NLC Series

Deep Cycle Solar Battery

Technical Manual

Contents

Chapter I: Product Introduction

Product Characteristics

Advantages

- Design life: 15 years at 25℃
- EUROBAT Classification: Very long life
- More than 3000 cycles at 70% DOD
- Special negative active material formula, improve the charge acceptance ability, reduce the negative plate sulphation, more suitable for the partial state of charge (PSOC) application
- Modular design and installation, compact structure, saving the installation area and space, easy installation, convenient maintenance

Design features

Positive plates	Thick flat pasted plate with special high tin lead polybasic grid alloy
Negative plates	Flat pasted plate with lead-calcium-carbon grid alloy
Separators	Microporous super thin AGM separator
Container and Lid	High-strength & heat resistant ABS (option: available in Flame Retardant UL94 V0 version)
Posts sealing	Double sealing structure
Terminal posts	High-conductivity terminals with threaded inserts
Electrolyte	Absorbed low density sulfuric acid with special electrolyte additive
Vents	High-efficiency low pressure venting system
Plates suspension	Bottom supported
Inter-cell connectors	Insulated rigid copper
Terminal hardware	Stainless steel + Plastic cover

Main Applications

- Household energy storage system
- Solar and wind energy system
- Emergency system
- Other cycling systems

Standards

- IEC60896-21/22:2004
- BS6290-4
- Eurobat guide
- Installation compliant with EN50272-2

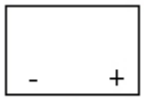
General Specifications

Table 1-1 General specification

Battery Type	Nominal Voltage (V)	Nominal Capacity (Ah,25℃)	Dimensions (mm)				Weight (kg)	Short Circuit Current (A)	Internal Resistance (mΩ,25℃)	Terminal Type	Terminal Layout
		C_{10} 1.80V/cell	Length	Width	Height	Total Height					
NLC12-50	12	50	350	165.5	175	175	25.5	1500	4.7	M6×Φ12	B
NLC12-100	12	100	345	172	275	282	45.0	2000	4.1	M8×Φ18	B

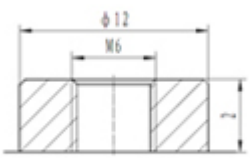
Note: Internal resistance is tested in battery fully charged state at 25℃±5℃ ambient temperature. The test equipment is HIOKI-3551 made by Hioki Jap

Terminal Layout

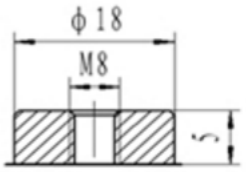


B

Terminal Type



M6×Φ12



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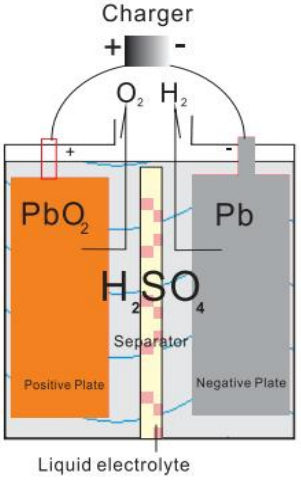
VRLA Technology

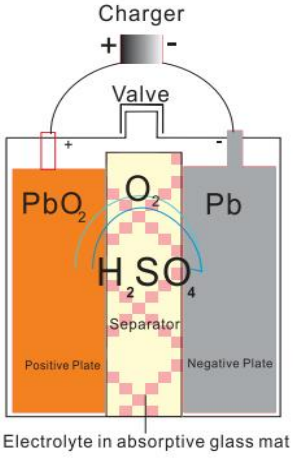
The electrochemical reaction of batteries in charge and discharge process is as follows:

$$PbO_2 + 2H_2SO_4 + Pb \underset{\text{Charge}}{\overset{\text{Discharge}}{\rightleftharpoons}} PbSO_4 + 2H_2O + PbSO_4$$

In the final stage of charge process, active substance in positive plate fully transformed to lead dioxide, negative plate has not reached fully charged stage, the process of active substance in negative plate transformed to spongy lead is not finished, oxygen gas generated in positive plate reaches the negative plate through separator pores and then reacts with active substance in negative plate, resulting depolarized state in negative plate, and restraining the generation of hydrogen.

Principle of the oxygen reduction cycle is as follows:



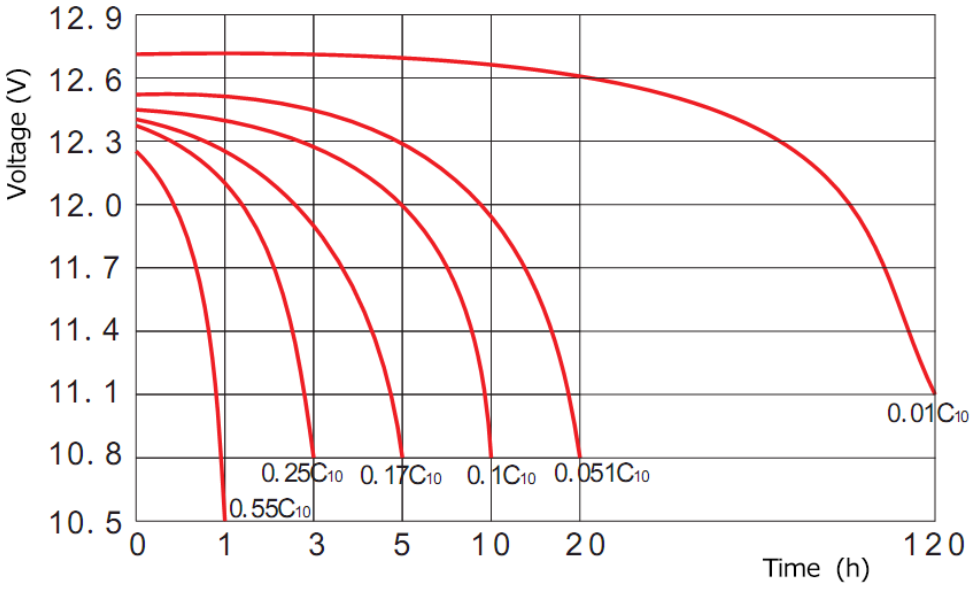


Chapter II: Electrical Characteristics

Discharge Characteristic Curve

The battery capacity is directly related to the discharge current, end voltage and discharge temperature. In general, the smaller discharge current, the lower end voltage, the higher temperature will cause larger discharge capacity. Figure 2-1 describes the discharge curves of NLC Series at different discharge rate at ambient temperature 25℃. Table 2-1 describes the end voltage at different discharge rate.

- Figure 2-1 Discharge characteristic curve under different discharge rates (25℃)



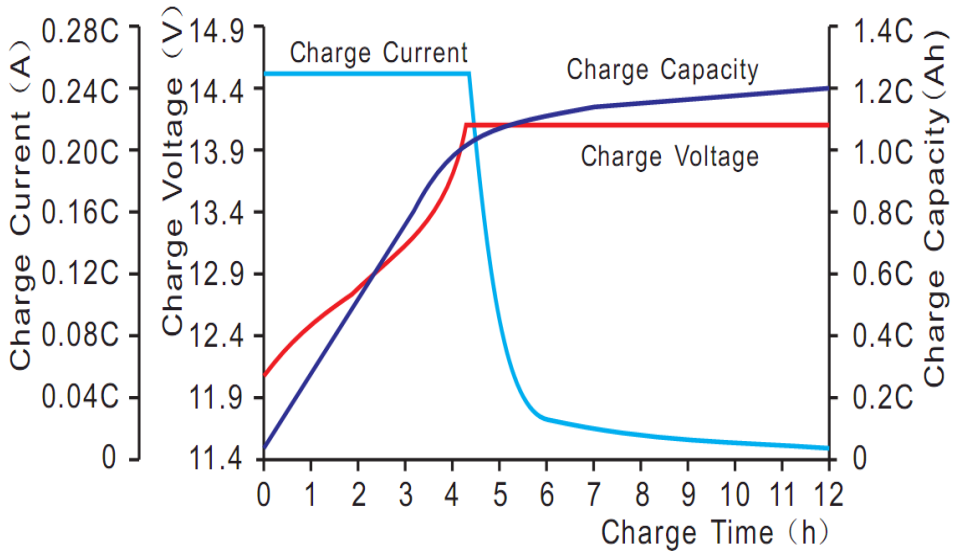
- Table 2-1 NLC Series Battery End Voltage at Different Discharge Rate (25℃)

Discharge Rate (A)	End Voltage (V)
$I \le 0.01C_{10}$	1.95
$0.01C_{10} < I \le 0.05C_{10}$	1.90
$0.05C_{10} < I \le 0.10C_{10}$	1.85
$0.10C_{10} < I \le 0.25C_{10}$	1.80
$0.25C_{10} < I \le 0.55C_{10}$	1.75
$0.55C_{10} < I \le 0.65C_{10}$	1.65

Charging Characteristic Curve

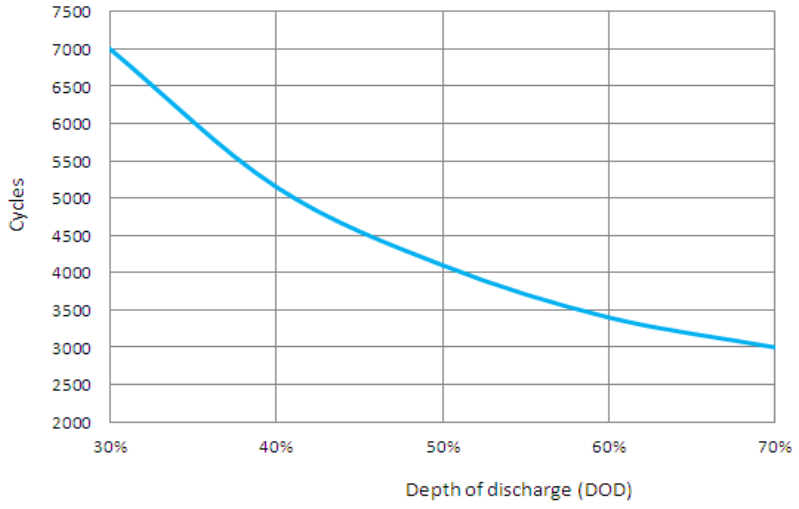
Figure 2-2 describes the battery charge characteristic curves with constant voltage of 2.35V / cell and limited current of 0.1C_{10} A. When charging the battery for 24 hours after fully discharged, the charge capacity can be as high as the 104% of the discharged capacity.

- Figure 2-2 Charge characteristic curve



Cycle Performance Curve

At different depth of discharge, the battery cycle life is different, in general, the more shallow depth of discharge, the longer cycle life; the deeper depth of discharge, the shorter cycle life.Figure 2-3 is the NLC battery cycle performance curve



Performance Data

Constant current discharge data

- Table 2-2 NLC Series Battery Constant Current Discharge Data Sheet (Amperes, 25 ℃)

Constant Current Discharge Data Sheet (25℃)-------Amperes(A)												
Battery Type	End Voltage (V/cell)	Discharge Time										
		1h	2h	3h	5h	8h	10 h	20 h	50 h	100 h	120 h	240 h
NLC12-50	1.70V	30.3	21.8	15.8	11.2	7.53	5.78	3.14	1.26	0.651	0.561	0.297
	1.75V	29.7	21.3	15.4	11.0	7.34	5.71	3.09	1.24	0.639	0.555	0.295
	1.80V	28.9	20.6	14.8	10.6	7.00	5.46	2.96	1.19	0.627	0.545	0.291
	1.85V	27.9	19.7	14.0	10.0	6.50	5.16	2.80	1.14	0.601	0.528	0.281
	1.90V	26.0	18.2	12.9	9.11	5.94	4.57	2.55	1.04	0.563	0.491	0.258
NLC12-100	1.70V	56.6	41.6	27.2	18.4	14.0	10.6	6.28	2.52	1.302	1.122	0.594
	1.75V	55.0	40.6	26.4	18.0	13.7	10.5	6.18	2.48	1.278	1.110	0.590
	1.80V	53.8	39.2	25.0	17.0	13.0	10.0	5.92	2.38	1.254	1.090	0.582
	1.85V	52.0	37.4	24.0	16.0	12.0	9.60	5.60	2.28	1.200	1.056	0.562
	1.90V	48.0	34.4	21.8	14.4	10.9	8.72	5.10	2.08	1.126	0.982	0.516

Constant power discharge data

- Table 2-3 NLC Series Battery Constant Power Discharge Data Sheet (W/cell, 25℃)

Constant Power Discharge Data Sheet (25℃)-------Watt (W)												
Battery Type	End Voltage (V/cell)	Discharge Time										
		1h	2h	3h	5h	8h	10 h	20 h	50 h	100 h	120 h	240 h
NLC12-50	1.70V	54.7	39.4	28.5	20.3	14.0	10.7	5.82	2.37	1.26	1.10	0.587
	1.75V	54.0	38.9	28.1	20.0	13.8	10.6	5.76	2.34	1.24	1.09	0.583
	1.80V	53.1	38.1	27.5	19.6	13.5	10.4	5.66	2.29	1.22	1.07	0.574
	1.85V	51.9	37.0	26.8	19.1	12.9	10.0	5.48	2.23	1.17	1.04	0.556
	1.90V	50.0	35.2	25.0	17.8	12.0	8.98	5.02	2.04	1.11	0.969	0.511
NLC12-100	1.70V	102.2	75.2	49.1	33.4	26.1	19.6	11.6	4.74	2.52	2.20	1.174
	1.75V	100.0	74.1	48.2	32.7	25.7	19.5	11.5	4.68	2.48	2.18	1.166
	1.80V	98.9	72.5	46.5	31.4	25.1	19.0	11.3	4.58	2.44	2.14	1.148
	1.85V	96.7	70.2	45.9	30.6	23.8	18.6	11.0	4.46	2.34	2.08	1.112
	1.90V	92.3	66.5	42.2	28.1	22.0	17.1	10.0	4.08	2.22	1.94	1.022

Chapter III: Operation and Maintenance

Safety Instructions

Please read these instructions carefully in order to ensure correct, safe and effective operation. This manual provides you very important guidance for installation and operation, which will guarantee your equipment with optimal performance and longer service life.

- For your safety, please do not open the batteries;
- As batteries contain lead which can potentially be harmful to the environment and health, and as batteries are connected to electricity, they must be installed, maintained and replaced by skilled personnel only.
- Used batteries must be recycled and disposed properly as improper disposal of batteries is harmful to the environment and health. Used batteries shall be properly disposed following relative regulations and laws.
- It is strictly forbidden to mix batteries with different specifications, manufacturers and capacities.
- All installations must comply with the safety regulations and norms. Read through our Operation Guide / Safety Instructions before starting any installation work.

Notices

				
Warning	Electrical shock	Protective eyewear and clothing required	Keep children away from the batteries	No short circuit
				
No flames and sparks	Recycle	Proper disposal	Read instructions	Electrolyte is highly corrosive

Operation Parameters

Floating/equalizing charge voltage

- Floating (25℃): 2.25V/cell
- Equalizing (25℃): 2.40V/cell
- Temperature compensation coefficient: -3.5mV/cell/℃

Charge current-limiting valve: charge current-limiting valve range is $0.1C_{10}$-$0.4C_{10}$

According to the grid condition of the BTS, we divided the grid conditions into five types, see the table 3-1 below:

Table 3-1 Grid conditions definition

Type I: Total power failure time per month <10 hours
Type II: Total power failure time per week <10 hours
Type III: Power failure time every day ≥2hours, but <4 hours
Type IV: Power failure time every day ≥4hours, but <8 hours
Type V: (Including no grid): Power failure time every day ≥8hours

For the Type I and Type II, the charge current-limiting value is $0.10C_{10}$, for Type III and Type IV, the charge current-limiting value is $0.2C_{10}$ and the maximum charge current shall not exceed $0.4C_{10}$, in case the grid condition is type V, contact our technical team for assistance.

Vertical Installation

To prevent acid stratification (electrolyte layering due to gravity), it is recommended to install the battery vertically to make sure battery system with longest service life and cycle performance.

Warning:
Fail to comply will void warranty.

Factors Influencing Capacity

Quantity of electricity battery discharge under certain condition is called battery capacity, symbol is “C”, normal unit is Ampere Hour, in short is Ah. Usually discharge rate is indicated through the suffix of “C”, such as C10 means capacity at 10 hours discharge rate. C3 means capacity at 3 hours discharge rate.

Battery capacity consists both of nominal capacity and actual capacity, for nominal capacities of the FTC series battery please refer to Table 1-1. Actual capacity is the real quantity of electricity battery discharge under certain condition, it equals to discharge current multiplied by discharge time, the unit is Ah.

Battery capacity is directly related to discharge current, end voltage and discharge temperature. In general, the smaller discharge current, the lower end voltage, the higher temperature will cause larger discharge capacity.

Temperature Effect On Battery Capacity

Figure 3-1 describes temperature effect on battery capacity (C_{10}). For example, if temperature falls from 25℃ to 0℃, battery capacity will be 85% of the nominal capacity, low temperature will cause long term charge shortage, negative plate will be irreversibly sulfated and as a result the battery cannot be used normally. If discharge temperature is not 25℃, the capacity can be converted to $C_{25℃}$ according to the following formula.

$$C_{25℃} = \frac{C_T}{1 + k\ (T - 25)}$$

In the formula:

T---Discharge temperature

C_T---Capacity at temperature of T

k---Temperature coefficient;

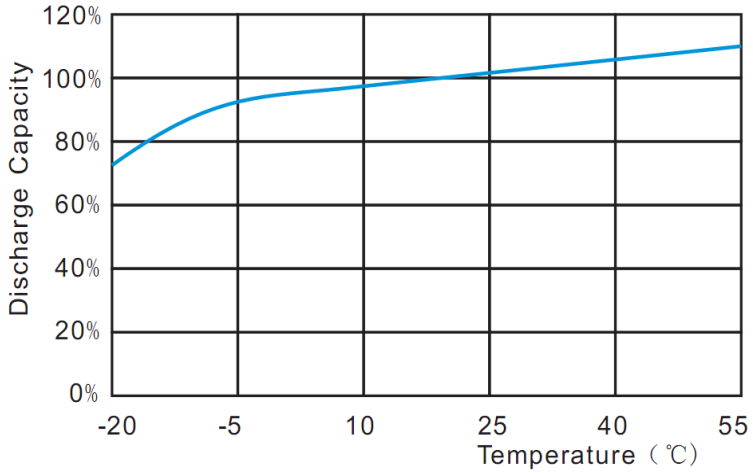
k=0.006/℃ at C10 discharge;

k=0.008/℃ at C3 discharge;

k=0.01/℃ at C1 discharge.

As temperature rises, battery capacity will increase to a certain point. For example, if temperature rises from 25℃ to 35℃, capacity will be approximately 105% of the nominal capacity. From 35℃ to 45℃, the capacity increase is very low and if temperature rises beyond 45℃, there is no increase in battery capacity.

- Figure 3-1 NLC series temperature effect on battery capacity curve



Temperature and Floating/Equalizing Charge Voltage

Choose suitable floating charge voltage for reaching perfect service life and Nominal capacity. If floating charge voltage is too high, floating current will be high accordingly, that will speed up plate corrosion and battery water loss, thus shortening battery service life. If floating charge voltage is too low, battery can't be kept in fully charged state, irreversible sulfation will be caused easily and capacity will be reduced accordingly, thus shortening battery service life as well.

In a floating charge application, charge voltage should be adjusted according to the ambient temperature, using temperature compensation coefficient -3.5mV/℃/cell. The same way is used to adjust equalizing charge voltage.

After the temperature compensation, the floating charge voltage range is 2.20-2.28V, the equalizing charge voltage range is 2.35-2.50V. When battery float/equalizing charge voltage according to the temperature compensation coefficient calculated values over the range, according to the corresponding upper limit or lower limit setting

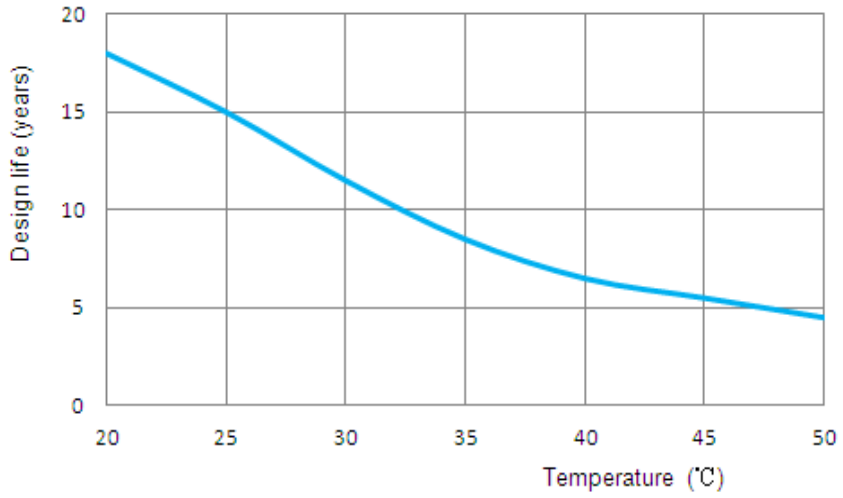
Temperature Effect on Battery Design Life

Temperature range of the NLC series is -20℃~+75℃. The battery can be used in 15℃~40 ℃ environment for a long time. Corrective measures should be taken in case the temperature deviates from the optimum temperature range. If the room / cabinet temperature is too high, take

cooling, ventilation and other measures to improve the environment temperature. If it is too low, take corrective measures for heating. At the same time and according to the manufacturer's requirements, use temperature compensation for the floating/equalizing charge voltage.

Higher temperature will speed up the battery grid corrosion and water loss, thus greatly shorten the battery life. The battery floating design life and temperature curve are shown in Figure 3-2.

- Figure 3-2 NLC series temperature effect on battery design life curve



Storage

Storage Interval:

- Battery should be stored in fully charged state. It is strictly prohibited to storage after discharge.
- Battery storage location must be away from heat, sparks and smoke.
- Battery must be stored in an upright position, avoiding impacts of external force or abrupt loads. Safety valve should be tightened.
- It is strictly prohibited to stack battery without properly protective packaging.
- Battery can be stored in -20～45℃ environment.

Storage temperature	Maximum storage times / Freshening charge intervals	Recommended freshening charge method
-20～25℃	Every 6 months	Using constant current 0.1C_{10}A～0.2C_{10}A to charge battery bank till battery average voltage rises to equalizing charge voltage, then switch to constant voltage charging. Charging time is generally 16~24h.
26～35℃	Every 3 months	
36～45℃	Every 2 months	

Maximum storage time (Shelf life) is 18 months (25℃).

- Battery must be stored in a dry, ventilated and clean environment.
- Protect the battery from harsh weather, moisture, flooding, direct or indirect sun radiation, organic solvents, corrosive substances and gas.

Maintenance

1. Cleaning Notes:

- Battery appearance, terminal area and working environment must be kept clean and dry.
- In battery cleaning process, avoid use of electrostatic cleaning tools.
- Clean the battery with damp cloth. Do not use of gasoline, alcohol or other organic solvents; also do not use cloth containing these substances.

2. Inspection and Maintenance

VRLA batteries are not maintenance-free batteries, battery operation process gradually changes with time. In order to ensure good battery usage, operational management and control are very important. To understand the operation status of batteries and equipment and to prevent accidental damage, regular maintenance is required. Periodically check and record the measurements using the following method for batteries used in UPS system room and base station (including outdoor station) site.

2.1 Monthly Maintenance Inspection Items

Item	Content	Standard	Maintenance
1-Temperature Detection	1-Measure and record battery terminal and container temperature by using infrared thermometer. 2-Use infrared thermometer to measure ambient temperature.	1-Ambient Temp: -20℃~+45℃ 2-Recommended Temperature: 25±5℃	1-Check that the battery temperature compensation functions are turned on and that the battery temperature probe is properly installed. 2-Check that the room temperature conditioning equipment such as air-conditioning is turned on.
2- Battery Float Voltage Measurement	Measure floating voltage on positive and negative terminal of the battery group with multimeter.	Measurement and control module display operating voltage differences within 0.05V	If the monitoring module shows inconsistency even after adjusting, replace or repair it.
3-Battery Appearance	Inspect the battery container for bulging, leakage and damage.	Normal Appearance	Confirm the reason for any abnormal appearance, if it affects normal use, replace the battery.

	Check for dirt stains	Clean Appearance	Clean dust and dirt with damp cloth
	Inspect the connection cables, terminals, etc. for oxidation, rust & other abnormalities	No oxidation, rust	If you find oxidation or rust, replace the connecting wire, and swab terminal with Vaseline etc.

Item	Content	Standard	Maintenance
4- Joints	Use hex or torque wrench to tighten loose bolts.	Securely connected	If found bolt loosened, tighten it
	1-Battery cables, terminals clean / non-corrosive. 2- Follow the installation sequence: 1. Spring washers 2. Flat washers 3, Nuts	No evidence of corrosion	If slight corrosion found after connecting bar removed, clean it with cloth. If severe corrosion, replace the connection bar and clean terminal with sandpaper after tightening.
5-Safety Valve Testing	Inspect for white crystalline or liquid surrounding the safety valve.	No crystalline or liquid surrounding the safety valve	1-For crystalline, use a dry cloth for cleaning. 2-If there is crystalline or liquid, clean it with a dry cloth. Check and tighten the safety valve

2.2 Quarterly Maintenance Inspection Items

In addition to the monthly maintenance items above, inspect the following items:

Item	Content	Standard	Maintenance
1- Measurement of each battery's floating voltage	Measure each battery's floating voltage by using multimeter.	Battery floating voltage differential pressure must meet the following values: 2V series 90 mV 6V series 240 mV 12V series 480 mV	If there are deviations from the reference values, first discharge the battery group and then equalizing charge. After equalizing charge is completed, change to float charge and run for two months. If there are still deviations from the reference values, replace and recycle the battery.
2-Use the equalizing charge to recover the batteries which have either lower capacity or discharge voltage than the other batteries.	Use the equalizing charge to charge the battery 10 hours or more. In case a battery has a severe deviation compared to other batteries, perform charge / discharge cycles three times.	Single battery discharge voltage in the battery group must meet the following values: 2V: 200mV, 6V: 350mV 12V: 600mV	If the battery performance cannot be recovered, it must be replaced.

2.3 Annual Maintenance Inspection Items

In addition to the quarterly maintenance items above, inspect the following items:

Item	Content	Standard	Maintenance
1- Discharge test	Disconnect the AC, take load discharge or discharge online method to check that discharge capacity is minimum 30%-40% of nominal capacity	At the end of discharge, battery voltage should be more than 1.90V/cell, differential pressure must meet the following values: 2V series 200mV 6V series 350mV 12V series 600mV	If the battery voltage is lower than a voltage reference value or the differential pressure is greater than the reference value, discharge the battery, then equalizing charge, then change to float charge and run for 1-2 months. If reference values still exceeded, contact our technical team for assistance.
2- Capacity Test	Use on-line or off-line intelligent discharge device for discharging batteries until the end voltage has reached 1.80V / cell	In back-up use the capacity to be maintained must be more than 80% and in energy storage use more than 60% of the reference capacity	Recovery test: measure and record various parameters specified in the monthly / quarterly maintenance items as well each battery's end voltage during the discharge test. If the battery performance cannot be recovered, replace and re-cycle the battery.
3-Measure and verify the controller parameters	1-Measure the limited charging current values. 2-Check that the equalizing charge starts and ends automatically. 3- Verify the automatic start of battery discharge protection.	Actual operation parameters to meet with the set parameters	In case power equipment and/or controller fails, arrange repair in a due course to ensure correct battery performance and avoidance of reduced battery lifetime.

Maintenance notes

- Operate and store batteries only in an upright position.
- Ensure that the battery installation complies with the design requirements and installation documents.
- Please use only insulated tools during operation and maintenance, any metal objects to be put on top of the battery is strictly prohibited.