

User's Manual for VRLA Battery

—Shenzhen Center Power Tech Co. Ltd

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一、Battery sizing

- ◇ □ Deep cycle series or GEL series is recommended if frequent discharge is expected during service.
- ◇ HP&HF series is recommended if short duration with high current/power discharge is expected.
- ◇ Requirement for batteries in series: Recommended total system voltage limit is no higher than 450V, consult VISION technical support for guide if voltage exceeds the limit.
- ◇ Requirement for batteries in parallel: Less than three strings in parallel is recommended, if more than three strings, pls consult VISION technical support for guide.
- ◇ Aging factor, consider the aging,, no less than 20% margin is needed when sizing.
- ◇ Battery capacity goes high after put into service, an initial capacity of 95% is acceptable.
- ◇ Sizing procedures, by capacity/current and by power as following, pls also refer to VISION sizing software.

1、Sizing by capacity/current (working current ,duration and cut-off voltage are known)

For example: A 48V DC power system with working current of 18 amps and backup time of 5 hours, cut-off voltage of 42.0V, CTA series is needed, sizing calculation as follow

- (1) End of discharge voltage per cell: $42.0 \text{ volts}/24 \text{ cells}=1.75\text{Vpc}$
- (2) Hence the system requires a battery which can deliver a current of 18 amps for 5 hours to an end of voltage of 1.75V per cell.
- (3) Check VISION product data sheet and get the discharge current of CTA12-100X at 5h rate is 18.8amps, higher than 18 amps and with a margin of 5%.
- (4) Sizing result: Select 4 pcs CTA12-100X batteries connected in series.

2、Sizing by power (System voltage, power, duration and end of voltage are known)

Calculation formula: $\text{Power of UPS} \times \text{factor} / \text{efficiency} = \text{Power on batteries}$

For example: A UPS system with power of 20KVA, DC voltage 408V, power factor 0.8, conversion efficiency 0.85, backup time 2 hour, system lower voltage limit 357V, size a FM series battery type.

- (1) Power on batteries: $20\text{KVA} \times 0.8 / 0.85 = 18823.5\text{W}$
- (2) Power per cell: $18823.5\text{W} / 204 \text{ cells} = 92.3\text{W/cell}$
- (3) End of voltage per cell: $357 \text{ volts}/204 \text{ cells} = 1.75\text{Vpc}$
- (4) Hence the system requires a battery which can deliver 92.3 for 2 hours to 1.75 Vpc
- (5) Check VISION product data sheet and get the discharge power per cell of 6FM150-X at 2hrate & 1.75V/cell is 106W/ cells >92.3W/cell, with a margin of 15%.
- (6) Sizing result: Select 34 pcs 6FM150-X connected in series.

二、Shipment, delivery and storage

- ◇ Choose adequate means for shipment, delivery and handle, for the weight of a battery is heavy. Don't roll and throw a battery pack.
- ◇ Avoiding of upsid- down.
- ◇ Be careful and not damage the terminals and valve plugs.
- ◇ Avoiding of short circuit a battery, since it's fully charged.
- ◇ Store batteries at dry, clean, well-ventilated are. Batteries can be stored at 0~35°C for 6 months with recharge. Recharge the batteries once if storage period exceeds 6 months.
- ◇ Self-discharge during shipment and storage increase due to higher temperature and poor ventilation. Keep ventilation well and away from heat, flame and spark.
- ◇ Disconnecting batteries from a load and charging system when store the batteries.
- ◇ Recharge the batteries as per table two during storage.

三、Environment requirements

- ◇ Temperature range, AGM batteries: Charge $-10\sim+60^{\circ}\text{C}$, discharge $-20\sim+60^{\circ}\text{C}$, storage $-20\sim+60^{\circ}\text{C}$;
- ◇ Keep away from flame, heat, spark.
- ◇ Keep away from sunlight and heat sources.
- ◇ Keep away from moisture, water. If batteries be used under ground or in water, pls choose VISION special design batteries.
- ◇ Not use a battery in a sealed enclosure.

四、Requirement of application conditions

- ◇ Requirement for batteries in series: Recommended total system voltage limit is no higher than 450V, consult VISION technical support for guide if voltage exceeds the limit.
- ◇ Requirement for batteries in parallel: Less than three strings in parallel is recommended, if more than three strings, pls consult VISION technical support for guide.
- ◇ Multi-layer installation: Temperature difference between layer no greater than 3°C .
- ◇ Batteries can be installed on bottom or on side, for 2-volt batteries, installation position be selected to avoid plates inside suspended, consult VISION technical support when need.
- ◇ Clearance: Keep a clearance of 20mm at least between batteries for better heat dissipation.
- ◇ Ventilation: Well ventilation to keep hydrogen level below 0.8%.
- ◇ Float charging parameters (25°C): Initial current limit $\leq 0.30C_{10}$, voltage setting 2.23~2.30V/cell (Recommended voltage setting point: CL series, deep cycle series and gel series 2.25V/cell; CP series, FM series, HP & HF series 2.27V/cell).
- ◇ Equalization charge parameters (25°C): Initial current limit $\leq 0.30C_{10}$, voltage 2.35~2.40V/cell (recommended voltage setting point 2.35V/cell), charging time not exceed 48 hours.
- ◇ The favorite ambient temperature for long battery service life is $25\pm 5^{\circ}\text{C}$, battery service life shorten half for every 10°C increase above 25°C .
- ◇ Not mix up batteries from different types,, different production date, different manufacturers, different size, different models in a group. Consult VISION technical support for guide when such case happens.
- ◇ Replacement of battery: When individual batteries need to be replaced in a string, make sure all the batteries, original ones and the new ones, be fully charged. Measure the OCVs four hours after the charging, and the OCV difference be less than 0.025V.
- ◇ Warranty may be invalid if above requirements are not followed.

五、Installation and service

1、Inspection upon unpacking

- ◇ Handling:
 - Avoiding pull or push on terminals, to prevent damage of terminals and sealing of terminas.
 - Avoiding upside-down, impact, throw of batteries.
 - Avoiding metal rope, wire for handing, to prevent short-circuit of batteries.
- ◇ Inspection: Package and appearance of batteries should be no sign of damage.
- ◇ Counting out: batteries number, connectors and hardware are correct.
- ◇ Refer to installation drawing and manual for guide.

2、Cautions before installing

- ◇ Batteries matching. The OCVs of batteries in a group should be close, difference less than 0.01V.
- ◇ If total system voltage is more than 450V , Insulation pad should be set under the batteries.

- ✧ Begin installing only after no abnormality be found.
- ✧ Install the batteries at lower position, as far as possible, in the battery room.
- ✧ The position should be away from heat sources, such as a transformer.
- ✧ The position should be away from spark sources, such as a fuse, to prevent the possible ignition of hydrogen.
- ✧ Clean or polish the terminals before connection of batteries.
- ✧ Be careful to prevent the short circuit of battery positive and negative terminals by metal items.
- ✧ Make sure the connection of batteries is correct before connecting the batteries to equipment. Connect the positive end of batteries to positive output terminal of the charger (the equipment), connect the negative end of the batteries to negative output terminal of the charger, otherwise damage of charger (equipment) or injure of body may occur.
- ✧ Use a torque wrench for adequate tightness of the connection. Recommended torque value is as table one.

Table one Torque setting

Item	Terminal size	Value
1	M5	6.2N*m
1	M6	8.5N*m
2	M8	12.4N*m

- ✧ The safe current value of VISION standard cable connectors for long duration is as follow
 Cable 70mm², 220A/cable.
 Cable 50mm², 170A/cable.
 Cable 35mm², 130A/cable.
 State clearly if working current is higher than above value and VISION will specify correct connectors for the application.

3、Connecting of batteries

- ✧ Use isolated tools for the connecting.
- ✧ Connect batteries first, then connect batteries to charger and load.
- ✧ Connect batteries in a string first, then connect strings in parallel.
- ✧ Clearance between batteries no less than 20mm for better heat dissipation.
- ✧ After connecting the cables with battery terminals, antirust such as vaseline may be applied onto the junction points.
- ✧ Measure the total voltage of battery group before connect to power.


4、How to use the batteries

4.1 Recharging

- ✧ Recharge the batteries before put into service to makeup the self-discharge during shipment and storage.
- ✧ If no service for a long period of time, recharge the batteries on schedule.
- ✧ Refer to table two for recharge schedule

Table two Storage temp. and recharge schedule

Temp. range	Recharge interval	Recharge parameters
Less than 20°C	Every 9 months	a) Constant voltage 2.23~2.30V/cell, initial current 0.30C(A), for 2~3 days.
20°C~30°C	Every 6 months	b) Constant voltage 2.30~2.40V/cell, initial current 0.30C(A) for 10~16 hours.
30°C~40°C	Every 3 months	c) Constant current 0.1C (A) for 8~10hours.

□  Note: C means nominal capacity of the battery.

For example: The nominal capacity of 6FM100X is 100AH, $0.1C (A) = 0.1 \times 100 = 10A$.

Charge voltage: 12V battery $2.25 \times 6 = 13.50V$, 6V battery $2.25 \times 3 = 6.75V$

4.2 Capacity test and end of discharge

4.2.1 The end of battery discharge

◇ The cut-off voltage of discharge and low voltage limit are specified as table three.

Table three: Cut-off voltage and discharge rate

Disch. rate (A)	Cut-off (V/cell)	Disch. rate (A)	Cut-off (V/cell)
Less than $0.1C_{10}$	1.80	$0.5-0.7C_{10}$	1.65
$0.1-0.2C_{10}$	1.75	$0.7-3.0C_{10}$	1.50
$0.2-0.5C_{10}$	1.70	Higher than $3.0C_{10}$	1.30

□  Note:

1) Not allowed to discharge a battery to a voltage below the low voltage limit.

2) Recharge the battery in 24 hours after discharge, not store a battery in discharged conditions. Not attempt to discharge an empty battery, the SOC is at least 60% before discharge.

4.2.2 Capacity confirmation test

During service regular capacity confirmation test, such as yearly, is recommended. One of the following methods may be used.

◇ Off-line test

- Batteries are disconnected from power supply and stand by for one trough four hours, then connected to a dummy load and perform 10 hr capacity test at $25 \pm 5^\circ C$.
- Measure and record voltage, ambient temp. and time of starting.
- During discharge, measure and record voltage, ambient temp. every one hours. The deviation of discharge current should be less than 1% of the setting value.
- Near the end of discharge, measuring of voltage should be frequently performed in order to catch the cut-off voltage of discharge.
- Discharge capacity is calculated by discharge current multiply discharge time. If the temp. is other than $25^\circ C$, capacity at $25^\circ C$, C_e is converted as per the formula:

$$C_e = Cr / \{ 1 + K(t - 25^\circ C) \} \text{ ----- (A)}$$

Where: t—average ambient temp. during discharge.

K—coefficient (for 10hr capacity, $K=0.006/^\circ C$; 3hr capacity $K=0.008/^\circ C$;

1hr capacity $K=0.01/^\circ C$)

- Recharge the batteries after discharge with a charging amount of 110% through 120% the discharged capacity.

◇ On-line test

- Disconnect the system from power line, discharge the batteries with load and set the cut-off voltage at low voltage limit, find out the battery with lowest voltage during discharge, i.e. the one with lowest capacity.
- Recharge the batteries fully with charging system and stand for one hour or longer.
- Discharge the batteries at 10hr, measure and record the voltage, temp. of the selected battery once an hour, measure and record the room temp.
- Calculate the discharged capacity and converted to that of $25^\circ C$.
- Recharge the batteries after capacity test.
- Make discharge curve from recording data.

Remark:

(1) For UPS batteries, off-line test is not recommended.

(2) When perform on-line test, switch the UPS to discharge-test mode if available. If no discharge-test mode, then disconnect AC power and discharge the batteries with load.

 Note:

1) Above mentioned capacity tests are for routine maintenance use. Make sure the test is well arranged and safety of system is guaranteed.

2) Before discharge test, preventative tests using multi-meter, IR or conductance tester is recommended.

3) In order to get correct result, calibrate the load, current precision before test.

4.2.3 The judgment of low capacity battery

The battery may be considered as low capacity if its voltage is 5% lower than average value during three consecutive discharges. Perform an equalization charge if a low capacity battery found.

4.3 Battery charging

4.3.1 Floating charge

◆ Charging parameters

◇ Voltage: 2.23~2.30V/cell (25°C) (set point of 2.25V/cell is recommended).

◇ Max. initial current: 0.30C₁₀

◇ Temp. compensation coefficient: -3mV/°C. Per cell (from 25°C)

◇ Voltage deviation allowed: ±0.02V/cell.

 Note:

1). The initial deviations of battery voltages in a group will reduce to a low level after a period of service, for example, after a half year.

2). Effects of lower or higher voltages:

Higher voltage (overcharge) : Shorten battery life.

Lower voltage (under-charge) : Low battery capacity and shorten battery life.

4.3.2 Equalization charging

◆ Parameters

◇ Voltage: 2.35~2.40V/cell (25°C) (set point of 2.35V/cell recommended)

◇ Max. initial current: 0.30C₁₀

◇ Temp. compensation coefficient: -3mV/°C.cell (from 25°C)

◇ Voltage deviation allowed: ±0.02V/cell.

◆ Condition of terminating equalization charge

Charging current drop to 0.01C₁₀.

 Note:

Only perform an equalization when:

- Discharge capacity 20% lower than nominal value.
- Storage period more than 3 months.
- Individual floating voltage less than 2.18V/cell.
- Low capacity battery is found after 3 through 6 months' floating service.
- After one year of floating service.
- Recharge after installation & before service.
- Recharge after capacity test.

4.3.3 Cyclic charging

◆ Parameters

- ◇ Voltage: 2.40~2.45V/cell (25℃) (Set point of 2.45V/cell is recommended).
- ◇ Max. initial current: 0.30C₁₀
- ◇ Temp. compensation coefficient : -5mV/℃.per cell (from 25℃)
- ◇ Voltage deviation allowed: ±0.02V/cell
- ◇ Recharge amount 1.1~1.2 times of the discharged capacity, upper level of recharge amount is selected when ambient temp. below 5℃. If discharge capacity is not sure, recharge the batteries as table four:

Table four

Ambient temp. (℃)	Charging voltage (V/cell)	Charging time (h)
5	2.31	7
	2.46	4
20	2.25	7
	2.40	4
35	2.21	7
	2.34	4

□  Note:

- 1) Charging time in table four means charging period after voltage reach the specified value, initial max. current is less than 0.03C.
- 2) Follow above charging specifications, otherwise batteries will be overcharged or undercharged, service life of batteries will shorten.
- 3) Charge the batteries as per cyclic charging parameters after capacity test discharge.

4.4 Cautions

- ◇ Measure the output voltage of equipment once every 2 hours for new installations for the initial 72 hours, to make sure the stable output of charging voltage. The output voltage should also be confirmed during yearly maintenance check preventing the deviations due to aging.
- ◇ If a current value at final charging stage is over 0.05C₁₀A, damage on battery service life may occurred.
- ◇ For cycle charging, timer is recommended to switchover to trickle charging mode, preventing over-charging.
- ◇ For temperature other than 25℃, charge voltage setting need to be compensated as formula:

$$U_T = U_{25℃} - K \times (T - 25)$$
(T—actual temperature, K—compensation coefficient)
- ◇ Judging on completion of charging

When one of the following conditions occurs, charging is considered be completed.

- 1) Charging amount reaches 1.1~1.2 times of discharged value.
- 2) Charging current is less than 0.005C₁₀A at final stage of charging.
- 3) Charging current keeps stable for 3 hours.

4.5 Hydrogen emission volume during charging

Charging voltage (V/cell)	Hydrogen volume (ml/cell/Ah (C ₁₀) /month)		
	FM	CL	CT/CTA
2.23~2.28	3.8	1.5	3.5
2.40~2.45	25	12	22

For example: Hydrogen emission volume of 6FM100X under floating charging at 13.62V is $3.8 \times 6 \times 100 = 2280\text{ml/month}$.

六、Maintenance

1、Cleaning

- ◇ Keep batteries and battery room clean and dry.

- ◇ Avoiding induce of static electricity during clean of batteries.
- ◇ Use damp cloth for cleaning, don't use gasoline, alcohol and other organic solvents.

2、Check and maintenance

Perform following routine checks and keep records.

2.1 Monthly checks

Items	Details	Benchmarks	Maintenance
① Total battery group voltage	Use multi-meter checking total voltage across positive and negative terminals	1.The value of measured and displayed on equipment should be close. 2. Voltage error after compensation should be less than $\pm 50\text{mV}$	Adjust the charging voltage to recommended range if there is a deviation; Repair the equipment if voltage can't be adjusted.
② Battery appearance	Bulge, leakage or damage	Appearance should be ok	Replace the battery if bulge, leakage or damage
	Dust, dirty	Clean	Cleaning
	Connectors, terminals	No rust	Clean and antirust dealing
③ Battery surface temperature	Use infrared thermometer measure surface temperature	Less than 35°C	Further check and analyse if high temperature found
④ Connections	Use torque wrench to check connection hardware	Refer to torque values	Re-tight if there is a loose connection
	Connector appearance	No rust	Clean or replace if rusted connectors found
⑤ Valve plug check (2V batteries)	Loose plug check	Plug should be tight, no loose	Re-tight the loose plug
	Soap water to check air-tightness	Intermittent bubbles	Further check if no bubble or frequent bubbles
⑥ Switch-over	Disconnect AC power, switch-over to UPS, or DC power	Switch-over is smooth	Further check if there is a problem

2.2 Quarterly check

Following items be checked except the monthly items.

Items	Details	Benchmarks	Maintenance
① Float voltage for each battery	Measure the voltage of each battery under floating, using a meter with four and half digits.	Voltage differences less than 2V: 90mV 6 V: 240mV 12 V:480mV	If there is a deviation, discharge the batteries and perform a equalizing charging, observe for one through two months under floating. Contact us if no improvement.
② Correct the low voltage batteries	1、 Charging the whole battery group, using equalizing voltage and discharge for one through three times. 2、 Use a charger to repair the individual battery	Voltage differences less than 2V: 90mV 6 V: 240mV 12 V:480mV	Replace the battery if can't be corrected.
③ Activated discharge	Perform a discharge-charge cycle, using lower level of equalizing charge voltage for the charge.	Discharge around 30% of the nominal capacity.	Perform the discharge-charge cycle if no power-off for six months.

2.3 Yearly check

Following items be checked except the quarterly items.

Items	Details	Benchmarks	Maintenance
① Check-up discharge	Disconnect the AC power and discharge the battery to a DOD of 30%~40%	The final voltage be greater 1.90V/cell.	Perform a equalizing charge if voltage less than 1.90V/cell. Observe for one through two months. Contact us if no improvement.
② Capacity test	Discharge battery at I_{10} current to 1.80V/cell	Remained capacity higher than 80%	Replace battery with low capacity

2.4 Requirements and cautions

- 1) .Insure personal and utilities safe during check operation.
- 2) .Follow the instructions of operation and keep records.
- 3) .Refer to recommended parameters of batteries.
- 4) .Wear preventative clothes, use insulated tools.
- 5) .Use calibrated tools and meters.

七、 Replacement of batteries

1、 Criteria

Batteries should be replaced if the capacity is lower than 80% of nominal capacity.

2、 Time of replacement

Batteries are consumable and have a service life range. Batteries need to be replaced when reach the end of life, considering the application conditions, ambient temperature and etc, to insure the safety of power system. The used batteries should be disposed of properly, according to national laws and regulations.

八、 Other cautions

- ✧ Keep batteries away from children's reach.
- ✧ Use a battery for its specified application, don't misuse a battery, avoiding fire, explosion or corrosion.
- ✧ Don't disassemble, rework, impact, toss a battery, avoiding fire, explosion or corrosion.
- ✧ Don't put a battery in water, fire, or heat a battery.
- ✧ Don't short-circuit a battery across the terminals.
- ✧ Wear preventative clothes and use insulated tools when battery group voltage exceeds 45V.
- ✧ Don't lean on or over a battery during test or maintenance, keep a certain range from the battery.
- ✧ Battery contains acid, wash immediately if acid spoil on cloth, skin, or eye. See a doctor if necessary.
- ✧ To use batteries in $25 \pm 5^{\circ}\text{C}$ for a long service life.