VALVE REGULATED LEAD-ACID BATTERY

Technical Manual

Suit for NP/NPD/NPL/NPG/NPF/HR Series

NPP

Clean Energy Safe Power

GUANGZHOU NPP POWER CO.,LTD.

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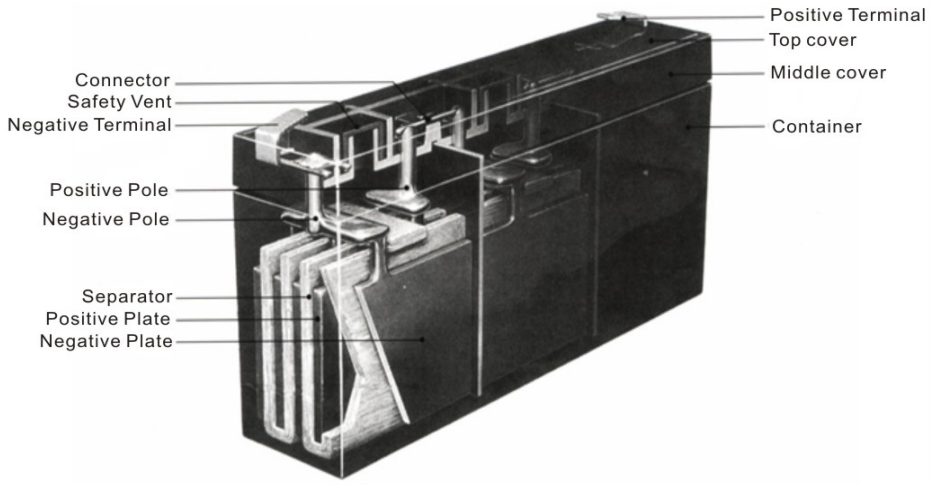
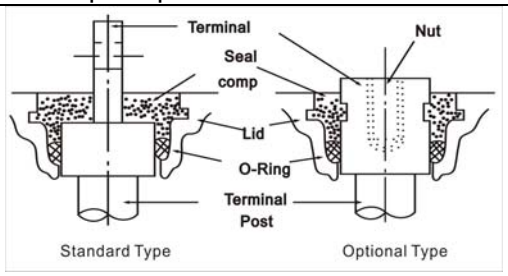
1. VRLA BATTERIES GENERAL INFORMATION

1.1.1 VRLA Battery Construction



1.1.2 VRLA battery parts and functions:

Parts	Material of Construction	Functions
Positive & Negative Plates	• Pasted type plate in which special • lead-calcium alloy grids are • pasted with active material.	• Retain sufficient capacity. • Maintain capacity performance for long period of time (long life performance.) • Minimize self-discharge.
Separator	• Mat made of glass fibers with excellent heat oxidation resistance. • PVC or PE	• Prevents short circuit between positive and negative plates. • Retains electrolyte. • Prevents active material fall by pressing plate surfaces.
Electrolyte	• Dilute sulphuric-acid in quantity to preclude free electrolyte.	• Causes electron motive reaction in negative and positive active material.
Container & Cover	• ABS synthetic resin. • ABS with fire-resistant	• Accommodates plate group consisting of positive and negative plates and separators. • Retains sufficient mechanical strength to withstand battery internal pressure.
Safety Valve	• Synthetic rubber with excellent acid resistance and little deterioration by aging. • In cap shape.	• Releases gas if cell internal pressure rises abnormal high and normalizes internal pressure. • Prevents ingress of oxygen.
Terminal	 • Made of copper or lead alloy. • Terminal section employ s dual complete seal construction of o-ring and sealing compound. • Color of sealing compound: red for positive section and black for negative • Optional type: Insert nut.	• Terminal with a large and non welded sectional area enhances high rate discharge characteristics and reliability. • Perfect seal is given at a terminal sealing section. • Facilitates fixing of connecting bars and take off terminal.

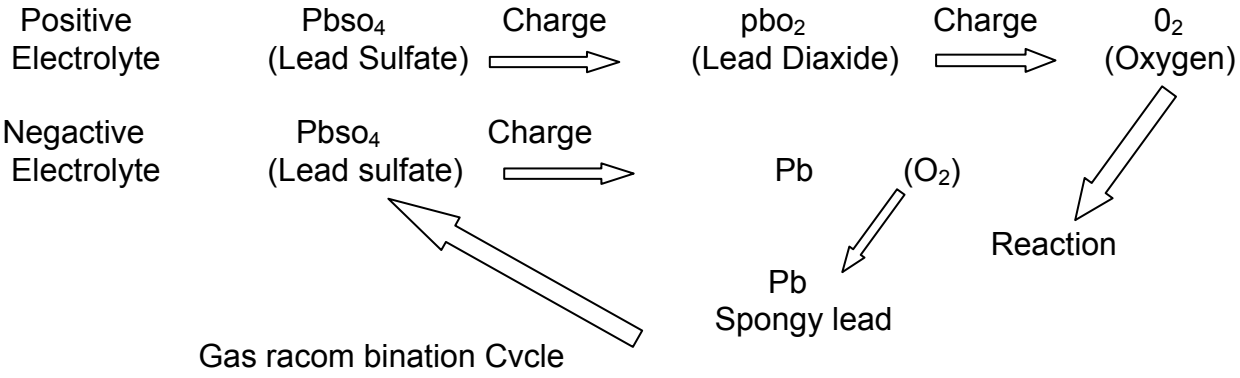
1.2. Electrochemical Reaction on Electrodes

The electrochemical reaction processes of the VRLA battery(negative electrode recombination type)are described below. Where “charge” is the operation of supplying the rechargeable battery with direct current from an external power source to change the active material in the negative plates chemically, and hence to store in the battery electric energy in the form of chemical energy. “Discharge” is the operation of drawing out electric energy from the battery to operate external equipment.

$$\underset{\substack{\text{(Lead dioxide)}\\ \text{Positive pole}}}{PbO_2} + \underset{\substack{\text{(Sulphuric acid)}\\ \text{Electrolyte}}}{2H_2SO_4} + \underset{\substack{\text{(Spongy lead)}\\ \text{Negative pole}}}{Pb} \underset{\text{Charge}}{\overset{\text{Discharge}}{\rightleftharpoons}} \underset{\substack{\text{(Lead sulphate)}\\ \text{Positive pole}}}{PbSO_4} + \underset{\substack{\text{(Water)}\\ \text{Electrolyte}}}{2H_2O} + \underset{\substack{\text{(Lead sulphate)}\\ \text{Negative pole}}}{PbSO_4}$$

1.3. Oxygen cycle

In the final stage of charging, an oxygen-generation reaction occurs at the positive plates. This oxygen transfers inside the battery, then absorbed into the surface of the negative plates and consumed. The electrochemical reaction processes are expressed as follows.



1.4.VRLA Battery Applications:

(1) Cycle Use:

Power tools, lawn mowers and vacuum cleaners, Cameras and photographic equipment, Portable measuring equipment, Various power toys…

(2) Standby Use:

Emergency lighting equipment, Fire alarms and security systems, UPS power supplies, Emergency power supplies in power generation plants and substations Telecommunications

1.5 VRLA battery Features

Safety

Patent design to prevent the battery burning, exploding and leakage.

NAPEL VRLA batteries unique construction and sealing technique to guarantees no electrolyte leakage from terminals or case of any battery. This feature insures safe and efficient operation of Napel batteries in right position. Napel batteries are classified as " Non-Spillable " and meet all requirements of the International Air Transport Association.

Maintenance-free

VRLA batteries do not need the electrolyte specific-gravity check nor the watering filling during the expect floating service life; this make the battery function fully maintenance -free.

Low Self Discharge

Use Lead Calcium grids alloy to keep the battery self-discharge rate only approx. 3% of norminal capacity per month. To keep VRLA battery can be stored for long periods without recharge at room temperature.

Long Life Design

Use heavy-duty lead-calcium alloy grids with anti-corrosive construction to enable the Napel AGM battery to remain in float service for 10-15 years and the Napel Gel battery to remain in float service for 15-20 years at the operation temperature of 20C.

High Reliability and Stability

Advanced AGM and GEL production technology and strictly quality control systems to ensure battery stability and reliable performance. The battery voltage, capacity and seals are 100% tested during production.

Quality certification

UL、CE (Certification no.: MH47211、and CGZ3171220-02375-E) approved, and approved ISO 9001 quality manage System and ISO 14001 environment manage system.

1.6. International Certification and standard

UL certification (MH 47211)

All NPP Power batteries are tested and certified according to UL-1989 standard of standby batteries (Emergency Lights and Power Equipment). Section 38 requires that the battery is free from the hazard of bursting, that is when the battery Is overcharged the vent valve opens to release internal pressure.

● CE certification

All NPP Power batteries are tested and approved according to CE/EMC EN61000-6-1: 2007 and EN61000-6-3: 2007.

● JIS and IEC standard

Our VRLA batteries comply with JIS C 8702, and JIS C 8707. IEC 60896 2004 standard.

● ISO14001:2004 and ISO9001:2008

After an evaluation by SGS UNITED KINGDOM LTD SYSTEMS & SERVICES CERTIFICATION, our company has been assessed And certified as meeting the requirements of ISO 9001:2008 and ISO 14001: 2004 for the design and Manufacture of sealed lead acid battery.

2. VRLA BATTERY SAFETY TEST ITEMS

Item	Test method	Check point
1.drop test	A fully charged battery is allowed to drop from the height of 20cm onto a hard board having thickness of 10mm or more. Test is repeated three time.	The battery should not get breakage or leak, and its terminal voltage should be held or higher than the nominal voltage.
2.Vibration test	A vibration frequency of 1000 time/minutes and amplitude of 4mm is applied to the x-. y- and z-axis directions of a fully charged battery for 60 minutes respectively,	No battery part should be broken, the battery should not get leak, and its terminal voltage should be held or higher than the nominal voltage.
3.oven test	A fully charged battery is left standing in a atmosphere of 70℃ for 10 hours.	The battery case shouldn't be deformed, the battery should be free from leak.
4. cold proof test	A fully charged battery is connected to a resistor with 60 hour rate discharge curent and left for 4 days, then the battery is left standing in an atmosphere of -20℃ for 24 hours	No crack should develop in the battery case, the battery should be free from leaks.
5. heat cycle test	A fully charged battery is exposed to 10 cycles of 2 hours at 40℃ and 2 hours at 65℃	No crack should develop in the battery case,. the battery should be free from leaks.
6.short circuit test	A fully charged battery is connected with a small resistor of 10 ohms or less is allowed to discharge.	The battery must not burn nor burst
7. Large current discharge test	A fully charged battery is allowed to discharge at 3C A to 4.8V/6V battery level.(this test is not applicable to batteries having built-in thermostat.)	The battery must not burn nor burst, and the case should not get deformation, leak and any irregularity in the internal connections
8.vent valve function test	A fully charged battery is submerged in liquid paraffin in a container, then overcharged at 0.4CA(UL 1989)	Release of gas from the vent should be observed.
9. overcharge test	A fully charged battery is overcharged at 0.1 C A for 48 hours, left standing for one hour, and allowed to discharge at 0.05C A to 5.25V/6V battery level.	No irregularity should be notices in the battery appearance, the battery should retain 95% or more of the initial capacity.

3. VRLA BATTERY CHARACTERISTICS

3.1. CHARGING

3.1.1 Methods of charging

To charge the VRLA battery, a well-matched charger should be used, because the battery capacity and life are influenced by ambient temperature, charge current and other parameters.

Charging methods are dependent on battery applications, and the applications are roughly classified into main power application(cycle use) and stand-by/back-up power applications(trickle use/float use)

Classification By application
- (1)Main power source(cycle use)
  - (a) Standard charging(normal charging)
  - (b) rapid charging
- (2) stand-by power source(trickle use)
  - (a) trickle charging
  - (b) float charging

3.1.1.1 main power source (cycle use)

Cycle use is to use the battery by repeated charging and discharging.

a) standard charging (Normal charging)

For cycle use battery, the constant voltage charge method is advantageous as it allows the battery to exert full performance.

- **Constant voltage charging method**

  This method is to charge the battery with a constant voltage between the terminals.

  When the battery is charged with a voltage of 2.45V/cell (unit battery) at a room temperature (20℃to 25℃), charging will be complete when the charge current continues to be stable for three hours.

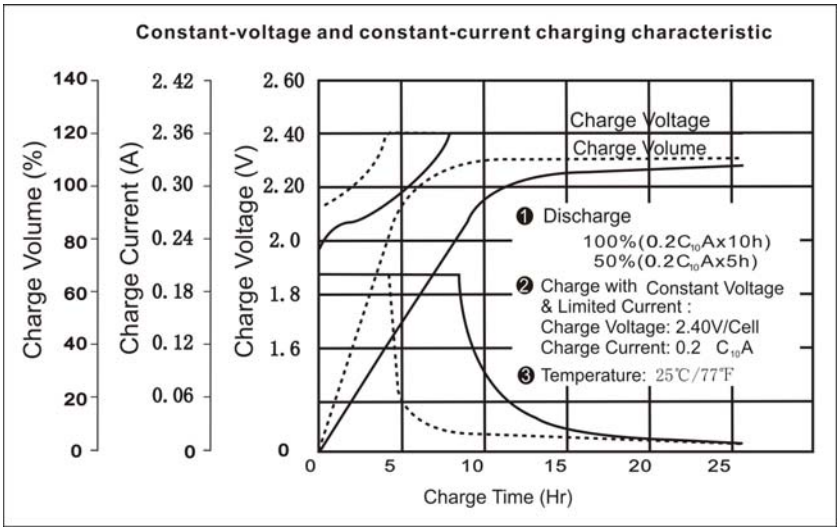
  If VRLA batteries are overcharged without constant voltage control. the water in the electrolyte will be decomposed by electrolysis to generate more oxygen Gas than what can be absorbed by the negative electrode. The electrolyte will be reduced, the chemical reactions of Charge and discharge become inefficient , hence, the battery performance will be severely deteriorated.

  Therefore, exact voltage control and proper charging time in constant voltage charging are essential for Securing the expected life of the battery.

- **Constant-voltage and constant-current charging method**

  This method is to charge the battery by controlling the current at 0.4CA and controlling the voltage at 2.45V/cell (unit battery) at a room temperature .(20℃ to 25℃.)

  Proper charging time is 6 to 12 hours depending on discharge rate.



b) Rapid charging

when rapidly charge battery, a large charge current is required in a short time for replenishing the energy which has been discharged. Therefore, some adequate measures such as the control of charge current is required to prevent overcharging when the rapid charging is complete. Basic requirements for rapid charging are as follows:

Sufficient charging should be made in a short time for fully replenishing the amount discharged.

Charge current should be automatically controlled to avoid overcharge even on prolonged charging The battery should be charged adequately in the ambient temperature range of 0℃ to 40℃

Reasonable cycle life of charge/discharge should be secured.

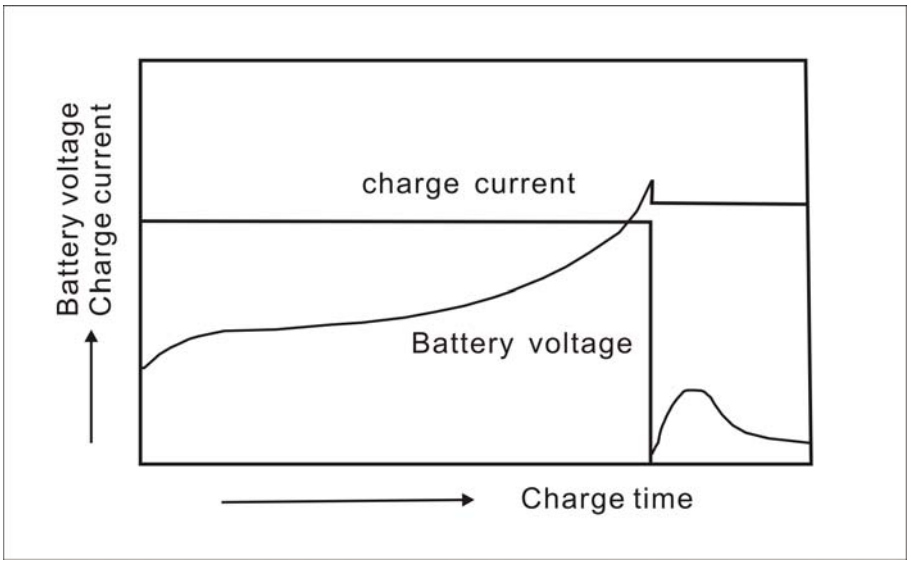
Typical methods to control charging so as to satisfy the above requirements as following.

● Two-Step Constant Voltage Charging

Two-step constant voltage charge control method uses two constant-voltage devices.

At the initial stage, the battery is charged by the first constant voltage device of high setup voltage (setup for cycle charge voltage). When the charge current, the value of which is detected by the current-detection circuit, has reduced to the preset value, the device is switched over to switch over to the second low setup voltage(setup for trickle charge voltage). This method has the advantage to allow trickle use application to charge the battery in a comparatively short time for the next discharge.

charging characteristics of the two-step constant voltage control charger

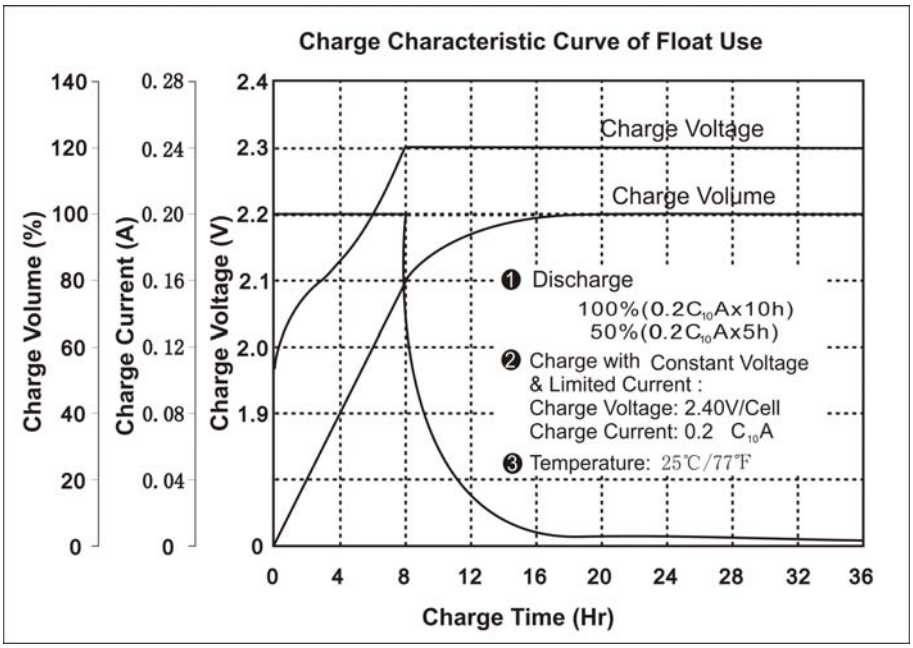


c) normal charging parameters

Models	Capacity	Current(A)	Voltage(V)	Time(h)
2V	50Ah-3000Ah	≤0.2C_{10}	2.35-2.40	12-15
6V	0.5Ah-200Ah	≤0.4C	7.20-7.50	12-15
12V	0.8Ah-280Ah	≤0.4C	14.40-15.0	12-15

3.1.1.2 Stand-by/back-up use (trickle use/float use)

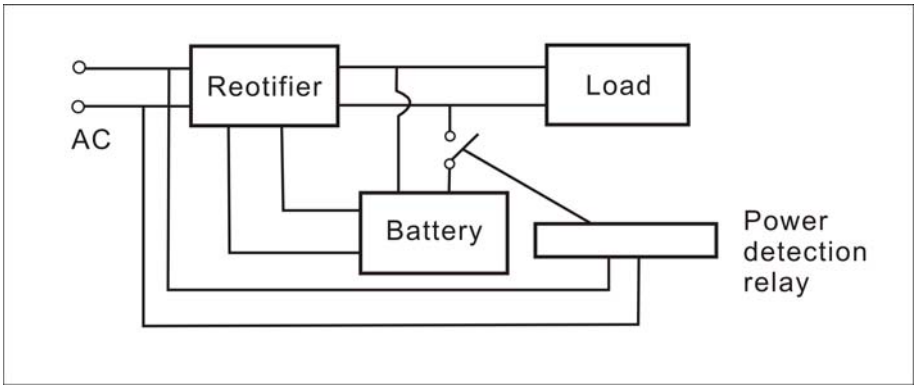
the application load is supplied with power from AC sources in normal state. State-by/back-up use is to maintain the battery system at all times so that it can supply power to the load in case the AC input is disrupted (such as a power failure). There are two methods of charging for this use.



a) trickle charge (compensating charge)

In this charge system, the battery is disconnected from the load and kept charged with small current only for compensating self-discharge while AC power is available. In case of power failure, the battery is automatically connected to the load to supply power. This system is applied mainly as back-up power source for emergency equipment. In this use, The battery is required rapid recovery after discharge. it is necessary to consider the recovery charge with a comparatively large current followed by trickle charge, or alternative measures. While the battery type and capacity is determined by the back-up time and the load (current consumption) during power failure, some reserve power should be taken into account considering, such as ambient temperature, capability of the charger and depth of discharge factors。

Trickle charge system model



● Equalization charging

As a team batteries continues to be charged over a long period(e.g. 3 months), or 90mV difference in a charging team voltage has been discovered. which may result in a significant difference in the battery life. Therefore, Equalization charging should be adopted. Which should control a narrow range charging voltage with initial current of approx 0.1C A.

● Float Charge

Float system is the system in which the battery and the load are connected in parallel to the rectifier, which supplies a constant-voltage current. In the float system, capacity of the constant-voltage power source should be more than sufficient against the load. Usually, the rectifier capacity is set at the sum of the normal load current plus the current needed in order to charge the battery.

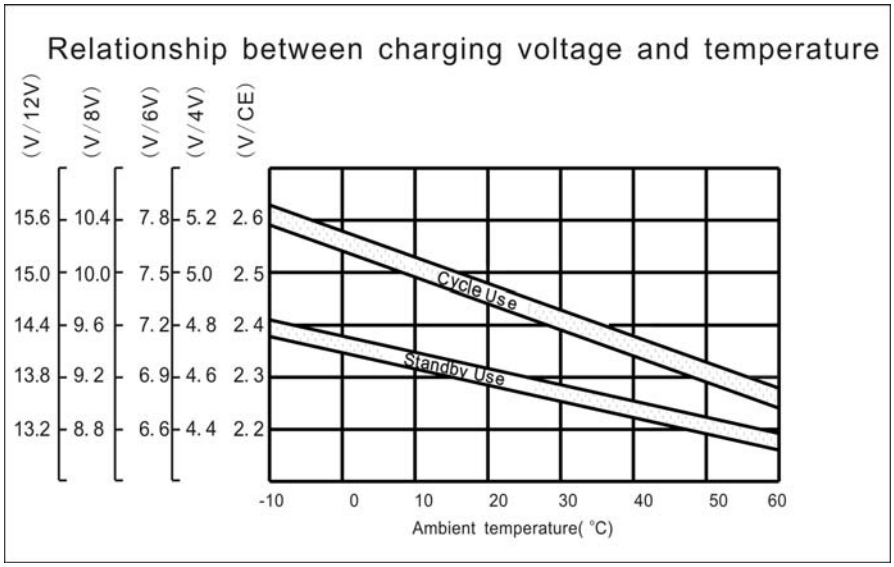
b) floating charging equalization charging parameters

Models	Capacity	Current(A)	Floating charging Voltage(v)	Equalization charging voltage(v)	Equalization charging time (h)
2V	50Ah-3000Ah	≤0.2C	2.23-2.27	2.33-2.38	20-24
6V	0.5Ah-200Ah	≤0.2C	6.75-6.9	7.10-7.30	20-24
12V	0.8Ah-280Ah	≤0.2C	13.50-13.80	14.20-14.60	20-24

3.1.2.charging condition

a) Temperature Compensation of Charge Voltage

Charge voltage of the battery should be compensated to the ambient temperature around the battery, as shown in below figure. Main reasons for the temperature compensation of charge voltage are to prevent the thermal runaway of the battery when it is used in high temperature conditions and to secure sufficient charging of the battery when it is used in low temperature conditions. Prolongation of service life of the battery by the above-described temperature Compensation is expected as following.



(1) when the ambient temperature is above 30℃, If the temperature increase 1℃, the charging voltage will be reduced 3.5mv.

(2) when the ambient temperature is below 20℃, If the temperature decrease 1℃, the charging voltage will be increased 3.5mv.

b) Charge Time

Time required to complete charging depends on the factors, such as depth of discharge of the battery, characteristics of the charger and ambient temperature.

For cycle charge, charging time can be estimated as follows:

(1). When charge current is 0.25C A or greater:

Charge time = Cdis/I+(3h to 5h)

(2). When charge current is below 0.25C A:

Charge time = Cdis/I+(6h to 10h)

Here: Cdis = Amount of discharge before this charging (AH)

I = Initial charge current (A)

Time required for trickle charge ranges from 24 to 48 hours.

SUMMARY

c) Charging temperature

(1) pls charge battery at an ambient temperature in the range from 0℃ to 40℃
(2) optimum temperature range for charging is 20℃ to 25℃
(3) charge battery at below 0℃ and over 40℃ is not recommended:
at low temperatures, the battery may not be charged adequately;
at high temperatures, the battery may become deformed.
(4) For temperature compensation values, see **section 3.1.2 a**）

d) Reverse charging

Never charge the battery in reverse, as it may cause battery leakage, heating or bursting.

e) Overcharging

Never overcharge battery, Continued overcharging would shorten the battery life. and it also may cause battery leakage, heating or bursting.

f) Charging before use

Recharge the battery before use to compensate for capacity loss due to self-discharge during storage.

3.1.3 complementarity charging:

When the battery store for a long time
As following conditions or the battery before use. The battery must be charged

Store temperature(℃)	Store time	Charging
≤20	Every 9 months	One time
20-30	Every 6 months	One time
30-40	Every 3 months	One time

Charging voltage	2.32-2.38V/cell
Charging current	≤0.2C
Charging time	5-12h

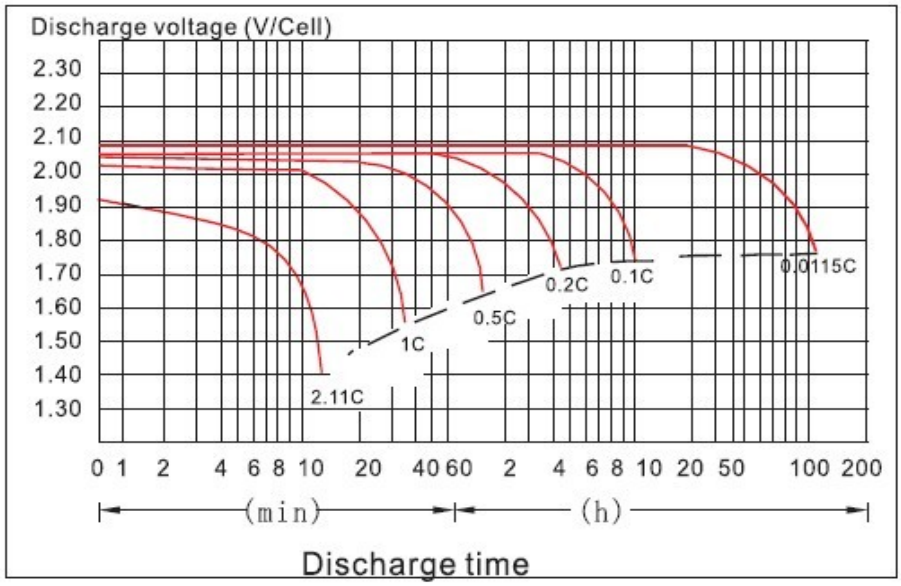
3.1.4.Precautions

1) When adoption charging methods and charging conditions, pls read its those described in the specifications or the brochures, thoroughly check the battery charging/discharging characteristics and life characteristics in advance. Selection of appropriate methods and conditions of charging is essential for battery safe-use and for fully utilizing its discharge characteristics.
2) In cyclic use of the battery, use a smart charger equipped to control charging timer and charge amount. otherwise, it will be difficult to judge the completion of the charge. Use of a charger as described above is recommended to prevent undercharge or overcharge which may cause the battery get fault.
3) Continue charging the battery for the specified time or until the charge completion lamp is light, if equipped indicates full charged,pls interrupt charging or it may cause battery life shortening
4) Do not recharge the fully charged battery repeatedly, as overcharge may accelerate deterioration of the battery.
5) In cyclic use of the battery, do not continue charging for 24 hours or longer, as it may accelerate deterioration of the battery.
6) In cyclic use of the battery, avoid charging more batteries connected in parallel simultaneously, Imbalance of charge/discharge amount among the batteries may shorten the life of batteries.

3.2.Discharging

a) Discharge current and discharge cut-off voltage

Recommended cut-off voltages for 2V batteries with consistent discharge rates are given in the figure below. With smaller discharge currents, there-fore discharge cut-off voltages are set to the higher side for controlling over discharge. For larger discharge currents, on the contrary, cut-off voltages are set to the lower side. (Note) Discharge cut-off voltage given are recommended values.



b) Discharge temperature

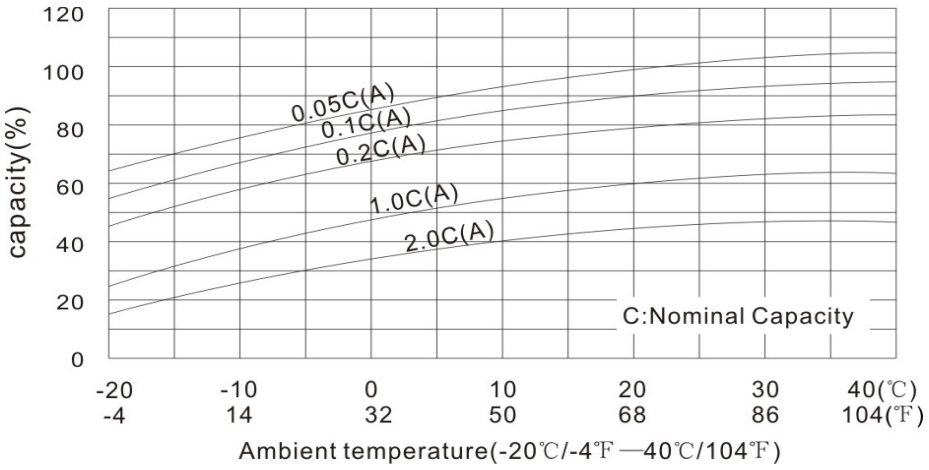
(1) control the ambient temperature during discharge within the range from-15℃ to 50℃ for the reason described below.

(2) Batteries operate on electrochemical reaction which converts chemical energy to electric energy. The electrochemical reaction will be reduced once the temperature is lower, thus, available discharge capacity will be greatly reduced at temperatures below -15℃, on the other hand, the discharge temperature should not be exceed 50℃ in order to prevent deformation of resin materials which house the battery or deterioration of service life.

c) Effect of temperature on discharge characteristics

Available discharge capacity of the battery varies with ambient temperature and discharge current as shown in the figure below.

Discharge capacity by temperature and by discharge current



d) Discharge current

Battery's Discharge capability of expressed by the 20 hour rate/10 hour rate (rated capacity). Select the battery for specific equipment so that the discharge current during use of the equipment within the range between 1/20 of the 20 hour rate value and 3 times that (1/20 C A to 3C A): discharging beyond this range may result in a marked decrease of discharge capacity or reduction in the number of times of repeatable discharge. When discharging the battery beyond said range, please consult NAPEL POWER in advance.

e) Depth of discharge

Depth of discharge is the state of discharge of batteries expressed by the ration of amount of capacity discharged to the rated capacity.

3.3. Storage

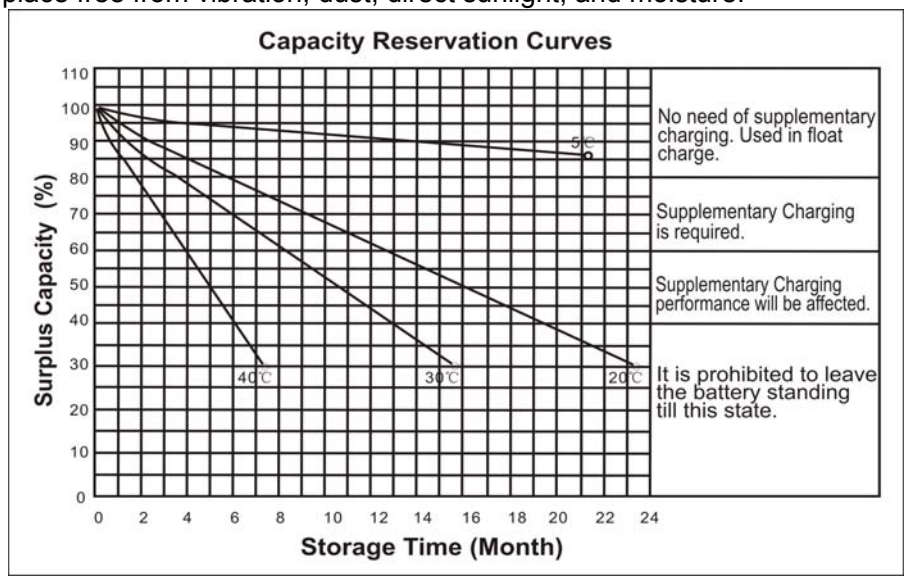
Storage condition

Observe the following condition when the battery needs to be stored.

1) Ambient temperature: -15℃ to 40℃ (preferably below 30℃)

2) Relative humidity: 25 to 85%

3) Storage place free from vibration, dust, direct sunlight, and moisture.



a) Self discharge and refresh charge

During storage, batteries gradually lose their capacity due to self-discharge, therefore the capacity after storage will be lower than its initial capacity. To recover capacity, pls repeat charge/discharge the battery for several times when it is in cycle use; If the battery is in trickle use, pls continue charging the battery as loaded in the equipment for 48 to 72 hours.

b) Refresh charge (Auxiliary charge)

When it is unavoidable to store the battery for 3 moths or longer, periodically recharge the battery at the intervals recommended in the table below depending on ambient temperature. Avoid the battery storing for more than 12 months.

Storage Temperature	Interval of auxiliary charge(refresh charge)
Below 20℃	9 month
20℃ to 40℃	6month
20℃ to 40℃	3month

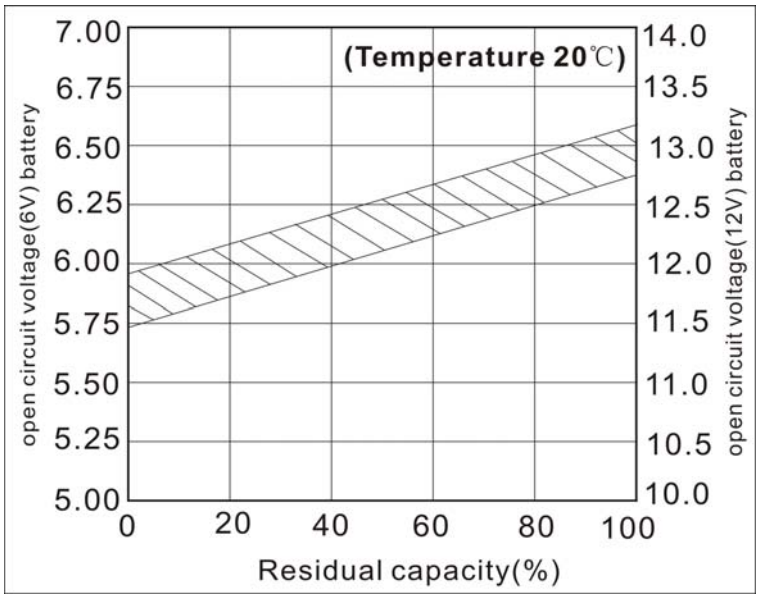
c) Residual capacity after storage

The result of testing the residual capacity of the battery which, after fully charged, has been left standing in the open-circuit state for a specific period at a specific ambient temperature is shown in the figure below. The self-discharge rate is very much dependent on the ambient temperature of storage. The higher the ambient temperature, the less the residual capacity after storage for a specific period. Self discharge rate almost double by research of each 10 rise of storage temperature.

d) Open-circuit voltage vs. residual capacity

Residual capacity of the battery can be roughly estimated by measuring the open circuit voltage as shown in the Figure.

Open circuit voltage vs. Residual capacity (20℃)



3.4.Temperature conditions

Recommended temperature ranges for charging, discharging and storing the battery are tabulated below.

Charge	0℃-40℃
Discharge	-15℃-50℃
Storage	15℃-40℃

3.5.Battery life

a) Cycle life

Cycle life (number of cycles) of the battery depends on the depth of discharge in each cycle. The deeper the discharge is, the shorter the cycle life (smaller number of cycles), providing the same discharge current. The cycle life (number of cycles) of the battery is also related to such factors as the type of the battery, charge method, ambient temperature, and rest period between charge and discharge. Typical cycle-life characteristics of the battery by different charge/discharge conditions are shown by the below figures.

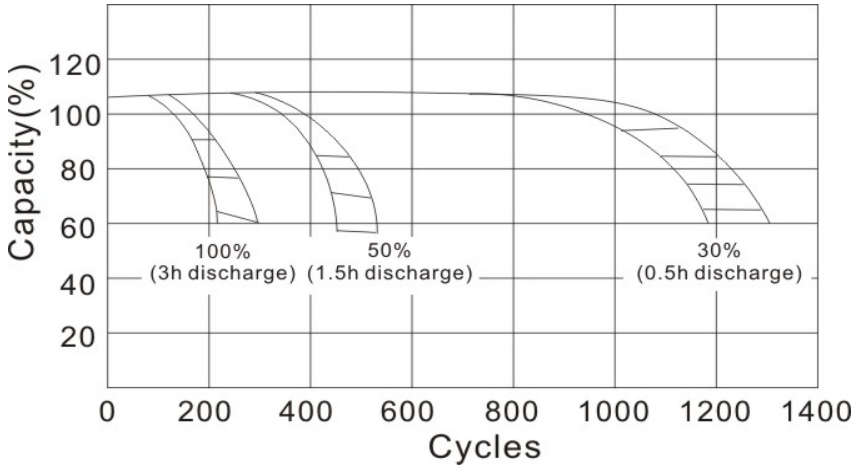
This date is typical and tested at a well-equipped laboratory.

Cycle times are different for each battery model.

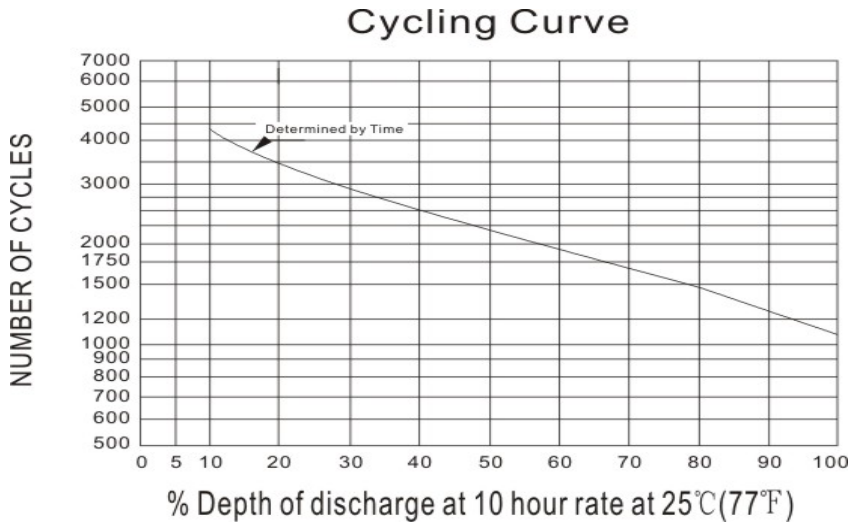
Cycle times are also different from this data when using batteries under real conditions.

- **General battery**

Cycle life vs. Depth of discharge



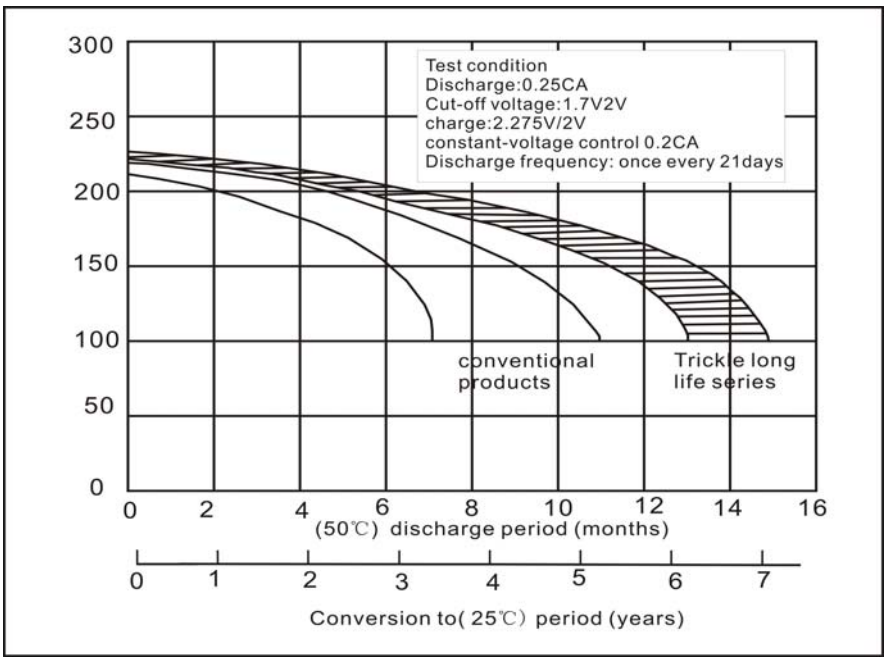
● **Long life battery**



b) Float life

Trickle life of the battery is largely dependent on the temperature condition of the equipment in which the battery is used, and also related to the type of the battery, charge voltage and discharge current. The respective Figures show The influence of temperature on trickle life of the battery, an example of trickle (float) life characteristics of the battery, and the test result of the battery life in an emergency lamp.
influence of temperature on trickle life.

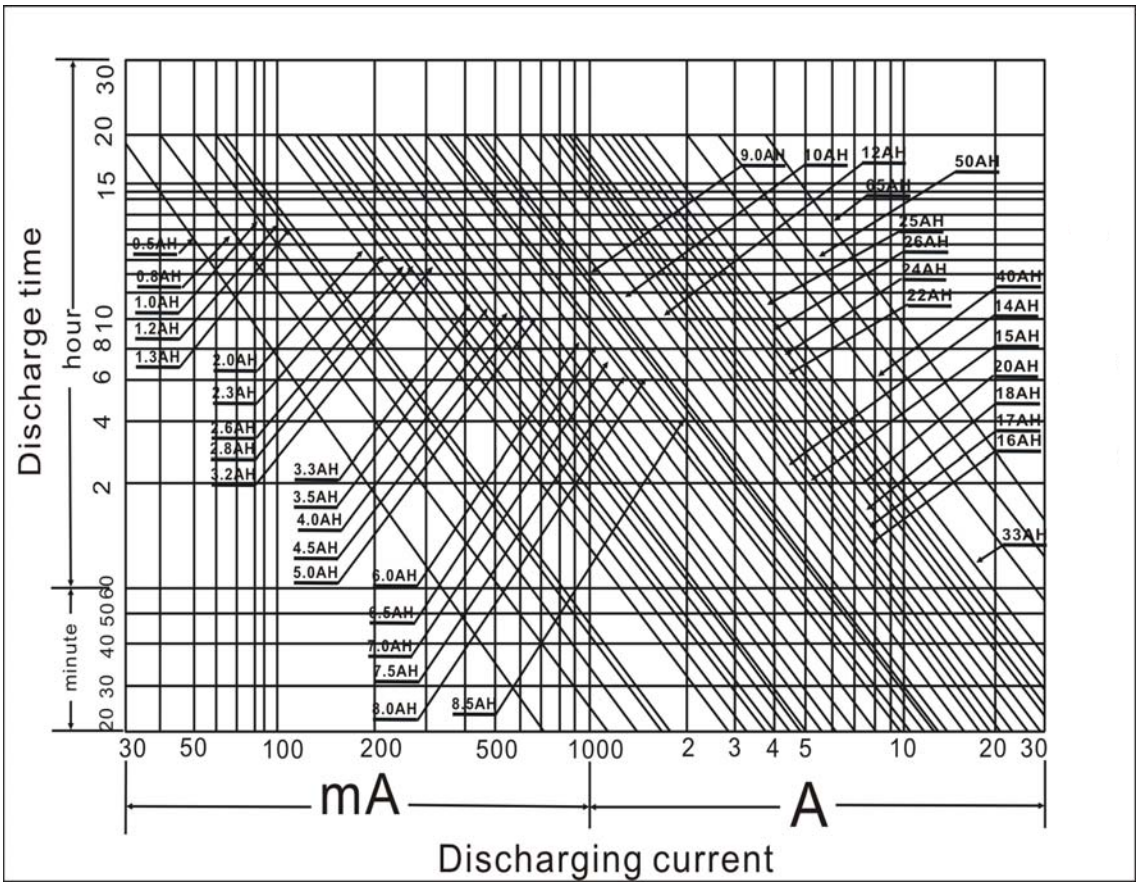
Trickle life characteristic at 25℃



4.BATTERY SELECTION

4.1 Method of battery selection(Estimation of that discharge time)

(1) determine discharge current.
(2) determine duration of discharge required.
(3) select batteries from the selection chart below.
Then, select a battery which meets the specification of the equipment in which the battery is loaded such as voltage. Capacity and dimension
(Note) date given are the average values obtained with in three cycles of charge/discharge, not the minimum values.



4.2 MODEL NUMBERS OF VRLA-BATTERIES

All series batteries of NAPEL POWER are set out below.

6V, 12V General battery (1.3Ah~28Ah)	----NP XXXXX
6V, 12 General battery (33Ah~250Ah)	----NPM XXXXX
2V series battery	----NPL XXXXX
Gel battery	----NPG XXXXX
Deep cycle battery	----NPD XXXXX
Hight rate battery	----HR XXXX W
Front terminal battery	----NPF XXXXXX
Gel front terminal battery	----NPFG XXXXX

5.THE INSTALLATION AND OPERATION

5.1. Mode of Installation

NPP Power small batteries usually come with lead wires or connectors, they can be used independently in actual use, or used in UPS system by plug-in or soldering the terminals.

5.1.1 Installed on the ground

For commodious battery room, the batteries can be installed on the ground or table-board in single column or more columns.

5.1.2 installed in Battery Best

For in capacious places, in order to decrease the floor area of batteries and to keep them uniform with equipments. batteries can be installed in battery chest.

5.1.3 Installed in Battery Rack

This mode can decrease the floor area of batteries as well as apply to different arrange of battery voltage. According to different voltage and capacity required, the batteries can be separated into monolayer single column or multiplayer multi-columns. The batteries can be lying horizontally or vertically according to their laying orientations.

- Installation Instance, series installed in battery rack:

The Sketch Map of Installation in Battery Rack

(1) In virtue of attachment plate <4>, connect the bracket<6> at the left of battery carrier with the horizontal baffle of the rear <7> with a M8 20 bolt <5>, and need not to fasten it closely.

(2) In the same way, connect the bracket on the right with horizontal baffle of rear well, and does not fasten it closely.

(3) Aim the bulge of the orientation sheath of bottom splint<2> at the recession of the active rack part, then insert one M10X25 hexagonal socket bolt <3> into the orientation sheath, connect them with a spanner, but don't fasten up closely. Finally connect other battery splints well.

(4) Adjust all connections among the parts, and if there is no misplacing, fasten every bolt tightly.

(5) Move battery rack into battery room, put the side without transverse baffle towards outside, make marks on the points which are corresponding to the feet of battery rack.

(6) Move battery rack away, bore a hole where a mark is made with an electric hammer, then clear up the installing site.

(7) Put the expanded bolt<1> into the hole, then move battery rack back, and fasten it well.

(8) Put battery into battery rack, and connect battery line well according to their layout.

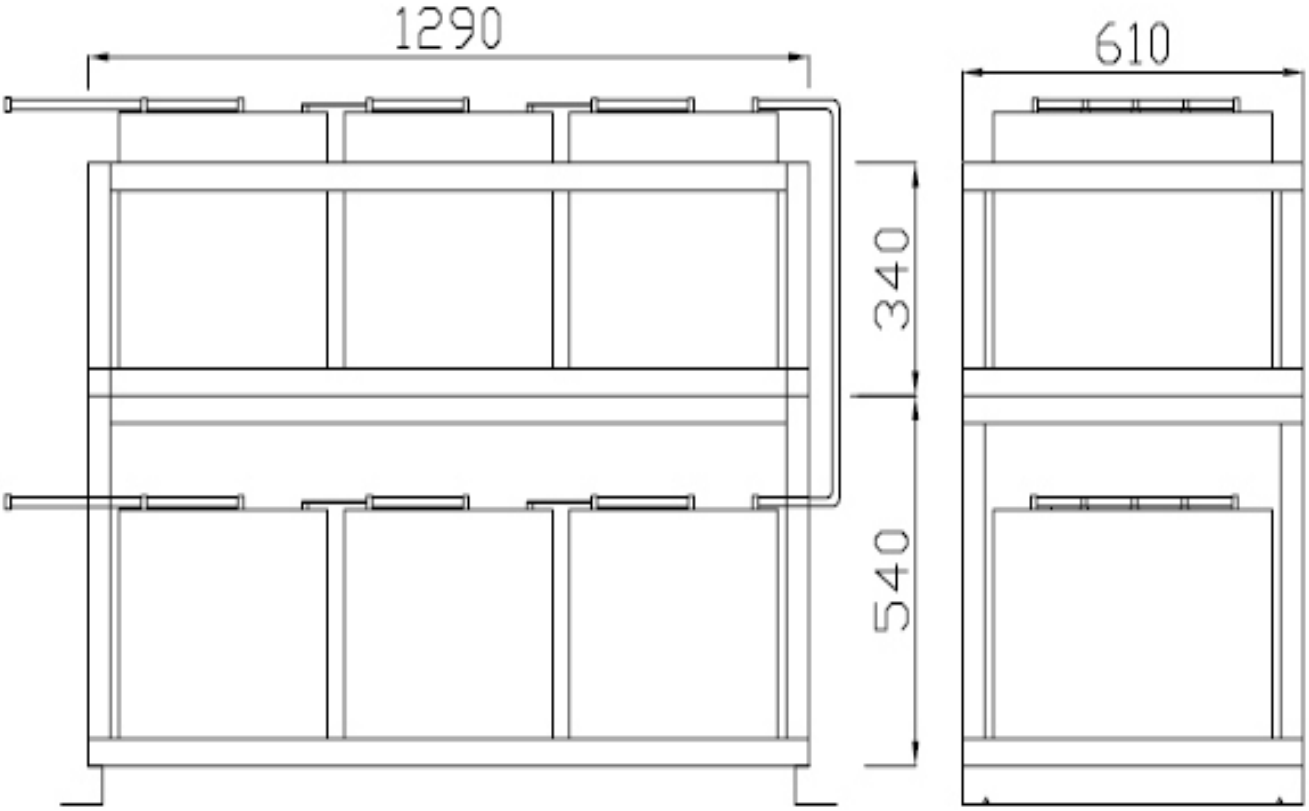
(9) Install other two horizontal baffles to the battery rack, and connect them firmly.

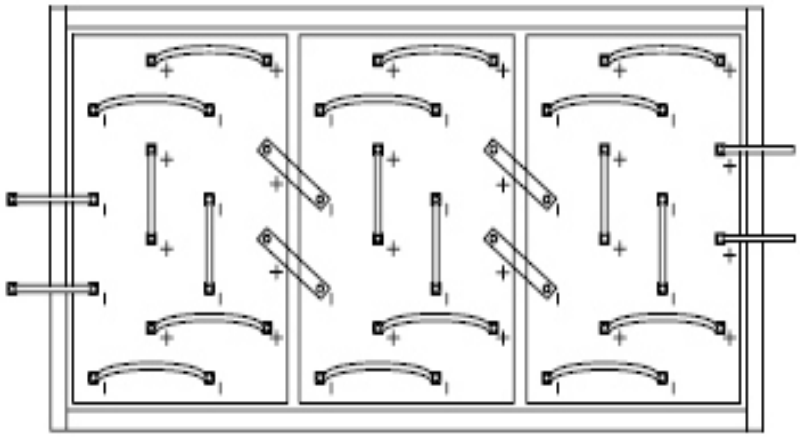
(10) after installation put some oil on the surface of bolt and connector to protect corrosion

For 48V200AH and 12V2000Ah batteries the installation as shown below:

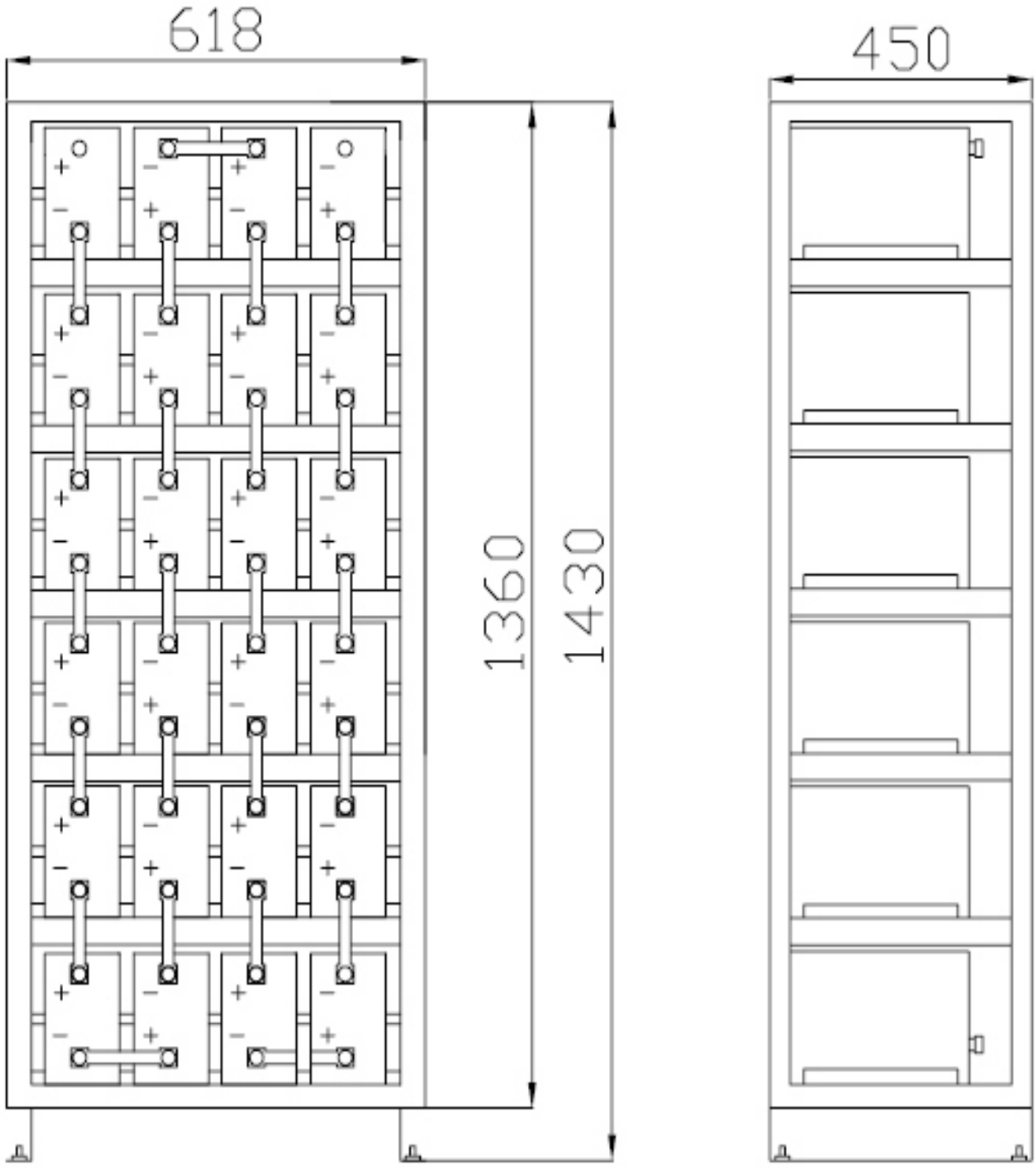
12V2000AH rack installation

(6PCS 2V2000AH BATTERIES IN SERIES)





48V200AH rack installation
(24PCS 2V200AH BATTERIES IN SERIES)



5.2. Precautions for handling VRLA-Batteries

This document should be read in its entirety and its contents fully understood before handling or using Napel batteries. If any questions, please contact Napel Power. Please keep this document available for reference. Due to the potential energy stored in the batteries, improper handling or use of the batteries without understanding this document may result in injury caused by electrolyte leakage, heat generation, or explosion.
*All description are subject to modification without notice.

5.2.1 Degree of danger

1) WARNING

When the batteries are handled or used improperly, death or severe injury may occur, and slight injury or loss of products often occurs.

2) CAUTION

When the batteries are handled or used improperly, damage to the batteries and equipment may occur.

3) REQUEST

When the batteries are handled or used improperly, damage to their quality or performance may occur.

Note (1): Improper handling and use of the batteries may cause dangerous conditions to arise. All precautions should be taken to prevent any harmful effects from the use of the batteries.

Note (2): Severe injury as a result of improper handling or use of the batteries may include but are not limited to loss of eyesight, injury / burn / electric shock / fracture of a bone / poisoning with after effect, or injury that requires long-term medical treatment. Slight injury covers such conditions as burns or electric shock that do not require Long-term medical treatment. Damage to products is defined as extensive damage to a house, a household effects, a livestock, or pets.

Note (3): Request are meant to prevent a decrease in the quality or the performance of the batteries.

5.2.2 Safety precautions

Environment and condition

1) WARNING

(1) DO NOT put batteries into airtight containers. The batteries tend to generate inflammable gas upon excess charge which may cause explosion if enclosed in an airtight container.

(2) DO NOT place the batteries near open fire or near a device that may cause sparks (such as a switch or fuse). Since batteries may generate an inflammable gas when charged excessively that may ignite upon contact with a spark or they may burn or explode due to sparks or fire.

(3) Always charge the batteries using the specified matched charger and maintain the charge conditions recommended by NAPEL POWER. If the batteries are charged under conditions. hey may leak, gas, generate excessive heat, or explode.

(4) When using the batteries in medical equipment, incorporate a back-up system to avoid the main battery in the event of power failure.

(5) Insert insulation that is resistant to heat and sulfuric acid between the batteries and any metallic housing. Failure to do so may cause the batteries to smoke or burn in case of electrolyte leakage.

2) CAUTION

(1) DO NOT allow the batteries to be exposed to rain or sea water. If the battery terminals should get wet, they may corrode.

(2) DO NOT use or store the batteries in a car or under direct sunlight. To do so may cause the batteries to lead gas, generate excessive heat or explode.

(3) DO NOT placing batteries near a heat-generating device (e.g. a transformer) which may cause the batteries to generate excessive heat, leak or explode.

(4) Use of store the batteries in the temperature range specified below:
Discharge (operating an application): -15℃~50℃ Charge: 0℃ to 40℃ Storage: -15℃ to 40℃
Temperature above or below those recommended could result in damage or deformity or the batteries.

(5) If more than one battery is required, first connect the batteries together before connect the batteries to the charger or the load. Be careful to connect the (+) terminal of the batteries to the (+) terminal of either the charger or the load. Improperly connecting the batteries, charger, or load may cause an explosion or fire to occurring some cases, bodily injury may occur.

(6) When handling the batteries, wear steel-tipped shoes to prevent possible injury to the feet if the batteries are accidentally dropped.

3) REQUEST

(1) Dropping a battery may cause a strong physical shock that may damage the performance of the battery.

(2) Confirm the life of the batteries using the real load and charge. Differences in the charging and the discharging condition may cause a big difference in the life of the batteries.

5.3. PRECAUTION FOR INSTALLATION

1) WARNING

(1) DO NOT install the batteries in a room without proper ventilation. Excessive charging of the batteries may cause the batteries to generate inflammable gas resulting in an explosion or fire.

(2) Tools such as wrenches used to install the batteries should be insulated. The use of bare metal tools may cause short circuit accident to occur resulting in body injury, damage to the battery, explosion or fire.

(3) DO NOT use organic solvents, such as thinner, gasoline, lamp oil, benzene, acetone or liquid detergent to clean the batteries. The use of organic solvents may cause the ABS container to crack. Furthermore, avoid the use of Plastic or resin or unknown nature with the batteries. Cracked batteries, in the worst case scenario, may cause the batteries to catch fire. Need to make sure the use of material will not cause the containers and /or the covers (ABS resin) of the batteries to crack due to the migration of plasticizer within the material by asking the
manufacturer of the material if necessary.
*Examples for plastic or resin which should be avoided using: Vinyl chloride, Oily rubber.
*Examples for plastic or resin which is proper for the use: Polyolefin resin such as polypropylene, polyethylene.

(4) DO NOT install the batteries in areas where they may have a chance to come in contact with water. If the batteries come in contact with water, an electric shock or fire may occur.

(5) ALWAYS wear rubber gloves when handling batteries with voltages higher than 45 volts in order to prevent severe bodily injury from occurring.

2) CAUTION

(1) DO NOT carry the batteries by picking them up by their terminals or lead wires. To do so may irreversibly damage the batteries.

(2) During unpacking, handle the batteries carefully and check for cracks, breakage, or leakage. Failure to handle the batteries carefully may result in damage.

(3) DO NOT cover the batteries with plastic sheet as static electricity from the sheet may cause a fire or an explosion.

(4) DO NOT remove the insulating covers that come with the batteries until it is ready to connect.

(5) Always consider installing the batteries for easy checking, maintenance and replacement. The VRLA batteries are designed for use in almost any position, but avoid charging the batteries in the upside-down position. The charging of the batteries in the upside-down position may cause the batteries to leak.

(6) Shock and jolt to the batteries may result in damaging the batteries.

(7) Be aware all lead acid batteries are relatively heavy. Improper handling may cause bodily injury..

(8) for heavy battery, please using a lifter.

(9) Fasten the bolts and nuts with the torque accordingly. The biggest torque is 11.3Nm. Not to do so may cause the battery terminals to spark and/or break.

3) REQUEST

If at all possible, one should ask a certified technician or a person who is familiar with the batteries to install the batteries.

5.4 PREPARATION PRIOR TO OPERATION

1) WARNING

Always use well insulated connecting plates between the batteries and the load or charger, insufficient insulation may cause an electric shock also heat generating from a short circuit resulting in an injuring, burn, smoke or fire.

2) CAUTION

(1) DO NOT plug the batteries directly into the outlet or the cigarette receptacle of a car without inserting a proper charger between the batteries and the outlet or the receptacle. To do so may cause electrolyte leakage, heat Generation or explosion of the battery.

(2) Turn off the circuit switch when connecting the batteries to the charger/load.

(3) Always check for abnormalities, such as: rust on the terminals, cracks, or other external damages before using The batteries. Using a damaged battery may cause electrolyte leakage, heat generation or explosion.

3) REQUEST

It is normal for the batteries to lose part of their capacity due to self-discharge during shipment and storage. Full Capacity can be restored by recharging the batteries.

5.4.1. Unspecified Use

CAUTION

Do not place the batteries in an unspecified use or they may leak, generate heat or explode.

5.4.2.HANDLING

1) WARNING

(1) DO NOT short-circuit the positive and negative terminals of the batteries. Only insulated tools should be used. Be careful while using a metal tool such as a wrench on the batteries. Short-circuiting the battery's terminals may cause heat generation, and explosion or a fire.

(2) Never dispose of the batteries in a fire as it may cause them to explode or generate a toxic gas.

(3) DO NOT attempt to disassemble the batteries as it could cause leakage of sulfuric acid that could resulting in bodily injury.

2) CAUTION

(1) To prevent accidents from happening, change any battery that is found to have an abnormality such as a crack, a Deformity or leakage.

(2) It is a good practice to keep the batteries clean and free from dirt.

(3) In the event the batteries show any abnormality of the charge voltage or the discharge voltage replace the Batteries with new ones immediately.

(4) Charging the batteries with an inverse polarity connection between the batteries and the charger could cause Electrolyte leakage, heat generation or a fire.

(5) Avoid the use of the batteries of different capacities, type, made, and history of use (charge/ discharge operation). These differences could cause electrolyte leakage or heat generation.

(6) Do not subject the batteries to any strong physical shocks or jolts while moving them. Treating the batteries Roughly could cause leaks, heat generation or a explosions

(7) Do not charge the batteries beyond the amount of the time indicated in the specification. Stop charging the batteries when the charge indication lamp indicates a full charge. Over-charging the batteries can cause leakage, Heat generation or explosions.

(8) Do not allow young children to handle or to perform any battery operations, such as charging the battery.

(9) Keep the batteries out of the reach of small children at all times.

3) REQUEST

(1) The cut-off voltage during discharge should vary depending on the discharge current. Do not discharge the batteries lower than the recommended cut-off voltage as shown in the NAPEL POWER specifications or technical handbook. Recharging a battery which was once discharged below the recommended cut-off voltage may damage the batteries. Over-discharging a battery may impair performance. Always recharge the SEALED LEAD-ACID BATTERY batteries immediately after discharge even if the batteries were not discharged to the recommended cut-off voltage. Prolong leaving the batteries in a state of discharge cause the batteries to 'sulfate'.

Note: The cut-off device should be effectively cut off all discharge current including any weak current.

(2) Thoroughly study and understand the Charging Methods as recommended by the NAPEL POWER technical handbook and the conditions of the batteries before adopting other charge methods. The use of different charging may cause the batteries not to perform proper and for safety reasons.

(3) When the batteries are used in a cyclic application, it is important to charge the batteries for the proper amount Of time. A timer should be incorporated into the charging circuit that will disconnect the charging current to prevent overcharging.

(4) Avoid parallel charging of the batteries in cycle used. This may shorten the life of the batteries by causing an imbalance in the charge/discharge operation of the batteries.

(5) When charging the batteries in series, measure the total voltage of the batteries during trickle charge (or float charge), using a voltage meter with the accuracy of Class 0.5 (JIS). If the total voltage of the batteries deviates from the specified voltage range, be sure to investigate the cause. If the total voltage is lower than that Specified, the batteries may be under charged. However, prolong overcharging time keeping the total voltage higher than that specified, may cause the batteries to lose their capacity or more seriously may cause the batteries to 'thermal run-away' and other accidents.

(6) Always switch off the equipment after use. Over discharging the batteries will shorten battery life.

(7) Always store the batteries by disconnecting them from the equipment or charger to prevent over-discharge and Loss of capacity. Do not store the batteries in a highly humid place to prevent rusting or unnecessary oxidation of the terminals

6.INSPECTIONS AND MAINTENANCE

6.1. Preparation for VRLA Battery Periodic Inspections & Maintenance

For optimum reliability, it is recommended that the battery system be monitored quarterly. If the battery system incorporates an automatic monitoring system to gather the electrical and environmental data, the quarterly checks are limited to the evaluation of the recorded data and a visual inspection of the battery.

In general the types of inspections to be made during periodic maintenance include:

●Visual battery inspection ● Battery system capacity test ●Battery system voltage inspection ●Ambient temperature ●Individual battery float voltage inspection ●High rate load test ●Electrical resistance and tightness of inter-unit connections A test of the individual unit resistance, impedance or conductance, while optional, is also recommended on a periodic basis. This data and its trends can be a valuable aid in troubleshooting the system and predicting the need for a system capacity test.

Prior to starting the periodic maintenance activity assure that all the required maintenance tools and equipment is available and functional. Notify anyone who will be affected by the intended maintenance or troubleshooting activity. All units in the battery should be numbered so as to facilitate the recording and analysis of data unique to each unit.

6.2.Tools and Equipment Required for Inspections & Maintenance

At a minimum, the following tools and equipment are required to maintain and troubleshoot VRLA battery.

1. Digital voltmeter	2. Current clamp	3. Impedance tester
4. System load bank	5. Recorder	6. Insulated socket wrenches
7. Insulated box end wrenches	8. Torque wrench	9. Screw driver
10. Rubber gloves	11. Face shield or goggles	12. Portable eyewash
13. Fire extinguisher		

6.3.Quarterly VRLA Battery Inspection

The following inspection should be completed quarterly.

1. Assure the battery room is clean, free of debris and with proper lighting.
2. Assure that all facility safety equipment is available and functional.
3. Measure and record the air temperature within the battery room.
4. Visually inspect the battery for: (a).cleanliness (b).terminal damage or evidence of heating (c).container or cover damage
5. Measure the DC voltage from each polarity of the battery to ground and detect any ground faults.
6. Measure and record the individual unit DC float charging voltage, and current.
7. Measure and record the system equalization voltage, and current.
8. Measure and record the temperature of the battery cabinet inspections.

6.4.Semiannual VRLA Battery Inspection

The following inspection should be completed semiannually.

1. Repeat the quarterly inspection.
2. Randomly measure and record the resistance/conductance of the individual units to trend the condition of the individual units over time and to detect dramatic differences between individual units and the norm.

6.5. Annual VRLA Battery Inspection

The following inspection should be completed annually.

1. Repeat the semiannual inspection.
2. Re-torque all of the inter-unit connecting hardware. This can be omitted if the connection resistance is measured and found to have not increased more than 20% from the value recorded at installation.
3. The battery should be capacity tested every two years at the service load or at the battery rating related to the service requirements. Ideally, this will be the same rate at which it was acceptable when tests were run upon installation.

Note:

If more than 24 units of batteries, another form should be attached.

For multi-cell batteries, the voltage of each cell should be recorded.

Caution;

If problems are found in each process, corrections should be taken immediately,

1. Equalized charging

2. Contact our customer service staff for replacement of batteries.

Or else it will affect the capacity and life of the batteries.

6.6.Data Analysis and Corrective Actions

The data accumulated during the periodic maintenance activities should be recorded on a form. Following is an explanation of how the data would be interpreted and the corrective action to be taken. However, it must be recognized that this explanation is not all inclusive and the analysis and corrective decision must be made by personnel familiar with VRLA batteries and their operation and failure modes.

VRLA Battery Regular Maintenance Record

Type					Place				
Status					Number of battery				
Total voltage(V)					Current(A)				
Number	Voltage(V)				Number		Voltage(V)		
1	Cell-1	IR(MΩ)	Cell-2	IR(MΩ)	13	Cell-1	IR(MΩ)	Cell-2	IR(MΩ)
2					14				
3					15				
4					16				
5					17				
6					18				
7					19				
8					20				
9					21				
10					22				
11					23				
12					24				
Check by sight					Temperature				
Result									
Tester:					Date:				

6.7 MAINTENANCE

1) WARNING

(1) When cleaning the batteries, use a soft damp cloth. A dry cloth may cause static electricity that could result in a fire or explosion.

(2) Always replace the batteries with the new ones before the end of their useful life (50% state of their initial Discharge duration time) as determined in the specifications. As the batteries near the end of their life their discharge time will be shorten dramatically. Finally the batteries will lose their available capacity by either drying out their electrolyte (causing increase in their internal resistance) or an internal short-circuit. When that happens, if the batteries were to go on charging, thermal runaway and/or leakage of electrolyte may occur. Therefore, the batteries should be replaced before becoming in these states.

The expected life of the batteries (in trickle or float use) will decrease to half (50%) with each 10 ℃ rise in temperature above 25℃. In particular, the life of the batteries will be shortened remarkably at approximately 40℃ accordingly. Therefore, precautions are required to prevent using batteries in a high temperature environment.

2) CAUTION

Avoid using organic solvents such as thinner, gasoline, lamp oil or benzene and liquid detergent to clean the batteries. These substances may cause the battery containers to crack or leak.

3) REQUEST

Always make sure the battery terminals are clean to prevent the development of unnecessarily high resistance. High resistance will impair battery performance.

6.8 Treatment at Emergency

1) WARNING

The batteries have toxic liquid-dilute sulfuric acid solution in them. If the acid comes into contact with skin or Clothes, wash skin or cloth with lots of clean water to prevent scalding from occurring. If the acid should come Into contact with the eyes, consult a physician immediately to prevent possible loss of sight.

2) CAUTION

Check the batteries visually for any sign of irregularities in appearance. If any damage exists such as crack, Deformation, leakage of electrolyte, or corrosion, the batteries must be replaced with the new ones. Irregularities In the batteries could result in bodily injury, electrolyte leakage, excessive heat generation or explosion. Furthermore, make sure the batteries are clean and free from dirt and dust.

6.9 STORAGE

1)CAUTION

(1) Always Store the batteries in a safe place away from metal or other conductive materials.
(2) Always keep the batteries from water that could cause corrosion on the terminals of the batteries.
(3) Always keep the batteries right-side-up during transportation. Avoid letting rough handling of the batteries, e.g. strong shock and/or jolt. Moving the batteries in other than the up-right position may impair battery performance.
(4) When storing the batteries, be sure to remove them from the equipment or disconnect them from the charger and The load. Always store them at room temperature 20℃(68 F)-25℃(77 F) or lower temperature. DO NOT store the batteries under direct sunlight, higher temperature or high humidity. To do so will shorten battery life, impair performance, and terminal corrosion.

2) REQUEST

(1) Charge the batteries at least once every six months if they are stored at 25℃ (77 F). Use the charge Method as specified in 'Preparation Prior to Use - Recommendation'. The interval of this charge should be Reduced to 50% by each 10℃(18 F) rise in temperature above 25℃ (77 F).It is important to remember the self-discharge rate doubles for each 10℃ (18 F)rise in temperature. Avoid storing the batteries for a Long time in a discharged state for their capacity may not recover even after charge. If the batteries are stored For more than a year at room temperature, the life of the batteries may be shortened.
(2) To prevent the shortening the battery life always store the batteries in a fully charged state.
(3) Always rotate the stock of the batteries by the simple rule of thumb 'FIRST IN FIRST OUT'. For battery user put the battery into use as soon as possible after receiving them as they gradually deteriorate even under proper storage conditions.

6.10 DISPOSALS & RECYCLING

CAUTION

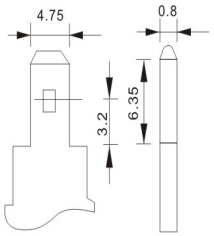
(1) Please write the information about battery recycling on the equipment, the package, the carton, the instruction Manual etc. in countries where legal or voluntary regulations on battery recycling are applicable.
(2) Design the equipment such that exchange and disposal of the batteries can be undertaken easily.
(3) Used batteries should be recycled. When returning used batteries, insulate their terminals using adhesive tape, Etc. Even used batteries still have electrical charge and an explosion or a fire may occur, if proper insulation is Not given on the terminals of the used batteries.

7.TROUBLESHOOTING

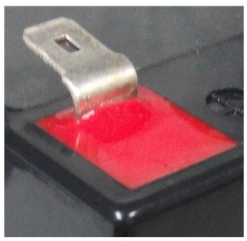
Check Category/symptom	Required tools	Possible cause	Possible end result	Remedial action
External	Visual, touch smell			
Plastic container distortion, Swelling and /or cracks	Visual	1 battery is over-charged 2.intemal short 3.poor grounding 4.gas buildup due to the continuous use of an expended battery 5.the combination of all of the above	1 .release of Hydrogen Sulfide-rotten egg smell 2.may cause battery to catch fire 3.loss of capacity 4.battery may explode causing equipment or bodily damage.	1 .replace the battery immediately. 2.perform voltage balance between batteries. 3.Correct all the possible causes.
Terminal corrosion	Visual	I .residual acid due to manufacturing 2.terminal leak	Increase terminal impedance causing terminal overheat and unexpected higher voltage drop	I .clean and retighten cable to terminal 2.replace battery if acid on terminal is due to internal leakage.
Rotten Egg smell (Hydrogen Sulfide-H2S)	Smell	Ditto	Thermal runaway.	Ditto
Overheated terminal	Touch	Loose screw on cable and terminal	Will damage terminal	Tighten screw or nut on cable and terminal

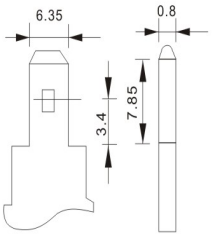
8.TERMINAL TYPE

Terminal Types(unit: mm)



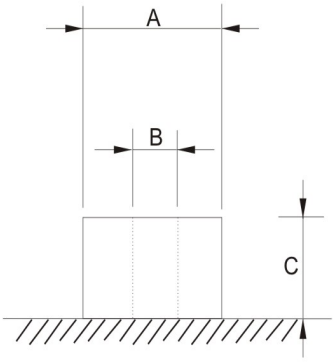
T1





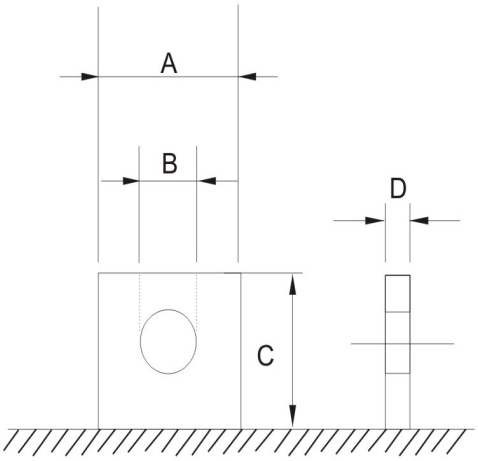
T2

Insert Terminal



Type	A	B	C	Material
T12	12	5	2	Cu
T14	14	6	4	Cu
T16	16	8	5	Cu
T16A	16	6	5	Cu
T18	18	8	5	Cu
T20	20	8	5	Cu

Flat Terminal



Type	A	B	C	D	Material
T3	12	6	12	2	Cu
T4	14	6	14	2	Cu
T5	16	7	17	8	Pb
T6	18	8	18	7	Pb
T7	18	7	20	8	Pb
T8	24	9	24	7	Pb
T9	26	9	25	8	Pb
T10	26	9	21	7	Pb
T21	20	6	18	3	Cu
T22	22	9	23	3	Cu
T25	25	9	23	3	Cu
T64	20	6	16	3	Cu