Operation Manual

For GTS-L Range

Stationary VRLA Batteries

CONTENT

1 Operation Principle

Lead-acid battery transforms electricity power into chemistry power while charging and transforms chemistry power into electricity power while discharging. During the course of charging and discharging, the chemical reactions to be detailed like the right scheme will occur in the battery. It is known from the scheme that water decomposable reaction lies in the charging course. While positive has been charged to 70% of the nominal capacity, oxygen will run out; while negative has been charged to 90% of the nominal capacity, hydrogen begin to get out. This will cause the loss of water, so it's essential to add water and electrolyte to maintain the battery usually. VRLA battery adopts the technique of oxygen decompounding, it lower the possibility of losing water of the battery to a lowest level.

Electrode Reaction

Positive:

$$P_bSO_4 + 2H_2O \underset{\text{Discharge}}{\overset{\text{Charge}}{\rightleftharpoons}} P_bO_2 + H_2SO_4 + 2H^+ + 2e^-$$

Subsidiary reaction: $H_2O \xrightarrow{\text{charge}} 2H^+ + 1/2O_2 + 2e^-$

Negative: $P_bSO_4 + 2H^+ + 2e^- \underset{\text{Discharge}}{\overset{\text{charge}}{\rightleftharpoons}} P_b + H_2SO_4$

Subsidiary reaction: $2H^+ + 2e \xrightarrow{\text{charge}} H$

Oxygen Recombination: VRLA battery adopts sealed design of safety valve and uses the supper fiberglass separator. The oxygen to be separated out from its positive at the late period of charging pass through the fiberglass separator to its negative and compound with lead. This reaction creates water which will flow back to the electrolyte. It not only reduces the release of oxygen, but also makes negative be in a state of depolarization and restrain the release of hydrogen. At the same time, VRLA battery adopts safety valve, when the gas press in the cell reachs to the value of opening valve, gas will get out itself. This ensures the safety of the running battery and realizes the seal of the battery.

3 Construction and Technique Characteristics

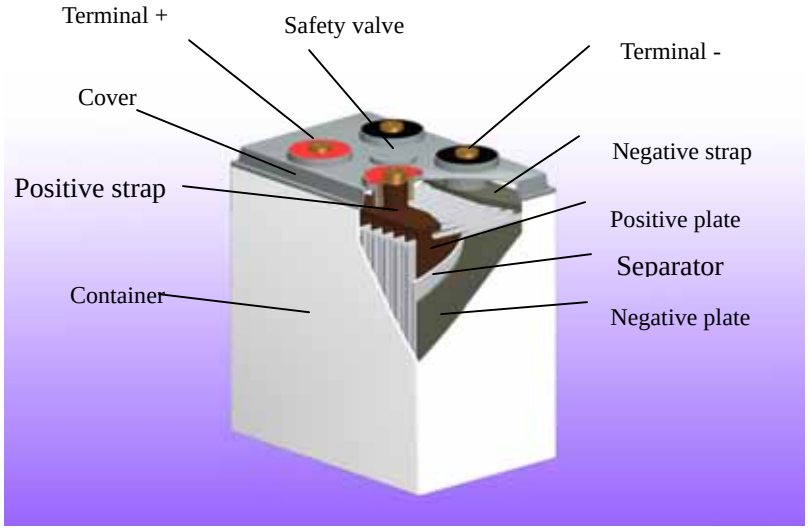
3.1 ***Positive:*** Adopt special Pb-Ca alloy, so the battery has a better cycle life and can discharge at a high rate. It raises the energy density and improves the refreshable performance of the battery after a deep discharge.

3.2 ***Terminal protecting cover:*** Make use of Terminal protecting cover, avoid short circuit between positive and negative for the growth of positive plate during the using period of battery, ensure the usage life of battery.

3.3 ***Separator:*** adopt AGM separator and the technique of plate cluster pressing; overcome the bad factor for shrinking when AGM separator has absorbed enough electrolyte. At the same time, the pressure on the plate cluster doesn't change by the outside factor, ensure a long

cycle life and a coincidence performance of AGM battery.

3.4 ***Special safety valve:*** adopt the most advanced adjustable pole structure, not only prevent oxygen outside battery from getting in, but also prevent acid fog inside battery from releasing. The safety valve has a good performance against blast, and ensures the normal running of battery.



Battery construction figure

3.5 ***Double sealed terminal:*** The terminal is welded in a inertia gas atmosphere (automatic argon arc weld), it ensures that there are no oxidation dregs around the weld site and gains the weld depth. Besides the automatic argon arc weld, the terminal is welded secondly by affusing seal glue, ensures that battery won't leak.

3.6 ***Cover:*** Enhance cover design. It can lighten the influence of positive plate's growing stress to battery, and ensures no leak around the terminal.

3.7 ***Battery jar:*** Adopt the material against striking and against water osmosis.

3.8 ***Compound efficiency:*** GASTON battery's oxygen decompounding efficiency is better than 99 percent, the possibility of losing water is reduced to a very low level.

4 Production Model and Specification

Table 1. Battery System Specification and Weight

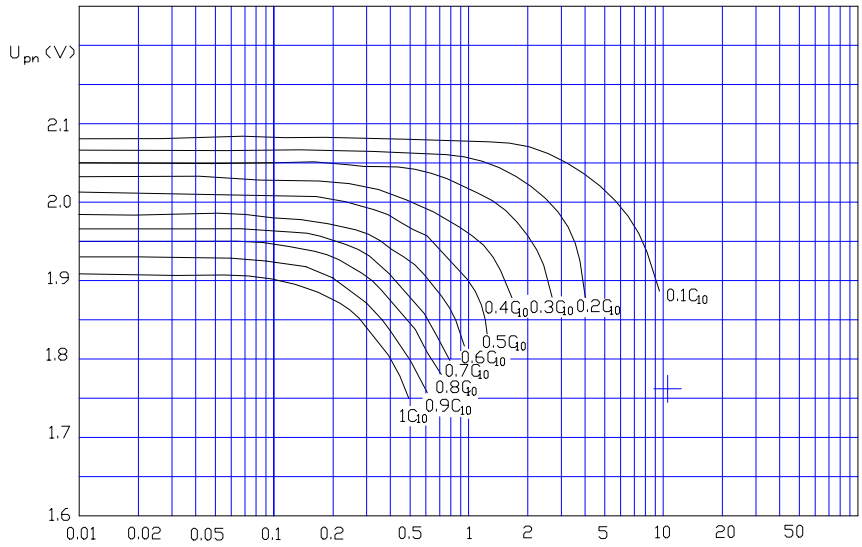
Serials	Battery Model	Nominal Voltage(V)	Nominal capacity (Ah)			Externality Dimension (mm)			Weight (kg)
			10hr to 1.80vpc	3hr to 1.80vpc	1hr to 1.75vpc	Width	Height	Depth	
1	GTS12-100L	12	100	75	56	437	218	330	66
2	GTS12-200L	12	200	150	113	665	218	330	106
3	GTS12-300L	12	300	225	169	893	218	330	153
4	GTS6-400L	6	400	300	226	623	218	330	104
7	GTS12-500L	12	500	375	282	957	218	516	157
8	GTS12-600L	12	580	435	336	1071	218	516	275
9	GTS6-800L	6	830	625	448	801	218	516	200
10	GTS6-1000L	6	1000	750	564	915	218	516	230
11	GTS6-1100L	6	1100	810	616	972	218	516	250
12	GTS4-1500L	4	1500	1125	856	793	277	465	255
13	GTS6-1500L	6	1500	1125	856	1147	277	465	370

Notes:

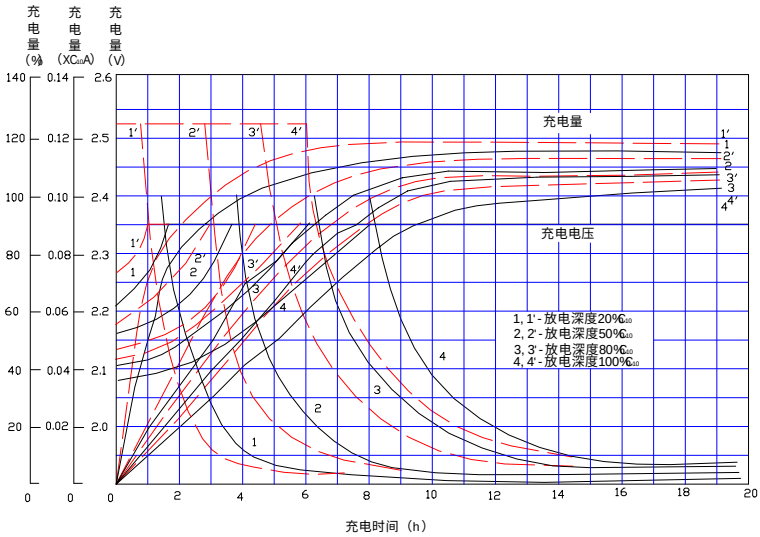
- ✓ System weight includes the weight of the individual cell, the steel modular, the front panel, the connector etc.;
- ✓ Externality dimension is the dimension of the modular batteries when horizontal installing. The depth excludes 86mm deep to the front panel.

5 Performance Curve

✓ **Discharge characteristic at various rates (at 25C)**



✓ **Charge characteristic at various rates (at 25C)**



6 The Floating Charge Voltage VS Temperature

Most of time, GASTON batteries are running in a state of floating charge. At 25℃, the floating charge voltage is 2.25V per cell. In order to gain a good performance of the battery, the floating charge voltage needs to change with the change of temperature. The temperature-equalizing coefficient is –4.0mV/cell.

Temperature (C)	Floating charge voltage (V)
0	2.353
10	2.313
20	2.273
25	2.253
30	2.233
35	2.213

7 The Equalizing Charge Voltage VS Temperature

VRLA battery need being charged termly, In order to ensure the normal running. At 25℃, the equalizing charge voltage of battery is 2.35V per cell. The equalizing charge voltage needs to change with the change of temperature. The temperature-equalizing coefficient is –5.0mV/cell.

Temperature (C)	Equalizing charge voltage (V)
0	2.475
10	2.425
20	2.375
25	2.350
30	2.325
35	2.300

8 Anticipated Battery Life VS Temperature

8.1 The designed battery life vs temperature

The designed battery life will change with the change of the different temperature and the different floating charge voltage. The following graph display the change of the designed battery floating charge life:

Temperature (C) / Floating charge voltage (V)	The designed battery floating charge life at different temperature (year)							
	15	20	25	30	35	40	45	50
2.23	22.28	16.5	11.7	8.3	5.8	4.2	3.0	2.1
2.25	20.25	15.0	10.6	7.5	5.3	3.8	2.7	1.9
2.28	18.41	13.6	9.6	6.8	4.8	3.5	2.5	1.7
2.30	16.74	12.4	8.8	6.2	4.4	3.1	2.2	1.6

8.2 The anticipated battery floating charge life vs temperature

The battery life is related with the temperature of the running battery, when the environment temperature raises 10C, the battery life will be halved. The normal battery life is 15 years. If the battery has been running at 40C for six months in a year, the battery life will reduce to 7.5 years rapidly.

8.3 Capacity vs temperature

The running temperature has an important effect on the battery capacity. At the different temperature range, temperature's effect on capacity is different. At low temperature, the battery capacity will increase when temperature is higher. However, the over-high temperature will cause the bad effect on battery, and lead to the decrease of the battery capacity and life. The following graph is the rates of the effective discharge capacity vs the rated capacity at different temperature. (the rated capacity is the 10hr discharge capacity at 25C when the final discharge voltage is 1.80V.)

temperature (C)	-30	-20	-10	0	10	15	20	25	30	35	40
Capacity (%)	30	45	60	75	87	93	97	100	104	106	107

9 Battery Inner-resistance

Battery inner resistance is a dynamic resistance out of proportion and will change with the change of battery temperature and discharge states. Oscillograph is applied to test 0-1s impact discharge current and the momentary discharge voltage. Battery inner resistance can be gained by the following formula:

$r_b = (U_0-U_t)/I_{kt}$

r_b ------ battery inner resistance, Omh
U_0 ----- battery terminal voltage, V
U_t ----- the momentary discharge voltage, V
I_{kt} ----- 0-1s impact discharge current, A

The right form displays the cell inner resistance data (includes battery connector; different battery types and different time of short circuit, terminal voltage 2.17V)

Inner-resistance (mOmh) / battery types	different time of short circuit (2.17V)			
	0.02	0.2	0.5	1.0
GTS12-100L	1.98	2.16	2.24	2.31
GTS12-200L	1.01	1.10	1.14	1.18
GTS12-300L	0.70	0.75	0.77	0.80
GTS6-400L	0.53	0.57	0.59	0.61
GTS12-500L	0.47	0.49	0.524	0.544
GTS12-600L	0.41	0.43	0.457	0.474
GTS6-800L	0.30	0.313	0.332	0.334
GTS6-1000L	0.256	0.267	0.282	0.292
GTS6-1100L	0.24	0.25	0.264	0.273
GTS6-1500L	0.157	0.163	0.175	0.181

10 Maintenance

10.1 Regulations for maintenance

- ***Floating charge voltage:*** The normal floating charge voltage is 2.253V per cell at 25℃, the temperature-equalizing coefficient is –4.0mV/C. When batteries are running in a floating charge state, the cell voltage is no less than 2.18V. if the cell voltage is lower than this value, this cell must do an equalizing charge.
- ***Equalizing charge voltage:*** Normally adopt the method of constant voltage and limited current to finish an equalizing charge, the normal equalizing charge voltage is 2.35V per cell at 25℃, the temperature-equalizing coefficient is –5.0mV/C, the equalizing charge frequency is one time yearly.

  battery need an equalizing charge referring to the prescriptive method, when the following situations happen:
  - ✓ The cell floating charge voltage is less than 2.18V;
  - ✓ Cell has finished discharging over 5%DOD;
  - ✓ To be in a unused state for more than 3 months;
  - ✓ To have been running in a state of completely floating charge over one year.
- ***Daily maintenance:*** battery does not need adding electrolyte and water to maintain , but the essential management work is required. In order to ensure that battery run good, some essential maintenance work should be done. The items which need to check is following:
  - ✓ The floating charge voltages of Cell and battery group (one time monthly);
  - ✓ The temperatures of battery jar and cover and terminal (one time monthly);
  - ✓ The status of leaking liquid and releasing acid fog around terminal and safety valve (one time monthly);
  - ✓ The status of distortion and leaking liquid about battery jar and cover (one time monthly);
  - ✓ The status of relaxing at connecting point (one time half a year);

- ✓ The battery management specifications of the switch power source (periodically, these specifications must satisfy the stated request.)

◆ ***Battery capacity test:***

- ✓ Doing a checking discharge when connecting the actual load yearly (30~40%DOD);
- ✓ Doing a capacity discharge test every 3 years (80%DOD,10hr), discharge current, cell voltage and battery group voltage should be checked and written periodically.

◆ ***Supplementary charge:*** (the charge method after discharging)

- ✓ ***Limited current and limited voltage:*** limit the charge current to less than $0.25C_{10}A$ (normally $0.1C_{10}$~$0.2C_{10}A$) and charge. When the terminal voltage rises to 2.30~2.35V per cell, charge with the constant voltage of 2.35V/cell. It is the time that battery has finished completely charging when the charge current reduces to less than $0.006C_{10}A$ and keeps unconverted.
- ✓ Constant voltage and limited current: limit the charge current to less than $0.25C_{10}A$, charge with the constant voltage of 2.30~2.35 V per cell. It is the time that battery has finished completely charging when the charge current reduces to less than $0.006C_{10}A$ and keeps unconverted.

10.2 Disposal of regular problem

Serials	Regular Problems	Disposal Methods	Remarks
1	Leaking liquid	Replacing by supply agent	
2	Appearance damage	Replacing by supply agent	
3	The cell floating charge voltage is low	Finishing an 18~24h equalizing charge	Refer to ***Equalizing charge voltage***
4	Capacity is lacking	Finishing an 18~24h equalizing charge	Replace the problem cell which is still bad after finishing an equalizing charge
5	Appearance is exceptional	Deal with assisting by supply agent	
6	Over-high temperature	Charge current is too high or cell is damaged, set a lower current value or replace the damaged cell	Check the charger and the charge method
7	Battery group has connected the earth	Clean the battery cover, check and replace the leak cell	Add insulating rubber cushion between the battery group and the earth