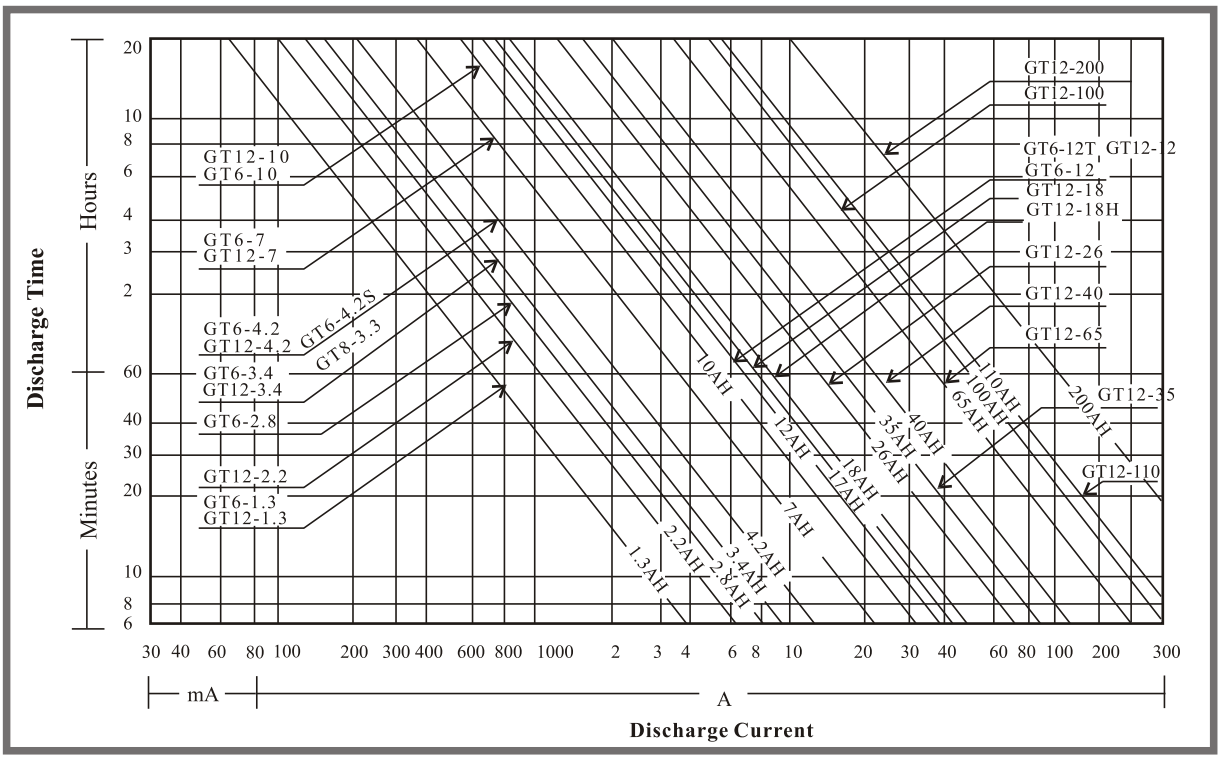
7. Capacity Selection Guide

Figure 2 below may be used to select the minimum battery capacity in 20-hour rate for a specific discharge current and the required discharge time. Find the specified current and time on the chart. The point where the current and time lines intersect on the chart with the diagonal AH line is the minimum capacity required for the application. In addition, it is recommended that the individual battery model specification sheet be considered prior to final selection.

Figure. 2 CAPACITY SELECTION CHART (At 20℃ / 68 ° F)



8. Discharging Characteristics

The battery capacity (Ah)is a product of the discharge current (A),and time (h) to the final discharge voltage:

Battery capacity (Ah) = Discharge current (A) X Discharge duration time (h)

From the above equation, the Discharge duration time varies depending on the discharge current. The battery capacity also greatly depends on the discharge current.

For example, compare 20 HR (Hour Rate) discharge and 1 HR discharge case:

For 20 HR,0.05C (A) × 20 (h) = 1C (Ah)

For 1 HR,0.6C(A) × 1 (h) = 0.6C (Ah)

This means that the capacity for the one hour case is 60% of the 20 hours case. Evidently, increasing discharge current causes decrease in the apparent Ah capacity. The final discharge voltage also varies depending on the discharge current.

The discharge capacity is affected by the battery temperature during discharge. Generally, the capacity decreases when the battery temperature decreases during discharge. Discharge characteristics are described below.

Table 1. Discharge current and final discharge Voltage

Discharge Current	Final Discharge Voltage(V/cell)
0.1C or below, or intermittent discharge	1.75
0.17C or current close to it	1.70
0.26C or current close to it	1.67
0.6C or current close to it	1.60
From 0.6 to 3C	1.50
current in excess of 3C	1.30

8.1 *Discharge current and final discharge voltage*

For the relation between discharge current and final discharge voltage, Table 1 is adopted. The battery should never be discharged to less than the predetermined final discharge voltage. Otherwise , overdischarge may result. Repeated overdischarge may cause failure to recover capacity even by charging.

8.2 *Discharge characteristics at various rates*

The curves in Figure 3 show currents that can be drawn at different discharge capacity rates at an ambient temperature of 20℃(68°F).
Using this figure, select the appropriate capacity for the sealed lead-acid battery.
For the final discharge voltage, refer to Table 1.

8.3 *Effect of temperature on capacity*

Figure 4 shows the relation between temperature and discharge capacity. This figure shows the result of charge at 20℃(68°F) and discharge at various temperatures.
Avoid operation of the battery below -15℃(5°F) or beyond 50℃(122°F) since damage may occur even though the battery may still operate.

Figure 3 DISCHARGE CHARACTERISTIC CURVES AT 20℃ (68°F)

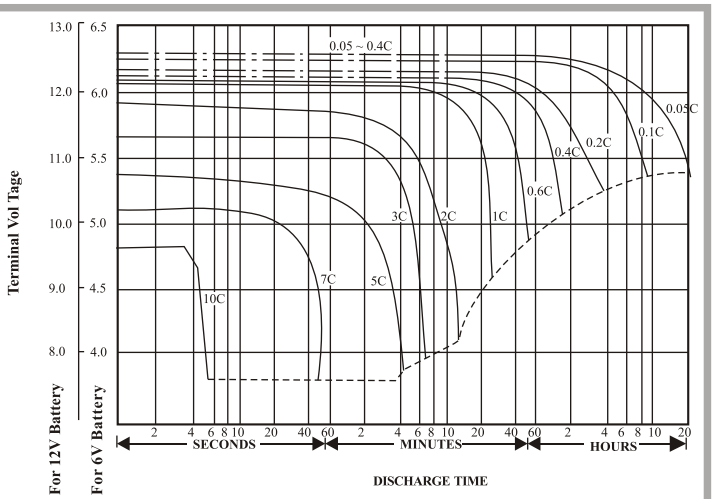
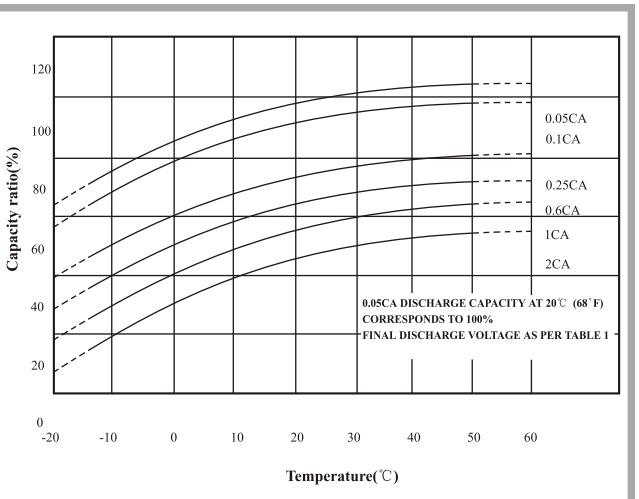


Figure 4 EFFECT OF TEMPERATURE ON CAPACITY



8.4 *Over-discharge (Deep discharge)*

The dotted line in Figure 3 indicates the lowest recommended voltage under load, or cut-off voltage, for **Gaston** batteries at various discharge rates. In general, lead-acid batteries are damaged in terms of capacity and service life if discharged below the recommended cot-off voltages. It is generally recognized that all lead calcium alloy grid batteries are subject to overdischarge damage.
For example, if a lead-acid battery was discharged to zero (0) volts, and left standing in either open circuit or closed circuit for a long period of time, severe sulfation would occur, raising the internal resistance of the battery abnormally high. In such an extreme case, the battery may not accept a charge.
However, **Gaston** batteries have been designed to withstand overdischarge. If a **Gaston** battery is overdischarged and left standing in a discharged state for several days, it can recover its original capacity when normally charged.
But it is necessary to avoid overdischarge situation as much as possible.

9. Charging Characteristics

Proper charging is one of the most important factors to consider when using maintenance-free sealed lead-acid batteries.
Battery performance and service life will be directly affected by the efficiency of the charger selected. The four charging methods are:

- Constant Voltage Charging
- Constant Current Charging
- Taper-Current Charging
- Two-Step Constant Voltage Charging

Among above four methods, the constant voltage charging method is the most suitable and commonly used to charge **Gaston** battery.
As charging proceeds, the lead sulfate of the positive plate becomes lead dioxide. When charging contimues further, the positive plate begins generating O_2 to cause a sudden rise in battery voltage.
A constant voltage charge, therefore, gives rise to ditection of the voltage increase and control of the charge amount. This type of charging generally employs a constant-voltage constant-current method with current limitation to prevent the initial current (at low battery voltage) from increasing.
Table 2 shows the charge voltage and maximum charge current. Figures 5 and 6 show the constant-voltage charge characteristic of **Gaston** Batteries when charge voltage at 2.30 volts/cell and 2.40 volts/cell, while the initial charging current is controlled at 0.1 CA and the battery was charged at the 100% discharged state and the 50% discharged state. A charge quantity of 110-120% of the discharge quantity is needed to fully charge the battery.
The charge voltage of the battery decreases with increasing temperature and increases with decreasing temperature. Accordingly, charging with a given voltage requires increased charge current when the temperature is high and decreased charge current at a lower temperature.

Temperature compensation is not necessary when the battery is charged at an ambient temperature of 5 。(41 F) to 35 。(95 F). At a temperature below 5 。(41 F) or above 35 。(95 F), however, temperature compensation for charge voltage is necessary.

(1) *For cycle use*
-5m V/ cell

(2) *For standby use (trickle charge or float charge)*
-3.3m V/ cell

Refer to Figure 7. In order to prevent a poor-charge under low temperature and overcharge under high temperature, the charge voltage must be set at the appropriate value according to the battery temperature.

Table 2 Charge voltage and maximum charge current

Applications	Charge Voltage(V/cell)			Max.charge current (A)
	Temperature	Set point	Allowable range	
Cycle use	20 。(68 F)	2.45	2.40 ~ 2.50	0.3C
Standby use	20 。(68 F)	2.275	2.25 ~ 2.30	

Figure 5
CHARGING CHARACTERISTICS

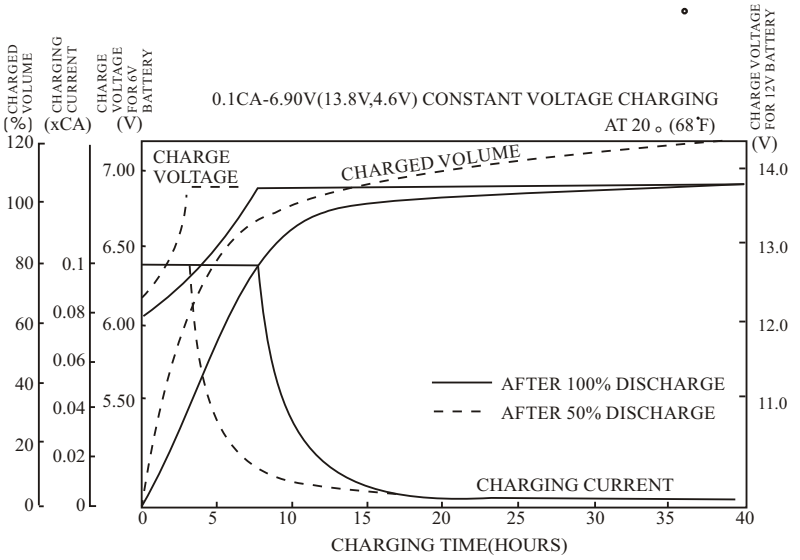
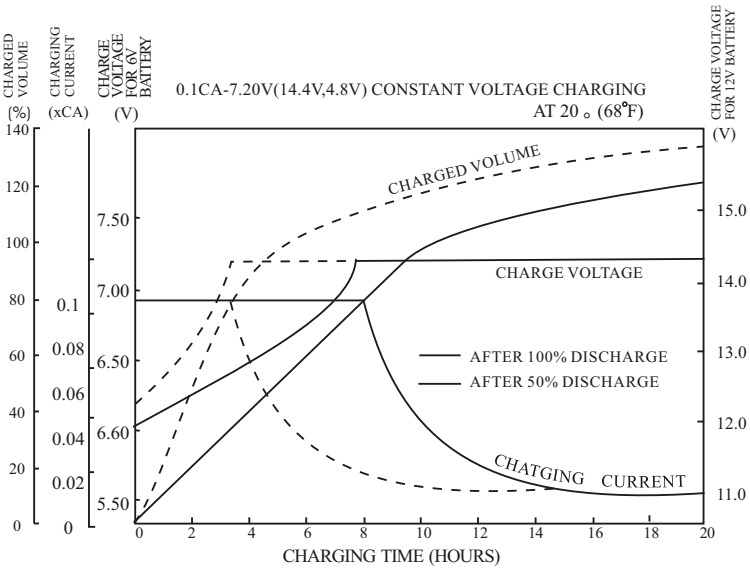


Figure 6
CHARGING CHARACTERISTICS



◆ Recovery charge after deep discharge

When a battery has been subjected to deep discharge (commonly referred to as overdischarge), the amount of electricity which has been discharged is actually 1.5 to 2.0 times as great as the rated capacity of the battery. Consequently, a battery which has been overdischarged requires a longer charging period than normal. Please note, as shown in Figure 8 below, that as a result of internal resistance, charging current accepted by an overdischarged battery during the initial stage of charging will be quite small, but will increase rapidly over the initial 30 minutes (approximate)untill internal resistance has been overcome, and normal, full recovery charging characteristics resume.

Figure7
RELATION BETWEEN CHARGE VOLTAGE AND TEMPERATURE

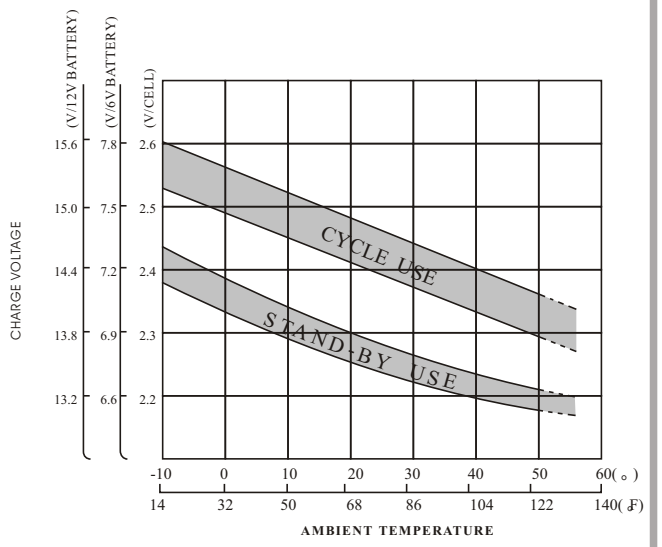
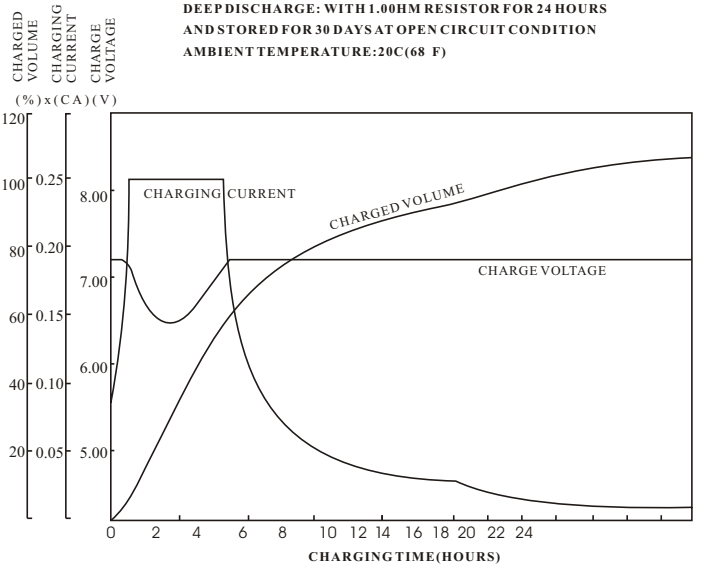


Figure 8
0.25CA.-7.25V CONSTANT VOLTAGE CHARGE FOR 24 HOURS. DEEP DISCHARGE: WITH 1.00HM RESISTOR FOR 24 HOURS AND STORED FOR 30 DAYS AT OPEN CIRCUIT CONDITION AMBIENT TEMPERATURE:20C(68 F)

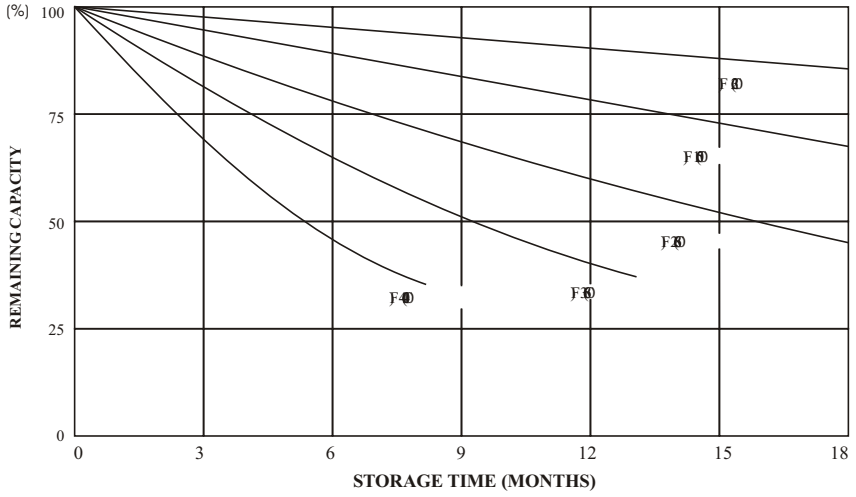


In view of the above, consideration should be given to the fact that if the charging method used is constant voltage in which the charger employs current sensing for either state of charge indication or for reducing voltage (a two step charger), during the initial stage of charging an overdischarged battery, the charger may give false "full charge" indication, or may initiate charge at a float voltage.

10. Battery Storage

It is recognized that Gaston SLA batteries have excellent charge retention characteristic. That is, their self-discharge rate is low and is typically less than 3% per month at 20。(68。F). The self-discharge rate will vary as a function of ambient storage temperature.

Figure 9 SELF-DISCHARGE CHARACTERISTICS



Storage

Lead-acid batteries previously were affected by long term storage after charging. But Gaston SLA battery is not so affected. This battery offers longer extended storage than conventional batteries. See Figure 9.

During storage, carry out supplementary charging according to the cycle shown in Table 3.

For supplementary charging after long storage, either the constant-voltage charge with 2.45v/cell, or the constant-current charge with 0.05CA, is recommended. But, sometime, one supplementary charge may not recover to the 100% capacity. Such

Table 3 Storage temperature and recommended supplementary charge interval

Storage temperature	Recommended supplementary charge interval	Supplementary charge method
Below 20 。(68 F)	Every 6 months	* More than 24 hours with a constant voltage of 2.275V/cell
	Every 3 months	* 6 to 12 hours with a constant voltage of 2.45V/cell
	Storage to be avoided	* 6 to 12 hours with a constant current of 0.05CA

Although the self-discharge rete is low, specific precautions must be taken against the battery over discharging itself by self-discharge when in storage or not operating. In general, to optimize performance and service life, it is recommended that Gaston batteries which are to be stored for extended periods of time be given a supplementary charge, commonly referred to as "top charging",Periodically.

Top Charging

Since any battery losses capacity through self-discharge, it is recommended that a "top charging" be applied to any battery which has been stored for a long perid of time, prior to putting the battery into service.

1.Ensure the OCV of the battery is greater than 2 vpc. If the Voltage is lower than 2 vpc please refer the problem to GASTON before attempting to recharge.

2. Excepting conditions in which storage temperatures have been abnormally high,top charging is recommended with the

Storage Time	Top Charging Recommendation
Less than 6 months from manufacture or previous top charging.	Maximum of 20 hours at a constant voltage of 2.4 vpc.
Up to 12 months after manufacture or previous top charging.	Maximum of 24 hours at a constant voltage of 2.4 vpc.
Note: A faster recharge may be obtained by using the constant current method of charging. This requires a closer supervision of the charging procedures.	
Less than 6 months (As above)	Maximum of 6 hours at a constant current of 0.1 C Amps.
Up to 12 months (As above)	Maximum of 10 hours at a constant current of 0.1C Amps.

Precautions Against Over Self-Discharge

a. The batteries should be stored in a cool, dry place.

b. The batteries should not be stored in direct sunlight.

c. The batteries should not be subjected to an external heat source.

11. Service Life

Similar to other batteries, Gaston valve regulated lead-acid battery develops electrode deterioration after extended use. When the service life is reached, the capacity cannot be recovered by charging.

Depending on the charge method or service temperature, this battery may have a shorter life than a lead-acid battery with a large quantity of electrolyte.

Discharge depth

Repetition of discharge with a large discharge quantity (that is,deep discharge) shortens the cycle life.

Discharge current magnitude

After repeating the discharge with a small discharge quantity (that is, light discharge), a very large discharge current will shorten the

Charge current magnitude

Excessively large charge current generates gas in a quantity exceeding the absorption rate of the battery. This causes internal pressure to rise, and gas is expelled by the valve. Finally the electrolyte decreases and becomes empty.

Overcharge quantity

When it is overcharged, the battery component (plates, separators, and so on) will suffer for deterioration due to electrolytic oxidation.

Influence of ambient temperature

High ambient temperature accelerates deterioration of battery components. With constant-voltage charging, high ambient temperature allows an unnecessary large quantity of charge current to flow, which results in a shorter service life. Charging at low temperature, however, causes generation of H2 gas. This gas causes the internal pressure to increase or the electrolyte to decrease,

(1) Cycle service life

figure 10 shows the relation between the discharge depth and number of cycle servicing. As the discharge depth increases during servicing, the number of service cycles decrease. When used for similar loads, the battery which is designed for expanded capacity will have a better service life.

(2) Trickle (float) charge service life

Figure 11 shows the battery capacity and trickle (or float) charge service life. The dark shaded portion indicates the range of the service life characteristic.

Figure 10 CYCLE SERVICE LIFE

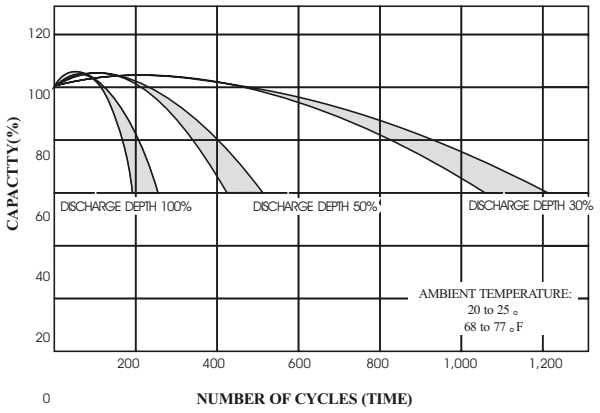
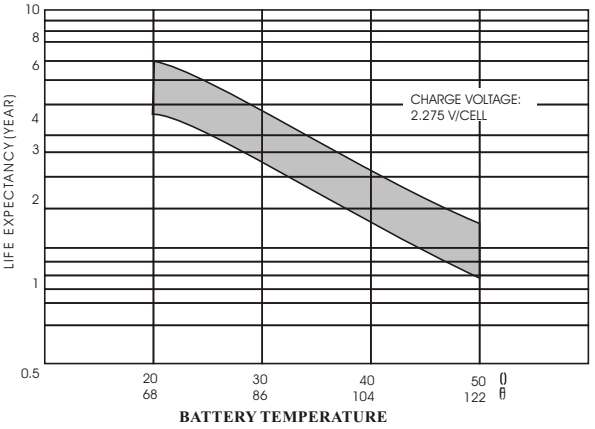


Figure 11RELATION BETWEEN BATTERY TEMPERATURE AND TRICKLE (FLOAT) CHARGE SERVICE LIFE



12. Design Application Tips To Assure Sustained Maximum Service

Gaston batteries are fully efficient maintenance free electrochemical systems designed to provide years of trouble-free electronical energy. The performance and service life of these batteries can be maximized by observing the following guidelines:

1. Heat kills batteries. Avoid placing batteries in close proximity to heat sources of any kind. The longest service life will be attained when the battery is operated over an ambient temperature range of 20 。(68 。F).
2. Since a battery may generate ignitable gases, do not install close to any item that produces sparks.
3. When the battery is used in a container or bag, a ventilation opening should be provided. A cubicle containing the battery should be provided with sufficient ventilation.
4. The battery is manufactured from high impact ABS plastic resin, placing it in an atmosphere of, or in contact with organic solvents or adhesive materials should be avoided.
5. Correct terminals should be used on battery connecting wires. Coldering is not recommended but if unavoidable the solder connection should be done as quickly as possible within three seconds using a 100 watt soldering iron.
6. Permissible operation temperature range of battery is -15 。to 50 。. But use at cycle service 5 to 35 。range is recommended.
7. Use shock absorber and fasten battery tightly when heavy vibration or shock is expected.
8. When connecting the batteries, free air space must be provided between each battery. The recommended minimum space between batteries is 0.02 inches (5mm) to 0.04 inches (10mm).
9. When the batteries are to be assembled in series to provide more than 100V ensure proper handling to prevent electrical leakage.
10. If 2 or more battery groups are used in parallel connection, they must be connected to the load through equal length of cable.
11. When the batteries are used in an UPS system,

    a) where D.C input exceeds 60volts, each battery should be insulated from the battery stand by using suitable polypropylene or polyethylene material.

    b) in high voltage systems, the resistance between battery and stand should always be greater than 1 Magohm. An appropriate alarm circuit could be incorporated to monitor any current flow.
12. Clean the battery with a wet cloth. Never have the battery splashed or deposited with oils or organic solvents such as gasoline and paint thinner, nor have it cleaned with cloths impregnated with these materials.
13. Do not attempt to dismantle the battery. If sulfuric acid is deposited due to mechanical damages on the skin or cloths, wash with liberal amount of fresh water to get immediate medical attention.
14. A battery is liable to rupture if thrown into fire. Avoid such conduct at all times.