Contents

廣隆光電科技股份有限公司
KUNG LONG BATTERIES INDUSTRIAL CO., LTD.

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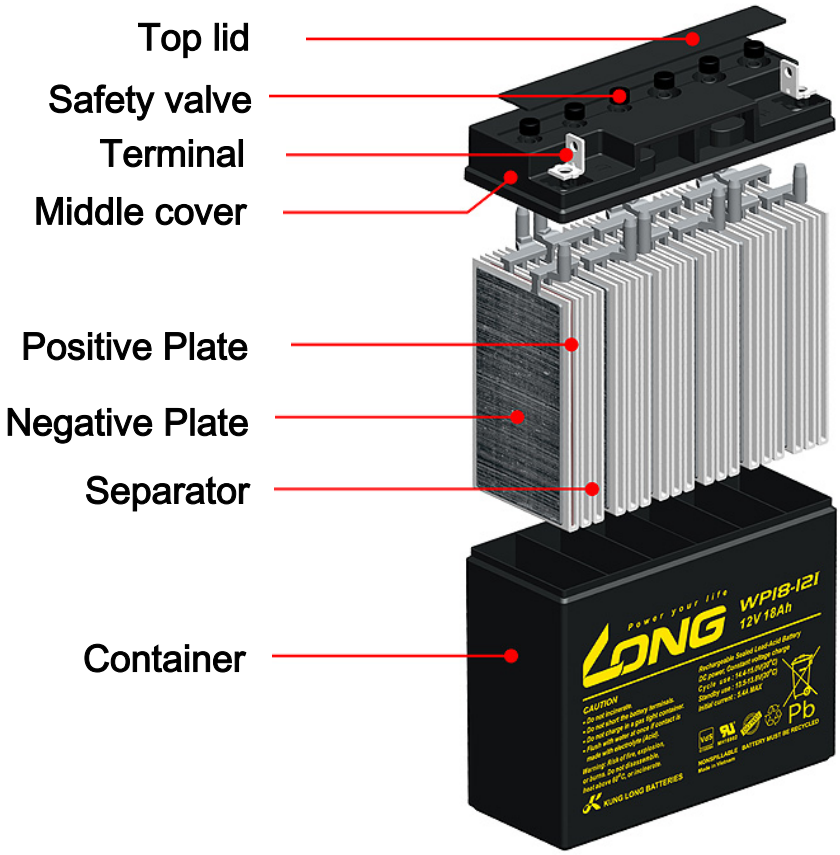
1. Introduction :

Our high quality VRLA batteries are developed with state-of-the-art technology. They have characteristics such as long life, no leakage, small size, no water or electrolyte supplement is required, maintenance-free….etc. They have been widely used in emergency lights, UPS, and other kinds of back-up power.

This manual not only describes the constructions and characteristics of VRLA batteries, but also provides a suitable method to use and maintain batteries.

2. Construction of Sealed lead acid batteries :



- **Positive plate:** Pasting the lead paste onto the grid, and transforming the paste with curing and formation processes to lead dioxide active material. The grid is made of Pb-Ca alloy, and the lead paste is a mixture of lead oxide and sulfuric acid.
- **Negative plate:** Pasting the lead paste onto the grid, and transforming the paste with curing and formation processes to sponge lead active material. The grid is made of Pb-Ca alloy, and the lead paste is a mixture of lead oxide and sulfuric acid

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- **Electrolyte:** A high purity sulfuric acid solution, which is a reactant in the battery's main reaction and the conducting ions for electricity
- **Separator:** The absorbent glass mat, which is placed between the positive and negative plates to prevent shorting and to store the electrolyte.
- **Safety Valve:** A one-way valve made of chloroprene rubber, which is to prevent the oxygen ingress into the battery and to release gas when internal pressure exceeds 0.5kgf/cm^2
- **Container:** A container made of ABS plastics, which is filled with plates group and electrolyte
- **Middle cover**：A cover made of ABS plastics, which is to seal the container with epoxy
- **Top lid**：A slip made of ABS plastics, which is to prevent safety valves from loosing
- **Positive terminal**：Positive pole is colored in red to ensure accurate installation and connection.
- **Negative terminal**：Negative pole is colored in black to ensure accurate installation and connection

3. Reactions of Sealed lead acid batteries：

When the lead acid battery is discharging, the active materials of both the positive and negative plates are reacted with sulfuric acid to form lead sulfate. After discharge, the concentration of sulfuric acid in the electrolyte is decreased, and results in the increase of the internal resistance of the battery.

On charging, the battery reactions are reversed, i.e., the lead sulfate of the positive plate is converted to lead dioxide, and the lead sulfate of the negative plate is converted to sponge lead, with the production of sulfuric acid and results in the increase of electrolyte concentration

Battery Charged				Battery Discharged			
（+ plate）	（- plate）	（solution）		（+ plate）	（- plate）	（solution）	
PbO_2	+ Pb +	$2H_2SO_4$	$\rightleftharpoons$	$PbSO_4$	+ $PbSO_4$ +	$2H_2O$	
(lead dioxide)	（lead）	（sulfuric acid）		(lead sulfate）	（lead sulfate）	（water）	

As the charge nears completion little lead sulfate remains to convert to lead dioxide or lead. The charging current begins to decompose water into oxygen and hydrogen, i.e., the oxidation of water into oxygen at the surface of positive plate and the reduction of proton into hydrogen at the

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surface of negative plate. For the conventional flooded lead-acid battery, the evolved oxygen and hydrogen bubble to the top of the electrolyte and escape to outside, and water loss is resulted. For the valve regulated lead-acid battery, the evolved oxygen from the positive plate is easily transport to the negative plate to be absorbed through the gas tunnel in the glass mat separator with starved electrolyte. The absorbed oxygen depolarizes the negative plate with the formation of lead sulfate, and no hydrogen is generated in this condition. With very little gas evolution, the water loss of VRLA battery is minimized.

4. Sealed lead acid batteries characteristics：

4.1 Battery Capacity

- Battery capacity is expressed as ampere-hour (Ah), which is the product of discharged current and the discharged time in hours (A*h).
- Discharge rate is indicated by C_t, C is the nominal capacity of the battery, t is the discharge time.
- The nominal capacity of sealed lead acid battery is calculated according to JIS C8702-1 Standard with using 20-hour discharge rate. For example, the capacity of WP5-12 battery is 5Ah, which means that when the battery is discharged with C20 rate, i.e., 0.25 amperes, till 1.75V/ cell cut-off, the discharge time will be 20 hours
- The battery capacity is varied with the discharge rate. The larger the discharge current, the smaller is the battery capacity. The relation between the battery capacity and the discharge rate is as follows:

Discharge rate		20HR	10HR	5HR	3HR	1HR	1CA	3CA
Capacity	Regular type	100%	95%	85%	75%	60%	50%	40%
	High rate type	100%	95%	85%	75%	60%	58%	50%
	Cycle type	100%	95%	85%	75%	60%	53%	43%

The information about the discharge current or power within specific discharge time of our regular or high rate types sealed lead acid batteries products are available through our product specification catalogues.

- The temperature influences the battery capacity. The relation between the capacity and temperature is as follows:

Temperature		-10℃	0℃	10℃	20℃	30℃	40℃	50℃
Capacity	2CA	20%	32%	41%	49%	54%	56%	57%
	0.05CA	74%	85%	93%	98%	102%	104%	105%

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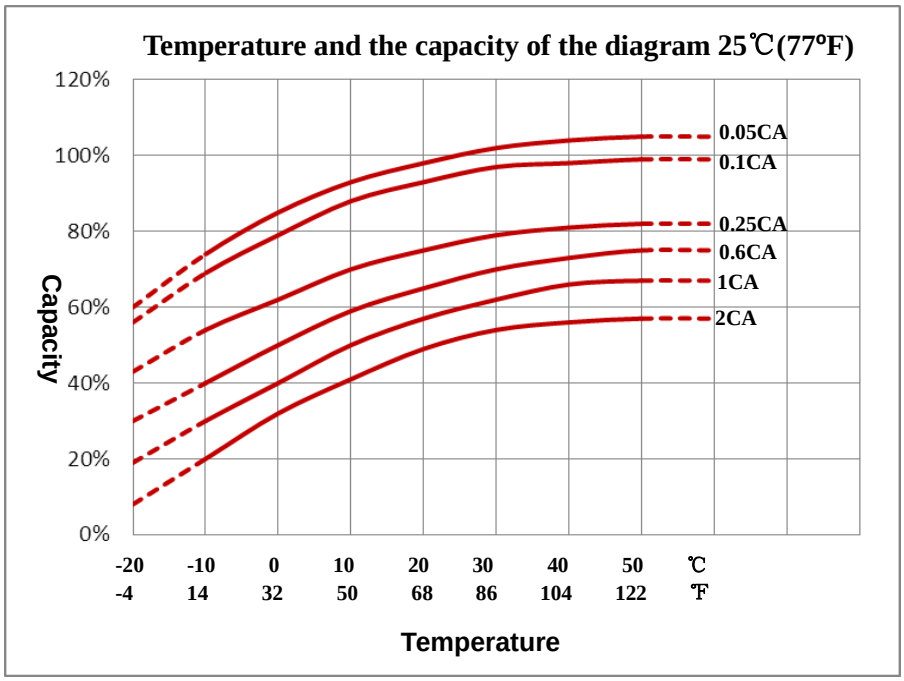

- The battery capacity sometimes will be represented at watts. For example, the model WP1236W is a 12V battery with constant power 36watts/ Cell [equal to 216W (36W * 6cell)], till 1.60V/ cell cut-off which can be discharged for 15 minutes at such constant power.

4.2 Battery Voltage

- The open circuit voltage of lead acid battery is indicated the equilibrium voltage of the battery's main reaction. The concentration of the sulfuric acid participated in the main reaction and the condition of batteries are the major factors influencing the open circuit voltage.
- Right after charge or discharge, the concentration of sulfuric acid inside the plates is still changing due to the diffusion process. It takes at least 24 hours to stabilize the open circuit voltage.
- The concentration of sulfuric acid in finished battery is an indicator of battery capacity. Therefore, the capacity of battery is available through measuring the open circuit voltage. The relation between the battery capacity and open circuit voltage is as follows:

O.C.V and the capacity of the diagram (Temperature:25℃)

Capacity	6V O.C.V	12V O.C.V
100%	V > 6.5V	V > 13.00V
90%	6.40 < V < 6.50	12.80 < V < 13.00
80%	6.33 < V < 6.40	12.65 < V < 12.80
70%	6.25 < V < 6.33	12.50 < V < 12.65

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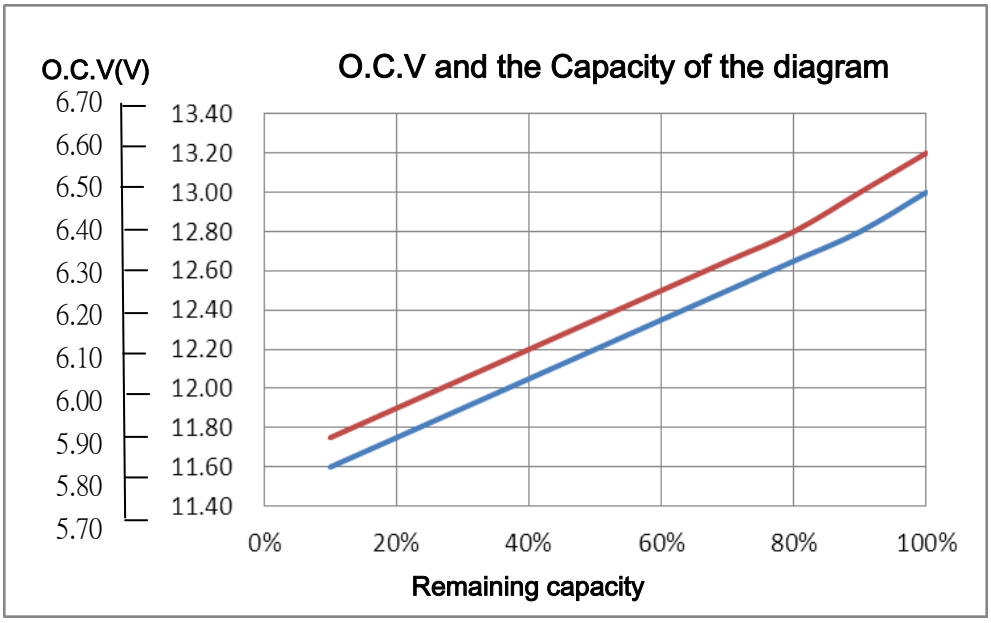
60%	6.18 < V < 6.25	12.35 < V < 12.50
50%	6.10 < V < 6.18	12.20 < V < 12.35
40%	6.03 < V < 6.10	12.05 < V < 12.20
30%	5.95 < V < 6.03	11.90 < V < 12.05
20%	5.88 < V < 5.95	11.75 < V < 11.90
10%	5.80 < V < 5.88	11.60 < V < 11.75



4.3 Battery Self-discharge

- The lead acid battery will have self-discharge reaction under open circuit condition, in which the lead is reacted with sulfuric acid to form lead sulfate and evolve hydrogen. The reaction is accelerated at higher temperature. The result of self-discharge is the lowering of voltage and capacity loss.
- Batteries will lose capacity due to self-discharge through packing, transportation and storage process at various temperatures. The relation between battery capacity and storage temperature and time is as follows:

time / Temp	1 month	3 month	6 month	9 month	12 month	15 month	18 month
0℃(32℉)	99%	98%	96%	94%	92%	90%	88%
10℃(50℉)	97%	95%	92%	89%	85%	81%	76%
20℃(68℉)	93%	91%	81%	72%	64%	58%	Not allowed
30℃(86℉)	90%	80%	68%	56%	Not allowed		
40℃(104℉)	83%	70%	53%	Not			

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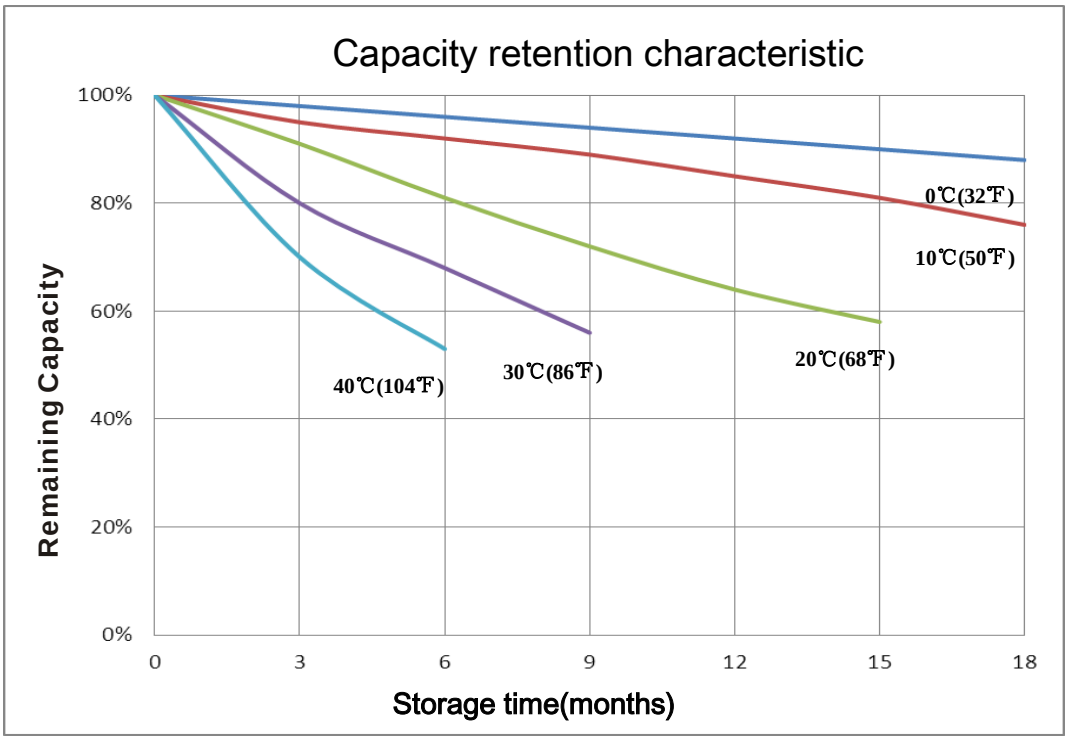
				allowed			

The above data is shown in the following graph:



- The remaining capacity of battery after storage can be obtained by measuring its open circuit voltage and referring to the capacity verse OCV table. The OCV should be measured before recharge.
- Batteries stored longer than three months should be recharged before shipping.

4.4 Battery Internal Resistance

- As the capacity of lead acid battery decreased or the battery is aged, its internal resistance will be increased. Therefore, the internal resistance data may be used to evaluate the battery's condition.
- There are several internal resistance measurement methods, and their obtained values are sometimes different each other.
- Conductance, i.e., the reciprocal of internal resistance, which is expressed as mho or Siemens, has some kind of positive proportionate relationship with the battery capacity.

4.5 Battery Life

- Regular Type
  - ◇ Standby use battery life:

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3 ~ 5 years under 2.3Vpc and 20℃ floating charge condition

◇ Cycle use battery life: 200 cycles (100%DOD)

225 cycles (80%DOD)

500 cycles (50%DOD)

- High Rate Type：

◇ Standby use battery life:

3~ 5 years under 2.3Vpc and 20℃ floating charge condition

◇ Cycle use battery life: 225 cycles (100%DOD)

250 cycles (80%DOD)

550 cycles (50%DOD)

- Cycle Type：

◇ Standby use battery life:

3~ 5 years under 2.3Vpc and 20℃ floating charge condition

◇ Cycle use battery life: 280 cycles (100%DOD)

380 cycles (80%DOD)

600 cycles (50%DOD)

- The floating service life of batteries is related to the ambient temperature during operation. High temperature will speed up the collapse of each part of batteries and result in shorter back-up time. Below illustration shows the relationship between floating service life and ambient temperature. Normal battery life time is 5 years. However, life time will be shortened when batteries are operated under high temperature. For example, if the battery is operated at 40℃ for 6 months in 1 year, its life time will decline to 2.5 years.

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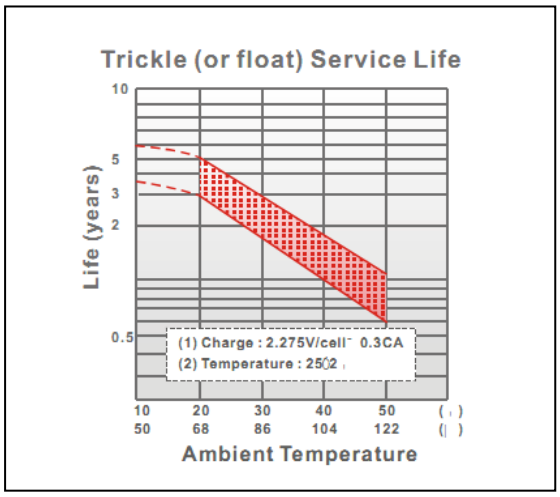

5. Operation of sealed lead acid batteries :

5.1 Incoming quality control

- VRLA batteries are delivered after full charge. Before application, it is required to measure the open circuit voltage to see if there's any piece with voltage lower than 12.65V (12V battery) or 6.33V(6V battery) (manufacturing date is within 60 days). If low voltage battery is discovered, please contact our factory or sales department immediately.
- After the receipt of goods, please check if there's any damage on the packages, then take batteries out carefully. Be careful not to damage the batteries. If corrosion, break, deformation, heating, or other abnormal phenomenon is discovered, please don't use the batteries. You should contact our factory or sales department immediately to avoid danger.
- Open the cartons near where the batteries will be installed. Hold the bottom of VRLA batteries to take them out. Don't pull them by dragging the terminals. The seal might be damaged if terminals are dragged to move batteries.

5.2 Preparation prior to operation

- Batteries should always be fully charged prior to use, especially when use it for the first time right after purchasing or after long period storage. Batteries after long period storage will lose some capacity due to self-discharge, and need recharge to restore its full performance.
- Do not put sealed lead acid batteries in airtight containers, or install the batteries in a room without ventilation. Gas generated by over-charging reactions in the battery may explode if ignited by sparks from machinery or switches.

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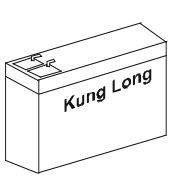
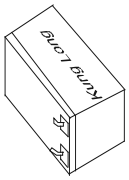
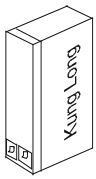
- Tightly screw the connector with the terminal of the batteries.
- Do not lay metallic object on top of a battery.
- Insert insulation that is acid and heat resistant between the batteries and any metallic housing.
- Do not charge the battery with upside down position, it may cause acid leakage.



Upright (○)



Side (△)



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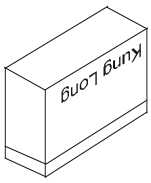

Upside down (╳)

- Batteries must be stored or used in the temperature range of:

  Charging: 0℃ ~ 40℃

  Discharging: -15℃ ~ 50℃

  Temperatures above or below these ranges could result in damage or deformity of the battery.

5.3 Installation and connection

- After VRLA batteries are confirmed ok, install them at appointed locations (i.e. battery rack or cabinet). If batteries are installed in the cabinet, try to put them at the lowest level.
- VRLA batteries should be installed firmly and safely and prevented from hitting or deforming.
- Be sure to keep batteries away from fire and heating parts (like transformers)
- Since VRLA batteries will generate inflammable gas, please don't install batteries at the places where there're sparks .
- When connecting multi-pc VRLA batteries, firstly please connect batteries one by one in a correct way, and then connect batteries with the equipment.
- The positive pole of VRLA batteries should be firmly connected to the positive pole of the chargers, and negative pole to negative pole. Wrong connection will damage the chargers.
- It is prohibited to touch the container, top cover, or top slip with the material which contains vinyl chloride. Otherwise batteries might be broken.
- It is prohibited to connect batteries with different characteristics, capacity, or ages.

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- Please avoid exposing VRLA batteries to direct sunshine.
- It is prohibited to connect any conductor between positive and negative poles of VRLA batteries. Please also make sure all the tools(i.e. wrench) used are wrapped by the insulator, because battery shortage could cause explosions or hurt people.

5.4 Description of torque value of hard ware for the terminals

The bolt kit we deliver together with VRLA batteries is already considered the material and aperture. Please only connect with this bolt kit. If non-standard kit is used, it is likely to cause loose, stripped, or broken screws. When doing connection, it is recommended to use electronic screwdrivers which can control torque and follow below instructions, so as to avoid hurting terminals and affecting battery performance due to exceeding max. torque

Diameter	Recommended torque value	Maximum allowable torque value
M5	5 N-m (51kgf-cm)	6 N-m (62kgf-cm)
M6	7 N-m (71kgf-cm)	9 N-m (92kgf-cm)
M8	12 N-m (122kgf-cm)	15 N-m (153kgf-cm)

5.5 Charging methods for standby use batteries

- The purpose of charging standby use batteries is to compensate self-discharge. The constant voltage charging method is commonly applied.
- Standby batteries are continuously overcharged at a voltage only slightly above their open circuit voltage, called float voltage. The low float voltage induces low float current and minimum grid corrosion, which are the requirements for long battery's float service life. Such charging mode, which is called floating charge, allows batteries to be continuously overcharged all the year round in order to provide full and stable capacity.
- Floating charge voltage is 2.25~2.30V/cell at 25℃. Because the setting of charge voltage will fall with the rise of temperature, and rise with the fall of temperature, therefore, floating charge current will go up with the rise of temperature and go down with the fall of temperature.

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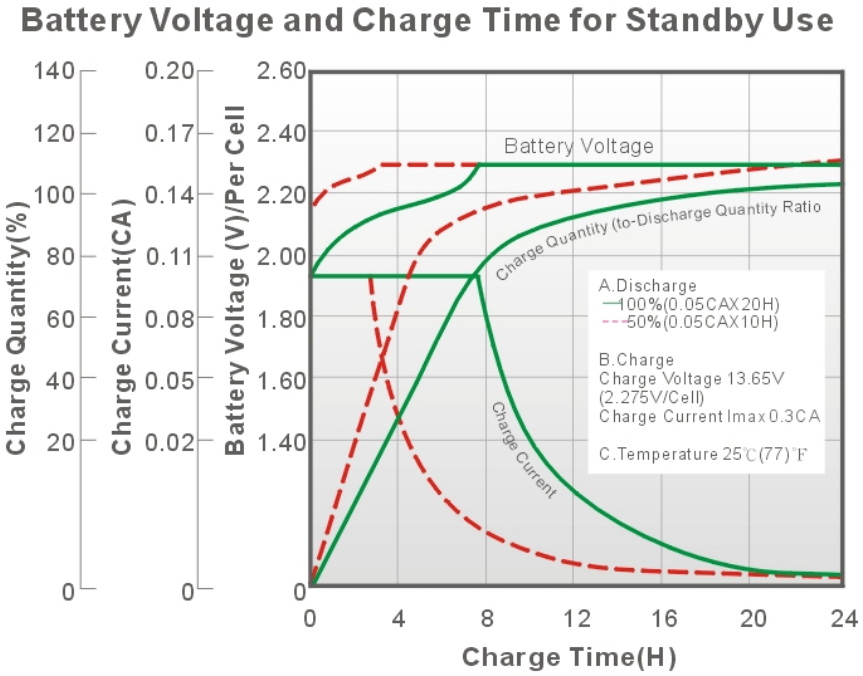

- When ambient temperature is between 20℃(68℉) and 30℃(86℉) during charging, temperature compensation can be ignored. When ambient temperature is lower than 20 ℃ (68 ℉) or higher than 30 ℃ (86 ℉), then temperature compensation must be considered. Compensation factor is -3.0mV/℃/cell

5.6 Charging methods for cyclic use batteries

- The cycle life of batteries is influenced by the following factors: the charging mode, the battery's temperature, the battery's charging frequency, and the depth of discharge. Proper charging mode is the most important factor which affects battery's cycle life.
- The charging voltage for the valve regulated lead acid battery should not be in excess of the gassing voltage, which is 2.4~2.5V/cell. The gassing voltage varies with temperature, and is decreased as the temperature is increased. Its temperature coefficient is –5.0mV/℃/cell.
- The most effective charging method for VRLA battery is the constant voltage (CV) charging mode. To take the fully discharged (100%DOD) battery as an example, the recommend charge mode is to charge at 2.4 ~ 2.5V/cell, with the highest possible current limit, within about 16 hours. For the 50% discharged battery, the recommend charge mode is to charge within 8 to 10 hours using a CV of 2.4 ~ 2.5V/cell.

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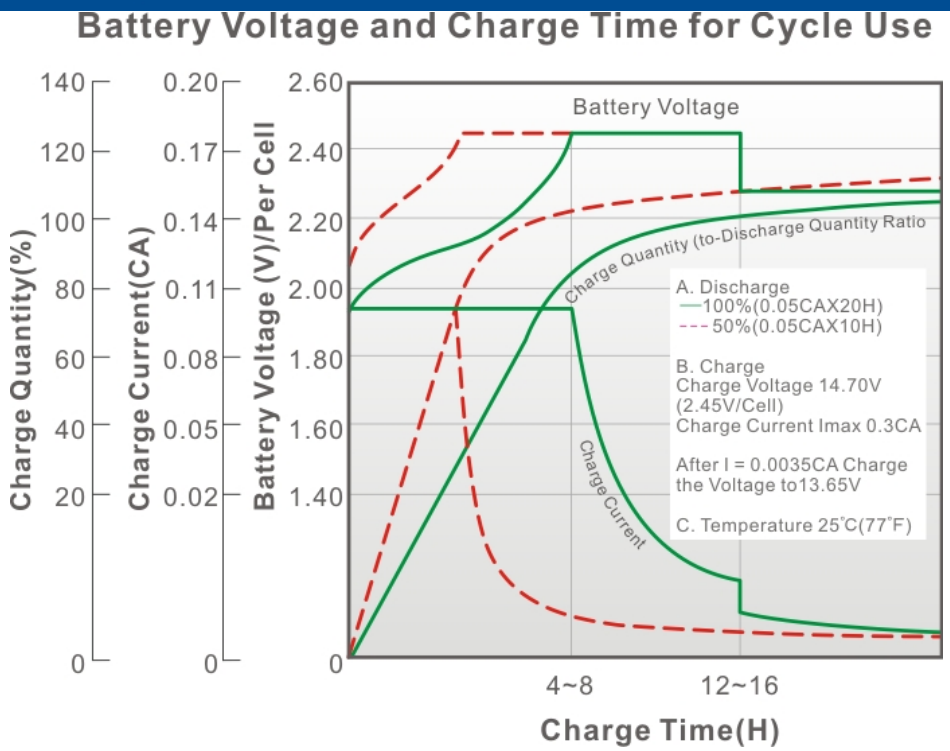

- Generally, this kind of charging mode will take a bit longer time to have battery fully recharged. It is usually found that battery is over-discharged in a cyclic use device/application which results in less performance life. It is recommended to set the starting charging voltage at lower level (the lower the better), so that the battery can get recharging more easily after it's been over-discharged due to improper usage or device/application failure.
- When battery is under overcharging, the chemical reaction of hydrolysis will accompany. Thus, if battery is recharged under high voltage for long time, it will lead battery water loss and battery life ends up. Therefore, while the second stage of float charging current reaches transition point, we recommend adjusting charging voltage into the third stage/floating charge process.
- The more pieces the batteries are connected in series, the more accurate charging voltage it has to be. Also, the tolerance of charging voltage should be as small as possible to avoid battery life ending up early because of too high charging voltage. Recommended tolerance is ±0.1V, no matter it is single piece or multi-piece connected.

5.7 Discharge protection of batteries

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- Under the lead acid battery capacity test, the discharge cut-off voltage of lead acid batteries should be decreased when the discharge rate is increased. The recommended values is as follows:

Discharge current(A)	Discharge cut-off voltage (V/cell)
(A) ≦ 0.2C	1.75
0.2C ＜ (A) ≦ 0.5C	1.70
0.5C ＜ (A) ≦ 3.0C	1.60
(A) ＞ 3.0C	1.40

- To deeply discharge the battery to voltage under 1.60V/cell, or to leave the battery in a discharged condition for long period of time, the battery will be seriously damaged, so this situation should be avoided.
- The discharged batteries should be recharged or floating charged immediately. If batteries are over-discharged for a long time, their capacity can't be recovered to the original level.
- If multi-pc VRLA batteries are connected in series, cut-off voltage should be increased. As the higher cut-off voltage is set, the more cycle life can be extended for the VRLA batteries. However, the discharge time will also be shorter. So The recommended values is as follows:

The total voltage in series	Discharge cut-off voltage (V/cell)
(V) ≦ 18V	9.6~9.8V
18V ＜ (V) ≦ 36V	9.8 ~ 10V
36V ＜ (V) ≦ 48V	10.2~10.5V
(V) ＞ 48V	Above 10.8V

- Over-discharge will have great impact on VRLA batteries. Once the batteries are over-discharged, it's impossible to recover them to normal capacity. Usually capacity will drop and life time will be shortened. The reason that causes over-discharge is batteries are in discharge condition for long time.

5.8 Equalization charging

- Cyclic use batteries after charge and discharge for 20 to 40 cycles are suggested to

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perform one equalization charge. Before such equalization charge, it is beneficial to allow the battery to be deep discharged with small current. The purpose of this treatment is to activate the plates and to restore the capacity of the battery.

- The discharge / charge treatment starts with further discharging the already high rate discharged battery with constant current of 40 hour rate (C40 Amp) to 1.75V/cell. After rest for one hour, a proper equalization charge to fully charge the battery is performed. A two-stage constant current charging is suggested. The first stage is the charging with 0.3CA constant current to 2.4V/cell. The second stage is the charging with 20-hour rate (C20 Amp) constant current until voltage reach to the maximum voltage (14.7~15.0V) and continue the charging without limiting charging voltage for 3 hrs.

5.9 Thermal runaway phenomena

Thermal runaway is an abnormal phenomenon happened in charging process, which is shown as a bloated battery. Thermal runaway means a state of operation where heat generation increases faster than heat dissipation, which may be happened on severe overcharging or electrolyte dry-out. The result is an increase of the battery's temperature. At elevated temperature, the internal oxygen cycle is accelerated, and the developed heat causes further increase of the battery temperature. With this self-accelerating cycle, the thermal runaway is resulted, and the battery will be severely deformed and bloated. Several precautions are listed as follows to prevent the thermal runaway:

- Avoid the dry-out of batteries: Do not charge at voltage higher than gassing voltage (2.4V/cell) for too long duration, e.g. >12 hours.
- Any defective battery, e.g., the short-circuited or aged battery, in a long string of batteries should be removed immediately to prevent the overcharging of other batteries.
- The internal oxygen cycle reaction is usually happened in the overcharging stage, where the originally decreasing current density may increase instead in the constant-voltage-charging mode. If the cut-off condition for the charger is relied on the smallness of the current density, this setting may be too low to be fulfilled when the battery is aged. The charger is continued to overcharge the battery until the thermal runaway happened.
- Always avoid the local overheating of batteries. Be equipped with heat dissipating devices or temperature sensors in order to stop charging when necessary.

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6. Maintenance of sealed lead acid batteries :

6.1 The storage and maintenance of batteries

- The storage temperature range: -15℃ ~ 50℃, the humidity range: 25%-85%.
- Fully charge the batteries before storage; if not, battery life will be shorter.
- Use the batteries on a first-come basis, as batteries gradually deteriorate even under proper storage conditions. Batteries stored for over long periods may not restore to their initial capacity even after recharging.
- Batteries under storage at ambient temperature of 25℃ should be recharged every six months to maintain their quality, performance and reliability. The interval of this charge should be reduced to 50% by each 10℃ rise in temperature above 25℃.
- Charge the batteries based on storage temperatures, as follows:

  <20℃(68℉) storage: charge every 6 months

  20℃~30℃(68℉-86℉) storage: charge every 3 months

  >30℃ (86℉) storage: charge every 1 months

RECOMMENDED RECHARGING INTERVAL & METHOD

STORAGE TEMPERATURE	RECHARGE INTERVAL & METHOD
Below 20℃(68℉)	6 months, charge for 5-8 hrs at 2.4V/cell
20℃-30℃(68℉-86℉)	3 months, charge for 5-8 hrs at 2.4V/cell
above 30℃(86℉) (avoid this storage condition)	1 months, charge for 5-8 hrs at 2.4V/cell

6.2 Periodical checking of batteries

- To ensure battery quality is in the best status, periodically checking batteries is necessary. Therefore, please arrange battery checking at least once every quarter.
- Checking can be done via automatic monitoring system or by professional workers.
- The purpose of checking is to confirm how large the capacity decline is, and to look for any factor or abnormal situation which could affect the reliability of system.
- When something abnormal like below happens to VRLA batteries, batteries might be damaged and need to be replaced.
  - ◇ Abnormal voltage (including open circuit voltage and floating voltage)
  - ◇ Abnormal appearance (deformed container or top cover, electrolyte leakage, terminal corrosion…etc.)
  - ◇ Abnormal heating

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- When strong peculiar smell is generated from VRLA batteries, it could be charging current being too large, battery short circuit, high ambient temperature, unworkable ground connection, or the mixture of above which cause this.
- When dusting off the batteries, don't use any organic solvent (i.e. alcohol or gasoline). Otherwise, battery container or top cover might be broken.

6.3 The detection and remedy of "defective" batteries

- This paragraph will describe how to differentiate the defective batteries from the restorable batteries when abnormal phenomena happened during the early usage or warranty period.
- Measuring the following parameters may disclose the battery's condition: open circuit voltage, internal resistance, battery capacity and the charging behavior. Using one parameter for criterion is better double-checked by other parameters. The most commonly method is the measurement of open circuit voltage.
- The OCV of new batteries should be above 6.45V(for 6V battery) or 12.9V(for 12V battery). After transportation, storage and different discharge factors, batteries' OCV will have values from 12.9V to even 0.0V. If the battery's OCV is below 1.93Vpc, or 5.79V(for 6V battery), or 11.58V(for 12V battery), this battery is a defective battery due to over-discharging or some kind of deterioration. This kind of battery has permanent damage even after recharge. If remedy of such kind of battery is desired, please contact our Company. To evaluate batteries with voltages higher than the above-mentioned value, fully recharge the battery is necessary before any measurements.
- If the fully recharging of batteries is not possible, battery with OCV or internal resistance values far from its average values can be classified as defective battery.
- The OCV should be measured one hour (24 hours is better) after recharge. The fully charged battery with OCV smaller than 6.2V (for 6V battery) or 12.5V (for 12V battery) is a defective battery.
- The fully charged battery should have OCV higher than 6.45V (for 6V battery) or 12.9V (for 12V battery). If the battery has values between 6.2 ~ 6.45V (for 6V battery) or 12.5 ~ 12.9V (for 12V battery), it may not be fully charged, and may need recharge with proper charger. If this condition is not improved, the battery's capacity may have been reduced.
- The remedy method for charging the hard-to-recharge battery is available through contact with our Company.

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6.4 Notes

- Do not disassemble the safety valves of VRLA batteries or supplement water. This is very dangerous and will disable batteries.
- If the battery is broken and acid is spilt to the skin or eyes, do flush with lots of water immediately and seek medical advice.
- Before touching VRLA batteries, please make sure the static electricity of the body is already released lest the static electricity should cause the spark and danger.
- When maintaining and checking VRLA batteries, be sure to remove personal metal stuffs (such as watches or any conductors which could probably result in short circuit) and use insulation tools.
- VRLA batteries are likely to release hydrogen, thus it is prohibited to install batteries in sealed environment or equipment or where will generate sparks.

7. The recycle of sealed lead acid batteries：

- The defective and used batteries should be recycled.
- When VRLA batteries are recycled, it’s necessary to isolate the terminals. Even if they are used batteries, there can be remaining electricity inside. This would probably cause explosions, fires, or other danger if terminals are not isolated.
- Dissecting or placing waste batteries at will should be avoided. It is required to recycle and reutilize via registered processors, governmental clean up party or local recyclers, in order to build better environment.

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