VALVE REGULATED SEALED LEAD ACID BATTERY

Intensive Cyclic Service

ICS series

Front Terminal Battery

OPERATION MANUAL

Version：V1.1

NARADA POWER SOURCE CO., LTD

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Chapter 1 Safety Precautions

Please read the operating instructions and safety precautions to avoid accidents before you operate batteries.

"Care, Caution, Warning, Danger" notification in Products and User Manual does not mean all the safety precautions to be observed, only as a supplement to safety precautions . Therefore, the operator install and operate Narada Power Source Co., Ltd.(Narada) product must be trained personnel and master the correct operating system and all the safety precautions. During operation Narada's product/ equipment, operator must comply with the safety rules in the industry, and strict compliance Narada related product/equipment safety precautions and special instructions.

1.1 High-voltage

Prohibit short-circuit the battery terminals, a short circuit may cause the batteries burning, and may cause casualties or explosion hazard.

Even without charging state, the high voltage may be present between the positive and negative terminals of the battery. Do not connect the battery positive terminal directly with any conductors, and tools such as wrenches must be insulated covered before operation.

1.2 Harmful gases

Emission of harmful gases from battery may occur during the charging process or abnormal operating conditions, such as rectifier failure or high temperature.

Prohibits the battery installed in an enclosed environment;
Prohibits place the battery near the fire;
Prohibits place the battery near flammable materials (such as a switch or fuse).
Prohibit put the battery in a fire.
Prohibit removal battery safety valve arbitrarily.
Use safety goggles when operating batteries.

1.3 Acidic electrolytes

Battery contains sulfuric acid which has a strong corrosive effect to metal and skin.
Rubber gloves and apron must be used during operation of the battery in case of the

electrolyte spill.

Incorrect operation may cause dangerous. Operation battery must be strictly and carefully to prevent a short circuit or battery electrolyte spill. Spilled electrolytes will corrode metal objects and circuit boards, may resulting in equipment damage and short circuit board.

Be care of following matter for safety before the install and operate battery.

- Take off watches, bracelets, rings and containing metal objects ect.
- Use special insulated tools.
- Use goggle and preventive measures.
- Use rubber gloves, wear apron to prevent electrolyte spill.
- Keep terminal upward during transport, prohibit upside down

1.4 Toxic Substances

Battery contains sulfuric acid, lead etc. toxic substances.

Wash your hands after the operation battery.

Disposal used battery in accordance with local environmental rules

1.5 Transportation

Be careful during transportation and prevent severe vibration or impact for heavy lead acid battery.

Place the batteries upright during transport.

If the battery is dropped, the battery case may break and cause electrolyte leakage.

If the battery rupture due to improper operation. Wash cloths with water immediately if electrolyte spilled on clothing. If splashed in the eyes, rinse with plenty of water and taken to hospital immediately.

Please take care of the following marks:

					
Warning	Electricity danger	Protecting your eye	Watch Short-circuits	With adults custody	Do not put batteries into dustbin
					
Read the manual	Fire forbidden	Circle used			

Chapter 2 ICS series product introduction

Narada's ICS series battery designed to provide high cycling and fast charge performance, idea for telecom service where power supply is unstable. With innovative structure design, high quality manufacturing and high quality material, ICS batteries are also capable of PSoC, hybrid, renewable energy storage application and other cycling/standby applications.

2.1 Features and Benefits

a) Extra high cycling and fast charge performance
b) Designed for intensive cycle service where unstable grid power supply or no-grid, such as Telecom BTS, hybrid genset, renewable energy storage application
c) Suit for 19" or 23" and ETSI power racks/cabinets with front terminal
d) 12 year design float life at 25℃
e) Wide operating temperature range -40℃ to +50℃
f) Superb security and reliability, more cost effective than nearest equivalent
g) True front-terminal design
-Not requiring any additional space between the top of the battery and the next shelf
-Easy paralleling of 48V strings (on 2 or more shelves) or 2x24V strings on one shelf via cost-effective flexible cables running along front surface
-With rotational symmetry not requiring expensive and long cables when long strings are assembled on multiple
h) Easy installation and verification of gas collection tubing via twin front-access gas nipples also with easy connection over several shelves
i) Fold-away handles for easy installation and removal from shelves
j) Bar code tracking system to facilitate battery management.

2.2 Main applications

- Telecom exchange and transmission system
- Renewable energy source such as solar and wind power
- Power plant and power transformer system
- Navigation aid signaling system
- Radio and broadcasting station
- Emergency lighting system
- Other standby, cyclic system

2.3 Configuration

Fig 1-1 Configuration

2.4 Types and Dimensions

Table 1-1 Type specifications

Type	Nominal voltage (V)	Rated capacity (Ah)	Dimensions (mm)				Weight (kg)
		C_{10}	Length	Width	Height	Total Height	
ICS12V100	12	100	390	108	287	287	35
ICS12V150	12	150	546	125	310	310	55

Chapter 3 Installation and Operation

3.1 Operation environment

3.1.1 Operation temperature range

Table 3-1 ICS series Operation temperature rage

	Temperature range	Note
Recommended temperature	15℃ to 25℃	⚠ Battery not permitted to operate at ultimate temperature for long period. Operate at high temperature for long time, battery life will reduce. Suggest operating battery at recommended temperature as possible.
Allow temperature	-40℃ to 50℃	

Notice:

- Avoid heat and direct sunlight place
- Avoid near water or in a wet or damp place
- Avoid completely sealed space

3.1.2 Ventilation

Battery room or cabinet must be ventilation. Ordinary indoor environment do not need to take special measures to ventilation. Battery ventilation requirements for 12.5L/2V100AH/h according to EN 50272-2 standard.

If charge battery with equalization voltage, ventilation requirement should be as five times as float charge.

3.1.2 Temperature

ICS series are high cyclic VRLA batteries, suit for operating at 25℃ for long period.

Battery must be installed in shade and dry environment, avoid heat and sun and humidity is less than 90%.

3.2 Battery operation conditions

- Parallel connection: recommended no more than four banks.
- Multilayer installation: the temperature difference between layer is controlled within 3℃.
- Cooling conditions: space between battery no less than 10mm
- Ventilation conditions: ensure hydrogen concentration is less than 0.8%
- Battery mixed use: new and old battery, different brand battery do not allow mixed use
- Float use: limit current ≤0.25C_{10}A, float voltage 2.25V/cell at 25℃
- Cycle use: limit current ≤0.25C_{10}A, charge voltage 2.35V/cell
- Recommend temperature: 15℃ to 25℃, allow temperature: -40℃ to 50℃

3.3 Storage conditions

3.3.1 Storage temperature range: -20℃ to 40℃

3.3.2 Storage battery should be fully charged. Recharge battery before use for self-discharge during storage and transport.

3.3.3 Recharge battery during long-term storage for self-discharge. ICS series have shelf life of 6 months when stored at 25°C then recharge is required. Higher temperatures increase the rate of self discharge and reduce storage life.
Recharge program (optional): Charge with 0.25C_{10}A and 2.35V/cell for 24h.

Table 3-2 Storage temperature vs recharge period

Storage temperature	Recharge period	Recharge program
25℃ and below	Once every 6 months	Charge with 0.25C_{10}A and 2.35V/cell for 24h
25～30℃	Once every 4 months	
30～35℃	Once every 3 months	
35～40℃	Once every 2 months	

Please avoid store battery above 40℃, otherwise affect battery life greatly.

3.3.4 Storage battery in dry, cool and ventilated environments.

3.3.5 Battery performance degradation after long-term storage, Please shorten shelf time as possible as you can.

3.4 Battery installation

3.4.1 Open-package inspection

- Inspection: Battery appearance—no damage
- Check: parts—complete
- Read: Installation drawing, safety cautions

3.4.2 Installation safety cautions

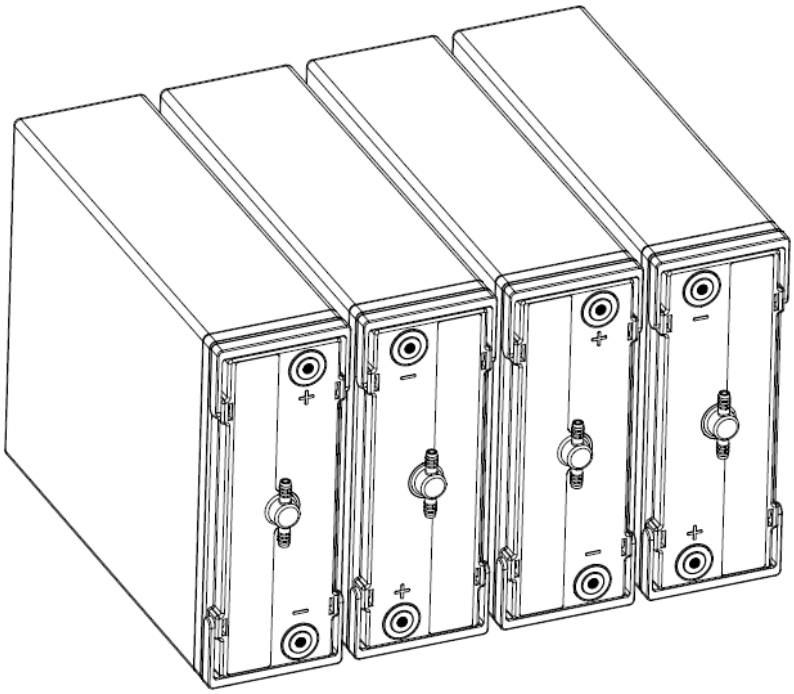
1) Fix battery, avoid vibration and shock
2) Do not put battery place where spark may be occurred (such as switch, fuse etc.) in case of hydrogen emission during charge
3) Do put battery in a sealed place or easy accumulation gas place
4) If need put battery into equipment, recommend put battery bottom of equipment to avoid temperature rise. Avoid battery contact inner wall of equipment
5) Do not put battery close to hot objects (such as transformers etc.)
6) Terminal hardware torque should be 10 to 12Nm

3.4.3 Install and connect battery

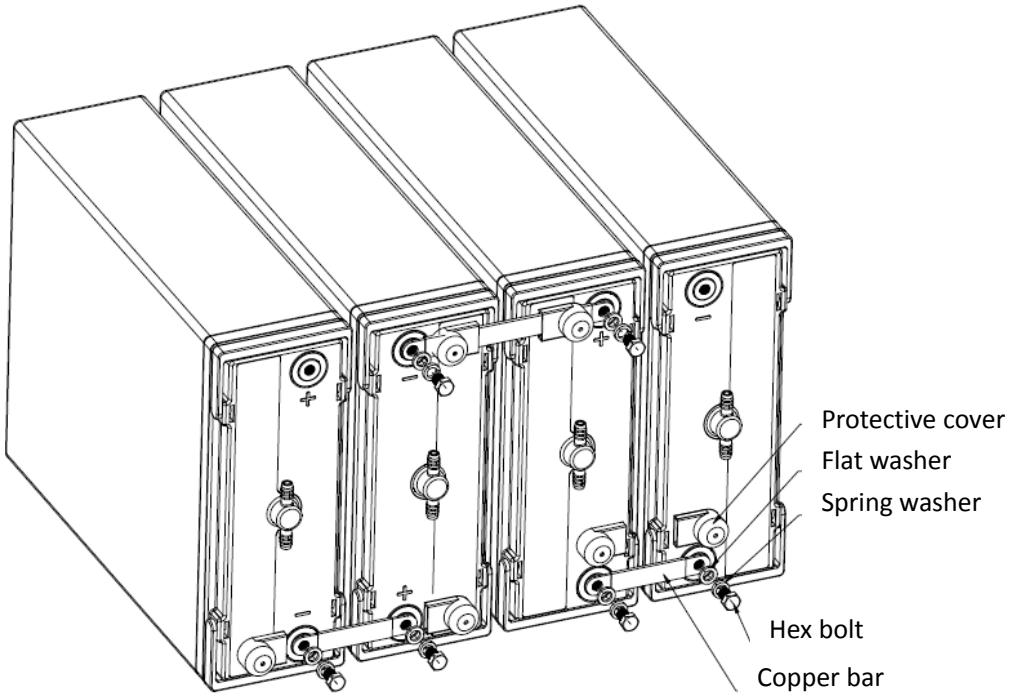
3.4.3.1 Insulating treatment metal installation tools (e.g. wrench) with insulating tape before installation.

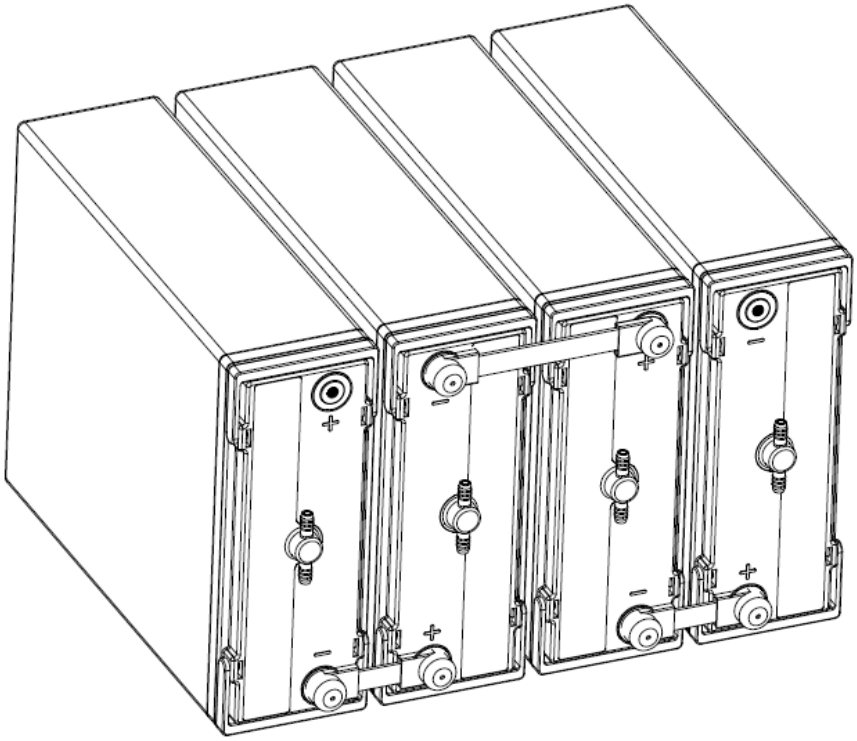
3.4.3.2 Connect batteries first, then connect battery bank to charger or load.

Step 1 Place battery side by side, keep space 10mm, shown as follow drawing

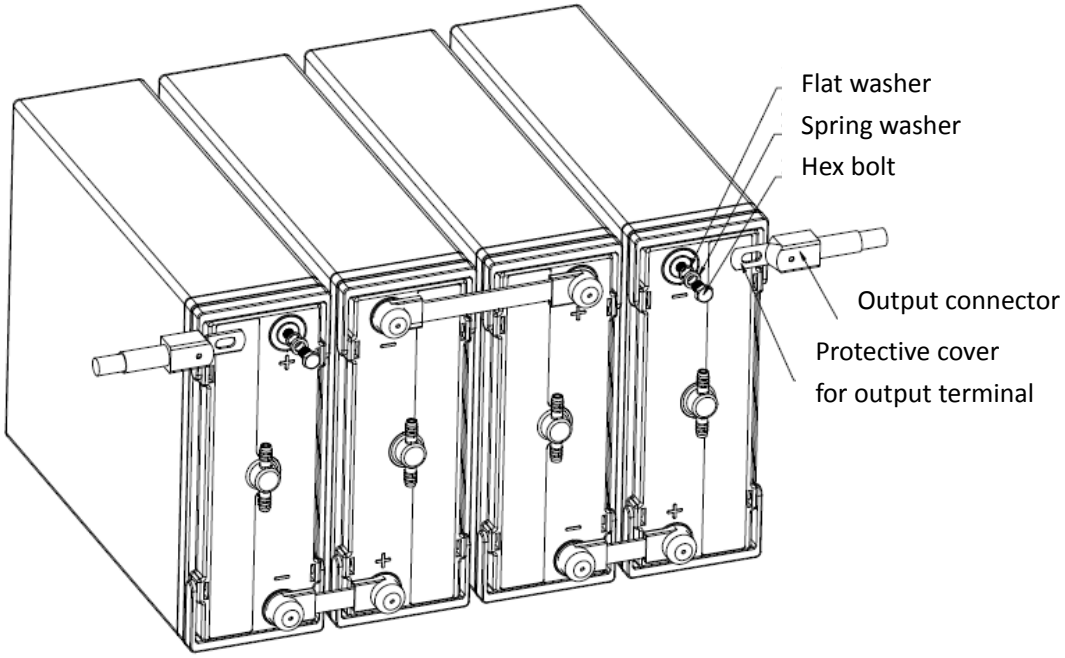


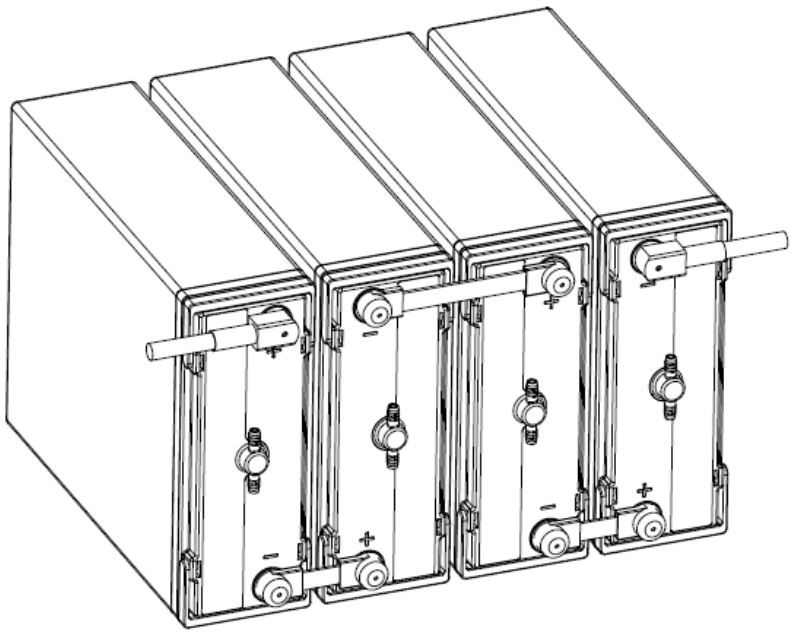
Step 2 Connect batteries with copper bar, hex bolts, flat washer and spring washer, and place protective cover to appropriate place, shown as follow drawing,





Step 3 Connect battery with output connector with hex bolts, flat washer and spring washer, move protective cover to appropriate place, shown as follow drawing,

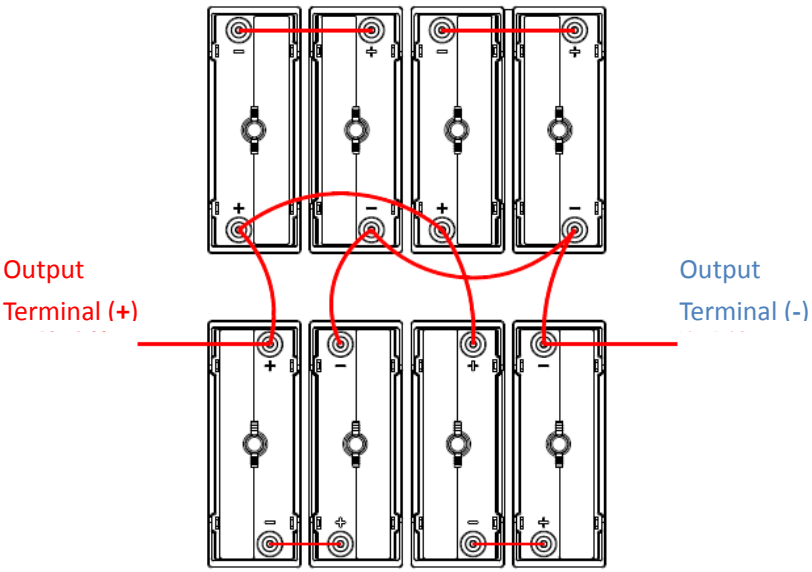




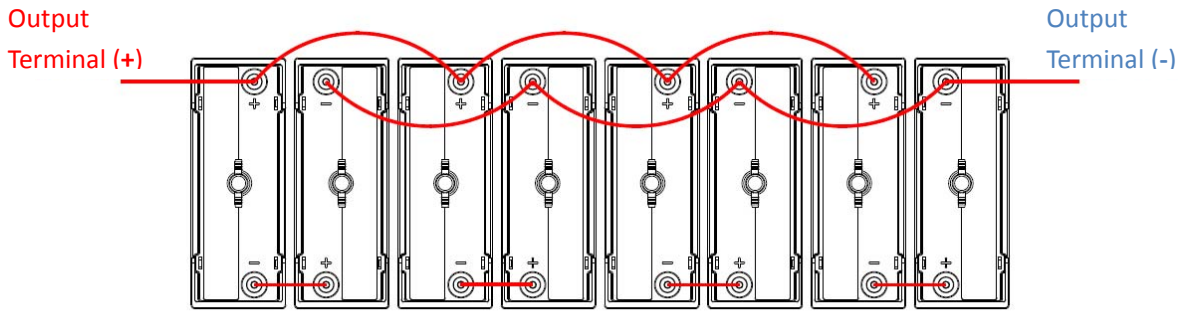
3.4.3.3 First series connection then parallel connection when multiple bank in parallel. Keep at least 10mm spaces for each layer to ensure better cooling condition.

3.4.3.4 Recommended connect mode:

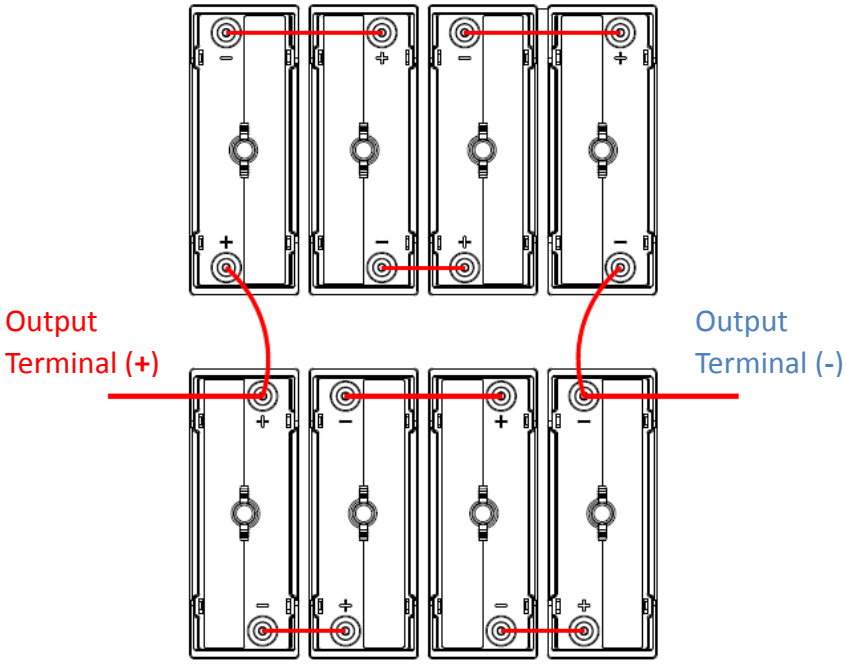
a) 24V system 2 layers 8 blocks (2 series 4 parallel). Series connection first, then parallel connection installation diagram



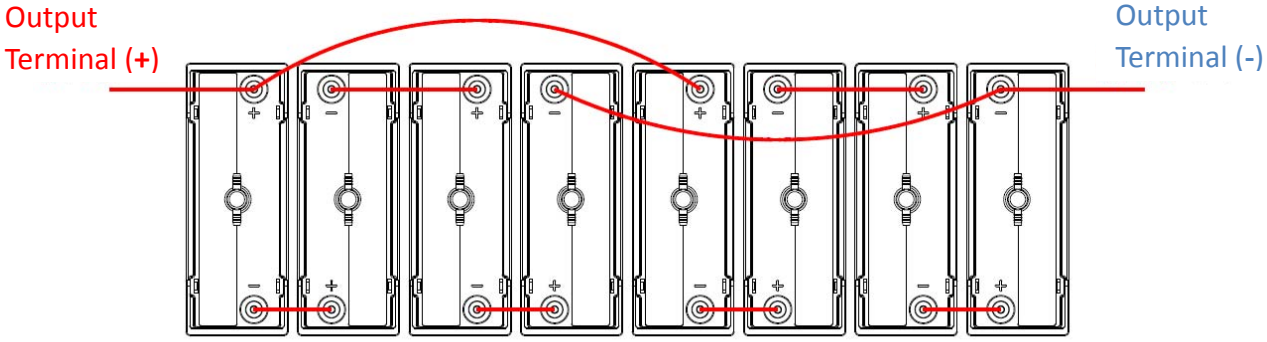
b) 24V system 1 layer 8 blocks (2 series 4 parallel). Series connection first, then parallel connection installation diagram



c) 48V system 2 layers 8 blocks (4 series 2 parallel). Series connection first, then parallel connection installation diagram

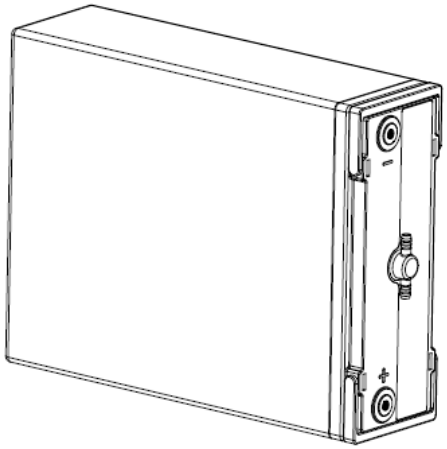


d) 48V system 1 layer 8 blocks (4 series 2 parallel). Series connection first, then parallel connection installation diagram

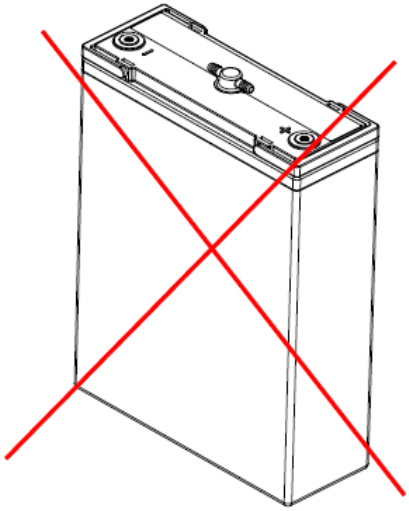


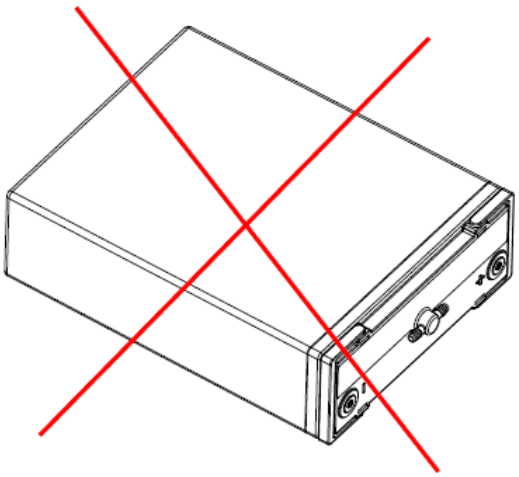
3.4.3.5 Battery installation orientation:

a) Right orientation



b) Wrong orientation





3.4.3.6 Spread appropriate antirust on surface of battery pole before and after installation.

3.4.3.7 Electrify battery bank after measure total voltage correctly.

3.5 Charge

3.5.1 Float charge parameter

Float voltage: 2.25V/cell (25℃)

Charge current: ≦0.25C_{10}A

Temperature compensation coefficient: -3mV/℃/cell

Note 1：

Float voltage may be inconsistent during initial period, float voltage will be consistent after six months

3.5.2 Equalization charge parameter

Equalization voltage: 2.35V/cell
Charge current: ≦0.25C_{10}A
Temperature compensation coefficient: -5mV/℃/cell

Note 2：

Normal float charge is not need equalization charge.
Do equalization charge as one of following conditions:
1) Discharge capacity more than 20% rated capacity.
2) Storage period 6 months max., 3 months is better.
3) Float charge for 3 to 6 months or cell voltage drop in bank.
4) Before capacity test.

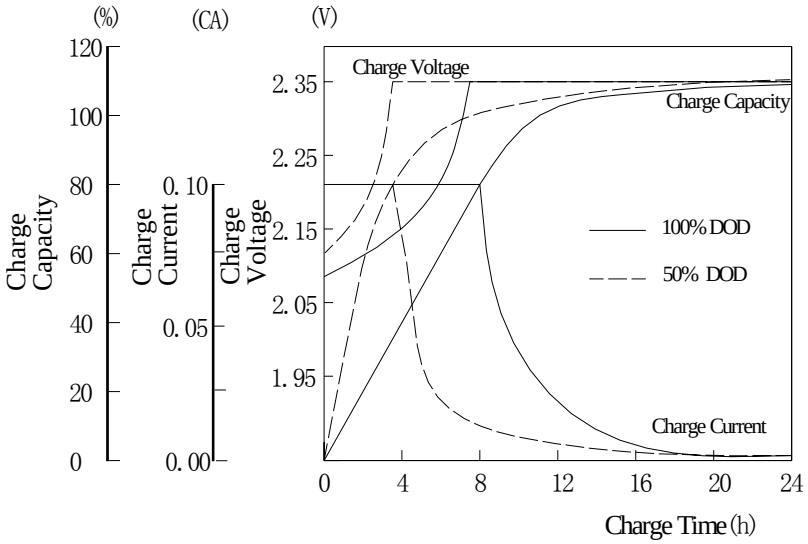
3.5.3 Setting charge capacity 105%-110% of discharge capacity. If temperature is below 5℃, Setting charge capacity 110% ~120% of discharge capacity.

3.5.4 Lower temperature (below 5℃), longer charge time. It is easy over-charge at high temperature. Charge at recommended temperature is better.

3.5.5 To avoid overcharge, control charge time or setting change to float charge mode automatically.

3.5.6 Charge Curve

Fig.2-2 Recharge characteristics of ICS battery with current of 0.1C_{10}A and limit voltage of 2.35V/cell. The 100% DOD battery can be recharged 105% of capacity after charging for 24 hours.



3.6 Discharge

3.6.1. No more than $3C_{10}A$ during continuous discharge

3.6.2. Discharge end voltage is varying with discharge current; voltage should not lower than specified value.

Table 3-3 Discharge current vs. end voltage

Discharge current（A）	End voltage(V/cell)
$<0.1C_{10}$	1.9
$\approx 0.1C_{10}$	1.8
$\approx 0.17C_{10}$	1.8
$\approx 0.25C_{10}$	1.8
$\geqq 0.6C_{10}$	1.7

3.6.3. Charge immediately after discharge. Charge immediately if unexpected over-discharge happen.

3.6.4. Discharge curve and discharge data

Fig. 3-2 Discharge Performance Curves at Different Discharge Rates（25℃）

Table 3-4 Constant current and constant power discharge data

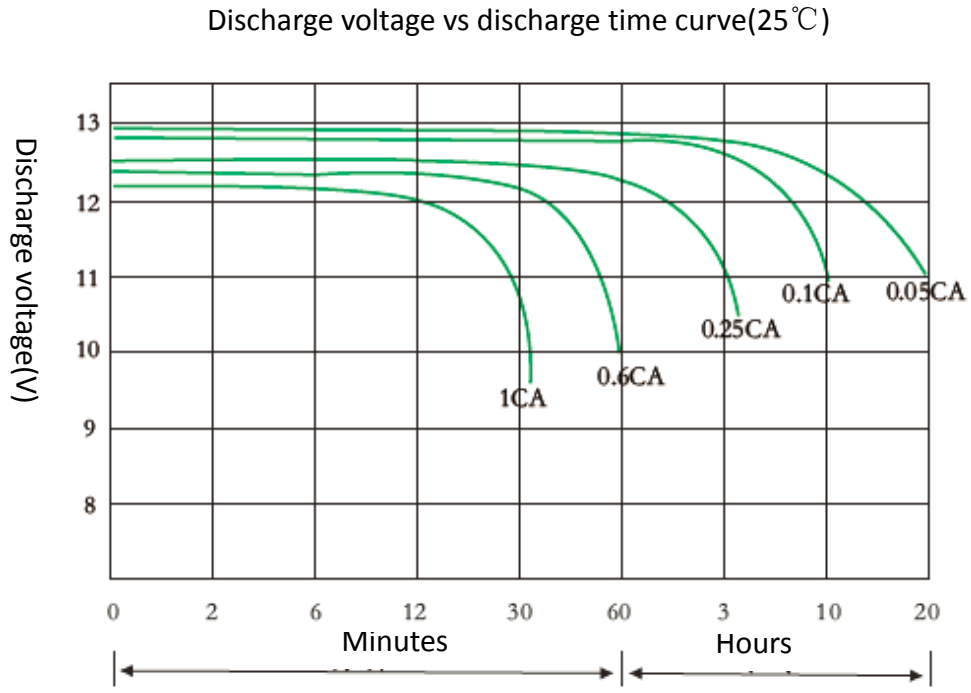


Fig 3-2 Discharge characteristic curve

Table 3-4 Constant current and constant power discharge data

a) ICS12V100

Constant Current Discharge Characteristics Units: Amperes (25°C, 77°F)

End Voltage	Time (minutes)				Time (hours)										
	5	15	30	45	1	2	3	4	5	6	8	10	12	20	24
1.85V	194	132	92.8	72.9	60.5	36.9	26.9	21.3	17.7	15.1	11.7	9.61	8.14	5.06	4.25
1.83V	200	138	97.3	76.3	63.2	38.3	27.8	22.0	18.2	15.5	12.0	9.80	8.28	5.12	4.30
1.80V	210	145	102	79.7	65.9	39.7	28.7	22.6	18.6	15.9	12.3	10.0	8.44	5.20	4.36
1.75V	223	153	107	83.1	68.5	41.0	29.5	23.2	19.1	16.2	12.5	10.2	8.57	5.26	4.41
1.70V	231	158	110	85.1	70.0	41.8	30.0	23.5	19.4	16.5	12.7	10.3	8.68	5.32	4.46
1.67V	234	159	111	85.8	70.6	42.0	30.2	23.6	19.4	16.5	12.7	10.3	8.69	5.33	4.46
1.60V	237	161	112	86.7	71.2	42.4	30.4	23.8	19.5	16.6	12.8	10.4	8.73	5.35	4.48

Constant Power Discharge Data Units: Watts per cell (25℃,77℉)

End Voltage	Time (minutes)				Time (hours)										
	5	15	30	45	1	2	3	4	5	6	8	10	12	20	24
1.85V	352	246	175	139	116	71.4	52.4	41.6	34.6	29.7	23.2	19.0	16.1	10.1	8.49
1.83V	363	256	182	144	120	73.6	53.8	42.7	35.4	30.3	23.6	19.3	16.4	10.2	8.56
1.80V	381	267	189	149	124	75.8	55.3	43.8	36.3	31.0	24.1	19.7	16.7	10.4	8.71
1.75V	409	280	197	154	128	77.7	56.6	44.6	37.0	31.6	24.5	20.0	16.9	10.5	8.82
1.70V	427	288	201	157	130	78.8	57.2	45.2	37.4	31.9	24.8	20.2	17.1	10.6	8.92
1.67V	435	291	202	158	131	79.0	57.4	45.2	37.4	32.0	24.8	20.3	17.1	10.6	8.93
1.60V	448	296	204	159	131	79.2	57.5	45.3	37.5	32.0	24.8	20.3	17.2	10.6	8.94

b) ICS12V150

Constant Current Discharge Characteristics Units: Amperes (25°C, 77°F)

End Voltage	Time (minutes)				Time (hours)										
	5	15	30	45	1	2	3	4	5	6	8	10	12	20	24
1.60V	468	262	159	115	93.0	53.4	41.8	32.1	28.8	24.2	18.8	15.6	13.1	8.16	6.80
1.67V	458	253	156	114	92.5	53.1	41.0	31.9	28.5	24.1	18.6	15.5	13.0	8.09	6.77
1.70V	444	248	154	112	91.8	52.7	40.8	31.7	28.2	24.0	18.4	15.3	12.9	8.07	6.75
1.75V	417	241	150	110	90.5	51.3	40.3	31.4	27.9	23.9	18.2	15.1	12.7	8.05	6.72
1.80V	374	224	146	108	88.1	50.9	40.1	31.3	27.2	23.4	18.0	15.0	12.6	7.97	6.68
1.83V	356	206	143	104	84.3	50.2	38.8	29.8	26.3	22.6	17.8	14.4	12.3	7.95	6.63
1.85V	334	199	133	100	81.7	48.4	37.7	29.4	25.6	22.1	17.3	14.3	12.2	7.80	6.57

Constant Power Discharge Data Units: Watts per cell (25℃,77℉)

End Voltage	Time (minutes)				Time (hours)										
	5	15	30	45	1	2	3	4	5	6	8	10	12	20	24
1.60V	815	460	287	216	175	101	79.5	61.5	55.2	46.7	36.5	30.2	25.4	16.2	13.6
1.67V	785	452	285	215	174	100	78.4	61.4	54.9	46.6	36.1	30.1	25.2	16.1	13.5
1.70V	780	447	283	212	172	99.8	78.0	61.2	54.4	46.5	36.0	29.6	25.1	16.1	13.5
1.75V	728	440	280	210	171	99.5	77.6	61.1	54.1	46.3	35.3	29.5	25.0	16.0	13.5
1.80V	680	419	277	209	168	99.2	77.4	61.0	52.9	45.9	35.1	29.3	24.9	16.0	13.4
1.83V	656	384	274	203	163	98.0	75.6	58.7	51.8	44.5	34.9	28.6	24.4	15.9	13.4
1.85V	621	375	254	194	158	94.8	73.5	58.0	50.5	43.6	34.2	28.4	24.2	15.7	13.3

Chapter 4 Maintenance

4.1 Maintenance stock tools

Following tools and equipments are necessary at least to maintenance and troubleshooting VRLA batteries.

1. Digital multimeter
2. Wrenches insulated
3. Adjustable wrench insulated
4. Torque wrench
5. Rubber gloves
6. Full set of masks
7. Plastic apron
8. Portable eyedrops
9. Fire extinguishers (C grade)

The following equipment is optional according to the type of maintenance.

1. Resistance tester
2. Charger and discharger special for storage battery (portable)

4.2 Maintenance

In order to assure service life, the batteries should be correctly inspected and maintained. The maintenance methods of ICS series batteries are recommended as follows:

4.2.1 Quarterly Maintenance

1) Keep the battery-room clean, no garbage and good light
2) Ensure all the safety equips are complete and available, especially ensure battery management parameter settings are normal
3) Measure and record ambient temperature of the battery-room
4) Visually inspect battery
   a. Cleanliness
   b. Damage and overheat trace of terminal
   c. Shell or cover damage
   d. Overheating traces
5) Measure and record float voltage and equalization voltage of system
6) Measure and record float voltage and equalization voltage each cell
7) Measuring DC voltage each battery polarity to detect ground faults
8) If possible, measure and record battery system DC and AC float current
9) Measure and record control equip temperature. Measure and record battery temperature in the center of side or negative post.

4.2.2 Six-month maintenance

1) Repeat quarterly maintenance
2) Measure and record each cell internal resistance to anomaly battery trends and detection of individual cells deviation from normal cells.

4.2.3 Yearly maintenance

1) Repeat six-month maintenance
2) Re-tightening all connectors between cells

4.2.4 Two-year maintenance

Do capacity test every two-year, or choose discharge rate according to load. Test process as following:

Charge battery fully, rest 5h-24h at 25±2℃, then discharge battery with current to end voltage shown in table 4-1, record discharge voltage and time.

Table 4-1 Discharge current and end voltage

Discharge rate	Capacity	Discharge current（A）	End voltage (V/cell)
10HR	C_{10}＝1.00C_{10}	I10	1.80
8HR	C_8＝0.92C_{10}	1.15I_{10}	1.80
5HR	C_5＝0.89C_{10}	1.78 I_{10}	1.80
3HR	C_3＝0.75C_{10}	2.5 I_{10}	1.80
1HR	C_1＝0.55C_{10}	5.5 I_{10}	1.75

Standard Capacity temperature is base on 25℃, Convert the testing capacity(Cr) to standard capacity(Ce) according to formula if test temperature is not 25℃

$$C_e = \frac{C_r}{1 + k(t - 25)}$$

Wherein：t— ambient temperature during discharging

k—temperature coefficient:

10hhr rate discharge，k=0.006/℃

5～8hr rate discharge，k=0.007/℃

3hr rate discharge, k=0.008/℃

1hr rate discharge, k=0.01/℃

If standard capacity (Ce) is less than 80% rated capacity, please contact manufacturer to analyze the reasons for the reduction in capacity.

4.3 Replace battery

4.3.1 If standard capacity is less than 80% rated capacity (see clause 4.2.4 test method), user should consider replacing battery.

In some special cycle mode, user can replace battery until lower capacity according to practical situations.

4.3.2 Replace period

Storage battery is belong to consumables with certain life cycle. Recommend replace the old battery with the new one before battery design service life to ensure system safety.

4.4 FAQ analysis and solving measures

No.	FAQ	processing method
1	High float Voltage variation	1. Check if setting parameter are right 2. Replace cell which's float voltage lower than 2.18Vpc with the new batter. New and old batteries production data should be no more than 6 months. If one in third float voltage lower than 2.18Vpc, then replace whole strings batteries. 3. Discharge battery with 100% DOD after replace, effect will be obvious
2	Battery can't be charged and discharged	1. Check battery connection, ensure no loose connector, corrosion, cut, reversal connection. 2. Check the battery whether leaking, bulging, cracking happen 3. If no above abnormal occurrence, then test open circuit voltage (OCV) after rest 30min, if cell's OCV less than 2.08Vpc, replace it.
3	Reverse polarity /broken	Replace reverse polarity battery Replace broken battery
4	There are white crystal in terminal or valve ports	If it is false leaking, clean white crystals with a soft cloth dipped with soapy water, then wipe it dry with a dry soft cloth. You can also wipe with a soft dry cloth directly. Be careful not to plug the valve port.
5	Electrolyte leakage	If battery leakage, replace it and clean corrosion rack and ground.
6	Battery bulge or crack	Replace the battery with serious bulge immediately. If battery only Slight bulging (the sidewall bulge size 5mm-10mm), handle it as following: 1. Check whether battery outlet of safety valve cover plate is blocked, if blocked, replace the cover plate or clean obstruction. If no hole in cover plate, replace it immediately. 2. Check whether the cell voltage is too low (below 2.08V) or reverse connection battery. 3. If it is no cause of clause 1 and 2, then check system voltage sitting, if too high, adjust the setting parameters. Open valve for a while to let internal gas escape after disconnect the circuit with special tools.

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Annex 1

VRLA Battery Regular Maintenance Record

Type		Place	
Status		Number of battery	
Total Voltage（V）	Current (A)	Temperature	
No.	Voltage（V）	No.	Voltage（V）
1		13	
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			
Result:			
Tester:		Date:	