GasTon

Valve Regulated Lead-Acid (VRLA) Battery

Manual of Operation and Manintenance Training

Content

1. History of lead-acid battery development

Lead-acid battery is invented in 1859 by a Frenchman – Plante. It has been of one hundred years in history. With raw materials readily available, inexpensive and recyclable use, reliable in use, suitable for high current discharge and extensive range of ambient temperature…etc., lead acid batteries are widely used in automotive, traction power, electricity, communications, emergency lighting, signal , solar and wind energy storage and other fields. It is of absolute advantage in the chemical power, especially in the field of large-capacity of which lead acid battery is irreplaceable.

In1859, Caston Plante after testes of a large number test of secondary battery, invented lead-acid battery. He used two pieces of lead as electrodes, separated by a thin rubber roll into a spiral as partitions, immersed in 10% sulfuric acid (H_2SO_4) solution (specific gravity 1.06g/cm3), the form a lead-acid battery. He found that the battery can be charged and discharged repeatedly. And observes that this lead electrodes, mounted in sulfuric acid solution consisting of lead-acid batteries, release strong currents the charging current immediately after the the power source cut off. It is of significantly better than electrodes made with other test materials. Plante submitted a lead-acid battery constituted of nine single cells to the French Academy of Sciences, which is the world's first Plante batteries. Because of its main raw material is lead and acid, so called lead-acid battery or LA batteries in short.

Although there are many shortcomings in manufacturing and performance of Plant cell, but it shows the advantages in obtaining secondary current (through the store of current obtained by the electrochemical reaction, and supply in need as the secondary current), but this huge contribution to industrial production and scientific development, bring the human a bright future. Thus, people keep on reaearch with perseverance, and found that lead oxide and sulfuric acid can be made of plaster - lead paste, applied to the chip can greatly shorten the lead time information, would improve the electrode utilization. and battery discharge capacity. With these results, it promotes the the development of lead-acid batteries.

In 1881, Faure invented the pasted plates. But it has a serious defect, the lead paste is very easy to fall off from the plate. To improve this situation, at the end of 1881, someone poeple suggested the grid-shaped grid design. The whole design change to the stereotype perforated grid that will plug in the hole in the lead paste. This plate can maintain the active substance does not fall off plate. In 1889, the shape of the grid is improved. The grid's appearance of stereotype changed to triangular cross-section bar. This increases the contact area between the lead paste and the grid. The lead paste is intimately bound to the grid, which greatly improves the performance and service life of lead-acid batteries.

By the early 1900s, lead-acid batteries gone through many significant improvements, improved energy density, long cycle life, high rate discharge performance…... However, the open lead-acid battery has two major drawbacks: ① In later stage of charging, the water breaks down into hydrogen and oxygen, it need to add acid, add water and lead to heavy workload in maintaining; ② Gas overflows carry mist corrosion around the equipment, and pollute the environment which limiting battery applications. In past two decades, in order to solve the above two problems, the world race to develop sealed lead acid batteries, hoping to achieve a sealed battery and access to clean green energy.

In 1912, Thomas Edison published patent of using a platinum wire filed in the upper space of the single cell. During current ipassed, platinum is heated, lead to hydrogen bonded oxidation catalyst, H2 and O2 re-precipitated are combounded and return in the electrolyte . However, the patent failed to put into practice: ① platinum catalyst soon lapsed; ② Gas precipitated is not of according to stoichiometric number Two unit of H & One unit of O, and there is still some gas still inside the battery; ③ explosion hazard exist.

In 1957, West Sunshine Company produced Gel sealed lead-acid battery and launched it in market, marking the birth of practical sealed lead acid batteries.

1960s, the United States Gates Company invented lead-calcium alloy, enhance the development of sealed lead acid batteries. The world's major battery companies invest a lot of manpower and resources in the development.

In 1969, in the implementation of U.S. moon program, sealed valve regulated lead acid batteries and nickel-cadmium batteries are taken as power supply of the lunar vehicle. In final, nickel-cadmium batteries are used, but sealed lead-acid battery technology has brought further developed.

1969-1970, U.S. EC companies produced about 350,000 pcs small sealed lead-acid battery. Battery separator is of glass fiber cotton and poor hydraulic system, which is the oldest commercial VRLA batteries, but in this stage, the oxygen recombination principle not yet realized.

In 1971, U.S. Gates Company to produce glass fiber separator suction-type battery, which is Valve Reular Lead Acid batteries (VRLA batteries).

In 1975, Gates Rutter Company, after many years' hard work and costly investment, get an invention patents for D-type sealed lead-acid battery, a prototype of today's VRLA batteries.

1979, GNB Company purchase Gates's patent. Then, he invented the patented MFX positive grid alloy, and began mass production of large-capacity suction sealed maintenance-free lead-acid batteries.

1984, VRLA batteries have small-scale application in the United States and Europe

In 1987, with the rapid development of the telecommunications industry, VRLA batteries promote fast and use in the telecommunications sector.

In 1991, the British Telecommunications Sector inspected and tested VRLA batteries. It found VRLA batteries are not as releiable as advertised by the manufacturer - there is phenomena of Battery thermal runaway, burning capacity and early failure. This caused the battery industry discussed widely on future development of VRLA battery. They expressed doubt on capacity monitoring technology, thermal runaway and reliability. VRLA battery market share is of less than 50% of flooded batteries. The original reference name of "seal free maintenance of lead-acid battery" was officially replaced by" VRLA batteries "instead, because the VRLA battery is need some management on the batteries, the use of" maintenance-free" would be misleading.

In 1992, based on questions in 1991, battery experts and technical staff of manufacturers published articles and views on countermeasures. Among them, Dr Darid Feder proposed method of using measured conductance to moniore VRLA batteries. Ic Bearinger comments the advancement of VRLA batteries by the technical aspects. These articles played a great role in promoting.on the development and application of VRLA batteries

1992, for the world's VRLA battery usage, have increased significantly in Europe and the Americas. In Asian countries, the telecommunications sector promote to use VRLA batteries.

In 2001, VRLA batteries are widely used in electric bicycles and electric scooters and other fields. Explore and develop the new market of of environmentally friendly power car s.

In 2006, big international companies and operators of telecommunications equipment procured VRLA batteries from China. China has become the world VRLA battery manufacturing and machining centers.

In 2011, new energy and power lead-acid batteries in China have been vigorously developing. It form the scale use of lead-acid battery in the field of smart grid, solar and wind power plants, electric vehicles and other fields.

2. Market and the usage of lead-acid batteries

Although VRLA's battery energy lower than the energy of lead-acid batteries Ni-Cd, and Ni-MH battery, even lower than the liquid lithium-ion battery (Li-ion) and polymer lithium ion battery (PLIB), but it is still a big price and performance advantage . Especially as a backup power supply in power supply and other energy storage applications, due to the large current discharge performance, no memory effect, cheap, and made into single large-capacity battery (eg 12000Ah submarine batteries), so lead acid battery is in the first place of sales amng the chemical power products.

In 1998, the global chemical power output is 264 million, of which $ 9.2 billion is from first battery, and secondary battery is of $ 17.2 billion. Among the secondary battery, $ 12.4 billion is of lead-acid batteries. Others - alkaline batteries (Ni-Cd, Ni -MH) is $ 4.2 billion, the lithium-ion battery is $ 1.9 billion.

According to a survey BCI (Battery Council International), in 2000, annual industrial growth rate of lead-acid batteries is 8%, the total global sales is $ 1.1 billion. In 2004, will maintain an annual growth rate of 7%, the global sales reached is $ 1.5 billion .

From the above market research and forecasting instructions of Lead-acid batteries, during 20 years' VRLA batteries commercialized use, although there have been some problems, such as leakage, early loss of capacity, short life and other issues, once aroused people's doubt on VRLA batteries, but after years of effort, VRLA battery design technology has made significant progress, so in all application areas of lead-acid batteries, VRLA batteries accounted for an absolute advantage, which is especially true in the field of UPS (see table 2-1), anti-acid flooded batteries are mainly used in automotive starter batteries (SLI).

Table 2-1

Proportion of VRLA batteries and flooded batteries	Precentage per totol use of lead acid battery		Use in UPS application	
	1999	2012	1999	2012
VRLA type	77%	90%	77%	96%
Flooded type	23%	10%	23%	4%

3. Definition and basic characteristics of VRLA battery

Valve Regulated Lead-Acid Battery (VRLA battery in abbreviation), its basic feature is without adding acid or water free-maintenance battery, sealed structure, will not leak acid, it will not exhaust mist, the battery cover is provided with a one-way exhaust valve (also called safety valve), the valve is in function when the amount of the gas inside the battery exceeds a predetermined value (usually atmospheric pressure values). When the battery internal pressure rises to a certain value, the valve automatically opens and exhausts gas, and then automatically closes to prevent air from entering the battery.

4. Classification and Advanced Technology Research

VRLA batteries divided into two type of battery - AGM and GEL (gel).

AGM battery use absorbed glass fiber cotton used (Absorbed Glass Mat) as separator, electrolyte adsorbed on the plate and the diaphragm, with poor electro-hydraulic design, the battery no flow of electrolyte insie the battry. Batteries can install vertically or horizontally.

gel (GEL) using SiO_2 as the coagulant, and colloidal electrolyte adsorbed on the plate, the batteries install vertically in general.

Unless otherwise specified, VRLA batteries are refer to the AGM battery.

According to the size of Capacity, batteries can be divided into (1) large size VRLA battery (2V100AH-2V5100AH), (2) Mid size VRLA battery (6V, 12V26AH-300AH), and (3) small size VRLA battery (6V, 12V0.3AH-24AH), generally, large size battery design life is 10 years, mid size batteryl design life is of 3-12 years (depends on application), the small size battery design life is generally 1-3 years

4.1 AGMT echnology

It use the ultra-fine glass wool separator, which separator has a porosity of more than 93%, can absorb sufficient electrolyte from the reaction. Thus, allowing no flow of electrolyte inside the battery. When separator glass wool absorbed sufficient electrolyte, it Still maintained at 10% of the pores as channel for the combination of O2. O2 precipitated from positive electrode compound at the negative electrode In order to achieve the oxygen cycle, that is H2O → 1/2O2 → H2O, the battery can achieve the sealing effect (Figure 1). AGM batteries are poor fluid design. Compared with flooded batteries, the electrolyte has higher density. For problem of VRLA batteries in early development, manily because there was no emphasis on depleted fluid design. Now, VRLA batteries adopt AGM technology mainly because the AGM battery has the following advantages:

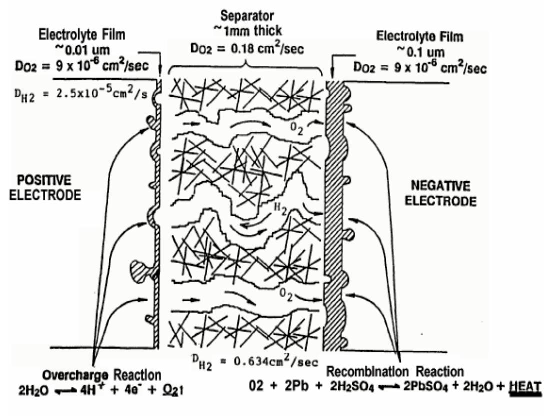


Fig 1 AGM oxygen recombination

1). Using Pb-Ca alloy grids and high purity materials, battery self-discharge is slow. The self-discharge rate of <2.0%.for storing at 25 ℃ under three months,

2). AGM battery has a good efficiency of charging

3). Using tight assembly, the resistance is less (typically 0.2-0.9mΩ), suitable for high current discharge.

4). As a result of poor liquid design, gas recombination efficiency is high,> 98%, so there is no mist, revealed

5). Higher capacity even in initial cycle, and from the third cycle, it can reach more than 100% of the rated capacity.

6). Have good discharge performance under low temperature

Because of above advantages, making use of AGM VRLA battery technology is developed rapidly, the majority of domestic and foreign manufacturers VRLA batteries are used AGM technology.

4.2 Gel Technology

The principle sealing technology of Gel batteries is, similar as AGM , by oxygen cycle. But the oxygen from positive cathode is not transmitted through the separator to the negative electrode of the pores, which is achieved through the crack of the colloid. Crack is the for channel oxygen colloidal recombination. Cracks are generated by the shrinkage during colloid formation. In initial using of the gel battery, because of less crack in colloidal that the efficiency of oxygen recombination is low, then valve easily open have more mist precipitation. As battery is using for longer time, cracks increases and the oxygen recombination efficiency improved.

The major manufacturers of Gel batteries are Sonnenschein (Germany), Gromptor Parkinson company (USA) and FIAMM company (Italy) .

Oxide Combination of gel electrolyte battery shown in Figure 2

Three method for Preparation of the gel electrolyte ：“Neutralization method”, “Silicon Sol method”, and “dioxide silicon method”, “Silicon Sol method” used in many foreign countries, of which the gel electrolyte stability is better.

Advantages of Colloid technology

1). gel batteries use rich liquid design, have good characteristics of deep discharge recovery, a better prevent from electrolyte dry.

2). As use of colloid, the gel battery is almost without any stratification of the electrolyte.

3). At higher ambient temperatures, gel batteries have a longer life than AGM batteries, Gel technology development technology is slower then AGM technology. It is due to gel battery has the following disadvantages: in use of colloids and PVC separator, colloidal easily block the hole of the between separator and active substance, so that the battery internal resistance is large, Compared with AGM batteries, there is about 15% lower in capacity at room temperature 20 hr rate, there is about 20% lower in load voltage at -18 ℃ discharging

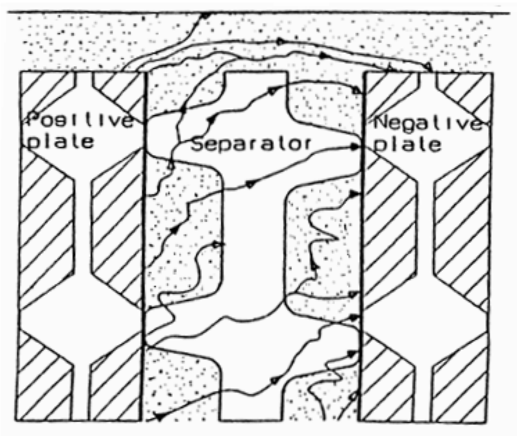


Fig 2 Oxygen recombination of GEL battery

a) during the initial using period, the oxygen recombination efficiency is low, mist discharge more
b) gel batteries are more sensitive to overcharging, if the battery is tilted or lying down, the battery inside the gel may flow out
c) it is not suitable for fast-charging and high-rate discharge, especially at low

temperatures.

d) it is not suitable for thin plate designs.

Overall: AGM battery is more efficient than gas recombination Gel batteries, and Gel battery water loss rate is higher than AGM batteries - As Shown in Figure 3.

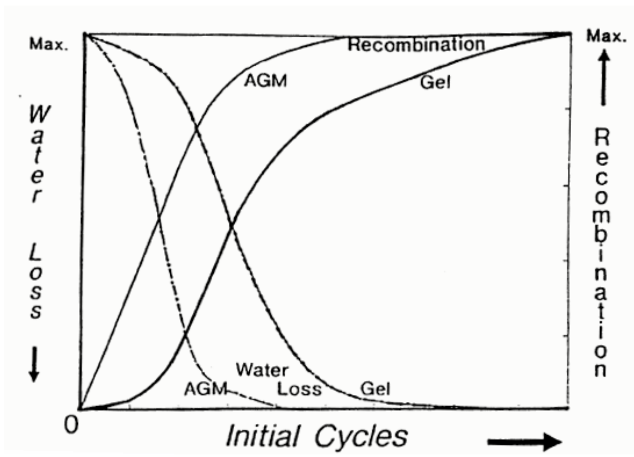


Fig 3 Water loss and recombination of AGM vs GEL battery during initial cycles

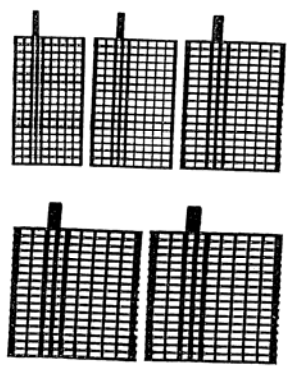
In recent years, in the international conference on lead-acid batteries, ther is trends of increasing emphasis on Gel technology, but there are different views on the advantages and disadvantages in the application of the AGM and Gel technology. Some believe that the power type batteries such as electric vehicle batteries, traction batteries using AGM technology is good, because of its large current discharge performance; and for backup battery, UPS battery using Gel technology is good. However, John Wertz of U.S. Trojan Battery Company said that gel batteries have better deep cycle performance than AGM batteries, so they designed VRLA battery powered traction battery using Gel technology, and used AGM technology for UPS, backup battery.

4.3 Advanced Research in VRLA batteries Technology

The 63 member of Advanced Lead Acid Battery Consortium (ALABC) cooperated in the development of advanced lead-acid batteries to improve the specific energy and deep cycle life. On the one hand is the research on active material utilization from the positive electrode; on the other hand is the studies of the cell structure for purpose of weigh reduce.

4.3.1 （Con-Roll）**Continuous casting roll plate grid structure**

Fig 4 Con-Roll casting grid struture



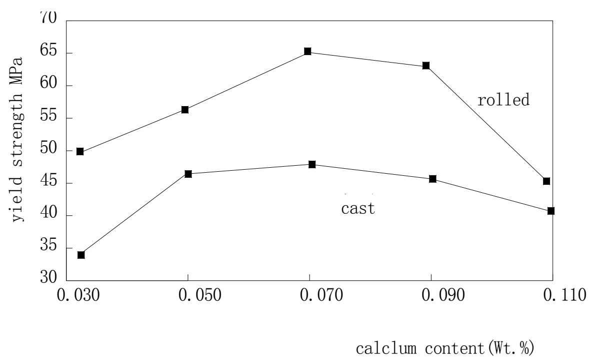


Fig 5 yield strength vs calcium content

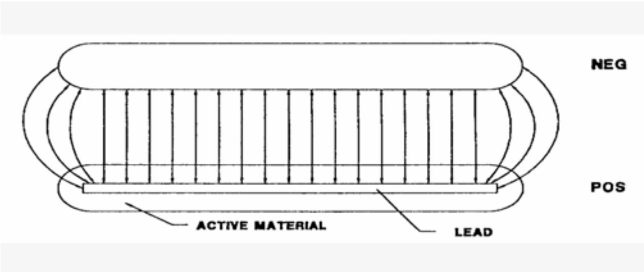
East Penn and Wirtz developed the continuous roll plate (Con-Roll Plate), shown in Figure 4

VRLA batteries using Pb-Ca alloy grid, the expansion and elongation of grid in the battery during use, is an important cause of battery failure. Pb-Ca alloy has a low yield strength (YS) and a high ultimate tensile strength (UTS). For Pb-Ca alloy, YS is more important parameter than UTS. Grid is pressed by continuous roller during the casting, YS significantly increased (Figure 5), reducing the UTS, so there is much less expansion and elongation of plate during operation.

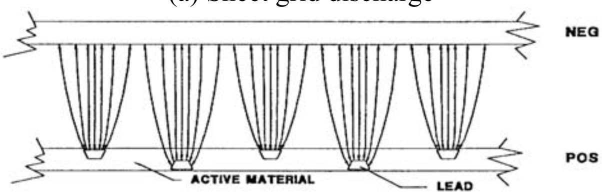
4.3.2 Sheet electrodes

Sheet grid s positive pole have more uniform charge and discharge performance then the ordinary cast or grid netting. Through the charge and discharge the surface of the electrode, the current is very uniform, as shown in Figure 6

In addition, high sheet grid surface area reduced the corrosion rate and has a low corrosion current density (Acm-2) than the normal grid.



(a) Sheet grid discharge



(b) ordinary grid discharge

Fig 6 Sheet grid discharge vs ordinary grid discharge

Such electrodes, as described above, the Con-Roll grid developed by Wirtz, the grid thickness <1mm, with very light weight, this material is used in East Penn's ALABC project.

4. 3. 3 foil rolls Electrode

Electrodes as thin as paper are developed by the United States BOLDER, called as TMF technology (Thin Metal Film). Foil electrode has a very high specific power and excellent rechargeable performance. This battery grids' thickness is of only 0.05mm-0.08mm. This thickness is substantially the same as the active material layer.

The grids roll up to form the electrode. This battery has a uniform charge-discharge performance. Battery positive electrode lead at one end, and a negative electrode at the other end - similar to alkaline manganese batteries- the electrode is greatly improved with high-rate discharge performance. Bolder battery has been widely used in power tools, automotive starter, hybrid electric vehicles which required high power and fast charging.

4.3.4 Planar tubular electrode

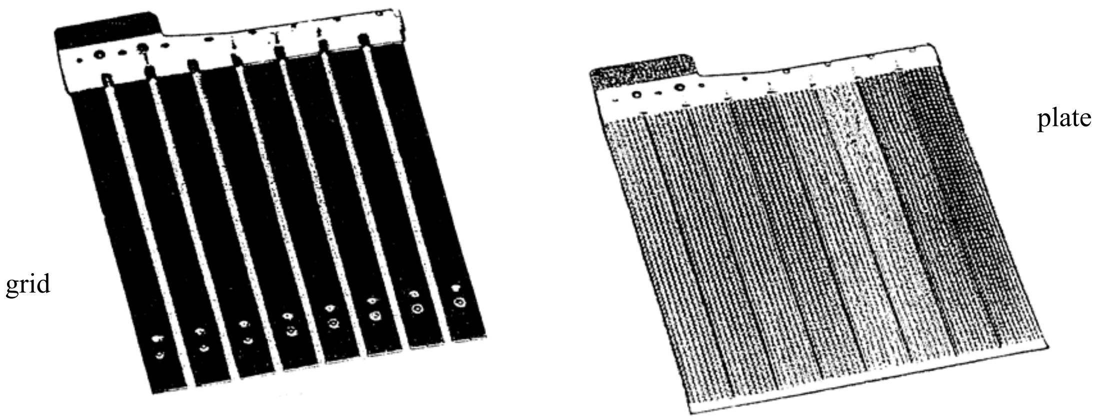


Fig 7 Yuasa / ABC's improved tubular positive plate

By the ALABC project commited by Yuasa company, planar tubular electrode battery has been used in EV, HEV and other recycled occasions. The grid is produced by casting or extrusion, and use of Pb-Ca-Sn alloy, as shown in Figure 7. Grids manufactured by Yuasa is with Pb-0.07wt% Ca-1.5wt% Sn alloy, which has a high strength. Further due to 0.75mm thickness, it is easy to bend, and improved tubular electrode withtweight light and high energy density (Figure 7). The active material of the plate evenly distributed around the gate, and thus the electrode section has a uniform charge-discharge performance, this structure improves the utilization of active material.

4.3.5 Horizon Battery

D.B. Edwards from University of Idaho developed pasted electrodes horizon lead-acid battery, which used in EV or HEV. The design of battery model shown in Figure 8, the characteristics of horizon battery are: (1) Bipolar ear plate placed horizontally. (2) use porous AGM separator. (3) positive electrode containing about 30% of the glass beads additives. (4) grid is thin and Pb cosated, battery specific power increased to 155W/kg, the highest specific energy 53-56Wh/kg, EV speed of 88km / h, maximum travel distance of 170 km, maximum travel distance of 110 km when speed up to 120km / h.

Electrosource (USA) developed the lead fabric batteries Horizon, use glass fiber filaments extruded plating Pb-Sn content, pull into the lead wire (φ0.4 or so), and then lead into the lead silk cloth, lead cloth replace the grid. Using bipolar structure, lead one end coated with positive paste one end, the other end coated with cathode paste, leaving lead wire in the middle for connection, which greatly reducing the electrically conductive pathway between positive and negative, so the battery internal resistance is small, in order to prevent the wetting of bipolar lead wire by intermediate electrolyte, which would casue short circuit, self-discharge, the surface is coated with an insulating polymer coating.

Characteristics of Horizon battery are: (1) high specific power and specific energy - specific energy up 45-50Wh/kg, specific power at 80% DOD > 225W/kg. (2) fast charge - high conductivity of pure Pb Lead cloth, allowing the accelerated charge, can be fully charged <30min (3) reduction in weight -25-50% lighter than conventional lead-acid battery (4) horizontal plates, no electrolyte stratification and the active material shedding.

4.3.6 sealed bipolar lead-acid batteries (SBLA)

American Arias'research's partners company has developed a bipolar plate (Bipolar plate), a double-sided plate, one side is A negative electrode active material, the other side is a positive electrode active material, two bipolar plates is separated by glass wool plate. Cell structure is shown in Figure 9. By the bipolar structure, current running from one monomer to the other monomers is reduced to the shortest distance, eliminating the consupmtion of electric potential in the bus occurred in othe common battery. The advantage of battery SBLA are (1) high specific energy, (2) long cycle life deep, (3) simple structure, in particular the combination of a high voltage (over 100V battery).

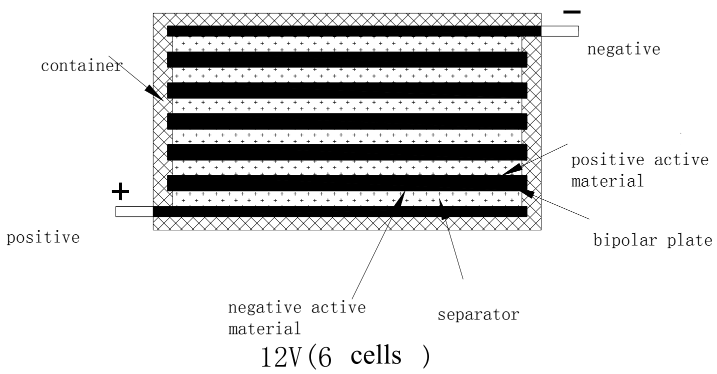


Fig 9 Bipolar lead acid battery

It is understood, SBLA battery technology is not yet fully mature. There is not a equipment can painted at the same time the positive and negative lead paste.

4.3.7 spiral tubular cylindrical electrodes battery

In 1999, U.S. EXIDE company launched the world's first spiral coil-shaped electrode garden car starter cartridge with a new VRLA batteries, called Orbital Select, This battery has a great surface area electrode, the active substance mechanically extruded into sheets grid, using the new continuous manufacturing technology allows a large compression ratio, reducing the thickness of the electrode (1.3mm-1.4mm), so the battery has a higher energy density (34Wh/kg) and a depth of up to 500 times or more cycle life. Even the battery is not used and stored for a few months, the car can still be started immediately. With annual sales of 200,000, and of 100 million / year in the future

5. Structure and working principle

5.1 Basic Structure

5.1.1 Cell structure

VRLA batteries' main component are the positive and negative electrolyte, separator, battery case and the lid, the safety valve, in addition to some parts such as terminals, connecting bar, pole, etc.

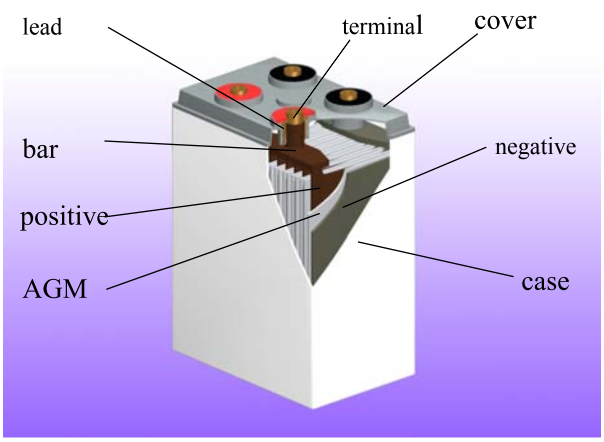


Fig 11 Schematic diagram

5.1.2 System Structure

Fig 12 System structure

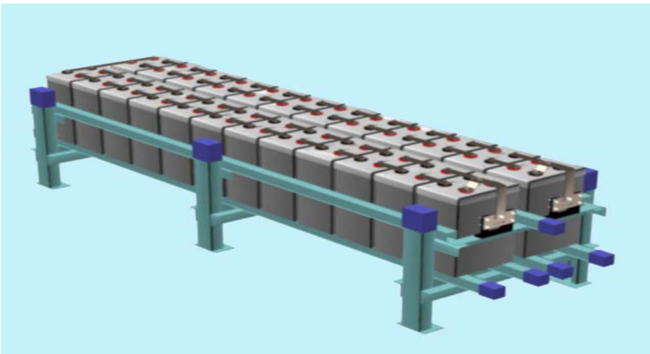


Fig 13 Vertical System Schematic

5.2 Principle of work

5.2.1 Chemical reaction principle of VRLA Battery

VRLA chemistry principle is : (1) Charging - convert the electrical energy into chemical energy and stored in the battery, (2) Discharging - the chemical energy convert into electrical energy and supplied to the external system.

The charging and discharging process is completed by a chemical reaction, the chemical reaction is as follows:

Positive ：

$$PbSO_4+2H_2O \underset{\text{discharge}}{\overset{\text{charge}}{\rightleftharpoons}} PbO_2 + H_2SO_4 + 2H^+ + 2e^- \qquad (3\text{-}1)$$

$$H_2O \xrightarrow{Charge} 1/2\ O_2+2H^+ + 2e^- \quad (3\text{-}2)$$

Negative electrode ：

$$PbSO_4+2H^++2e^- \underset{discharge}{\overset{charge}{\rightleftarrows}} Pb+H_2SO_4 \quad (3\text{-}3)$$

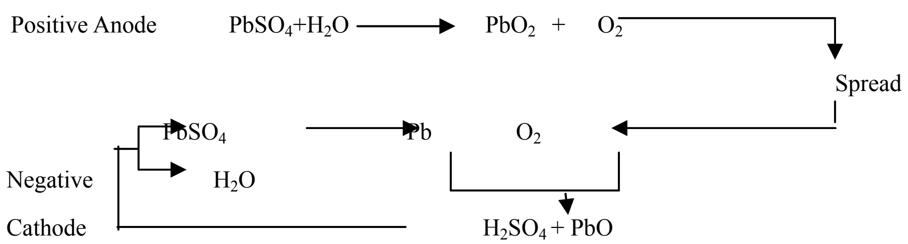
$$2H^++2e^- \xrightarrow{charge} H_2 \quad (3\text{-}4)$$

As can be seen from the above reaction, there is water decomposition reaction. During the charging process, when the positive electrode is charged to 70%, the oxygen begins to precipitate; when the negative electrode charged to 90%, hydrogen begins to precipitate. If precipitated gas can not be recombined to use, the battery will be dehydration and dry. For traditional lead-acid batteries used in early staage, the hydrogen and oxygen precipitates and escape from the internal battery, the recombination of gas can not be performed. It is major reason for need of adding acid water. Valve Regulated Lead Acid VRLA battery can perform internal recombination of oxygen utilization, and inhibiting the precipitation of hydrogen, to overcome the the main drawback.of traditional lead-acid batteries

5.2.2 Oxygen cycle principle

It is the design of excessive active material of negative electrode. In electrolyte adsorption system of AGM or GEL, oxygen produced from positive cathode in the late stage of charge spread through the AGM or GEL voids to the negative cathode, and reacted with the spongy lead spongy and converted into the water. Then he negative cathode is in depolarized state or insufficiently charged state, do not reach electricity potential, no negative hydrogen precipitates due to the charge. The battery’s water loss is very small, in the battery use, no need for acid and water adding during maintenance.

VRLA oxygen cycle illustrated as below



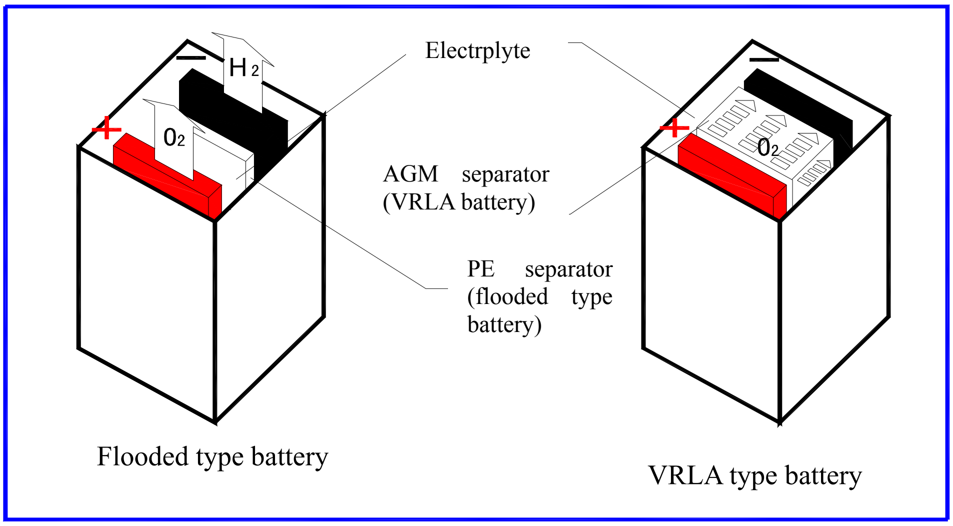


图 14 **Schematic oxygen complex reaction**

As seen from diagram, for VRLA batteries, the negative electrode plays a dual role, i.e. during later stage of charging or over-charging stage, on the one hand, the spongy of lead plate reacted with O2 produced from the positive electrode, being oxidized into a lead oxide; on the other, the lead sulphate of the plate is also receiving the electronic from external circuit to the to carry out he reduction reaction - the reaction of making lead sulfate into spongy lead.

Inside the battery, in order to preform the complex reaction of oxygen, the oxygen from the anode must spread to the negative cathode. The more in easy movement of oxygen, the more oxygen cycle canbe established.

Inside VRLA battery, the oxygen is transferred in two ways: (1) one is dissolved in the electrolyte - that is by diffusion in the liquid phase to reach the negative electrode surface; (2) the second is in the form of vapor diffusion to the cathode surface. For conventional flooded batteries, the oxygen transmission can only be dissolved in the anode region H2SO4 solution, and then spread on the negative electrod through the liquid.

If the oxygen gas was move between the electrodes through the open channel directly, then the migration rate of oxygen is much greater than liquid diffusion. Inlater stage of charging, oxygen precipitated from the positive electrode, as there is a slight overpressure around the positive electrode, and then negative oxygen compound at the negative cathode to produce a slight vacuum, so the positive and negative pressure difference drive the oxygen gas through the passage between the electrodes moves to the negative electrode. VRLA batteries are designed to provide such a channel, so that the valve-regulated battery is without loss of water in float charge (under the required work voltage range).

For oxygen cycle efficiency of the reaction, AGM battery has a good sealing reaction efficiency, efficiency is up to 99% in poor liquid state oxygen recombination; while this efficiency of gel batteries is relatively smaller and up to 70% -90 % in dry state ; flooded battery is almost do not create oxygen recombination reactions, the sealing reaction efficiency is almost zero.

6. Standards of Compliance

Fixed type VRLA batteries shall meet the following national and international standards

- Communication Systems YD / T 799-2002 <Communication VRLA battery technical requirements and test methods>
- UPS Systems YD / T 1095-2000 <Communications with the uninterruptible power supply>
- Power DL / T 459-2000 <Power Systems DC Power ordering technology>
- BS6290-1987 <Stationary lead-acid batteries (valve-regulated norms).>
- JIS C 8707-1992 <cathode absorption Seal Stationary lead-acid batteries>.
- IEC 60896-21 <Stationary lead-acid battery (VRLA) (2002)>

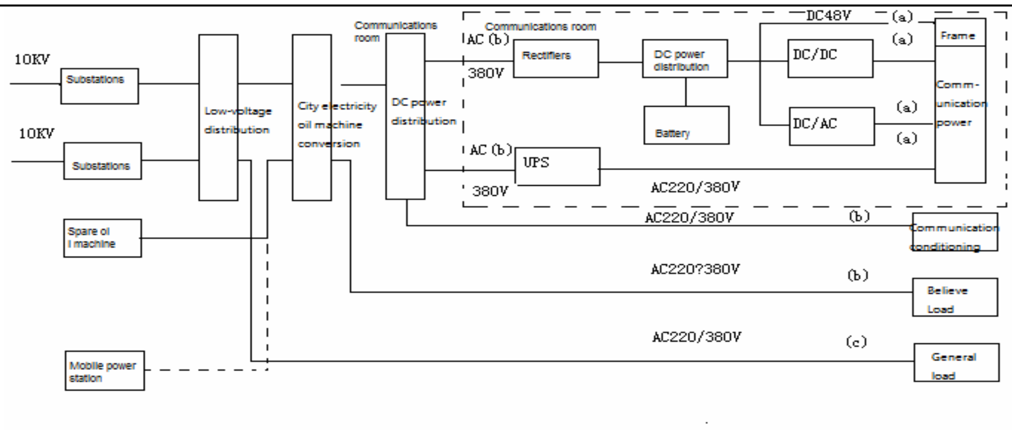
6.1 Telecommunication Power

Telecommunication power is indispensable component of its network communication power. Quality of power supply has a direct impact on the smooth flow of the entire telecommunications network. As a professional engineer, it is necessary to understand the whole communication power system.

For a long period of time, centralized power supply is the major DC power supply sysem for communications. Now, decentralized power supply has been widely used in domestic and abroad This so-called decentralized power supply is refer to section arrangement on the AC power supply. To decentralize DC power supply used by the communications equipment. In the communication system room, rectifiers, DC power distribution and VRLA batteries and communications equipment placed.

6.1.1 Power system of Communications Authority (station)

（1）Generally, power system of Integrated Communications Authority (station) is consist of equipment of high and low voltage power distribution, convert (full) flow, DC distribution, batteries and standby generator sets (or mobile station) and other equipment, as shown below:

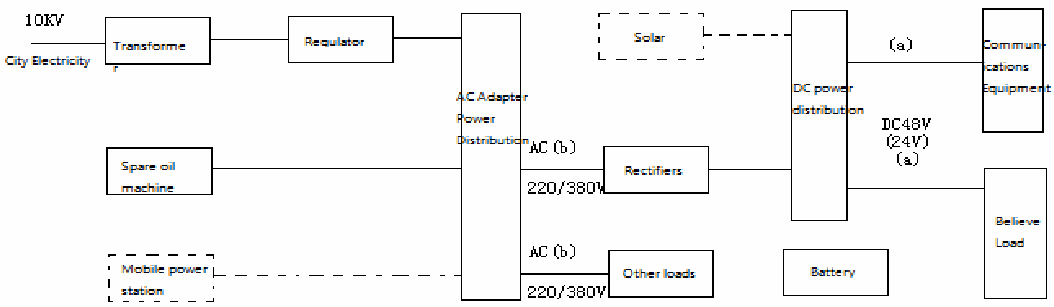


(a)Uninterruptible (b)A short-term interruption (c)Enable interrupts

Fig15 Distributed power supply system diagram

（2）Long-distance transmission communication station power system is consist of equipment of AC conversion and power distribution, transfer (steady) voltage, rectifier, DC distribution, batteries and automated (unattended) generators and other equipment. And some stations using solar and wind power and other new energy equipment, as shown below.

图 15



(a) Uninterruptible (b) A short-term interruption

图 16 Long-distance transmission communication station power system

6.1.2Unavailability indicators of Communications (Agency) station power system

Unavailability indicators (U) defined as :

$$U = \frac{MTTR}{MTBF + MTTR}$$

MTBF——Mean time between failures

MTTR——Mean Time to Repair (recover)

（1）For communication stations (Bureau) with over 50000 phone terminal, the power supply system unavailability (U) should not exceed 5 × 10-7.

（2）For long-distance transmission lines two stations or equivalent communication bureau (station) with 1 to 50,000 phone terminal, the power system unavailability should not exceed 1 ×

10-6.

（3）For Line (with line-level cities) Comprehensive Bureau, central office, county and local network end office tandem office with under 10,000 phone terminal, the power system unavailability should be less than 5 × 10-6.

6.1.3 The role of Battery power in communication supply system

(1) stand by

Communications equipment requirements uninterruptible power supply. When the AC interrupted, the battery is the only backup power to support communication system. In normal city electricity supply, the rectifier is in work, the output current can be satisfied the needs of maximum load current (including battery charging). When abnormalities in the city electricity suuply, it is powered by batteries. The battery output current should meet maximum power consumption of the communication device. The battery output voltage should meet the communications equipment. Back up time based on category of power supply.

For standby battery, the discharge rate is slower, the discharge time of up to 0.5 ~ 8h, and chose fixed-type large-capacity lead-acid batteries.

(2) Smoothing

When batteries is in float during, the rectifier cover loss of power of battery self-discharge every day and night, or batettery perform charging procedures and being full charge.

For output voltage of thyristor rectifier or high frequency switching rectifier, it still exists various harmonic voltage ripple which is not yet eliminated by the filter. Since the minimal internal resistance exist from the low frequency harmonics battery voltage - only tens of milli-Europe. The load resistance (in parallel) is much greater than the internal resistance of the battery. Therefore, battery preforma BYPASS function namely Smoothing effect, to the output ripple voltage of rectifier. In the city electricity supply, under normal circumstances, so that the battery Is not departing from powered systems will help improve the quality of power supply.

6.1.4 Communication power system‘s requirements to VRLA battery

Executive Standard YD/T799-2002

(1) Table of Testing items

item	Project Name		Technical Requirements
1	Apprence And structure	① battery case	Battery case without stains, cracks, deformation
		②polarity and	There are clearly marking, easy to connect, meet the

		terminal sizes	manufacturers product design
2	Air Tightness		withstand 50Kpa and the positive or negative is not broken. Casing without deformation after pressure release
3	容量 Capacity	1)Float charge 2)1h arte 3) 3h rate 4)10h rate	Discharge Currrent （A） / End voltage （V） / Capacity （Ah） 1.0 / 1.80 / $0.95C_{10}$ 1.0 / 1.80 / C_{10} 2.5 / 1.80 / $0.75\ C_{10}$ 5.5 / 1.75 / $0.55\ C_{10}$
4	Large current discharge		30I10A discharge &1min pole without fuse, - no distortion
5	Rate of Capacity preservation		Battery stored for 28 days- the capacity not less than 95%
6	Sealing reaction efficiency		not less than 95%
7	Anti-mist properties		PH value - neutral
8	Safety valve requirements	(1)Valve opening pressure （2）valve closing pressure	10～49Kpa 1～10 Kpa
9	Resistance to overcharge capacity		with 0.3 I10A current charging for 160h, the shell should be with no significant deformation and exudate
10	The balance of the battery terminal voltage	Static state	Bank bank formed by two or more unit cells of 2V cells, each single cell open circuit voltage difference between ≤ 20mV
		Dynamic static	Into the floating state for 24h, terminal voltage between the battery ≤ ± 45 mV
11	Explosion-proof performance		In case of fire during charging process, battery should not be detonated inside
12	Sealant performance	(1)Cold weather	Battery under the conditions of -30 ± 3 ℃ for 6h, there should be no cracks. Should be no grooves

		(2)Hote weather	separation between the covers Battery under the conditions of 65 ± 2 ℃ and tilt 450 degree for 6 h, it should be no overflow
13	voltage drop of the between the of Connection the batteries		≤10mV
14	Battery Life		（1） Not less than 8 years for 2V series battery life （2） Not less than six years for 6V or higher voltage series battery life

6.2 UPS Field

"UPS" is AC uninterruptible power supply systems. In modern communication devices, computer is the used for satellite earth station, submarine cable communication and key communications hub, and automatic switching device, facsimile and other equipment. They require high performance and high reliability AC power supply, not allowed to have 3 ~ 5ms power supply interruption that data stored in computer will be lost. Uninterruptible power supply system is a high-reliability, high-quality power supply. Telecommunications companies have been widely used UPS.

The following diagram depicts the basic structure of the UPS.

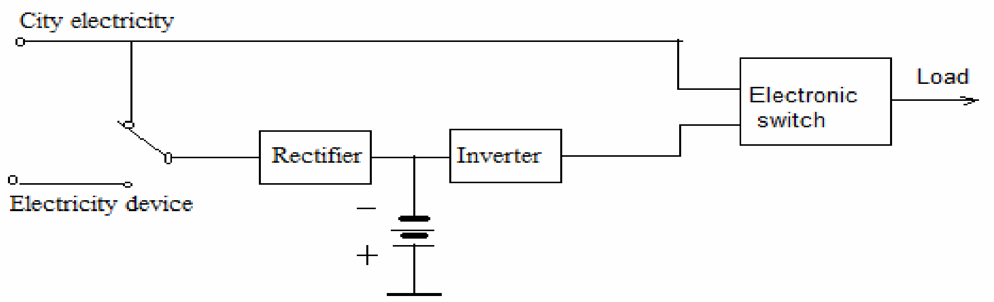


Fig 17 Basic Structure of UPS

Under normal circumstances, the load by the mains, the rectifier rectified mains power to charge the battery. When the mains fails, the inverter using the energy storage in battery, uninterrupted direct current into the same frequency in phase with the mains AC power, so the load on the power supply does not have a short break or significant voltage fluctuations. Therefore, the battery in the UPS system plays an important role in back-up power.

For UPS system, in order to reduce the current inverted by inverter into main circuit, it should choose high rate voltage of batteries (such as 260,280 V), to reduce the size, weight of the device and number of batteries used,. But due to the need of fast back up supply, it usually selected faster discharge rate and smaller capacity battery.

7. VRLA performance parameters

7.1 Open-circuit voltage and the operating voltage

7.1.1 Open-circuit voltage

The voltage in the open state of the battery terminal is called open circuit voltage. Open circuit voltage is equal to difference of the battery potential between the the positive electrode and the negative electrode .

7.1.2 Operating voltage

It is the voltage in discharge process as the battery is connected to the load, it also known as the discharge voltage. The voltage in the initial discharge process is called initial voltage.

While battery connected to load, due to ohmic resistance and polarization overpotential, the battery operating voltage is lower than the open circuit voltage.

7.2 Capacity

Under certain conditions, the battery discharge capacity can be called the given battery capacity, represented the symbol **C**. The unit is “ampere hours” (Ah) or mAh (mAh).

Battery capacity can be divided into “theoretical capacity”, “rated capacity” and,”actual capacity.”

Theoretical capacity is the quality of the active substance calculated according to Faraday's law the maximum theoretical value. When compare between different series of batteries, it commonlu use the concpet of capacity. The capacity per mass and weight of unit cell give the theoretical power, in units of Ah / L or Ah / Kg.

The actual capacity is the output power.of battery under certain conditions. It equal to the discharge current (A) X Time of discharge (H) of the product; in units of Ah, which is less than the theoretical capacity.

Rated capacity is also called guaranteed capacity, according to national standards or domestic departments, to ensure that the battery should emit a minimum capacity. in a certain discharge conditions

7.3 Resistance

Battery internal resistance included ohmic resistance and polarization resistance. Polarization resistance also includes electrochemical polarization and concentration polarization. With the presence of resistance, the battery terminal voltage during discharging / charging is lower / higher than open circuit voltage. The internal resistance of the battery is not constant. It s change over time during charge-discharge proces, because the composition of the active material, the electrolyte concentration and temperature are constantly changed.

ohmic resistance comply with Ohm's law. Polarization resistance increases as the current density increase; and not in a linear relationship, but as the current density increases, then the linear relatiohsip is increae.

7.4 Energy

Under certain discharged system, energy given by battery usually indicate as Wh (Wh)

Energy of the battery divided into “Theoretical energy “iand “Actual energy”

Theoretical energy equals to “ theoretical capacity X electric potential (E)” .That is $W_{理}=C_{理}$ E

$W_{实}=C_{实}U_{平}$

Actual energy equal to “actual capacitance” x “ the average operating voltage” of a battery under certain discharge conditions. That is $W_{实}=C_{实}U_{平}$

It used **Engergy Ratio** to compare difference of energy between battery systems. It is the ratio of output power per unit mass or unit volume of the battery , namely unit Wh / kg or Wh / L.

There are (1) theoretical energy ratio and (2) actual energy ratio. The former (1) refers to the theoretically energy output from 1 kg battery-reactive substances when fully discharged; while (2) refer to actual energy output from 1 kg battery-reactive substances.

Due to various factors, the actual battery ration is far less than the theoretical energy ratio. Relatioship between theoretical energy ratio and actual energy ration can be expressed as follows: $W=W_e \cdot K_V \cdot K_R \cdot K_m$

K_V—voltage efficiency； K_R—reaction efficiency; K_m—quality efficiency。

Voltage Efficiency refers to the ration of battery voltage and electric potential. During battery discharge, due to electrochemical polarization, concentration polarization and ohmic drop, the working voltage is smaller then electric potential.

Reaction efficiency is the utilization.of active material.

Battery energy is a comprehensive index, which reflects the quality of the battery level and manufacturer's technical and management level.

7.5 Power and power ratio

Battery power is, under certian a discharge system, the size of the energy output in a given time; in units of W (Watts) or kW (kilowatts). Power ratio is the power given by unit mass of the battery, in unnits of W / kg or kW / kg. Power ratio is one important indicator of battery performance. A battery is of large power ratio, which means that it can withstand large current discharge.

Battery’s energy ratio and power ratio is an important parameter when selecting the battery.

Because the battery and the electric equipment, instruments, motors etc. are used as a set. It has to select the battery type according to the power requiremetn of electrical equipments. Of course, it should also consider the quality, volume, specific energy, the temperature range and prices and other factors.

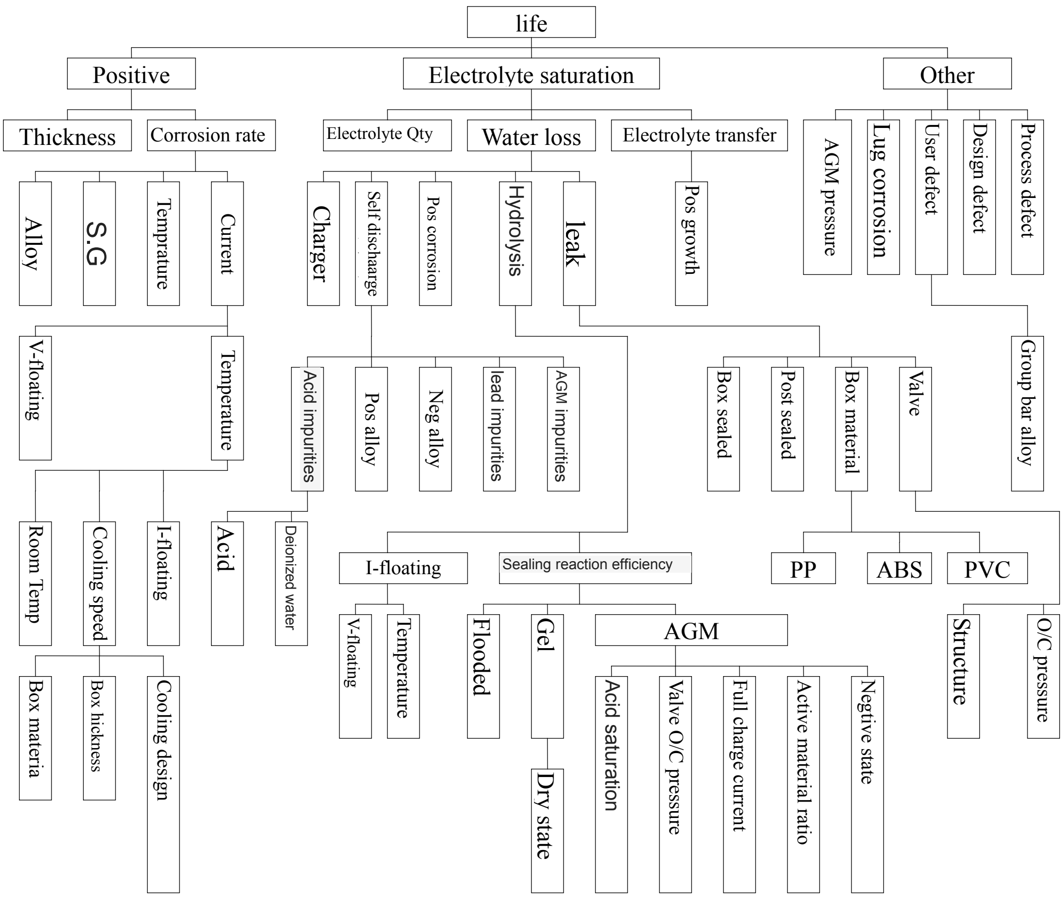
7.6 Battery life

Under specified conditions, the effective life time of a battery is called the battery life. When an internal short circuit, or damage the battery can not be used, as well as the capacity not reaching rated requirements that the battery fails, then the battery life is terminated.

The battery life included the service life and life cycle. Battery service life is the time duration available for use, including the battery storage time. Life cycle refers to the number of times the battery for reuse (recharging).

8. VRLA Battery life factors

VRLA battery life factors diagram



9. VRLA batteries self-discharge (capacity retention)

9.1 Cause of self-discharge

Self-discharge refers to the the battery capacity decreases during storage phenomenon. Due to battery self-discharge, there is capacity loss in open circuit

Self-discharge is mainly in the cathode. The negative electrode's active material is of active spongy lead electrode, their electrical potential in the electrolyte is negative than hydrogen, substitution reaction can occur. If there is low hydrogen overpotential metallic impurities in the electrode, they react with negative electrode's active material and form corrosion micro-cell, this lead to dissolution of negative electrode metal and precipitate hydrogen, thereby reducing capacity. Impurities in the electrolyte will have the same harmful effects.Generally, self-discharge is small in anode. Anode is an extremely strong oxidizing agent If impurities present on the electrolyte or the separator, which are easily oxidized, can cause the reduction of the positive electrode active material, thereby reducing capacity.

9.2 Self-discharge rate

Self-discharge rate is the percentage.of reduced capacity per unit of time

$$\text{Self}-\text{discharge rate} = \frac{C_a - C_b}{C_a \times T} \times 100\%$$

C_a—Battery capacity before storage（Ah）

C_b—Battery capacity After the storage（Ah）

T—Battery storage time (days, months….)

9.3 self-discharge in positive electrode

During battery storing, positive electrode active material is decomposed and form lead sulfate and precipitated with the oxygen, then occurs following conjugate reactions:

$PbO_2+H_2SO_4+2H^++2e^- \longrightarrow PbSO_4 + 2H_2O$ （3-5）

$H_2O \longrightarrow 1/2\ O_2+2H^++2e^-$ （3-6）

①Total reaction：$PbO_2+H_2SO_4 \longrightarrow PbSO_4+ H_2O + 1/2\ O_2$ （3-7）

Self-discharge in the positive electrode may also be formed by the following cause:

② $5PbO_2+2Sb+6H_2SO_4 \longrightarrow (Sb_2)_2SO_4+5PbSO_4+6H_2O$ （3-8）

③ $PbO_2+Pb_{(板栅)}+ 2H_2SO_4 \longrightarrow 2PbSO_4 +2H_2O$ （3-9）

④ Concentration cell （3-10）

As concentrations of sulfuric acid is different in upper and lower ends of the electrodes, and the surface / pores of the electrodes, thus forming concentration cell in the upper, lowers and outside electrode. In relatively dilute region, lead dioxide acts as negative electrode and process oxygen. In high density sulfuric acid area, lead dioxide acts as anode, and perform the reverse process. Lead dioxide reverses into lead sulfate. This concentration cell can be foremed during charging and discharging at the positive electode, and oxygen precipitated. However, concentration in the electrolytic solution tends to be uniform, the concentration difference disappears, the self-discharge will stop.

Self-discharge rate at the positive electode is affected by grid alloy composition and concentration of the electrolyte, there are different values corresponding to the concentration of sulfuric acid

9.4 Self-discharge in negative electode

In the open circuit state, the dissolution of lead causes loss of capacity.

$$Pb+H_2SO_4 \longrightarrow PbSO_4+H_2 \qquad (3\text{-}13)$$

10. factors affecting VRLA battery capacity

10.1 How Discharge rate affecting the battery capacity

Lead-acid battery capacity decreases as discharge rate increasing, Speaking about capacity, it ahs to specify the discharge hour rate, or current ratio. Battery capacity varies as discharge hour rate or current rate varies.

10.1.1 The relationship between capacity and discharge hour rate

For a given battery, it has different capacity under different discharge hour rate. Below table shown the capacities of 1000AH battery with different discharge hour at room temperature :

discharge hour rate(hr)	1	2	3	4	5	8	10	12	24
capacity（Ah）	550	656	750	788	850	952	1000	1044	1128

10.1.2 Reasons for the capacity decline in high rate discharge

The higher the discharge rate, the denser of discharge current , the current distribution is not uniform in the electrode. the current priority distribute on the nearest surface of the electrolyte, so that PbSO4 generate firstly on the outermost surface of electrode. The volume of PbSO4 is large then PbO2 and Pb, so lead sulfate orifice clogged the porous of electrode, the electrolyte can not supply adequately for the needs of the reaction inside the electrode, the electrode material inside can not be fully utilized, and thus capacity decreases under high-rate discharge

10.1.3 Relationship between discharge current and electrode effect

in large current discharge, the active substance's effect in the thickness direction is of limited depth: the greater current, the smaller the depth effect. the degree of use of the active substance is the lower, the smaller the capacity of the battery is given. When the electrodes discharge at low current density - i ≤ 100A/m2, the depth effect of active substance is 3 × 10-3m-5 × 10-3m, inner porous of electrode surface can then be fully utilized. When the electrode is discharged at a high current density - i ≥ 200A/m2, the depth effect tof active substance decline sharply of about 0.12 × 10-3m, At his low depth effect of the active material, diffusion is the main factor of capacity limit.

In the large current discharge, since the existence of polarization and internal resistance, the battery terminal voltage is low, the voltage drop loss increases, the battery terminal voltage drops quickly, this also affect the capacity.

10.2 The impact of temperature on battery capacity

Ambient Temperature have greater impact on the capacity of the battery. As the ambient temperature decreases, the capacity decreases. The change in the battery capacity with 1 ℃ ambient temperature change is known as the temperature coefficient of capacity

According to national standards, if ambient temperature is not at 25 ℃, it has to convert the actual measured capacity into 25℃ basic capacity with the following formula .

$$Ce = \frac{Ct}{1+K(t-25℃)}$$

t = the ambient temperature of the discharge

K=temperature coefficient

10hr capacity, K = 0.006/℃,

3hr capacity,K = 0.008/℃,

1hr capacity,K = 0.01/℃

10.3 calculation of VRLA battery capacity

VRLA battery's actual capacity is related to the discharge system (discharge rate, the temperature, the termination voltage) and battery structure. If the battery is discharge with a constant current, and the discharge till reaching the end voltage, the actual capacity of the battery C_t= discharge current I × discharge time t, in units of Ah.

11. Characteristics of VRLA battery charge and discharge

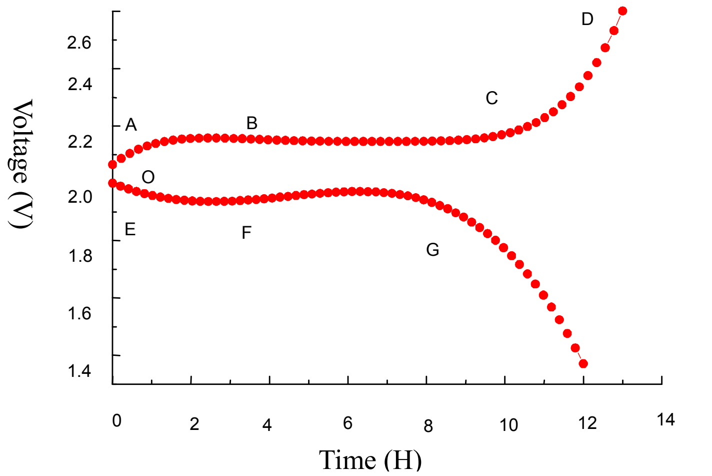


Fig 18 Characteristics charge and discharge

Battery capacity VS the depth of discharge, charge voltage, current and time (25 ℃) - see Figure

19

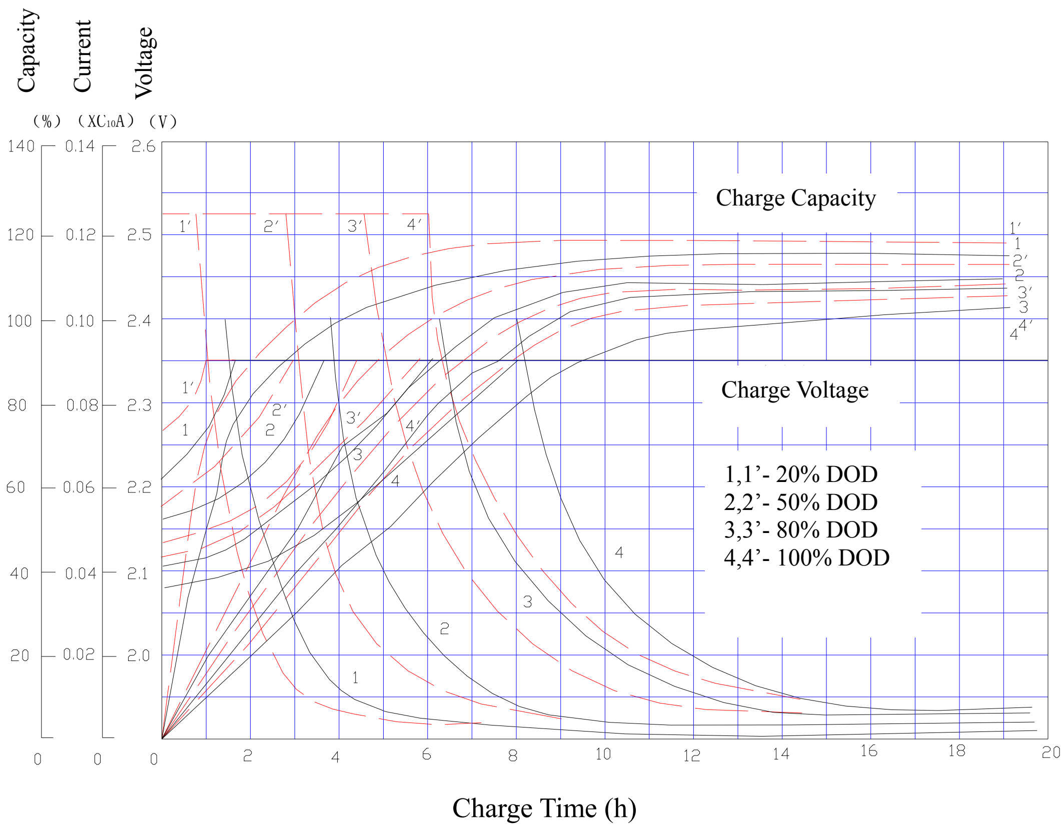


Fig 19 **Charge characteristic at various rates (at 25℃)**

12. failure modes of VRLA battery

12.1 Dry Failure Mode

VRLA battery exhausts hydrogen, oxygen, water vapor, mist. These are the ways of loss of wate and and battery dehydration. Dehydration is a specific factor of Dry battery failure of VRLA battery. There are four reasons : ① gas recombination efficiency low; ② water seeping from the battery casing; ③ grid corrosion water consumption; ④ loss of water in self-discharge.

12.1.1 **Gas recombination efficiency**

Gas recombination efficiency is of a great relationship with the float voltage selection. If Selected Voltage is too low, although less oxygen precipitation and high complex efficiency; but the individual battery charge, due to long-term under charged, cause negative electrode salinization and failure, the battery life is shortened. If selected float voltage is too high, the gas precipitation increases, gas recombination efficiency is low, although it avoids the failure of negative electrode, but frequent open of safety valve, increase water loss; there are positive grid corrosion which affect battery life.

12.1.2 Moisture penetration from the housing material

The performance of various battery shell material is shown in table below. Seen from the data in the table, ABS materials with large water vapor permeability, but the strength is good. Penetration of the battery case depending on housing material type, nature, and its thickness, vapor pressure difference between the inside and outside on the housing.

Table 12-1

Material \ data	relative Water vapor permeability (%)	relative Oxygen permeability (%)	Mechanical strength	
			Tensile strength (Mpa)	Notched impact strength ($KJ \cdot m^{-2}$)
ABS	16.6	0.35	21~63	6.0~53
PP	1.00	1	30~40	2.2~6.4
PVC	4.22	4.41	35~55	22~108

12.1.3 Grid corrosion

Grid corrosion will cause the consumption of water, the reaction is

$$Pb + 2H_2O \longrightarrow PbO_2 + 4H^+ + 4e^-$$

12.1.4 Self-discharge

In self-discharge of anode, oxygen is exhausted., which would be compound at the negative electrode and which is not further dehydration. But hydrogen exhausted from negative electrode can not combinationd at positive electrode, and accumulate in the battery, discharge form the valve and water is lost; in particular as the battery stored at high temperatures , self-discharge speed.

12.2 failure mode of Premature capacity loss

VRLA batteries used low-or no antimony antimony grid alloy. Early capacity loss often occurs easily in the following conditions:

① inappropriate cycling conditions, such as continuous high rate discharge, deep discharge, charging begins with the low current density;

② lack of special additives such as Sb, Sn, H3PO4;

③ low-rate utilization of active material, electrolyte excess , plate too thin, etc.;

④ low density of active material, assembly pressure is too low and so on.

12.3 Failure modes of thermal runaway

Most battery systems have heat problems, and large possibility forVRLA batteries. It is due to: oxygen recombination process allows more heat generated within the battery; amount of the exhaust gas exhaust is small, reducing the dissipation of heat;

If the working environment VRLA battery is of too high temperature, or the charging device is out of control, the battery charge level will increase too rapidly, the battery internal temperature increases, the battery cooling is poor, resulting in overheating, battery internal resistance decreased, the charging current further increases, the resistance is further reduced. A vicious cycle is repeated until the thermal runaway of the battery casing severely deformed, split up. To prevent the occurrence of thermal runaway, to adopt appropriate measures:

① charging equipment should have a temperature compensation function or limit;

② strict quality control valve, so that the gas inside the battery is discharged normally;

③ To set the battery in a well ventilated position and control the battery temperature.

12.4 Negative irreversible sulfation

Under normal conditions, lead sulfate crystals formatted during discharge; it can be reduced back to lead during the charging. If the battery is used and maintained not properly, for example, often in insufficient charge or over-discharge, the negative electrode will gradually form a thick hard lead sulfate, it almost does not dissolve, it is difficult with conventional charging method converted to the active substance, thereby reducing the the battery capacity, and even become the reason for termination of battery life, a phenomenon known as plate irreversible sulfation.

In order to prevent irreversible sulfation on negative electode, you must charge the battery in time and can not be over-discharge.

12.5 Grid corrosion and elongation

In the lead-acid battery, the positive grid thicker than the negative grid, one of the reasons is that in the charge, especially the over-charging, the positive plate grid to be corroded, lead dioxide is oxidized gradually lost the function of grid, to compensate for the amount of corrosion, the positive plate grid is of thicker.

So in actual operation, be sure to choose the right float voltage according to the ambient temperature. For float voltage is too high, it causes accelerated loss of water, and also lead to positive grid corrosion acceleration. When the alloy grid corrosion occurs, this resulting the stress, making plate deformation and elongation, then it occurs short circuit in the edge of the plate or between the top plate and the bus. VRLA Battery life depends on the life of positive plate, battery design life is based on positive grid alloy corrosion rate calculation. The more the positive grid corrosion, the less the remaining capacity of the battery; battery life is shorter.

13. Design of VRLA battery

13.1 Grid alloy selection

Lead and lead dioxide of active materials (Participate in the battery reaction) are loose porous body which needs to be fixed on the carrier. Usually, fence made of lead or lead alloy sheet acts as the carrier, which the active material fixed therein, such an object is called grid. Its role is to support the active material and the current transmission.

13.1.1 Positive grid alloy

VRLA battery is a new battery, in the process of using without adding acid and water for maintainenance, which requiring positive grid alloy of good corrosion resistance, small self-discharge. Different manufacturers use different positive grid alloys such as Lead / calcium, lead/calcium/tin, lead/calcium/tin/aluminum, lead /antimony/cadmium. Different type alloys has dffierent performance. Pb/ Ca, Pb/Ca/Sn alloy has good floating properties, but the lead-calcium alloy barrier layer is easy to form calcium sulfate cause early failure of the battery, and poor creep resistance alloys, not suitable for recycling. Pb/Ca/Sn/ aluminum and lead/antimony /Cadmium is relatively good in all aspects of performance, both suitable for float use, and for recycling.

13.1.2 Negative grid alloy

VRLA batteries generally use negative grid alloy of lead /calcium alloy to minimize the amount of hydrogen evolution.

13.2 Grid thickness

Positive plate thickness determines the battery life. Relationships between Plate thickness and the battery life expectancy as below table

表 13-1

Positive grid thickness（mm）	Cycle life (times)（10h rate 80% depth of discharge, 25 ℃）	Expected float life (years)（normal float）
2.0	150	2
3.0	257	4
3.4	400	6
4.5	800	12

13.3 Percentage of positive and negative active material

Positive % negative electrode active material utilization is generally 30-33% & 60% -70% .according to calculations, the positive and negative active material ratio of 1:1. In practical application, active material utilization of the negative electode is higher than the positive electrode. For VRLA batteries, taking into account the needs of the oxygen recombination, the negative electrode active material is designed in excess, generally is preferably 1:1.0 to 1.2.

13.4 Select the diaphragm

VRLA battery's separator used glass fiber cotton, which have the following characteristics:

① excellent acid resistance and oxidation resistance;

② uniform thickness, look no pinholes, no mechanical impurities;

③ porosity of small and large diameter;

④ good electrolyte absorption and retention capacity;

⑤ resistance is small;

⑥ have a certain mechanical strength to ensure the process operating requirements;

⑦ low impurity content, especially iron, copper content is lower

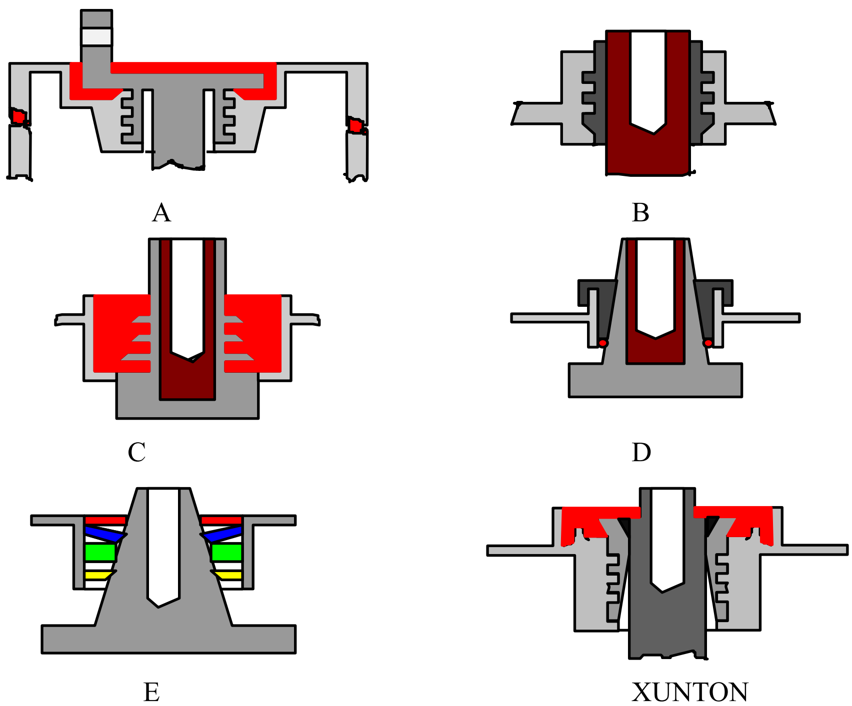
13.5 selection of Shell lid structure and material

Designe of VRLA battery case cover structured primarily strength design, thermal design and pole cover seal design. Cell wall strength design require wall should not have significant deformation during assembly and the inside air pressure. For PP shell, steel rack should be added. For ABS and PVC shell, wall thickness generally reach 8-10mm. Thermal design require battery casing with large heat dissipation area; good thermal conductivity and thickness as thin as possible. Shell structure's requirement is relatively simple, jit ust consider the strength and fixed with the lid.

13.6 Pole shell cover seal and pole seal structure

Battery case cover seal divided into heat sealing and adhesive sealing.. Heat sealing is the most reliable sealing method, PP materials using heat sealing, ABS and PVC materials commonly used adhesive seal, key of adhesive seal is the use of appropriate epoxy.

Pole sealed technology of VRLA battery production is a key technology, different manufacturers use different sealing mode



13.7 Electrolyte

The sulfuric acid content of VRLA battery electrolyte is generally 1.5 times of the theoretical amount. Electrolyte specific gravity is generally about 1.30g/ml

13.8 Safety valve

Safety valve is a key component of VRLA batteries, valve quality directly affects battery life, uniformity and safety.

Accordance with the relevant standards and the use of VRLA batteries, safety valves shall meet the following technical requirements:

①one way open

②One directional sealing to prevent air from entering the battery;

③In same group of cells, the opening and closing pressure difference between valves should not exceed 20% of the mean;

④life should not be less than 15 years;

⑤acid filter - prevents acid and acid mist from the safety valve exhaust out;

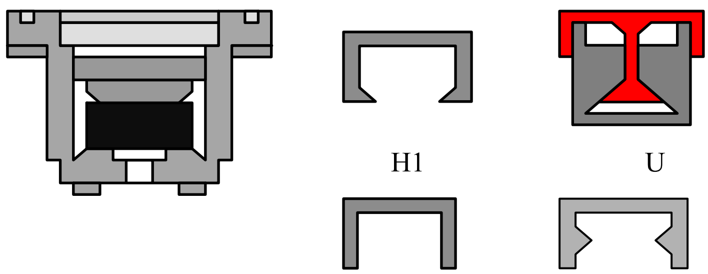
⑥Burst proof - in case of fire outside the battery, should not be detonated inside the battery

⑦Shock proof -, during transport and during use, the valve does not failure for frequent open and close

⑧acid proof

⑨resistant to high and low temperature.

Safety valve commonly used are: column, hat (H) and umbrella (U)valve, its structure is shown in the diagram below



（XUNTON）column, H2 H3

14. VRLA battery manufacturing process

14.1 Formation Process

Lead shot - lead powder manufacturing → paste → plate coated (plate casting)→ curing → cut brush ear → (pack plate) grouping → welding → hot glue seal → acid filling → internal formation → Storage → recheck

14.2 Slot into process (plate formation process)

Lead shot →lead powder manufacturing → paste → coated plate (plate casting) → curing → formation → ear cut brush (grouping)

→ welding→ hot glue seal → acid filling → activation → Storage → packing → recheck

15. Use of VRLA battery

15.1 Select the Capacity

VRLA battery's rated capacity is 10 hour rate discharge capacity. If battery discharge current is too large, then it can not reach the rated capacity. Therefore, it should be based on the device's load, voltage, size and other factors to select the appropriate battery capacity. The total capacity of the battery should comply to YD5040-97 "Communication Power Equipment Installation Design" provisions configuration, calculated as follows:

$$Q \geqslant \frac{KIT}{\eta[1+\alpha(t-25)]}$$

Q---Battery capacity（Ah）; K--- Safety Coefficient 1.25; I--- Load current（A）;

T--- Time of discharge（h）;

η--- Discharge capacity Coefficient;

t --- lowest ambient temperature values of actual battery location. Take 15 ℃ for location with heating equipment ; Take 5 ℃ for location without heating equipment

- Battery temperature coefficient (1 / ℃). Take α = 0.006 when Discharge hour rate ≥10; Taking α = 0.008 when 10> Discharge hour rate ≥1; Taking α = 0.01 when the discharge hour rate <1,

Calcualtion may refer to the selecting system:

15.1.1 Telecom system

Telecommunication sysyem included 48V and 24V battery systems, which mostly is 48V.

15.1.1.1 Calculation factor

$V_{总}$——Total float voltage（V） V_f——single cell float voltage（V）

$V_{低}$——lowest total voltage（V） I——Total current load（A）

T——Discharge duration（h） t——Ambient temperature（℃）

K_{it}——Capacity conversion Coefficient (C_t/C_{10})

K_a——Aging coefficient (0.6~1.0)

K——Reliability coefficient (1.0~1.4)

K_t——Temperature correction coefficient (0.006)

15.1.1.2 Calculation step

——Calculate the number of battery cells：$n= V_{total}/ V_f$

——Calculate single cell termination voltage：$V_{end}=V_l/n$

——Calculate theoretical capacity：C_e=IT

——Calculate the 10 hour rate capacity：$C_{10}= C_e/ K_{it}$

——Calculate the actual capacity：$C=KC_{10}/\{K_a[1-K_t(25-t)]\}$

15.1.1.3 Conclusion of Calculation

According to the calculation of the actual capacity; and select the appropriate type of battery.

15.1.1.4 Examples of calculation

In a mobile company communications room, no air conditioning, and with heating supply in winter, operating temperature range of 5 ~ 30 ℃, the load current is 973A, 48V system system, bacvk up time is 2 hours, the system minimum operating voltage of 42V, which battery models is more appropriate? Answer: n = 48/2 = 24 pcs

$V_f=V_l/n=42/24=1.75V$

$C_e=IT=973\times2=1946Ah$

$C_{10}= C_e/ Kit=1946/61\%=3190.16Ah$ (2 hours rate discharge battery can emit 61% of rated capacity, ie Kit = 61%)

In the case of 5 ℃, take K = 1.2, * = 0.8, the actual capacity is

$C=KC_{10}/\{K_a[1-K_t(25-t)]\}$

$=1.2\ C_{10}/\{0.8[1-0.006(25-5)]\}$

$=1.2\ C_{10}/(0.8\times0.88)=5437.77Ah$。

According to the battery specification table, you can choose two or three groups 2000AH/48V group 3000AH/48V or four or six groups 1000AH/48V GFM-1500/48V batteries in parallel. Specific installation space according to the environment, ease of maintenance, cooling effect is good or bad and other factors.

15.1.2 Caculation for UPS selection

UPS battery includes 380V and 220V, 48V and 12V and other systems, which mostly use 380V battery .

15.1.2.1 Calculation factor

V_T——Float total voltage（V） V_f——single cell float voltage（V）

V_l——lowest total voltage（V） P_T——total power load（W）

T——Discharge duration（h） t——Ambient temperature（℃）

K_a——Aging coefficient (0.6~1.0) K——Reliability coefficient (1.0~1.4)

K_t——Temperature correction factor (0.006)

15.1.2.2 Calculation step

——Calculate the number of battery cells：$n= V_T/ V_f$

——Calculate single cell termination voltage：$V_{end}=V_l/n$

——Calculate single cell power：$P=P_{end}/n$

——According to the discharge time, the termination voltage and power, check Constant Power Discharge Data Sheet, select the theoretical capacity (C10) of the battery.

——Calculate the actual capacity：$C=KC_{10}/\{K_a[1-K_t(25-t)]\}$

15.1.2.3 Conclusion onCalculation

According to the calculation of the actual capacity to locate; and select the appropriate type of battery.

15.1.2.4 Examples of calculation

An UPS projects with the power P = 6KW, system voltage 220V, requires back up time of 30 minutes. What kind of battery model is more suitable?

Answer: P = P total / n = 6000/18 = 333W (220V system wih12V battery 18 pcs)

Discharge time requiredT=30min，V_{end}=1.75V/ single cell。

Discharge power（404W），Theoretical capacity C_{10}=40Ah。

Actual capacity: In the case of 25 ℃, take K = 1.2, Ka = 0.8, the actual capacity is:

$C=KC_{10}/\{K_a[1-K_t(25-t)]\}$

$= KC_{10}/K_a$

$=1.2\times40/0.8$

=60Ah

It can determine the most appropriate battery choice is 12V65AH, using a total of 18 series, constitute a group 65Ah/220V system.

15.1.3 Caculation for power Selection

Power battery includes 380V, 220V, 110 V and 48V systems, in which mostly is 220V

15.1.3.1 Calculation factor

V_T——Total float voltage（V） V_f——single cell float voltage（V）

I_{touch}——Closing current（A） I_n——Each phase fault current(A）

T_n——The duration of each stage discharge incident（h）

t——Ambient temperature（℃）

K_{it}——Capacity conversion coefficient Ct/C_{10})

K_a——Aging coefficient (0.6~1.0)

K—— Reliability coefficient (1.0~1.4)

K_t——Temperature correction coefficient (0.006)

Cn——Capacity of each stage C_{10}——10h rate capacity

C——Actual capacity

15.1.3.2 calculation step

——Calculate the number of battery cells connected in series：$n= V_T/ V_f$

——Calculated single cell termination voltage：$V_{end}=V_l/n$

——Discharge time calculated for each phase： $T=T_n-T_{n-1}$， based on Shock time calculated = 5s

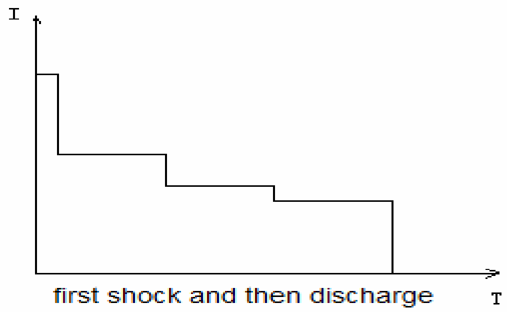
——Calculate the required 10 hours accident rate discharge capacity: $C_{10}=C_1+C_2+----+C_n$

$C_n=(I_n-I_{n-1})T/K_{IT}$

Note: After the first discharge and then shock, capacity is the total of each stage class; If first shock and then discharge, it need higher capacity, if insufficient capacity, then have to replenish.

——Calculate the actual capacity

$C=KC_{10}/\{K_a[1-K_t(25-t)]\}$



15.1.3.3 Conclusion on Calculation

According to the calculation of the actual capacity ; and select the appropriate type of battery.

15.1.3.4 Examples of calculation

a power plant project of 2 × 300MW unit, each battery DC load Parameters required refer toTable 15-1 - To calculate the battery capacity of each group.

Parameters required

	Rated Voltage	end Voltage	Discharge Time	Discharge current（A）				
				0-1min	1-30min	30-60min	60-180min	Random
Battery bank 1	220V	1.85V	3h	890.27	466.91	340.01	20.00	20.00
Battery bank 2	110V	1.80V	1h	215.36	179.36	179.36	0	10.00

Calculation:

a. Battery bank 1

Battery bank 1 -Battery capacity calculation of each stages

	Rated Voltage	end Voltage	Discharge Time	Discharge current（A）				
				0-1min	1-30min	30-60min	60-180min	Random
bank 1	220V	1.85V	3h	890.27	466.91	340.01	20.00	20.00
Discharge capacity				Impulse discharge	233.455	170.01	40	

(Ah)								
Capacity Coefficient	Compared with 10hr capacity				35%	35%	61%	
10hr capacity	Total	1218.3Ah			667	485.74	65.6	

As Impulse discharge capacity is small, it need to calculate the discharge capacity of each stage, Take temperature is 25 ℃, from the table view, the increase the capacity of the C10 = 1218.3Ah, Ka - aging factor (0.6 ~ 1.0), K - reliability factor (1.0 to 1.4), I f choosing Ka = 0.8, K = 1.2

Then C = KC10 / {Ka [1-Kt (25-t)]}

= KC10/Ka

= 1.2 × 1218.3/0.8

= 1827.5Ah

Therefore, the safest option is to choose 1000AH/220V/2 set of batteries, each bank of 104 pcs

b. Battery bank 2

Battery bank 2 -Battery capacity calculation of each stages

	Rated Voltage	End Voltage	Discharge Time	Discharge current（A）				
				0-1min	1-30min	30-60min	60-180min	Random
Battery Bank 2	110V	1.80V	1h	215.36	179.36	179.36	0	10.00
Discharge capacity (Ah)				Impulse discharge	89.68	89..68		
Capacity Coefficient	Compared with 10hr capacity				35%	35%		
10hr capacity	Total	512.46			256.23	256.23		

As Impulse discharge capacity is small, it need to calculate the discharge capacity of each stage, Taking temperature is 25 ℃, from the table view, the increase is the capacity of the C10 = 512.46Ah, Ka - aging factor (0.6 ~ 1.0), K - reliability factor (1.0 to 1.4), if choosing Ka = 0.8, K = 1.2

Then C = KC10 / {Ka [1-Kt (25-t)]}

= KC10/Ka

= 1.2 × 512.46/0.8

= 768.69Ah

Therefore, the safest option is to choose 800AH/110V batteries, each bank of 52.pcs

15.2 Charger selection

Since in float use and not monitored, requires the charging device for f VRLA battery has The following features:

1) Automatic Voltage Regulator (2) automatic steady flow (3) constant voltage limiting current (4) high temperature alarm (5) ripple coefficient of less than 5% (6) failure alarm (7) Float / Equalize automatically converted (8) Temperature Compensation

15.3 VRLA battery installation

15.3.1 Installation

VRLA batteries have two designs of high and short shape. (1) High-shaped design with of the large battery size (height), higher weight; of which large concentration polarization and affect battery performance; recommoned the horizontal placement. (2) Short-shaped battery can install vertically, but also be horizontal . Installation is according to actual condition of workplace and facilities.

15.3.2 Connection and wire

In VRLA batteries practical applications, high current discharge performance is of particular importance. In addition to the battery itself, the voltage decrease by the connections and wiring is important.

15.3.2.1 Connection Method

Consider batteries of higher then 1000Ah, these large battery is of 500 Ah-1000Ah in parallel connection, some connection cables are used;, to implement the principle of "more seriees and less paralle” and, “first series and then parallel"; the largest monoboc is 2000 Ah.

15.3.2.2 connecting wires

General requirement for voltage drop between the connecting wires (bipolar column roots measurement) is 10mV at 1hr large current discharge rate. Connecting wire have 3 factor of material (resistivity) / the length /and cross-sectional. During selection, if resistivity and length (mounting position) is fixed, the cross-sectional area may refer to the following formula:

$$Se = \frac{I \times \rho \times L}{\Delta U}$$

Se--- Cable cross-sectional area (mm^2);

I--- 1h rate discharge current (A); ρ --- Metal resistivity ($\Omega \cdot mm^2/m$)

L--- Wire length (poles column center distance) (m)； $\Delta U=0.01V$。

15.3.2.3 Precaution

⑴Batteries of different capacity, performance and recency can not be group together.

⑵Connecting screws must be tightened. Dirt and loose connections may cause the battery to explode ignition; which need to be carefully examined.

⑶Before the cable connection in last stage of installaion and conncted the battery system, you should double-check the system's total voltage and polarity to ensure correct wiring

⑷As the voltage of battery bank is higher, there is a risk of electric shock, therefore , insulated tools should be used when handling the connection to protect against short circuits.

⑸Batteries should not install in a closed equipment and room, it should have goodl ventilation; preferably with air conditioning. Battery keep away from heat source and place easily produced sparks; it should avoid direct sunlight shining.

15.4 Running the Charge

15.4.1 Supplementary charge and capacity test

VRLA battery is charged before delivered from factory. Due to self-discharge and other reasons, it needs to run supplementary charge and capacity test before operation run. Supplement charging should according to manufacturers's instructions, each manufacturer has its own manual.

Two methods of supplementary charge

⑴Constant current Constant voltage – First is to limit current, the charging current is limited to 0.25 C10 or less (usually with 0.1 C10-0.2 C10); charge until the battery terminal voltage rises to 2.35-2.40V; immediately changed to 2.35-2.40V voltage for continuous charging, the charge current drops below0.006C10 for three hours unchanged, that is considered fully charged (charge finish).

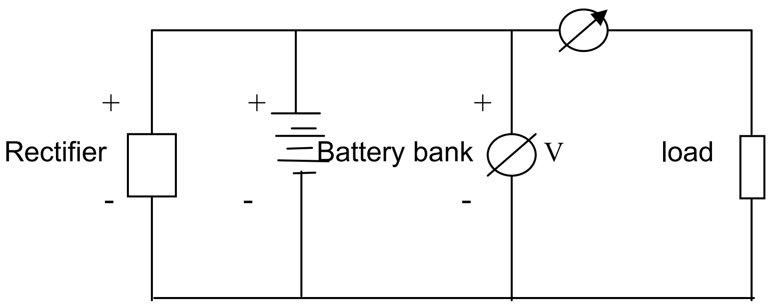
⑵Constant voltage limiting current charging – Charging between the voltage 2.30-2.35V; and charging current does not exceed 0.25 C10, until the charge current drops below 0.006 C10 and unchanged for three hours, the battery is considered adequate charge.

After the supplementary charge, conduct a 10h rate capacity check

15.4.2 Floating charge

15.4.2.1 float work

VRLA battery's work in the field work system is mainly float charge. In float work system, the batteries and rectifiers will be connected to the load circuit device and supports the work load as the back-up power, as shown below. Characteristic of floating work : battery bank usually do not discharge , the load current is supplied entirely by the rectifier. Of course, in actual operation, there is partial discharge of the battery and discharged as the load is unexpected increase suddenly.



15.4.2.2 Role of floating charge

Battery bank in a floating work system has two main roles:

(1)When utility power fails or rectifier failure, battery can take up the task of power supply to the load, in order to ensure communication is not interrupted;

(2)Have the smoothing effect. as battery and a capacitor, have harging and discharging effect;, and therefore bypass effect to the AC current. Thus, the ripple component to the load further reduced, thereby ensuring the load equipment by the voltage requirements.

15.4.2.3 the principle of float voltage

- float current compensate for battery self-discharge losses;
- When the battery is discharged, it can rely on floating charge and quickly replenish the loss of electricity, to prepare for the next discharge
- At he selected charging voltage, PbO2 porduced at battery plate is more dense, in order to protect the grid from fast corrosion.
- Minimize O2 and H2 precipitation; and reduce the negative salinization
- float voltage selection should also consider other factors(1) electrolyte concentration effects on the float voltage; (2) grid alloy on the float voltage.

According to principle of the float voltage selection and various factors on the impact of float voltage, some choose the higher float voltage range up to 2.25-2.33V, ans some chose lower,2.23-2 .27 V. Different manufacturers have its own an different provisions of the float voltage.Our company's float voltage is specified at 2.25V / cell (ambient temperature is 25 ℃ cases). According to the ambient temperature changes, the float voltage should be adjusted accordingly.

15.4.2.4 Float voltage temperature compensation

Floating charge and are closely related. Usually float voltage is refer to 25 ℃ ambient temperature. As the ambient temperature changes, adjusts the float voltage according to temperature compensation coefficient. Different manufacturers has different battery temperature compensation coefficient, and is not the same. When the setting charger battery parameters, it should be set according to the temperature compensation coefficient of instructions, If not specified in manual, it should consult the manufacturer. to determine the battery. Battery temperature compensation coefficient of our company is-3mV / ℃.

15.4.3 Function, voltage and frequency of Equalize charge

When the battery float voltage is low, or discharged battery needs recharging, or battery capacity is low, the battery bank needs a equalizing charge. Right charging voltage and battery charging frequency is a basis to ensure long-life. In normal operation, VRLA acid batteries are not recommended for usch charge; because equalizing charge may cause battery dehydration and early failure. Equilizing charging voltage is related to ambient temperature. Generally single cell at 25 ℃ ambient temperature, charging voltage is 2.35V or 2.30V. If temperature changes, it needs for timely adjustment to the charge voltage. Temperature compensation coefficient of equalizing charge is-5mV / ℃.

Recommendation: Battery's full floating run for six months, then it run one equalizing charge according to a predetermined voltage. The charge lasts for 12 hours or 24 hours.

If the battery is recharged after discharge, it needs to use "limiting current limiting voltage" or "Constant voltage limiting current" supplemental charging method.

16. Recommend conditions of Batteryuse and maintenance mode

Battery status is related directly with the switching power supply, Table 16-1 is a recommended settings value for different power state switching power. Different battery manufacturer has its own parameters and are not identical. It should be of strict accordance with the battery manufacturer prescribed parameter settings

Table 16-1 Recommended values of parameter settings from different switching power supply

Recommended parameter settings	class I power	Class II, III power	Class 4 or up power
Float voltage（V）	2.23-2.27	2.23-2.27	2.25-2.29
Equilizing charging voltage（V）	2.35	2.35	2.35
Charging current limit（A）	0.1 C_{10}	0.1 C_{10}	0.15 C_{10}
High voltage alarm value（V）	57.6	57.6	57.6
Low voltage alarm value（V）	46	46	47
Off voltage（V）	44	44	45
Reset Voltage（V）	50	50	50
Float voltage temperature compensation coefficient	-3m – 5V/℃ per cell	-3 - 4mV/℃ 5per cell	-3 -5 4mV/℃ per cell
High temperature alarm（℃）	35	35	35
Equalize charge cycle	3 to 12 months	3 to 12 months	1 to 12 months
Restoration Equalize START condition (capacity)	10~100%	10~100%	5~100%
Float switch equalize conditions（mA/Ah）	>50	>50	>50

Equiziling charging time during Blackouts（h）	10	16	24
Exit Exit conditions of Exit charge （mA/Ah）	<5	<5	<5

* Float voltage data in the table is theparameter settings at 25 ℃ ambient temperature
* Limit value refers to the switching power supply output current minus the current value required for communications equipment.

16.1 Float voltage:

Normal float voltage is 2.25V / cell (ambient temperature 25 ℃). Temperature compensation coefficient is:-4mV / ℃. In battery float running, the battery cell voltage should not be lower than 2.18V, if cell voltage is lower than 2.18V, it need for equilizing charge.

16.2 equilizing charge:

Equalizing charge generally use constant voltage limiting current for charging. Charge voltage is 2.35V / cell (ambient temperature 25 ℃). Temperature compensation coefficient is:-5mV / ℃. Equalize Frequency: half / second. (Note:-5mV / ℃ meaning for each 1 ℃ increase in the temperature, the charging voltage decreased 5 mV), Constant coltage limiting current Charge: 2.30-2.35V voltage for cell charging, and charging current should not exceed 0.25 C10, until the charging current down to 0.006 C10 for three hours unchanged, that the battery is charged sufficient.

VRLA battery needs equalizing charge under the following conditions :

* Single cell float voltage is lower than 2.16V.

- After new battery installation, the required 12 hours of equalizing charge.
- Battery discharge more than 5% of the rated capacity
- Store amd unused for more than three months
- Full Floating run more than one year

16.3 Routine maintenance

VRLA battery Is need management. Battery change is a gradual and cumulative process, in order to ensure good battery life, make operating records is very important to detect the following items

- float voltage of battey cell and battery bank (once / month)
- battery casing and pole temperature(once/ month);
- battery case cover for deformation and exudate (once / month)
- any fluid escape around pole, safety valve and mist (once / month
- retighten screw connections (once half a year);

It also need periodically check on switching power supply battery management parameters; to ensure that the battery parameters meet the requirements of the switching power supply section parameters are as follows: (24 cells. i.e 48V system)

- float voltage：54.0V（cell.25V）
- equalizing charge voltage：56.4V（cell 2.35V）
- float charge temperature compensation：　YES
- equilizing charge temperature compensation YEs
- float charge temperature compensation coeeificent– 4mV/℃/cell；
- equilizing charge temperature compensation coefficent 5mV/℃/cell
- equalize charge frequency：180 days；
- equilizing Recharge time：12 hr
- High voltage warning：57V；
- Low voltage alarm：47V
- Battery short circuit protection voltage：43.2V
- equilizing charge criterion

  Battery capacity：95%；

  Battery voltage：49V

  Discharge time：10 分钟
- float charge criterion：

  Last stage of steady flow - charging time：180 mins；

  Steady flow charging current：≤0.006 C_{10}/bank

16.4 Test and recharge of battery capacity:

16.4.1 Capacity Test Method

- Done once a year - An actual load discharges, emit 30-40% of rated capacity;
- Once every three years - A capacity test - discharge depth of 80% C10 (10 hour rate);

16.4.2 Recharging method (choose either one):

- Limiting current limiting voltage charging: First charge with limit current - 0.25C10 or lower (usually 0.1-0.2 C10), until the battery terminal voltage rises to 2.30-2.35V / cell, immediately continuous charging, with constant 2.35V voltage. Till the charging current drops to 0.006 C10, and for following three hours, the battery is considered charge adequate.
- constant voltage limiting current charging. Charge voltage is 2.35V / cell (ambient temperature 25 ℃), and charging current should not exceed 0.25 C10, until the charging current down to 0.006 C10 for three hours unchanged, that the battery is charged sufficient.

  Discharge and During charging and discharging the battery, it should regularly measure and records the.current, single cell voltage and total battery bank voltage,

16.5 Battery common faults and Handling methods –below table 16-2

16-2

	Fault	Reason	Handling Method
1	Leakage or breakage	(1)Battery casing deformation-high temperature, (2) float voltage is too high that the battery pole not sealed properly	contact the manufacturer for replacement
2	Float voltage uneven	Battery internal resistance uneven	Equalizing charge for12-24h
3	cell float voltage is low	Uneven internal resistance of the battery	12-24h Equalizing charge for12-24h
4	Insufficient capacity	Severe dehydration, internal dry	Equalizing charge 12-24h, if still not work, it should fill additional acid or replaced
5	high temperatures on Battery pole or housing	Screw loose, float voltage is too high….	Check the screws or check the charger and charging method
6	high or low float voltage	Screw loose	Tighten the screw
7	Battery ground	dust or residue on battery cover and leakage cause conductivity	Clean the dust on battery cover, replace the leaking cell, add insulation pads

17. some of the problems should pay attention to in the VRLA batteries maintenance process

Based on years of maintenance experience on VRLA battery life and room environment, rectifier set parameters, as well as health information, below is some points for reference :

17.1 situation of power supply room：

To ensure the battery life, it is best not to have the battery being over discharged. Stable electricity supply and equipped with oil machine is a good guarantee for long battery life. The oil machine is best started once a month to check if it can work properly.

17.2 Environment of Battery use：

VRLA batteries should be installed away from heat and place easily produced sparks, preferably in a clean environment. Recommended at room temperature at 15 ℃ to 35 ℃, preferably air-conditioning; control the temperature around 25 ℃. Damp, poor ventilation, solar radiation and other environmental definitely make the VRLA battery life is shortened (if the temperature is 35 ℃, the battery life will be binary.). Therefore, a clean environment, good ventilation, ambient temperature and non-sunshine is essential. In addition, to facilitate the maintenance of the battery, consider adequate room space for maintenance in selecting battery room.

17.3 Rectifier (switching power) parameter settings:

For Some parameters (such as the float voltage, equalizing charge voltage, equalizing charge frequency and time, Equalize chARGE criterion, float switch criterion, ambient temperature, temperature compensation coefficient, DC overvoltage alarms, low voltage alarms, charging current limiting values, etc.) need to communicate with the battery manufacturers and then determine the specific number of these parameters.

17.4 The capacity configuration of the battery device:

In the course of our inspection, it found that battery capacity configuration is too small in some site, or even only of 2 hour rate discharge of the total battery rated capacity, frequent high-current discharge will shorten the battery life. It is appropriate to keep the battery capacity configuration of 8 - 10 hour rate.

17.5 Routine maintenance::

It is used to have a misconception that VRLA batteries are maintenance-free batteries, maintenance-free is very easy to mislead as no maintenance and being indifferent. In fact, the battery change is a gradual process, in order to ensure good use of the battery, ready to take battey run record is very important, the following items should be checked monthly

(1) single cell and battery bank float voltage
(2) temperature of battery case and the pole
(3) deformation of the battery case cover and exudate
(4) any exudate and mist overflow surrounding the pole and safety valve

17.6 Connecting strip are tightened:

If the battery connection bar does not tighten, it will increases the contact resistance; in the high current charge and discharge process, it is easy to make the connection bar ove heat, and even lead to melting of the battery cover, in severe cases may lead to fire. Maintenance staff should do tighten connecting strip once every six months to ensure the safe operation of the battery.

17.7 The internal resistance of the battery is too large:

For batteries have been in operation for 4-5 years or longer, some battery's internal resistance increased. It may due to the poor environment or wrong pre-set parameters. In this situation, it is generally the first contact the manufacturer to have battery activation processing, if the capacity can not be recovered, battery should be replaced.

17.8 High or low battery voltage：

There is some site with high or low battery voltage. It is because some manufacturers use a thick plate design, the battery life is improved; but for the uniformity of the battery voltage is more difficult to control, it generally takes more than two years of operation then voltage will gradually uniform. If for low battery voltage, it can have shallow discharge of the entire group battery, to see whether the discharge voltage of the battery is also significantly lower, if the discharge voltage is significantly low, then it should contact the manufacturer for a replacement.

17.9 Battery capacity detection：

For a battery has been running more than three years, preferably check a discharge test once a year; release 30 - 40% of rated capacity (rated capacity according to the actual discharge rate); a triennial capacity discharge test once 3 years, release 80% of rated capacity, record the cell voltage and the total voltage.

17.10 Precautions in battery discharge：

Firstly, check the battery connections of the entire group are tight, the according to the discharge rate table to determine the time interval for discharge recording. For connected system, it general use dummy load for a single set of battery discharge. Before discharge the battery in the other group, it should first recharge the discharged battery, and then discharge another group of battery. Should pay close attention to relatively low voltage battery cell in discharge, to prevent over-discharge of certain cell.

17.11 Battery charging methods and precautions：

It general use “Constant voltage imiting current”methods to charge the battery. With 2.35V/cell equalizing charge, current limited 0.25C10 or lower (e.g., for 2 groups 1000AH/48V system, the current should be limited to less 500A), the final stage of charge , the entire group current value reaches 0.006C10 (e.g. for two groups 1000AH/48V system, its current reaches 12A) for 3 hours unchanged, the battery has enough charge. It is emphasized that the battery should be promptly charged after installation and after discharge, and avoid over-or under-charging and discharging caused capacity declined. During the charging process, it should pay attention to the temperature of single cell , or voltage rises too fast or too high, if such a situation, it should be promptly stop charging and contact the relevant manufacturers for processing.

17.12 Mix batteries：

If mixed of old and new cells in battery bank, it may lead to actual load current between cells is not the same, and as fuse is equipped, it may happen that a bank of batteries disconnected due to excessive current, and then, another bank may also be disconnected due to the load is too large. Thus, it should try to avoid the mixe of old and new batteries mixed..

Cases lead to cell damage

- the battery vent valve is screwed open to allow air to enter inside the battery more than 24 hours, or even longer, will result in battery capacity decline and recovery is difficult;
- Battery is deep discharged. The recharge is after more than 72 hours. It leads to difficulty in battery capacity recovery .
- Battery valve opens, if a small amount of acetic acid enter in the valve, then the battery self-discharge increase and cause decreased capacity and can not meet the capacity requirements;
- Battery valve opens, if any, wire and other conductive objects have fallen into the battery, the battery will self-discharge seriously, even short-circuit
- Battery is deeply discharged, and a power out during the recharge, if such not full charge and then discharge is happen frequently, in short, battery will lose some capacity. For severe case, capacity loss and battery is out f function.
- Float voltage is too high, the temperature is too high will result in shorter battery life.
- Equalizing charge is too frequent (e.g. once a month) within 3 to 4 years period, it makes water loss and grid corrosion result in capacity decline, causing battery out of function
- Battery falling during handling, it will lead to damage and battery has to replace.

18. Battery installation process, the charge and discharge process and precaution

18.1 Battery installation process and precautions

1) Upon received the task of installation, installer (or project team) prepare for the relevant information (such as the manufacturer's installation manual, record sheets, etc.) and full set of installation tools (including multi-meters, etc.) and implement the project start date and the progress of projects .
2) Installer (or project team) should bring a small amount of system spare parts (such as screws, etc.). As arrived at the installation site, confirm detailed installation schedule and discuss details of the project (such as installation, loading, etc.).
3) Before starting the installation works, installation personnel should be organized (or project team)for training - introducing precautions during installation, battery use and maintenance. Safety must be paid attention during the installation process.
4) Installer (or project team) check the battery and accessories taking out from the packaging box in front of the supervisory officers. Packing list, battery mounting system diagrams, installation instructions and other documents should keep in good condition and hand over to company's technical staff after installation completed.

5) Accordance to the construction drawings, check the installation location is reasonable, whether there is space is spare for maintenance / or a distance of more than 0.5 meters from possible sparks and heat sources and places (such as fuse boxes, etc.) / or batteries is placed under the air conditioners. If not, you should first consult with Engineering Department, if amendment or modify is needed, and should keep memo.

6) According to system diagram of the battery system, installation should be strictly in accordance with the installation diagram. Not allowing any gaps in the installation (including the battery cell ,numbers paste), all system components (parts) to be installed matching exactly the same specifications of system diagram.
7) Installation.- Because the battery is charged, it pay attention to prevent short circuits, all installation tool must wrapped with insulating tape
8) Before Install connecting bar, the battery casing and steel pole should clean out any dust with linen wipe, in particular, to ensure that the very pillars is clean and without form dust. Cell number label to be affixed firmly
9) After installation, it has to make sure all screws are tight. Designate a person for checking, the person responsible for ensuring that all screws are tightened state.
10) After the installation check, measure and record the open circuit voltage of the each battery cell, and the total voltage of the battery bank. Then fill in installation tables (or other similar mounting table)
11) After installation, if it is not connected to grid power supply, disconnect the battery from the power supply source and microwave devices. If for some reason can not disconnect the device and battery (in principle, is not allowed, especially for a long time), it should connect all batteries bank and are not allowed connecting only one bank of batteries. Simultaneously, record the start time and power consumption current of the device. Whether or not such a connection carried out, battery banks must be recharged before the official opening. The supplementary charge time for the cell voltage of 2.35V is 12 hours. Otherwise, it will have great harm as in normal use of the battery.
12) Before connecting the battery with power supply, the settings of power supply device should check carefully (refer to Switching power setting parameter table), ensure that the settings are correct.
13) After installation and commissioning, fill the relevant required forms. Check and record the appearance of the battery, and then check whether the screws tighten in all connections, make sure the reliable of battery shockproof, anti-skid and connection between the batteries. Measure and records each battery‘s float voltage..

Communicate with company's technical personnel and sign document for confirmation.

18.2 Battery discharge process considerations.

1) Before discharge, the battery group should carry out, in advance, an equalizing charge with 2.35V /cell for 12 hours, and then stand by for 12-24h, to have battery group in fully charged state.
2) Record the battery group's float voltage, single cell's float voltage, load current, ambient temperature and parameters of rectifier (or switching power supplies)and other setup device. In same time, check that all screws are tightened.
3) Combined actual situation of the base station / switching station, disconnect the battery group from the power supply source, make sure dummy load is unloaded. Have the dummy load properly connected to the positive and negative terminals on the battery group, record the open circuit voltage of the battery after 15 minutes
4) According to the circumstances required, determine the battery discharge rate, generally is three hours or 10 hour rate discharge rate (3 hours rate of discharge current 0.25C10, 10 hour rate discharge current 0.10C10), selected on the dummy load to match the load file, and discharge the battery group.
5) In the discharge process, taking into account the data of dummy load on the meter may not accuracy enough, it need to make test with data from the discharge current clamp table. According to the actual display clamp data, adjust the dummy load, so that the discharge current of the battery group meeting the discharge current requirements. After discharge for 5 minutes, start recording the total battery bank voltage, cell voltage, the discharge current, the ambient temperature and the temperature of the connection (cable or bar).
6) If 10 hour rate chosen for discharge, it should measuring the total discharge time of the battery voltage, cell voltage, discharge current, etc. once a hour (if for 3 hour rate discharge, then measure once every 30 minutes); in the later stage of discharge, it should increase the frequency of measure, i.e. for 10hr rate discharge, take measure once every 30 minutes from 9th hour; and, for 3 hours rate discharge, take measure once every 15 minutes from 2nd hour.During discharge process, should monitor the ambient temperature, temperature of battery cells and connections for any no abnormality, or there is low voltage cell in the battery group
7) For the newly installed battery, the condition for end of discharge is (1) the release capacity of battery group reach the requirements of rated capacity, or (2) one cell in the battery group reaches 1.80V. For battery group has already been online for use, the condition of end of discharge is based on the total voltage of the battery bank

reaches 43.2V (for a 48V battery system).

8) In case at end of discharge process , the capacity released by the battery group do not reach rated capacity required of the system, it would be problem in the ex-production capacity of battery, you should promptly contact the relevant manufacturers for solution.
9) As discharge finished, have the dummy load being load, then disconnect the battery bank with dummy load, connected to the battery with switch of power., at this stage, you should pay attention to voltage difference between battery bank and the rectifier will be large, ignition phenomena may occur during connection , it is best to reduce the float voltage of power supply as close as possible float open circuit voltage of the battery bank, to reduce the spark..
10) If the discharge conditions in normal, observed and recorded the data as charging begins. If the discharge situation is abnormal, monitored the charging of battery bank; to ensure the battery is properly charged.
11) Tools: dummy load, connecting cables, handling tools, clamp meter, multi-meter, etc.

19. the advantages Compare to similar products

19.1 Leading technology

1) using steel structure, and can be modular installation, occupy small area and space , strong space adaptable, easy to install in a variety of complex field
2) Connecting bar made of flame-retardant soft PVC wrapped material, which greatly reduces the contact resistance, avoiding battery bank voltage drop due to the large rcontact resistance, that the power supply of battery bsnk is more efficient;
3) Soft connection strip can connect to reliable patent detection head, to eliminate monitoring signals errors caused by false welding and false connection, improve the reliability of the battery monitor;
4) Use plug-in panel, so that maintenance checks is more convenient and save
5) With Unique grid alloy formula and anode plate thickening design, it improve the corrosion resistance of the plate
6) The volaune energy ratio (47.33 Ah/dm3) and weight energy ratio energy (15.38Ah/kg) is high, i.e. With the same capacity, battery cell is of smaller volume and light weight than other ead-acid batteries, in a leading position international and domestic;
7) Battery’s internal structure use polar group supporting technology, eliminating the stress generated from gravity in the welded parts as battery placed horizonally; minimize the corrosion rate of welded parts, to eliminate the internal short circuit of battery, ensure the safety of battery operation and improve battery life ;

8) Against the inevitable phenomenon of growth in positive electrode plate during battery running, use technique of growth direction controlling, the positive electrode plate grow in the direction which space reserved for the growth of electrode plate, to eliminate battery internal short-circuit casued by the growth.
9) Shell cover is of strengthen design, to eliminating the battery bulging, deformation and burst, to improve battery's vibration resistance and impact resistance;
10) Dring the life of the battery, electrolytes may be consumed. In 4-5 years time, diaphragm elastic fatigue occurred in AGM batteries, then produce partition between the diaphragm and the plate, to terminate the transmission of the electrolyte, the battery life is prematurely terminated. Our battery use plate group pre-compression technology to ensure that the battery, throughout its entire battery life, maintained required diaphragm compression ratio, to provide smooth flow of battery electrolyte through transmission channel;
11) For grouping of large-capacity batteries, it use high and wide plate design, reducing the cost of a large-capacity battery, to avoid bulky and unreliable from internal parallel connection; eliminating heat problems caused by the increased number of plate; eliminating the capacity reduction and the possibility of radiation problem caused by the temperature rise inside the battery,

19.2 Safe and reliable

1) Long life design - Normal float life is more than 10 years. The current capacity is still up 100% after 10 yesr's (or longer) actual use
2) Use patented high Focus automatic welding technology in pole sealing, and with epoxy outside for secondary seal, to ensure no leakage, it has not found a leaking in weld area of which reaching "6σ" level;
3) Battery terminal using the embedded copper pole structure, increase the copper area, improving the safety and reliability in large current discharge.
4) Using patented pressure adjustable column safety valve and flame arrestor device, both are anti-mist escape and also with explosion-proof performance;
5) Inside the battery bank, it uses the closed connection strap, to prevent short circuit by abnormal use of the battery.
6) Battery case cover use PP copolymer material of good radiation performance; and also the steel casing provides cooling channels, intense heat generated by the battery complex reaction. It has not occurred phenomenon of thermal runaway, eliminating the explosions and fires caused by uncontroll of heat;
7) Battery use V0 ~ V2 grade reinforced flame-retardant materials, which greatly improve battery fire safety performance;

8） Steel combination structure is of excellent anti-seismic performance, and passed the seismic performance testing by Ministry of Information Industry.

9） Passed the United States UL & European CE safety certification

Appendix 1

Battery parameter setting and maintenance management

Parameter settings management：

Float voltage：2.23-2.25V/cell （25℃）

24V system：26.76-27.0V 48V system：53.52-54.0V

Float charge voltage temperature compensation coefficient: -4.0mV/℃ (Reference temperature is 25 ℃)

Equalizing charging voltage：2.35V/cell（25℃）

24V system：28.2V 48V system：56.4V

Equalizing charge voltage temperature compensation coefficient :-5.0mV/℃(Reference temperature is 25 ℃)

Equalizing charge frequency： 6 months / time (180 days)

Equalizing charge time ： 12hr

Equalize charge limit current value：0.1-0.25C_{10}

High voltage alarm： 24V system：28.5V 48V system：57V

Low voltage alarm： 24V system：23.4V 48V system：47V

Off voltage： 24V system：22.2V

48V system： Not set (depneds on the case)

Equalizing charge and Float charge conversion criterion：

Equalizing charging criterion：

1、 capacity ratio: 95%；

2、 discharge time over 30 minutes；

3、 discharge voltage is less than 49V

float charging criterion

1、 Post stage of steady current equalizing charge time: 180 minutes

2、 steady current equalizing charge current: ≤ 0.006 C10 / group

Routine maintenance and management

Items checked once a month

cell float voltage、

battery bank’s voltage and total load current；

battery Appearance

Battery pole

any acid lead or mist from the valve

Battery's ambient temperature and environmental conditions

Required equipment: digital multimeter, clamp meter, thermometer

Note: If conditions permit, you can use resistance meter to measure the battery internal resistance.

Items checked once half a year

Tighten the screw of connection

12 hours Equalizing charge of battery bank

Required equipment: wrench (or socket wrench)

Items checked once a year

Discharge verification tests on battery bank - emits 30-40% C10

Measuring the voltage drop of feeding bus, cables and connectors

Required equipment: digital multimeter, clamp meter, thermometer, dummy load, and cable.

Items checked once 3 year

Discharge capacity tests on battery bank - emits 30-40% C10

Required equipment: digital multimeter, clamp meter, thermometer, dummy load, cables, wrenches, etc.