VRLA battery

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A **VRLA battery** stands for (**valve-regulated lead-acid battery**)<sup>[1]</sup> more commonly known as a **sealed lead-acid (SLA)**, **gel cell**, or **maintenance free battery**, is a type of lead-acid rechargeable battery. Due to their construction, the Gel and AGM types of VRLA can be mounted in any orientation, and do not require constant maintenance.<sup>[2]</sup> 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.



A 12V VRLA battery, typically used in uninterruptible power supplies

There are three primary types of VRLA batteries, Sealed VR wet cell, AGM and Gel. Gel cells add silica dust to the electrolyte, forming a thick putty-like gel. These are sometimes referred to as "silicone batteries". AGM (absorbed glass mat) batteries feature fiberglass mesh between the battery plates which serves to contain the electrolyte. Both designs offer advantages and disadvantages compared to conventional batteries and sealed VR wet cells, as well as each other.

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## Basic principle

Lead-acid cells consist of two plates of lead, which serve as electrodes, suspended in diluted sulphuric acid, which is then the electrolyte. In conventional lead-acid cells, the diluted acid is in liquid form, hence the term "flooded" or "wet" cells. VRLA cells have essentially the same lead-acid chemistry, but the AGM and Gel types have the diluted acid electrolyte solution immobilized, either by soaking a fiberglass mat in it (hence: glass-mat batteries), or by turning the liquid into a paste-like gel by the

addition of silica and other gelling agents (hence: gel batteries). The wet cell type contains acid in the liquid form similarly to the flooded lead acid batteries, just the wet cell VRLA battery case is better sealed.

When a cell discharges, the lead and diluted acid undergo a chemical reaction that produces lead sulphate and water (see lead–acid battery for details of the chemical reaction). When a cell is subsequently charged, the lead sulphate and water are turned back into lead and acid. In all lead-acid battery designs, charge current must be adjusted to match the ability of the battery to absorb the energy. If the charging current is too great, some of it will be wasted decomposing water into hydrogen and oxygen, in addition to the intended conversion of lead sulphate and water into lead dioxide, lead, and sulphuric acid which reverses the discharge process. If these gases are allowed to escape, as in a conventional flooded cell, the battery may need to be topped up with water from time to time. In contrast, in VRLA batteries the gases are retained within the battery as long as the pressure remains within safe levels. Under normal operating conditions the gases can then recombine within the battery itself, sometimes with the help of a catalyst, and no topping-up is needed<sup>[3]</sup>[1] (<http://www.tms.org/pubs/journals/jom/0101/nelson-0101.html>). However, if the pressure exceeds safety limits, safety valves open to allow the excess gases to escape, and in doing so regulate the pressure back to safe levels (hence "valve-regulated" in "VRLA").

In flooded lead-acid batteries, the liquid electrolyte is a hazard during shipping and makes them unsuitable for many portable applications. Furthermore, the need to maintain water levels makes them unsuitable for maintenance-free applications. The immobilized electrolyte in VRLA batteries (AGM and Gel types) addresses these problems. At the same time, since VRLA cells can't be "topped off" with water, any hydrogen lost during outgassing can't easily be replaced. To some extent, this can be compensated for by overprovisioning the quantity of electrolyte, but at the cost of increased weight. The main downside to the VRLA design is that the immobilizing agent also impedes the chemical reactions that generate current. For this reason, VRLAs have lower peak power ratings than conventional designs. This makes them less useful for roles like car starting batteries where usage patterns are brief high-current pulses (during starting) followed by long slow recharging cycles. VRLAs are mostly found in roles where the charge/recharge cycles are slower, such as power storage applications.

Both flooded and VRLA designs require suitable ventilation around the batteries; both to prevent hydrogen concentrations from building up (hydrogen gas is highly flammable), and to ensure that the batteries receive adequate cooling.

## Construction

VRLA cells may be made of flat plates similar to a conventional flooded lead–acid battery, or may be made in a spiral roll form to make cylindrical cells.

VRLA batteries have a pressure relief valve which will activate when the battery starts building pressure of hydrogen gas, generally a result of being recharged. Valve activation allows some of the gas or electrolyte to escape, thus decreasing the overall capacity of the battery. Rectangular cells may have valves set to operate as low as 1 or 2 psi; round spiral cells, with metal external containers, can have valves set as high as 40 psi.<sup>[2]</sup>

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.<sup>[2]</sup>

At high overcharge currents, electrolysis of water occurs, expelling hydrogen and oxygen gas through the battery's valves. Care must be taken to prevent short circuits and rapid charging. Constant-voltage charging is the usual, most efficient and fastest charging method for VRLA batteries, although other methods can be used.<sup>[2]</sup> VRLA batteries may be continually "float" charged at around 2.35 volts per cell at 25 °C. Some designs can be fast charged (1 hour) at high rates. Sustained charging at 2.7 V per cell will damage the cells. Constant-current overcharging at high rates (rates faster than restoring the rated capacity in three hours) will exceed the capacity of the cell to recombine hydrogen and oxygen.<sup>[2]</sup>

## History

The first lead-acid gel battery was invented by Elektrotechnische Fabrik Sonneberg in 1934.<sup>[4]</sup> The modern gel or VRLA battery was invented by Otto Jache of Sonnenschein in 1957.<sup>[5]</sup> The first AGM cell was the Cyclon, patented by Gates Rubber Corporation in 1972 and now produced by EnerSys.<sup>[6]</sup> The cyclon is a spiral-wound cell with thin lead foil electrodes. A number of manufacturers seized on the technology to implement it in cells with conventional flat plates. In the mid-1980s two UK companies, Chloride and Tungstone, simultaneously introduced 10 year life AGM batteries in capacities up to 400 Ah, stimulated by a British Telecom specification for batteries for support of new digital exchanges. In the same period, Gates acquired another UK company, Varley, specialising 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 and its derivative the AV8B, and some F16 variants as the first alternatives to the normal NiCd batteries.

Moves to higher capacity AGM batteries were led by GNB's Absolyte range extending to 3900 Ah. VRLA/AGM technology is now widespread in both stationary and vehicle batteries.

## AGM (Absorbent glass mat)

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 surface area enough to hold sufficient electrolyte on the cells for their lifetime. The fibers that compose the fine glass mat do not absorb nor are they affected by the acidic electrolyte. These mats are wrung out 2–5% after being soaked in acids, prior to manufacture completion and sealing.

The plates in an AGM battery may be any shape. Some are flat, others are bent or rolled. AGM batteries, both deep cycle and starting, are built in a rectangular case to BCI battery code specifications.

## Gel battery

Originally a kind of gel cell was produced in the early 1930s for portable valve (tube) radio LT supply (2, 4 or 6V) by adding silica to the sulfuric acid.<sup>[7]</sup> By this time the glass case was being replaced by celluloid and later in 1930s other plastics. Earlier "wet" cells in glass jars used special valves to allow tilt from vertical to one horizontal direction in 1927 to 1931 or 1932.<sup>[8]</sup> The gel cells were less likely to leak when the portable set was handled roughly.

A modern **gel battery** (also known as a "gel cell") is a VRLA battery with a gelified electrolyte; the sulfuric acid is mixed with fumed silica, which makes the resulting mass gel-like and immobile. Unlike a flooded wet-cell lead-acid battery, these batteries do not need to be kept upright. Gel batteries reduce the electrolyte evaporation, spillage (and subsequent corrosion problems) common to the wet-cell battery, and boast greater resistance to shock and vibration. Chemically they are almost the same as wet (non-sealed) batteries except that the antimony in the lead plates is replaced by calcium, and gas recombination can take place.

The modern gel formulation and large scale production was from Otto Jache's and Heinz Schroeder's U.S. Patent 4,414,302 (<https://www.google.com/patents/US4414302>) assigned to the German company Accumulatorenfabrik Sonnenschein GmbH. With gel electrolyte the separator was no longer such a critical, hard-to-make component, and cycle life was increased, in some cases dramatically. Shedding of active material from the plates was reduced.

More importantly, gas recombination was used to make batteries that were not "watered" and could be called maintenance-free. The one-way valves were set at 2 psi, and this was high enough for full recombination to take place. At the end of charge when oxygen was evolved from overcharge on the positive plate, it traveled through the shrinkage cracks in the gel directly to the negative plate (made from high surface area pure sponge lead) and "burned" up as fast as it was made. This oxygen gas and the hydrogen adsorbed on the surface of the sponge lead metal negative plate combined to make water that was retained in the cell.

This sealed, non-spill feature made it possible to make very small VRLA batteries (1 –12 Amp hr. range) that fit into the growing portable electronics market. A large market for inexpensive smaller sealed lead acid batteries was generated quickly. Portable TV, light for news cameras, children's toy riding cars, emergency lighting, and UPS systems for computer back-up, to name a few, were powered with small sealed VRLA batteries.

## Applications

Many modern motorcycles and ATVs on the market use AGM batteries to reduce likelihood of acid spilling during cornering, vibration, or after accidents, and for packaging reasons. The lighter, smaller battery can be installed at an odd angle if needed for the design of the motorcycle. Due to the higher manufacturing costs compared with flooded lead–acid batteries, AGM batteries are currently used on



Disassembled AGM battery. From left: positive plate, glass mat separator, negative plate. On the right are the five remaining cells (of the six-cell battery).

premium vehicles. As vehicles become heavier and equipped with more electronic devices such as navigation, stability control, and premium stereos, AGM batteries are being employed to lower vehicle weight and provide better electrical reliability compared with flooded lead–acid batteries.

5 series BMWs from March 2007 incorporate AGM batteries in conjunction with devices for recovering brake energy using regenerative braking and computer control to ensure the alternator charges the battery when the car is decelerating. Vehicles used in auto racing may use AGM batteries due to their vibration resistance.

Deep-cycle AGMs are also commonly used in off grid solar power and wind power installations as an energy storage bank and in large-scale amateur robotics, such as the FIRST and IGVC competitions.

AGM batteries are routinely chosen for remote sensors such as ice monitoring stations in the Arctic. AGM batteries, due to their lack of free electrolyte, will not crack and leak in these cold environments.

VRLA batteries are used extensively in power wheelchairs, as the extremely low gas and acid output makes them much safer for indoor use. VRLA batteries are also used in the UPS (uninterruptible power supply) as a back up when the electrical power goes off.

VRLA batteries are also the standard power source in sailplanes, due to their ability to withstand a variety of flight attitudes and a relatively large ambient temperature range with no adverse effects.

However, charging regimes must be adapted with varying temperature.<sup>[9]</sup> Both AGM and Gel cells are commonly used in powered aerobatic aircraft, for the same reasons.

VRLA batteries are used in the US Nuclear Submarine fleet, due to their power density, elimination of gassing, reduced maintenance, and enhanced safety.<sup>[10]</sup>

AGM and Gell-cell batteries are also used for recreational marine purposes, with AGM being more commonly available. AGM deep-cycle marine batteries are offered by a number of suppliers. They typically are favored for their low maintenance and spill-proof quality, although generally considered a less cost effective solution relative to traditional flooded cells.

In telecommunications applications, VRLA batteries that comply with criteria in Telcordia Technologies requirements document GR-4228 (<http://telecom-info.telcordia.com/site-cgi/ido/docs.cgi?ID=SEARCH&DOCUMENT=GR-4228&>), *Valve-Regulated Lead-Acid (VRLA) Battery String Certification Levels Based on Requirements for Safety and Performance*, are recommended for deployment in the Outside Plant (OSP) at locations such as Controlled Environmental Vaults (CEVs), Electronic Equipment Enclosures (EEEs), and huts, and in uncontrolled structures such as cabinets. Relative to VRLA in telecommunications, the use of VRLA Ohmic Measurement Type Equipment (OMTE) and OMTE-like measurement equipment is a fairly new process to evaluate telecommunications battery plants.<sup>[11]</sup> The proper use of ohmic test equipment allows battery testing without the need to remove batteries from service to perform costly and time-consuming discharge tests.

## Comparison with flooded lead–acid cells

VRLA Gel and AGM batteries offer several advantages compared with VRLA flooded lead acid and conventional standard lead-acid batteries. The battery can be mounted in any position, since the valves only operate on over-pressure faults. Since the battery system is designed to be recombinant and eliminate the emission of gases on overcharge, room ventilation requirements are reduced, and no acid fume is emitted during normal operation. Flooded cell gas emissions are of little consequence in all but the smallest confined areas, and pose very little threat to a domestic user, so a wet cell battery designed for longevity gives lower costs per kWh. In a gel battery, the volume of free electrolyte that could be released on damage to the case or venting is very small. There is no need (or ability) to check the level of electrolyte or to top up water lost due to electrolysis, reducing inspection and maintenance requirements.<sup>[12]</sup> Wet cell batteries can be maintained by a self-watering system or by topping up every three months. The requirement to add distilled water is normally caused by overcharging. A well-regulated system should not require top-up more often than every three months.

The underlying fault with all lead acid batteries is the requirement for an excessively long charge time arising from a two-stage process: bulk charge and float charge. All lead acid batteries, irrespective of type, are quick to charge to 70% of capacity within 2 or 3 hours, but require another 9 to 10 hours to "float charge" after the initial charge. If users fail to float charge, battery capacity is dramatically reduced. All types of batteries have a "memory" in that every time a user charges to less than 100% charge, battery capacity is shortened. A lead acid battery could reach 4,600 cycles if it were kept on a shelf and kept at the right state of charge. To ensure a life of 8 years, a lead acid battery should be kept at full charge when stored (or dry), and, when working, kept at depth of discharge of less than 20%. In addition, its discharge rate should be not more than three hours and its charge rate should be not more than three hours (C0.333), and it should be float charged properly. With less careful use, a lifetime of two to three years or 700-800 cycles might be expected, dependent upon the use environment.

Because of calcium added to its plates to reduce water loss, a sealed AGM or gel battery recharges more quickly than a flooded lead acid battery of either VRLA or conventional design.<sup>[13][14]</sup> "From a standard car, 4WD or truck alternator they will recharge quickly from full use in about 2 to 3 hours. A deep cycle wet cell battery can take 8-12 hours to achieve only 70% to 80% of its potential charge."<sup>[15]</sup> Compared to flooded batteries, VRLA batteries are more vulnerable to thermal run-away during abusive charging.<sup>[2]</sup> The electrolyte cannot be tested by hydrometer to diagnose improper charging that can reduce battery life.<sup>[14][16]</sup>

AGM automobile batteries are typically about twice the price of flooded-cell batteries in a given BCI size group; gel batteries as much as five times the price.

AGM & Gel VRLA batteries:

- Have shorter recharge time than flooded lead-acid.<sup>[17]</sup>
- Cannot tolerate overcharging: overcharging leads to premature failure.<sup>[17]</sup>
- Have shorter useful life, compared to properly maintained wet-cell battery.<sup>[17]</sup>
- Discharge significantly less hydrogen gas.<sup>[17]</sup>
- AGM batteries are by nature, safer for the environment, and safer to use.
- Can be used or positioned in any orientation.

## See also

- Gaston Planté
- Automotive battery
- Rechargeable battery

## Further reading

### Books and papers

- Valve-Regulated Lead-Acid Batteries. Edited by Patrick T. Moseley, Jurgen Garche, C.D. Parker, D.A.J. Rand. p202 (<https://books.google.com/books?id=5Rwryml3YMEC&pg=PA202>)
- The storage of electrical energy (<https://books.google.com/books?id=uDFPAAAAMAAJ>). By Gaston Planté.
- How to Make and Use the Storage Battery. By Percy B. Warwick. Bubier Publishing Company, 1896. (Flint glass p 121 (<https://books.google.com/books?id=MS9PAAAAMAAJ&pg=PA121>))
- Vinal, G.W. (1955 Jan 01) Storage batteries. A general treatise on the physics and chemistry of secondary batteries and their engineering applications. Energy Citations Database (ECD) : Document #7308501 ([http://www.osti.gov/energycitations/product.biblio.jsp?osti\\_id=7308501](http://www.osti.gov/energycitations/product.biblio.jsp?osti_id=7308501))
- Storage Batteries (<https://books.google.com/books?id=3S9PAAAAMAAJ>): Their Theory, Construction and Use. By Arthur Eugene Watson. Bubier Publishing Company, 1911.
- John McGavack. The Absorption of Sulfur Dioxide by the Gel of Silicic Acid (<https://books.google.com/books?id=0z3PAAAAMAAJ>). Eschenbach Print. Company, 1920.

### Patents

- U.S. Patent 417,392 (<https://www.google.com/patents/US417392>) Treatment Of Porous Pots For Electric Batteries. Erhard Ludwig Mayer And Henry Liepmann
- U.S. Patent 3,271,199 (<https://www.google.com/patents/US3271199>) Solid Acid Storage Battery Electrolyte. Alexander Koenig et al.
- U.S. Patent 4,134,192 (<https://www.google.com/patents/US4134192>) Composite battery plate grid
- U.S. Patent 4,238,557 (<https://www.google.com/patents/US4238557>) Lead acid battery plate with starch coated glass fibers

## References

1. "A guide to AGM batteries and Gel batteries". *Canbat Batteries*. 2016-03-27. Retrieved 2016-11-03.
2. "Answers to Frequently asked Questions about Canbat Batteries". *Canbat Batteries*. Retrieved 2016-11-03.
3. Robert Nelson, "The Basic Chemistry of Gas Recombination in Lead-Acid Batteries", JOM 53 (1) (2001)
4. <http://www.netaworld.org/sites/default/files/public/neta-journals/NWSU06-OakesFeature.pdf>
5. <http://www.sonnenschein.org/PDF%20files/GelHandbookPart1.pdf>
6. John Devitt (1997). "An account of the development of the first valve-regulated lead/acid cell". *Journal of Power Sources*. doi:10.1016/S0378-7753(96)02516-5.
7. Watterson, Michael (2014-06-28). "Exide Gel-Cel Accumulator JSK2 Power-S Chloride Electrical". Radiomuseum.org. Retrieved 2015-03-01.
8. Walchhofer, Hans Martin & Watterson, Michael (2013-11-27). "Super Range Portable (without tuning dial) Radio McMichael L". Radiomuseum.org. Retrieved 2015-03-01.
9. Linden, Reddy (ed), Handbook of batteries, third ed, 2002

10. Business Wire (2005). "Exide Earns First-Ever Production Contract Awarded by U.S. Navy for Valve-Regulated Submarine Batteries; Shift to Advanced Product Prompts Closure of Kankakee, Illinois, Battery Plant". Retrieved 7 September 2016.
11. GR-3169-CORE (<http://telecom-info.telcordia.com/site-cgi/ido/docs.cgi?ID=SEARCH&DOCUMENT=GR-3169&>), Generic Requirements for Valve-Regulated Lead-Acid (VRLA) Battery Ohmic Measurement Type Equipment (OMTE).
12. Donald G. Fink and H. Wayne Beaty, *Standard Handbook for Electrical Engineers, Eleventh Edition*, McGraw-Hill, New York, 1978, ISBN 0-07-020974-X pages 11–116
13. Barre, Harold (1997). *Managing 12 Volts: How to Upgrade, Operate and Troubleshoot 12 Volt Electrical Systems*. Summer Breeze Publishing. p. 44. ISBN 0-9647386-1-9.(stating sealed battery plates are hardened with calcium to reduce water loss which "raises the batteries' internal resistance and prevents rapid charging.")
14. Sterling, Charles (2009). "FAQ: What Is The Best Battery System to Use for an Auxiliary Charging System". Retrieved 2 February 2012.(discussing excessive cost and poor performance of newer sealed gel or AGM batteries versus regular lead-acid flooded batteries in leisure boats.)
15. First Start. "Frequently Asked Questions". Retrieved 21 August 2013.(Discussing AGM Facts and Questions.)
16. HandyBob (2010) [2004]. "The RV Battery Charging Puzzle". Retrieved 1 February 2012.(noting that with sealed batteries, you "can't check the electrolyte to monitor their condition" and they give you "less power in the same amount of space and weight.")
17. Calder, Nigel (1996). *Boatowner's Mechanical and Electrical Manual* (2nd ed.). p. 11. ISBN 0-07-009618-X.

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