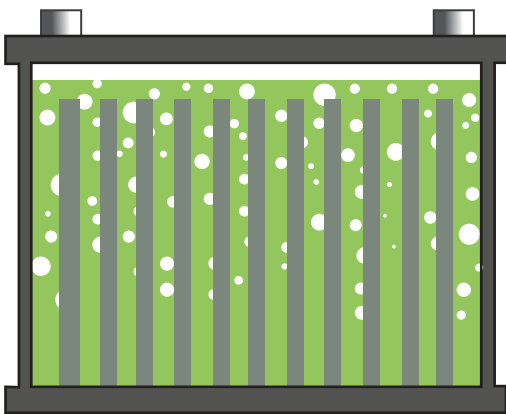


## 1. What causes lead acid batteries to fail?

According to the BCI Failure Modes Study, the main failure mechanisms for lead acid batteries which use liquid electrolyte have long been recognized as: corrosion, sulphation, acid stratification and premature water loss.

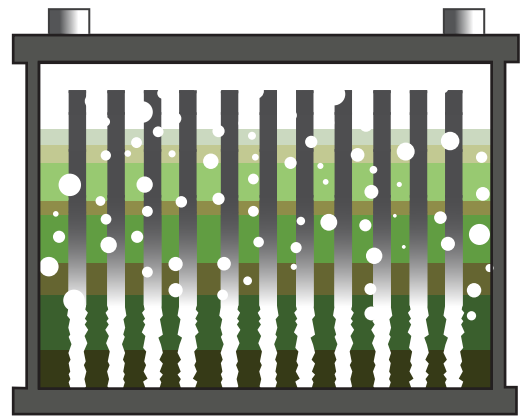
### 1. Acid Stratification - No.1 liquid electrolyte lead acid batteries killer.

In the cafe, you will find that a cup of coffee in which the sugar collects on the bottom if the waitress forgets to bring the stirring spoon. This effect is similar to the liquid electrolyte lead acid batteries, acid has a tendency to drop down to the bottom due to the force of gravity, and it concentrates on the bottom, causing the upper half of the cell to be acid poor. This phenomenon is called acid stratification which is very common in liquid lead acid batteries.



Normal battery

The acid is equally distributed from top to bottom. This battery provides good performance because the correct acid concentration surrounds the plates.



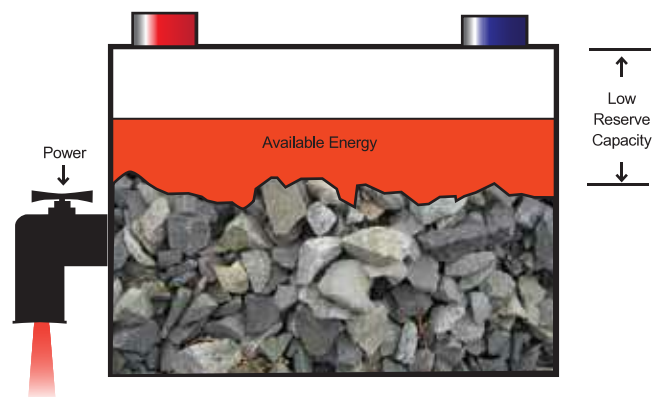
Stratified battery

Light acid in the upper limits plate activation and reduces performance, while high acid concentration on the bottom, artificially induces corrosion to the grids, leading to a shorted cell.

Acid stratification is a big contributor to the sulphation, as the higher dense electrolyte on the bottom promotes excessive reaction of active material and produce much lead sulphate. The amorphous lead sulphate deposits on the plates, and over time some lead sulphate converts to a hard crystalline structure: this process is known as sulphation.

Sulphation is dead material, causing battery to suffer:

- \* Loss of Ah - battery runs down quickly during use
- \* Reduced maximum current - lack of power
- \* Increased self-discharge rate - battery runs flat fast
- \* Battery boiling - battery gets very hot while in use & charging
- \* Case warping - plates expand causing the case to bulge or crack
- \* Shorted cells - the end result of plate expansion and sulphation
- \* Sludge build-up - occurs more rapidly due to sulphation
- \* Shorter life - battery dies prematurely



Sulphation is dead material, that cuts battery performance. The more sulphation takes over a battery, the less active material is left.

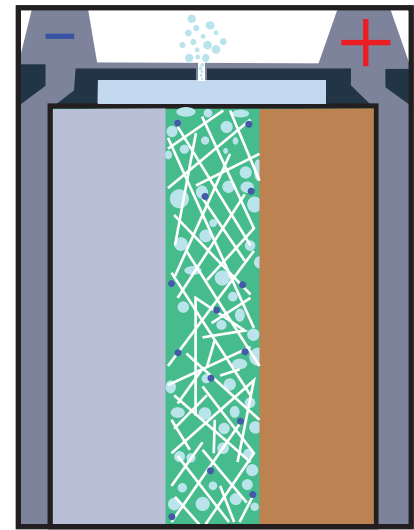
## 2. Water Loss and Resulting Dryout

AGM batteries utilize a microporous glass mat to immobilize the electrolyte. The electrolyte then fills the smaller pores of the mat, but a good portion of the larger pores remain unfilled, and these unfilled pores are the gateway for the oxygen to travel from positive plates to negative plates. Oxygen gas released at the positive electrodes travels to the surface of the negative plates through larger pores and forms water there. This process is called the "Internal Oxygen Cycle".



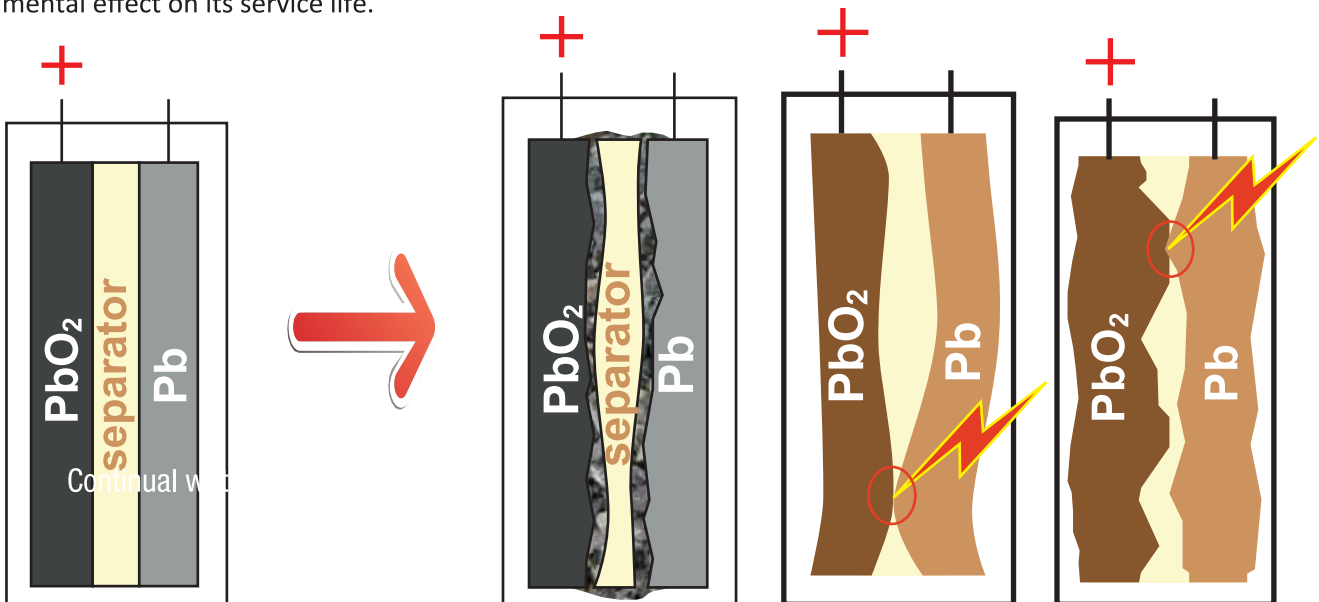
Hydrogen that is generated at the negative electrode must escape from the battery. An "Internal Hydrogen Cycle" is not established, since hydrogen oxidation at the positive electrode is an extremely hindered reaction. For this reason, a lead acid battery cannot be sealed hermetically but must have a valve that opens from time to time for gas escape.

Additionally, the oxygen recombination rate is not always 100 percent mainly depending on separator saturation. Therefore it is inescapable that if the AGM battery is being continually charged, it is continually gassing, water loss and resulting dryout.



AGM battery gassing and water losses.

Due to continual water loss, the separator shrinks (called compression loss) and results in loss of contact with the plates which produces gaps in the ionic continuity between the positive and negative plates. This not only increases the float current causing a higher risk of thermal runaway, but can also increase the internal resistance. As we all know, an increase of the internal resistance of a cell results in higher self-discharge, a decrease in capacity and has a detrimental effect on its service life.



Normal separators and plates

Warped separators and plates after compression loss

## II. What is a gel motorcycle battery?

Instead of the traditional liquid form, the electrolyte of gel battery is a highly viscous immobilized gel state, by adding a special additive - a very finely (Pyrogenic) dispersed silicone dioxide (SiO<sub>2</sub>). It first like Jell-O, then after subsequent discharge/charge cycles more like peanut brittle. Pyrogenic silica is a powder of very fine dispersed SiO<sub>2</sub> with an apparent density of 0,05g/ml. It consists of primary compact particles with a diameter of 10nm or 0,01µm in average. Due to the small size of primary particles, the internal surface is very high: 200m<sup>2</sup> per gram approximately. When the gelled electrolyte stiffens, a large number of micro cracks form in it to provide paths for the oxygen recombination reactions between the positive and negative plates.

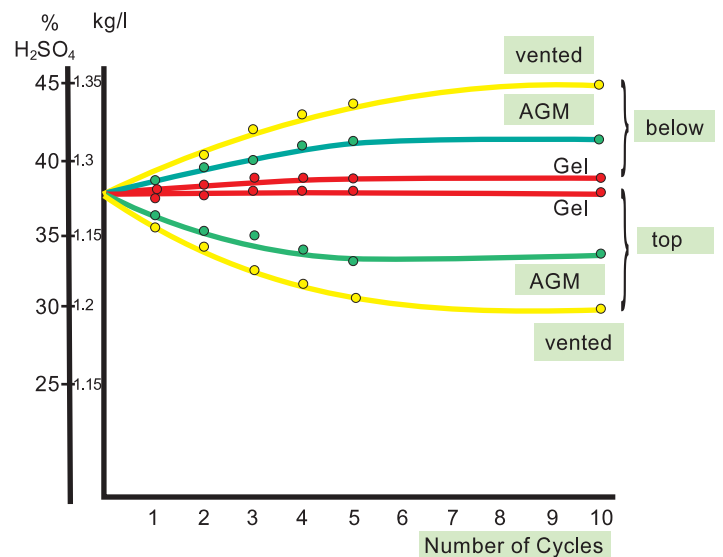
## III. Technical features of gel motorcycle battery

### 1. Gel battery shows no stratification by forming a three dimensional network in liquid systems.

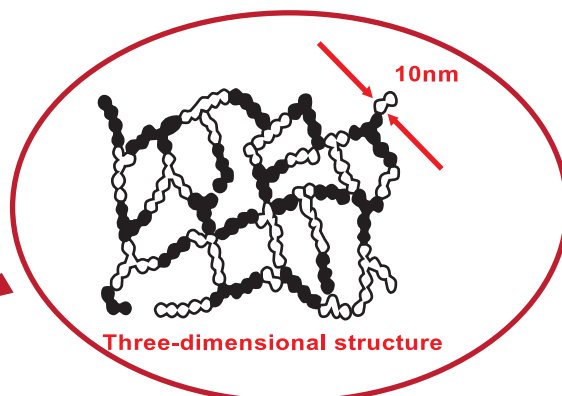
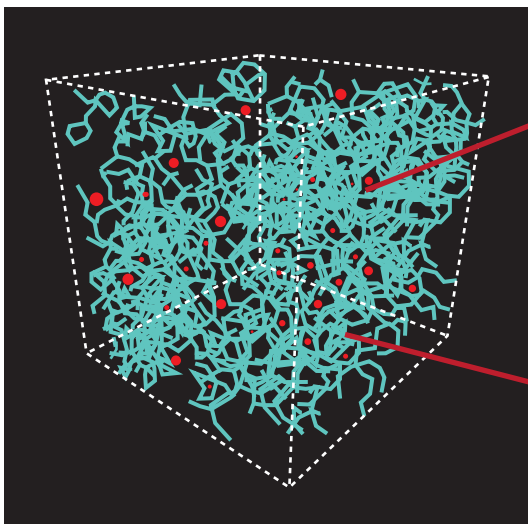
el electrolyte has a three dimensional network structure which is formed by chains with a diameter of only 10nm or 0,01µm, and water and sulphuric acid are permanently captured and contained in this structure effectively. While in traditional AGM battery, AGM separators consist of glass fibers with a thickness of 1 to 4mm, and the glass fibers have a diameter of 0,5µm to 3µm, which are several hundred times thicker than that of silicone dioxide chain. This factor several hundred times counts a lot to prevent acid stratification of battery.

During charging, the emerging concentrated acid has a tendency to sink down due to the gravity force and create acid stratification. Knowing that the pore system with the smaller pores attracts the liquid stronger, acid stratification can be prevented by: high absorption of the generated sulphuric acid (escaping from the pores of the active material) directly after leaving the pores. The smaller the pores and the fiber diameters are, the fewer problems there will be with acid stratification. The chain diameter of gel electrolyte's three dimensional network is several hundreds times smaller, therefore gel motorcycle battery shows no stratification.

Additionally, thanks to its NANO diameter, the fixed electrolyte in the gel system can fill all the gaps evenly from top to bottom of the plate structure, and there is solid continuity between the plates and the separator, therefore the ionic contact is secured in any case.



Water and sulphuric acid are permanently captured and contained in this three dimensional structure effectively which is formed by chains with a diameter of only 10nm or 0.01µm



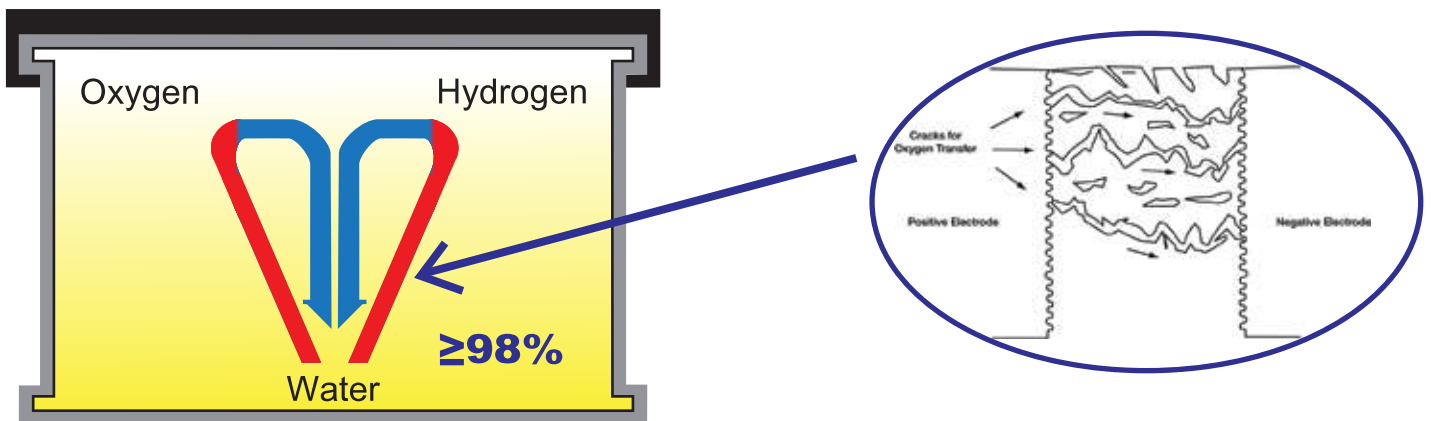
## 2. High efficiency gas recombination causes little water loss

When the oxygen is generated at the positive electrode, it must transport to the negative electrode surface immediately to recombine water, or it will escape and cause water loss. Thus the rate of this gas recombination is largely determined by the rate of oxygen transport. Data that determine this transport are shown as below:

$$\frac{\text{Transport rate in the air}}{\text{Transport rate in the liquid}} = \frac{0.18}{0.02 \cdot 2 \cdot 10^{-5}} = 4.5 \cdot 10^5$$

Thus oxygen transport is about half a million times faster in the gaseous phase than in the liquid. To provide void volume for such a fast transport, the "immobilized" electrolyte is the ideal choice.

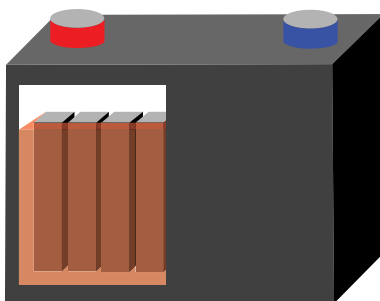
During the solidification process, gel electrolyte shrinks and leads to formation of numerous micro-fine cracks which allow fast transport, and the efficiency of the internal oxygen cycle in gel battery comes close to 100%. The recombination efficiency of AGM battery is typically 95% approximately



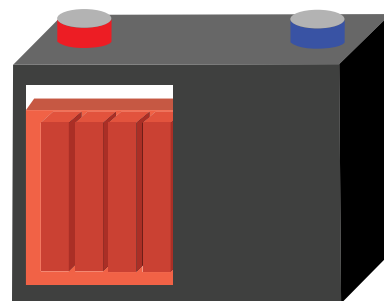
## 3. Proper excessive electrolyte

As discussed above, AGM battery is acid starved, because a good portion of the larger pores of separators need to be remain unsaturated to provide pathway for gas recombination. The separators used in gel battery are for preventing short circuits and controlling the spacing between the electrodes. The gel behaves like a very fine fibreglass separator and the oxygen travel to negative plates through micro-fine cracks of gel electrolyte instead of the separator's pores, therefore gel battery is allowed to have rich electrolyte, and some extra electrolyte can be added into.

### AGM battery: Acid-starved



### Gel battery: Proper excessive electrolyte



VS

Acid-starved battery like glass of wine containing some sand, therefore the available contents are less.



250 glass  
200 wine

Normal glass full of wine. The entire contents (250ml) are available for drinking.



250 glass  
250 wine





## IV. Advantages & Benefits

As discussed above, gel battery has following technical features:

✘ There is no acid stratification and sulfation can be prevented effectively.

✘ Gel electrolyte is a high homogeneity material with three-dimensional network structure which behaves like a very fine fiberglass separator that is wrapped around the edge of each element, and locks the active material & electrolyte onto the plates firmly to prevent plate growth.

✘ Due to its NANO diameter, gel electrolyte can permeate all the gaps of the battery, and having a complete contact with the active material and separators.

✘ High efficiency gas recombination causes little water loss, and proper excessive electrolyte is allowed to add in.



### Advantages & benefits of gel battery

● **Safer:** Gel battery guarantees no leakage or spill which insures safe operation in any position and high resistance to vibration, even if the battery case crack accidentally, our gel battery would still get you home.

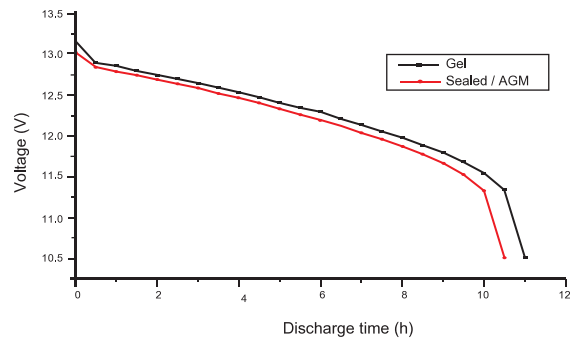
● **More tolerant of overcharging:** Gel electrolyte provides better heat dissipation which can prevent thermal runaway, and proper excessive electrolyte can help to avoid DRY OUT under high temperature or over charging.

● **Higher capacity:** Sulphation is dead & insulating material, the more sulphation takes over a battery, the less active material is left to store power. There is no acid stratification in gel battery, hence sulphation to the negative plates and corrosion to the positive plates will not happen. The increment in utilization of activate material in gel battery directly increases the capacity especially at the end stage of discharge, and it gives a longer plateau in working capacity;

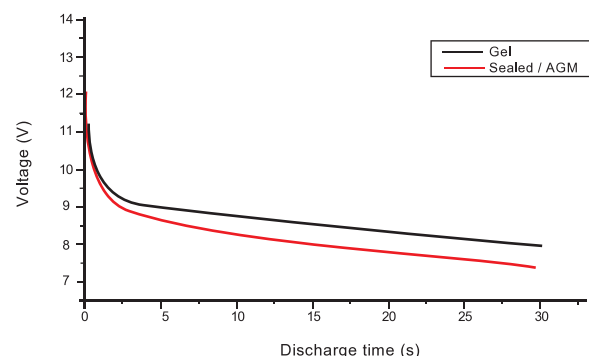
● **Better performance:** Gel battery can much better generate abrupt power for starting, and strong withstand the deep discharge and high current discharge.

● **Excellent full recovery ability:** Gel battery has excellent full recovery ability from deep discharge, even when it is not recharged immediately after 100% DOD discharge.

Capacity comparison(10HR at 25 C): Gel VS.Sealed / AGM



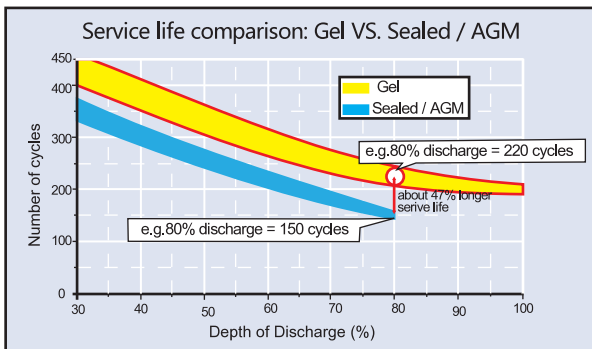
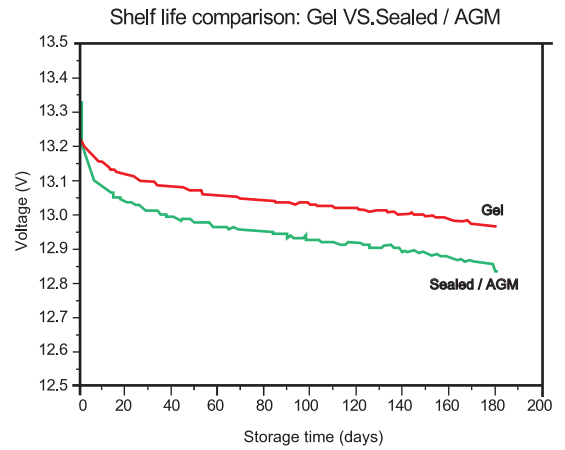
Big current discharge ability comparison(10C at -18 C): Gel VS.Sealed / AGM



● **Extended shelf life:** Gel battery has decreased internal resistance because of its less sulphation, the use of lead calcium grids and high purity materials, so the self-discharge rate is low and the shelf life can be extended largely. For the end users, this battery will be a huge benefit. Our gel battery is still able to start your bike after it hasn't been used for 6 months.

**POINTS TO REMEMBER (@ 20°C):**

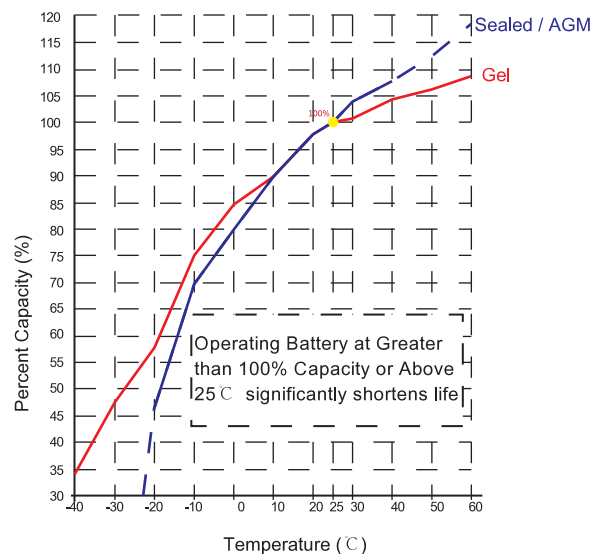
- Conventional lead-antimony battery discharge @ 1/100 volt per day approximately.
- Lead-calcium battery discharge more slowly @ 1/300 volt per day approximately.
- Gel battery discharge @ 1/600 volt per day approximately.
- Sealed battery is recommended recharging every 3-4 months.
- Gel battery is recommended recharging every 6-8 months.



● **Longer service life:** A benefit from the application of unique technical features, gel battery is the proof of greater performance and value for money: compared with traditional sealed/AGM battery, our gel battery allows a far higher number of cycles at the same discharge level. E.g. at 80% DOD, our gel battery can discharge 220 cycles approximately, while sealed/AGM battery can only discharge 150 cycles approximately.

● **Extreme temperature resistance:** Chemical reactions internal to the battery are driven by temperature. The higher the battery temperature, the faster chemical reactions will occur. While the increased rate of chemical reactions will result in a corresponding loss of battery life. Heat is an enemy of traditional lead acid batteries, and as a rule of thumb, for every 10°C increase in temperature the reaction rate doubles. So normally, the operating temperatures for AGM & standard motorcycle battery is limited to: -20 °C to +45 °C. While our gel battery can be performed well in -40 °C to +65 °C as normal, when AGM battery wouldn't work at all. In our factory testing, it outperforms AGM battery in both high and low temperatures.

**Capacity VS. Temperature**





## IV. Where there is GEL on the label, it is not always gel inside.

### Yucell true Gel battery

The NANO superfine fumed silica ( $\text{SiO}_2$ ) we used is produced by the world famous Germany manufacturer - WACKER. Its purity is  $\geq 99.8\%$ , with primary particle size 12 nm approximately, so our battery is fully deserved the name of TRUE NANO GEL (NANO scale is defined from 1 to 100 nm).



Proper gel mixing & filling is critical to life and performance of battery. Computerized gel mixing & filling facilities and vacuum filling technology assures complete evacuation of air and complete gel-to-plate interface. An evenly distribution of gelled electrolyte in all the gaps enhances the performance and increases the reliability.



### Other's "Gel" battery

Many of our competitors are producing two kinds of complete different "Gel battery":

Inferior gel & Semi gel

Inferior Gel: large size particle fumed silica with high impurities are used as the additive, which cut the performance & life-span of battery, instead of helping it.

Semi Gel: Essentially it is an AGM battery with gelled electrolyte material located only at the upper regions of the cell. They only usurp the name of "True Gel", and their performance & life-span do not have any difference with AGM battery.

Additionally, instead of the advanced filling proceeding, they mainly operate the acid-filling manually, by vibrating the battery after filling to release the air pockets instead of vacuum filling technology. This acid-filling way leaves air pockets which are non-reactive at the critical gel-to-plate interface, and finally it reduces the overall battery performance and shortens battery life-span



## V. What makes our gel motorcycle battery unique

### 1. Yucell environment and worker protection

We are all responsible for sustaining and protecting our co-workers and natural environment. In our company, we implement rigorous environmental management systems to completely comply with laws, regulations, official standards and directives.

One benefit is assurance of consistent source for batteries without fear of governmental interference or delays.



Lead dust treating device, zero pollution

Waste water purification system



## 2. Yucell Expertise:

Ample experience: after exhaustive testing of many & many formulations of gel, and finally we developed the TRUE NANO GEL motorcycle battery, and they have gone into mass production since 2004.

We use the latest manufacturing technology and equipment to make sure that our gel battery produced to the highest standards. Actually our TRUE GEL batteries meet and exceed the SAE and JIS standards.



Automatic lead powder grinders



Grid casting facilities



Automatic plate pasting proceeding



Advanced plate formation equipment



Battery charging equipment



modernized battery Grid (oxygen-free) Drying equipment

## 3. Yucell exquisite material selection

We only use brand-new and high-purity lead (99.9%) as our raw material to minimize the negative effects of impurities. The purer the components, the longer the shelf life.



High purity (99.99%) Lead ingot

## 4. Yucell multi-element alloy grids

The grids are made using gravity-casted multi-element alloys to reduce grid growth and corrosion to assure maximum conductivity. Metal Tin is also added into this grid alloy to raise the overpotential of hydrogen evolution for the minimum gassing (water loss).



Multi-element alloy grids



## 5. Yucell copper terminals

Batteries are equipped with copper terminals which is superior corrosion resistance and has better conductivity accordingly.

## 6. Robust construction

We design and mold our own robust construction ABS battery cases which are thermally stable and have excellent impact resistance. ABS has advantages in heat transfer and our battery internals stay cooler in summer, and loose less of its internal heat in cold weather.

When used in off-road vehicles, the battery must be able to function perfectly at extreme angles and withstand severe vibrations. Our robust construction coupled with the specific advantages of gel technology means that our GEL is characterized by its high vibration resistance.

## 7. Yucell true gel battery do not need special charger.

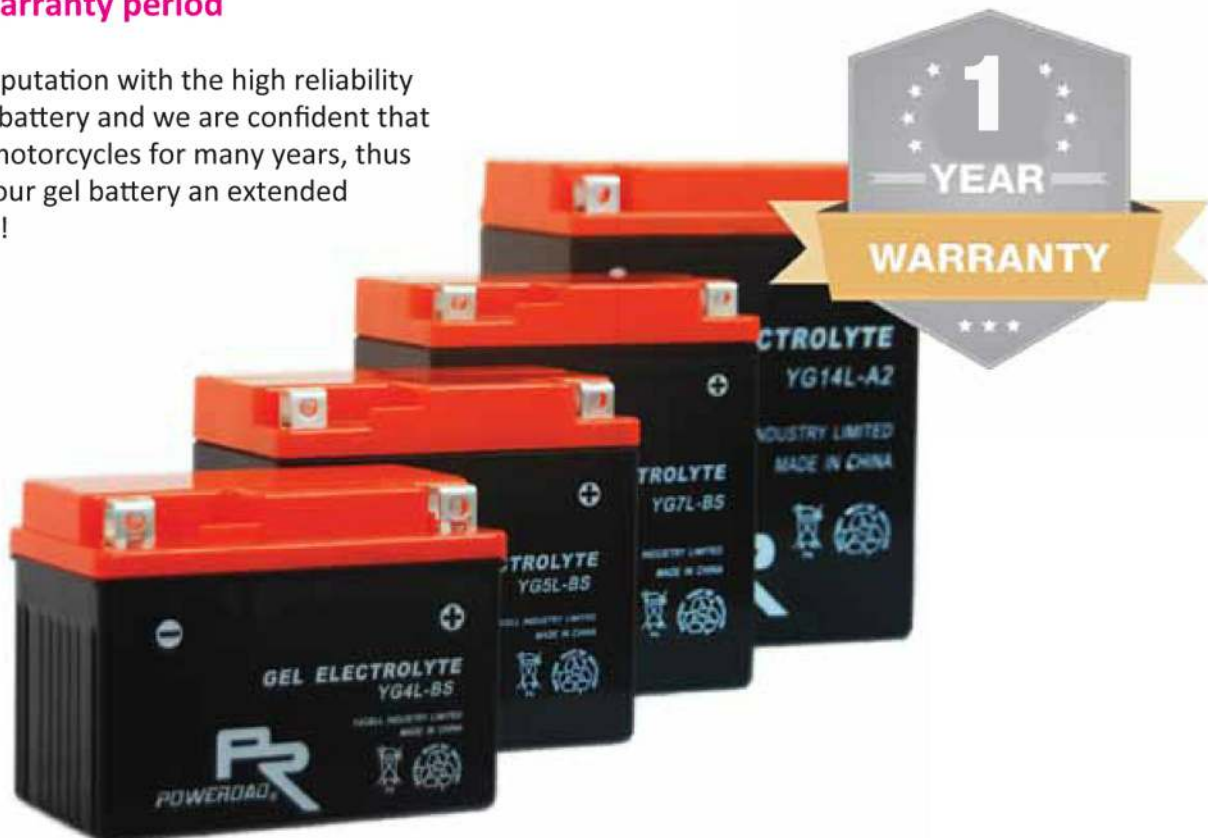
The normal lead acid battery charger can do the job to well charge our true gel battery, so do not hesitate to update your motorcycle battery to be our true gel type.

## 8. Trouble-free transportation

Because gel battery have immobilized electrolyte, they will not leak, even if punctured. This is why they are approved for air transport by ICAO & IATA & DOT. There are no restrictions for air, road, rail and sea transportation for our true gel motorcycle battery.

## 9. Yucell extended warranty period

We are proud of our reputation with the high reliability and longevity of our gel battery and we are confident that they will work for your motorcycles for many years, thus we are pleased to offer our gel battery an extended warranty period - 1 Year!

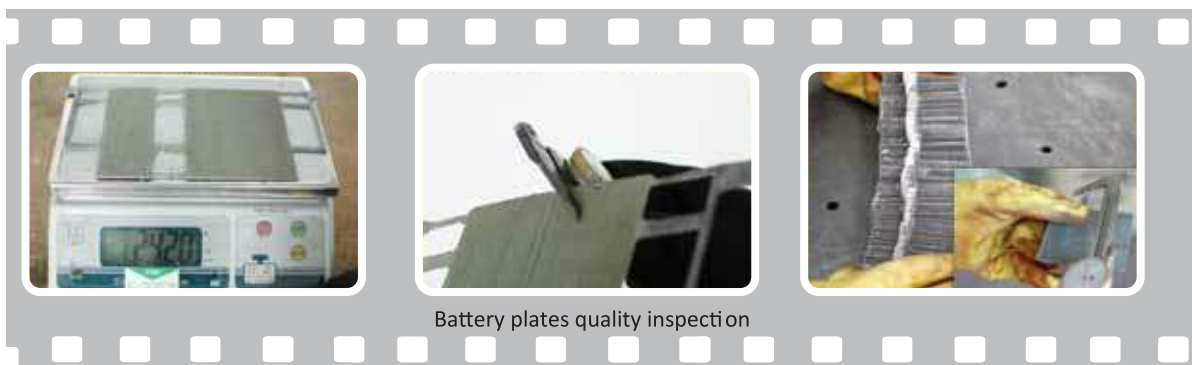




## 10. Yucell strict quality control

Many quality checks are performed to assure yucell's total confidence in battery performance. For example:

- (1). Raw material quality control: We exercise strict control over the raw material that will be used in our batteries.
- (2). Paste Mixing checking: Formula monitoring and extensive acid gravity and temperature checks provide best attributes for paste adhesion, power absorpition and performance.
- (3). Grid Casting Inspections: Specified checks such as alloy sampling, grid weight and thickness analysis assures patented alloy blend and precise conditions for proper grid formati on and applicati on into battery production.
- (4). Curing Checks: Assures proper time, temperature, and humidity to create the optimal environment to facilitate the curing process.



(5). Assembly Audits: Monitors assembly line speed, weld quality, terminal installation, internal short circuit testing, and air leak testing all to ensure the final assembled product meets rigid specifications and standards.

(6). 100% cycling: after initial charging, every battery is completely discharged and then recharged at the factory, and discharge - recharge cycles 3 times totally.

(7).High current discharge testing: every battery is exercised with high current discharge testing to monitor the voltage drop during this discharge to assure that every battery performs as designed.

(8).2 weeks shelf stand testing: before shipment, every battery needs to stand for 2 weeks. Begining and ending voltages are compared, to pick out the unqualified batteries.

