VALVE REGULATED GAS RECOMBINATION BATTERIES

Instruction & **Engineering Manual**

LEAD RETURN RECYCLE

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1. INTRODUCTION

MSB batteries are manufactured under the guidelines of ISO 9002. Each MSB battery undergoes a series of rigid manufacturing and quality control before the battery leaves the factory.

Features

- Maintenance-free operation/ Sealed construction

  MSB batteries have been classified as "Non-spillable." During the expected service life of MSB batteries, there is no need to check the specific gravity of the electrolyte, or add water.

  The MSB battery's unique construction and sealing technique guarantee that no electrolyte leakage can occur from the terminals or case of any MSB battery. These ensure the battery can operate safely in vertical or horizontal position.

- Wide operating temperature range:
  MSB battery will operate from -30°C (-22° F) to 60°C when it is fully charged.

- Long service life:
  Thick calcium grids extends service life.

- Low internal resistance and high discharge rate:
  The MSB SLA battery has low internal resistance when it fully charged, therefore has a high discharge rate.

- Working safely:

MSB battery equipped with a safe, low pressure venting system. Which operates at 1 psi to 6 psi, designed to release excess gas and reseal automatically in the event that gas pressure rises to a level above the normal rate. Thus, there is no excessive buildup of gas in the batteries.

2. APPROVALS

Conforms to BS 6290 Part 4* and IEC 896 - 2*

* for Ultra range only.

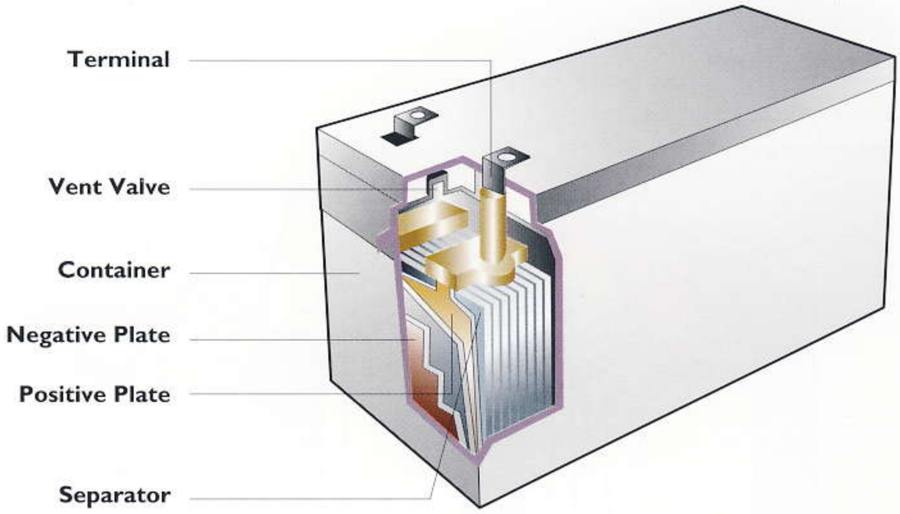
CE ETS Germany EMC tested

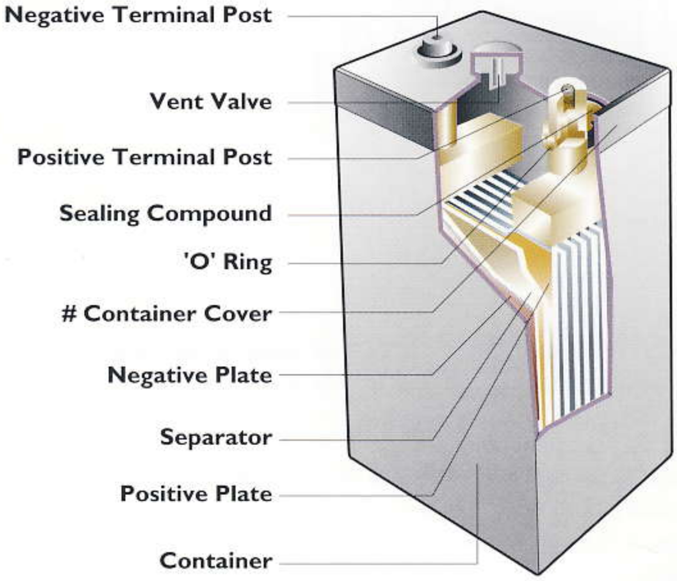
Certificate of CE

MH26866

Certificate of UL

3. CONSTRUCTION & OUTLOOK

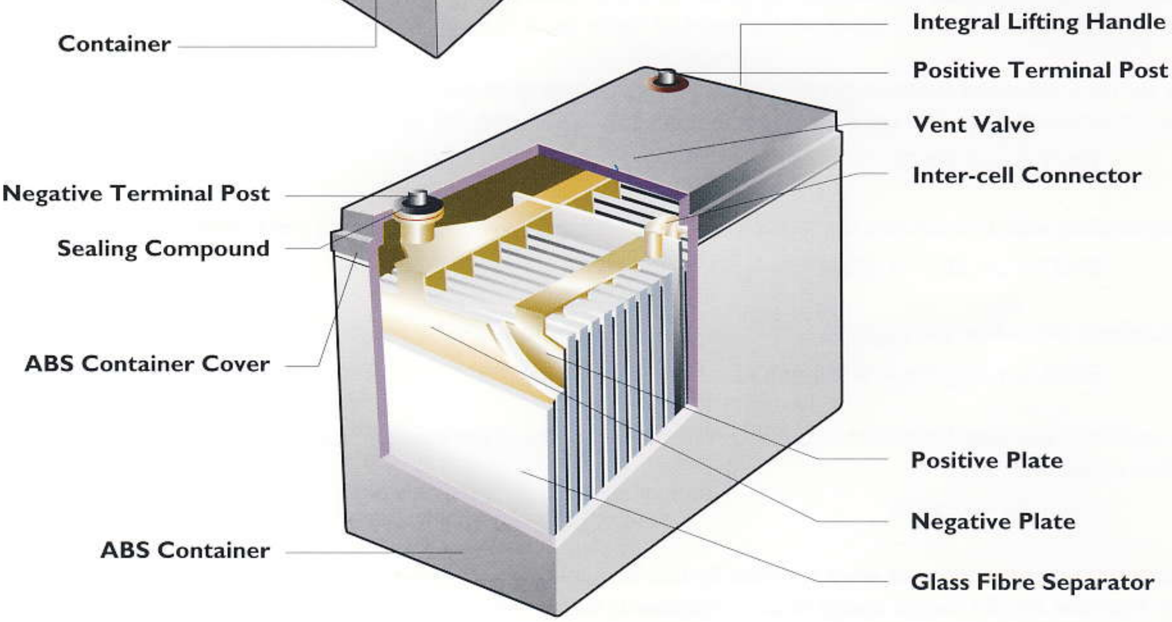




Note:

* Flame Retardant Container to BS6334 category FV '0' is available on request.

\# Optional Cover. Standard insulated flexible connectors are supplied.

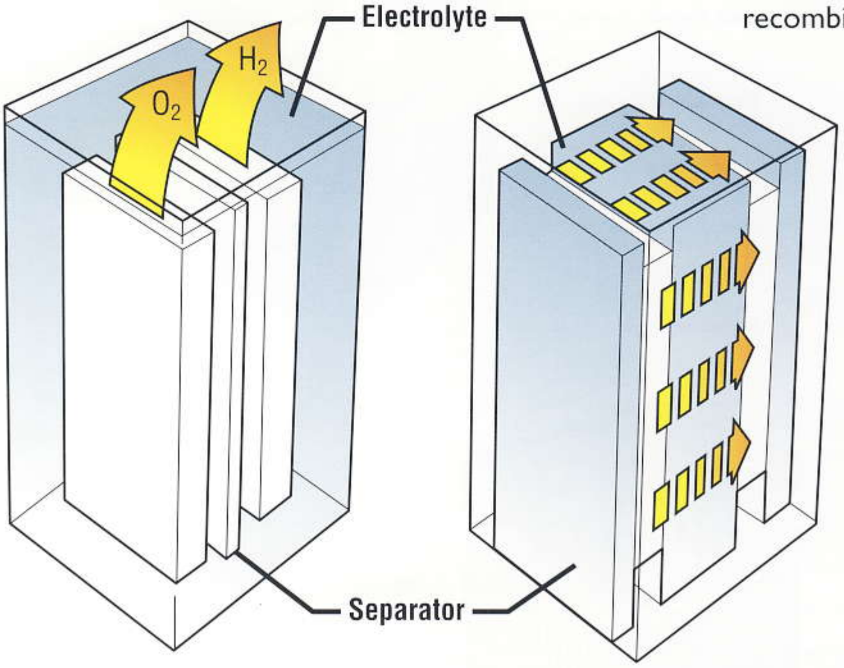


* Flame Retardant Container to UL 94 FV 'O' is available on request.

4. PRINCIPLE OF GAS RECOMBINATION

Conventional cell
Oxygen and Hydrogen escape to the atmosphere

MSB Ultra cell
Oxygen evolved from positive plate transfers to negative and recombines to form water



When a charge current flows through a fully charged conventional lead-acid cell, electrolysis of water occurs to produce hydrogen from the negative electrode and oxygen from the positive electrode. This means that water is lost from the cell and regular topping-up is needed.

However, oxygen and hydrogen are not evolved simultaneously. Recharging of the positive electrode is less efficient than the negative with the result that oxygen is evolved at the positive before hydrogen at the negative. At the time oxygen evolution begins, there is also a substantial amount of highly active spongy lead available in the negative plate.

In the gas recombination technology cell, a special highly porous glass microfibre separator is employed to allow the oxygen to diffuse through the cell to the negative where it reacts with the lead to form lead oxide.

$$2Pb + 0_2 \longrightarrow 2PbO$$

In the prevailing acidic conditions, the lead oxide reacts with the sulphuric acid in the electrolyte to form lead sulphate.

$$2PbO + 2H_2S0_4 \longrightarrow 2PbSO_4 + 2H_20$$

Lead sulphate formed on the negative is then reduced to lead and sulphuric acid by the evolving hydrogen.

$$2PbSO_4 + 2H_2 \longrightarrow 2Pb + 2H_2SO_4$$

If the equations are added together and 'like terms' on both sides of the equation are cancelled out, we finish up with an equation as follows:

$$2H_2 + 0_2 \longrightarrow 2H_2O$$

The above reactions summarise what is meant by Gas Recombination. If the process were 100% efficient, no water would be lost from the cell. By careful design of the constituents within the cell, gas recombination between 95% and 99% can be achieved.

5. APPLICATIONS

Main Applications

- Telecommunications
- UPS Standby
- Power Station Switching/ Tripping
- Fire Alarms
- Security Camera/ Alarm Standby
- Solar Standby

Other Applications

- Elevators
- Generator Starting
- Emergency Lighting
- Portable Electric Toys
- Electric Wheelchair/ Electric Bicycles
- Automatic Gates
- Power Tools

6. DISCHARGE CHARACTERISTICS

Final Discharge Voltage

Final discharge voltage is the battery terminal voltage in close circuit voltage per cell to which a battery discharged safely to maximize battery life.This data specified according to the actual discharge load and run time. As a rule of thumb, high amp loads and short run time will tolerate a lower final discharge voltage (e.g. 3C (A) at 1.3V/CELL), where low amps long run time discharge will require a higher final discharge voltage (e.g. 0.05C(A) AT 1.75V/CELL).

Discharge Current (A)	Final Discharge Voltage (V/CELL)
0.05C to 0.2C	1.75
0.2C to 0.5C	1.70
0.5C to 1C	1.60
Above 1C	1.30

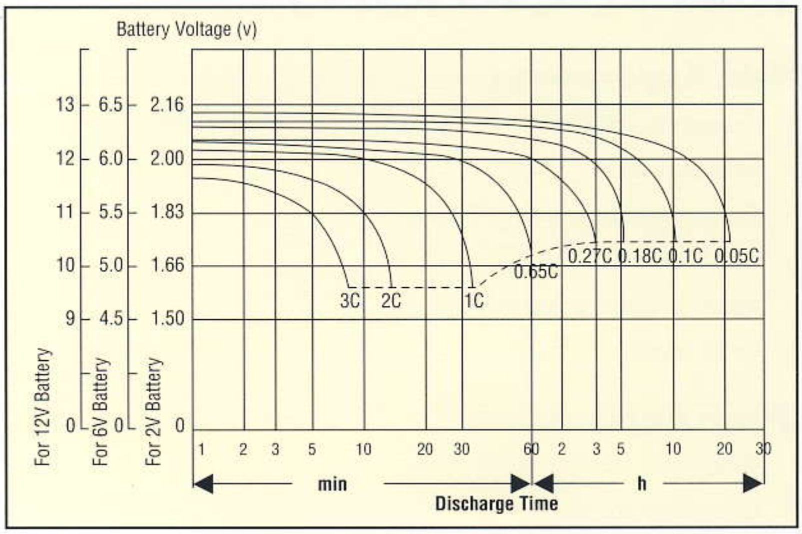
Suggestion: Too low amps and long run time discharge will do some damage to the battery. The load current less than 0.05C (A) is not recommended unless maximum depth of discharge is restricted to 50% DOD.

Battery Discharge Characteristics and Battery Selection

The discharge capacity of battery varies and is dependent on the discharge rate being used. MSB Ultra series batteries are rated at the 10 hours rate, MSB MS series batteries are rated at the 20 hours rate, that is, the capacity of battery discharge to an end voltage of 1.75V/CELL at the temperature of 25°C.

The battery discharge graph (Figure 1) may be utilized in battery selection. However, it suggested that a review should be made to the data sheet for each battery type or the chart showing the actual ampere hour capacity of each battery type at various discharge times.

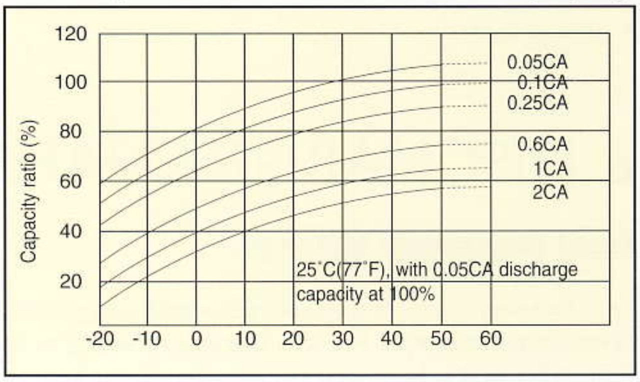
FIGURE 1. **MSB batteries discharge characteristic curves at various rate(25°C)**



Effect of Temperature on Battery Capacity

The nominal battery capacity is based on the temperature of 25°C. Above this temperature, the capacity increases marginally but it must be kept within the temperature design limitations of the product; below this temperature, the capacity decreases marginally. This decrease in capacity becomes larger at temperature below 0°C and in heavy discharge rates. The graph (Figure 2) illustrates the situation.

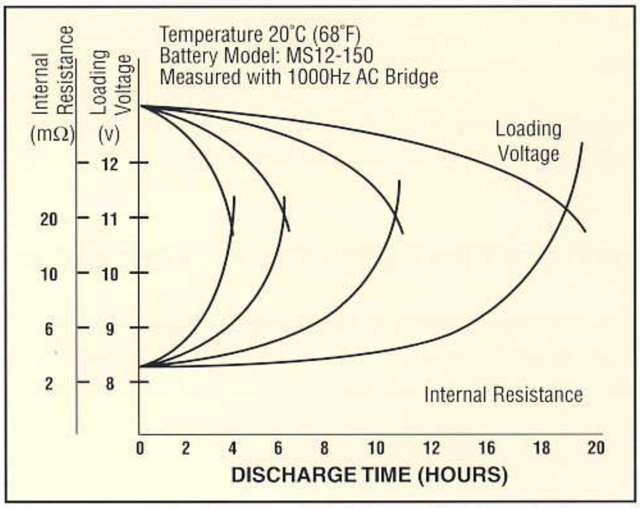
FIGURE 2. **Temperature effects in relation to MSB battery capacity**



Battery Internal Resistance Change

(Figure 3) shows the internal resistance changing with the discharge process. The internal resistance of MSB battery increases slowly during the discharge process; but rapidly at the final stage of discharge.

FIGURE 3. **Battery internal resistance**



7. CHARGE CHARACTERISTICS

Battery Charging Methods

Correct battery charging is very important to assure the maximum possible working life for MSB battery.There are four charging methods:

Constant Voltage Charging

Constant voltage charging is recommended method for battery. It is necessary to closely control the actual voltage to the limit advised.The initial current should be suppressed to less than 0.3C(A), during the final stage of charge, the current decrease automatically.

Constant Current Charging

It is generally not recommended for battery, yet it is an effective method for supplementary charge of many batteries at one time in series during storage.The charging time must be strictly controlled, if not, considerable damage will occur to the batteries due to overcharge.

Two - Step Combination Charging

This system employs two steps of charging, it can be constant current-constant voltage, maintained constant current, etc. Yet it should not be used where the battery and load are connected in parallel.

Taper Current Charging

In this system, a charging cut-off circuit should be incorporated in the charger to prevent overcharge. It can be utilized for some industrial uses and trickle charging system.

Battery Charging Application

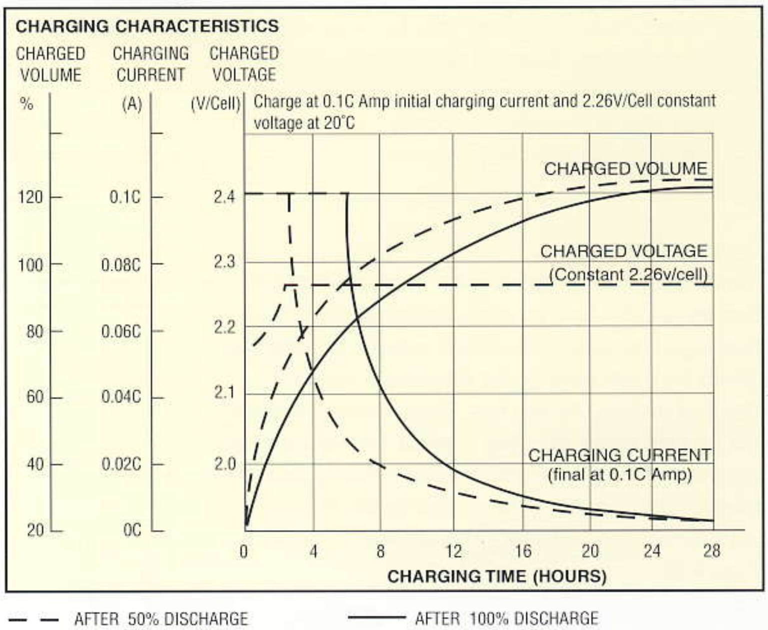
Float-Charge Standby Application

In this system, the battery and the load are connected in parallel with the rectified power source, only a constant voltage charger is required.The voltage applied is recommended as 2.25-2.30VPC(voltage per cell) at 25°C. The initial current is suggested to be set within 0.3C(A).The attached graph (Figure 4) indicates the time taken to fully recharge the battery.

Cyclic Application

Cyclic use requires a short time charge and protection against excessive charges and discharges.The constant voltage applied is recommended as 2.40 - 2.50VPC(voltage per cell) at 25°C .The initial current is suggested to be set within 0.3C(A).The attached graph (Figure 5) indicates the time taken to fully recharge the battery.

FIGURE 4. **Float-charge**



Trickle-Charge Standby Application

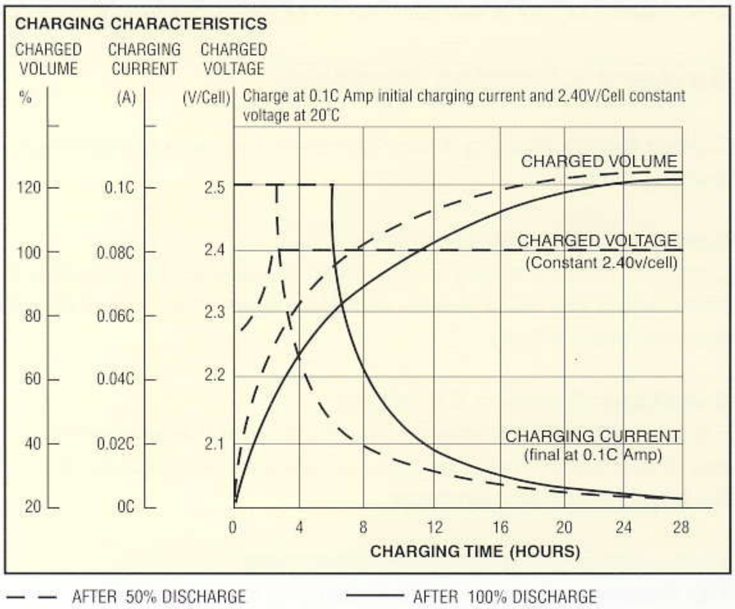
Under trickle charge operation, AC power is normally supplied for operating the equipment, the batteries are not connected to the load and are normally kept in fully charged condition. A two-rate charger or a constant voltage charger can be used.

Supplementary Charge

During battery storage, its' actual capacities decrease very slowly due to the battery self-discharge in relation to ambient temperature. Batteries need supplementary charge to maintain capacity. Constant voltage charging is recommended.

Storage Temperature	Charging Interval
20°C or less	every 9 months
20 – 30°C	every 6 months
30 – 40°C	every 3 months
40 – 50°C	every 1.5 months

FIGURE 5. **Cyclic use-recharge**

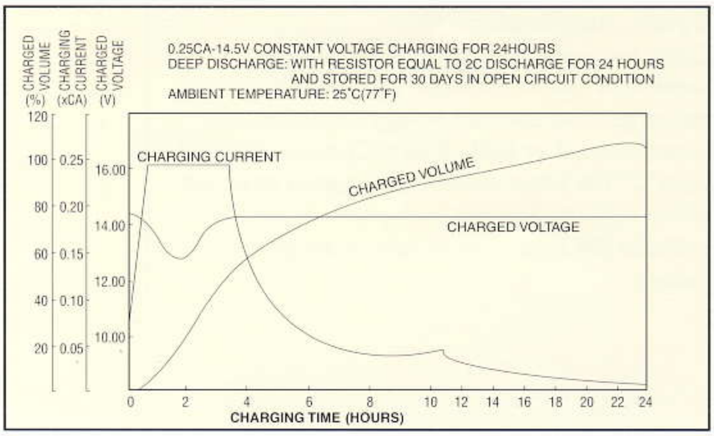


Storage Time	Top Up Charging Recommendation
Less than 6 months from manufacture or previous top up charge.	Maximum of 20 hours at a constant voltage of 2.40 VPC.
Less than 12 months from manufacture or previous top up charge.	Maximum of 24 hours at a constant voltage of 2.40 VPC.
Note: A faster recharge may be obtained by using the constant current method of charging. This require a closer supervision of the charging procedures.	
Less than 6 months (as above) Less than 12 months (as above)	Maximum of 8 hours at a constant current of 0.1C amps. Maximum of 10 hours at a constant current of 0.1C amps.

Recovery Charge After Deep Discharge

Battery is subjected to over-discharge when it is discharge below specified final voltage. Service life would be shortened and it requires a longer charging period. At the first stage, battery voltage will be high while charging current kept quite small for about 0.5–2 hours and increase slowly until the internal resistance has been overcome, then normal and full recovery charging characteristics resume. (Figure 6)

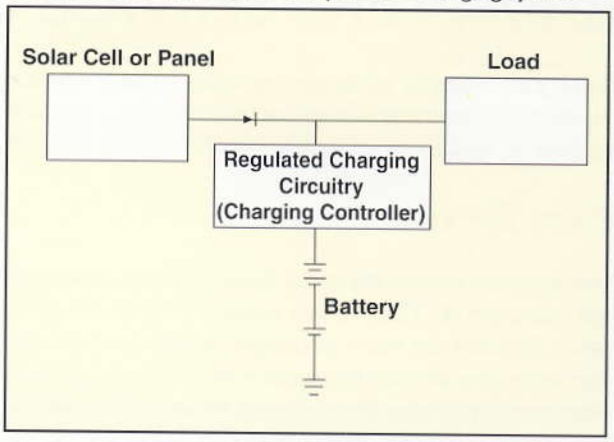
FIGURE 6. **Recovery charge**



Solar Powered Chargers

When the output of the solar array exceeds the capacity of the battery or weather conditions are potential for overcharging, it needs an appropriate regulated circuitry between the solar panels and the battery. MSB battery can be charged by the solar array using regulated circuitry as shown in (Figure 7).

FIGURE 7. Block diagram of a solar powered charging system



Equalization Charging

Due to their sealed maintenance free designs, MSB batteries do not normally require equalization charges. However, environmental condition or charger variations may cause voltage imbalances in battery systems. This inbalance can be resolved by a short term equalization charge.

An equalization charge is accomplished by raising the charging voltage for certain amount of time. For MSB batteries, the following table should be used for equalization charge. (25°C)

Voltage (VPC)	Time in Hours
2. 25 – 2.27V	Indefinite
2.28 – 2.32V	96 – 168
2.33 – 2.35V	72 – 96
2.36 – 2.37V	48 – 72

NOTE: Do not exceed 2.37 volts per cell (VPC), or the pressure release valve will open and gas is released. It is not recommended to use an equalizing charge on a regular basis.

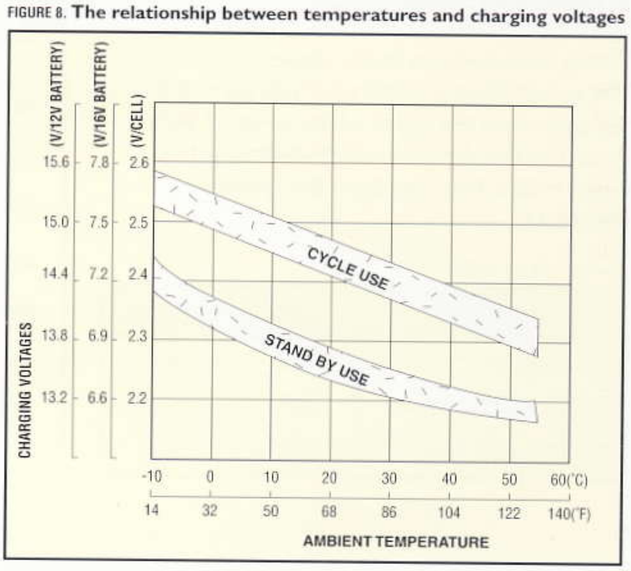
Initial Charge Current Limit

In the majority of standby applications, current limit is required. Under constant voltage charge to cyclic application, a discharged battery will accept a high charging current at initial stage of charging, but continuously high charging current can cause abnormal internal heating or thermal runaway that may damage the battery. So it is necessary to limit the initial charging current to 0.3 C(A).

Effect of Temperature on Charging Voltage

Electrochemical activities in battery increase as temperature rises and conversely decreases as temperature falls. Therefore, as temperature rises, charging voltage should be reduced to prevent overcharge; as temperature falls, charging voltage should be increased to avoid undercharge. To ensure optimum service life, it is recommended to use a compensation factor for battery -3mv/°C /Cell (standby use) and –5mv/°C /Cell (cyclic use). The standard centre point for temperature compensation is 20°C. (Figure 8) shows the relationship between temperatures and charging voltages in both cyclic and standby applications.

FIGURE 8. The relationship between temperatures and charging voltages



8. BATTERY SERVICE LIFE/ CYCLE LIFE

Battery life depends on factors including battery operating temperature, charging method, actual use of the product, i.e: float or cyclic service, and depth of discharge (DOD).

Float Service

The designed service life under float service is 5 years for MS series, 10+ years for MS 12Volt Ultra series, 15+ years for MS 2Volt Ultra series. Basically the more discharges suffered and the deeper the discharges, the shorter the battery life. The ambient temperature effect battery service life obviously, its service life will decrease while temperature increase. (Figure 9-11)

FIGURE 9. **Effect of Temperature on long term Float life**
(MS series)

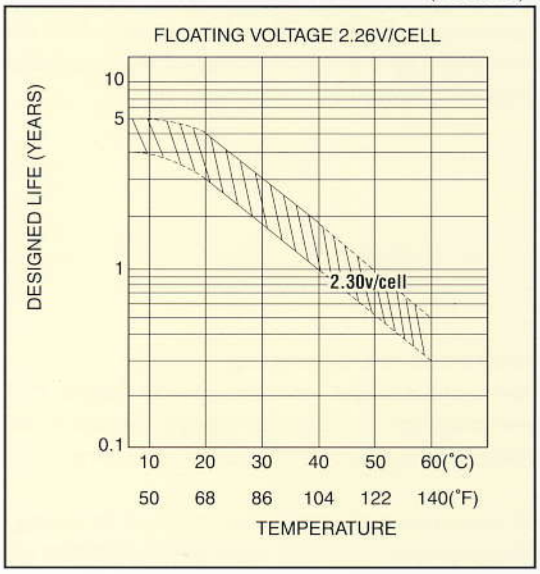


FIGURE 10. **Accelerated float service life characteristics**
MS Ultra (12V)

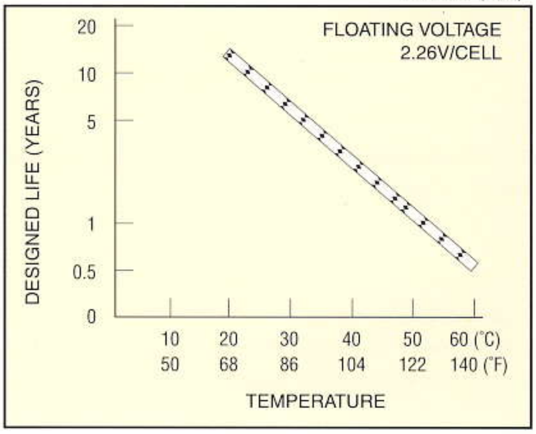
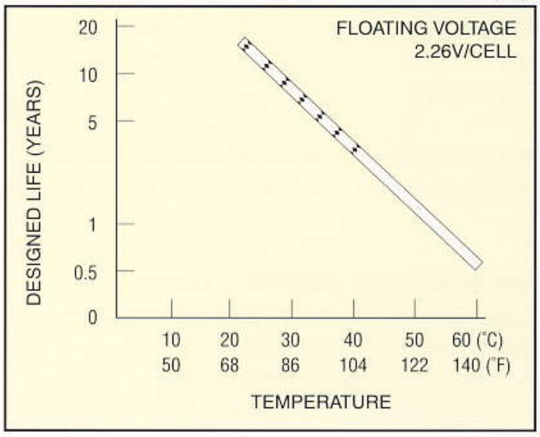


FIGURE 11. **Accelerated float service life characteristics**
MS Ultra (2V)



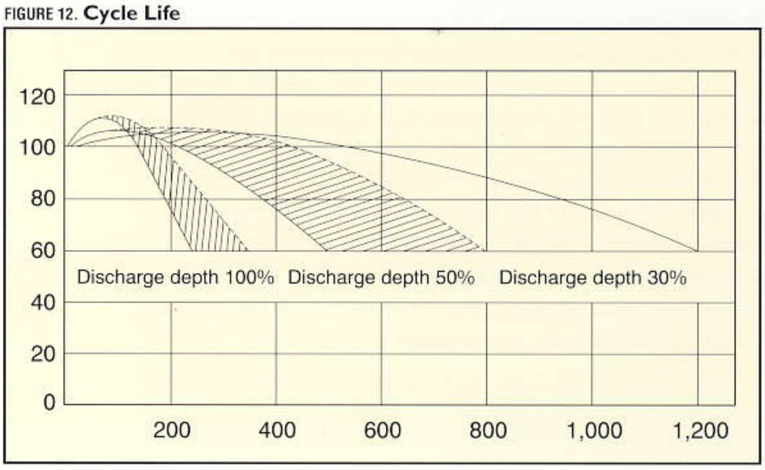
Cycle Service

Giving consideration to the above factors. The actual life of a battery in cycle service is dependent on the depth of discharge of each cycle. The deeper the battery discharge, the lesser cycles it can get from the battery. (Figure 12)

Cycle Life to DOD

Models	100%	50%
MS Series	250	500
MS Ultra 12V Series	300	600
MS Ultra 2V Series	350	800

FIGURE 12. **Cycle Life**

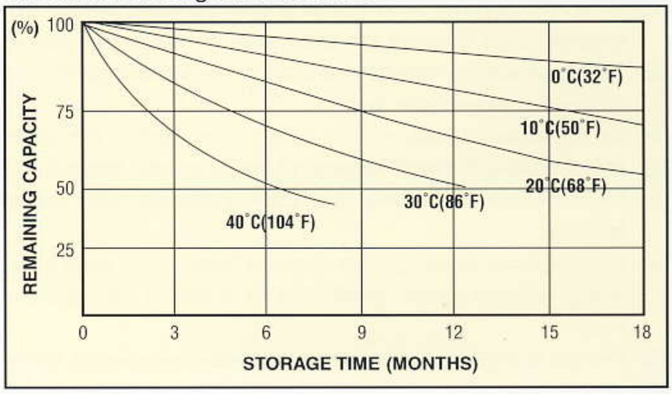


9. STORAGE/ SHELF LIFE

Battery Self Discharge Characteristics

The rate of self-discharge is approximately 3% per month when batteries are stored at 20°C. It varies with ambient temperature. Lower storage temperature will reduce the rate of self-discharge, higher temperature will increase the rate. A cool, dry area is the recommended environment in which batteries should be stored. (Figure 13) shows the relation between the storage time at various temperatures and the remaining capacity.

FIGURE 13. Self discharge characteristics



Shelf Life And Ambient Temperature

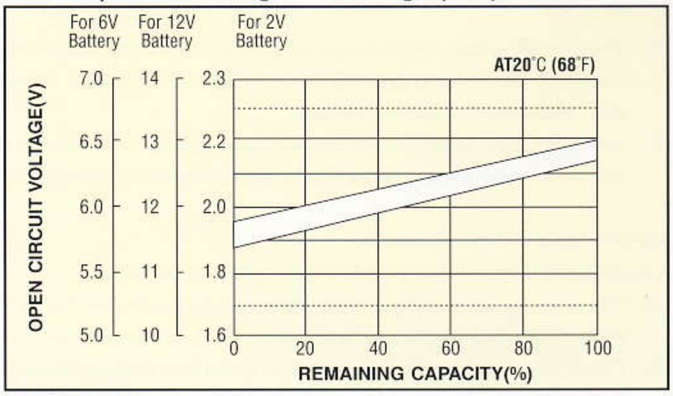
In discharging a battery, lead sulphate is formed and it can be converted to active material as soon as battery is recharged in time. However on self discharge during storage, the lead sulphate that is formed may become inactivated and cannot be reconverted. The lower the voltage that a battery is allowed to fall to under self discharge, the more likely the battery is damaged beyond recovery.

Ambient Temperature	Typical Shelf Life
0°C to 20°C	12 months
21°C to 30°C	9 months
31°C to 40°C	6 months
41°C to 50°C	2.5 months

Battery Open Circuit Voltage And Remaining Capacity

The open circuit voltage (OCV) is a relative measure of the electrolyte concentration contained within the battery, the latter is a direct measure of battery's state of charge and can be used to determine the percentage of battery capacity remaining approximately. This relationship is exhibited at figure 14.

FIGURE 14. Open circuit voltage vs remaining capacity



Determination of the battery state of charge

The battery state of charge can be determined by measuring the open- circuit voltage of cells in rest position for 24 hours

% of capacity at 20° C	Voltage per cell at different temperatures				
	0°C	10°C	20°C	30°C	40°C
100%	2.16	2.15	2.13	2.13	2.13
80%	2.09	2.09	2.09	2.09	2.09
60%	2.06	2.06	2.06	2.06	2.06
40%	2.02	2.02	2.02	2.02	2.02
20%	1.97	1.97	1.97	1.97	1.97

10. HANDLING/ INSTALLATION

Installation and Connection

(1) When the batteries are mounted in the equipment, exercise caution to ensure easy checking, maintenance and battery interchange. In addition, the batteries should be located in the lowest part of the equipment as possible.
(2) Study and test the material and shape of the battery connectors which form the interface between the batteries and the application, including life test.
(3) Set the batteries firmly, so they do not move freely in the equipment .This avoids unexpected vibration and/or shock.
(4) Avoid locating the batteries near a heat generating device (such as a transformer).
(5) Do not locate the batteries near a device that may cause sparks (such as a switch and a fuse). And do not bring fire close to the batteries.
(6) In applications requiring more than one battery, first make batteries mutual connections properly, and then connect the batteries strings with the charger or the load. Be careful to connect the + pole of the batteries to + terminal of either the charger or the load.
(7) Provide enough insulation for the lead wires between the batteries and the application.
(8) THE TIGHTENING TORQUE FOR CONNECTION SCREWS VARIES ACCORDING TO THEIR DIAMETER:
- M6 screws: torque from 4Nm to 6Nm maximum
- M8 screws: torque from 6Nm to 8Nm maximum

Daily Handling

Charge

(1) Study any new charging method and condition of the batteries which is not written in this specification.
(2) It is recommended that current limit is incorporated into the charger.
(3) Do not charge the batteries in a place where there is direct sunshine.
(4) Do not charge the batteries near a heater or the like where heat accumulation may occur.
(5) Charge the batteries for the time shown by the specification, or to the time when the charge indication lamp shows the end of charge.
(6) Avoid charging fully charged batteries frequently, it will shorten life.
(7) Do not continue to charge the batteries over 24 hours in cyclic operation.
(8) Avoid parallel charge in cyclic operations.

Discharge

(1) The cut off voltage of discharge varies higher or lower depending upon the discharge current. The relationship between the discharge current and the recommended cut-off voltage is shown on page 6, Figure 1. Do not discharge the batteries lower than this recommended cut-off voltage.
(2) It is important to avoid over discharge, and charge the battery immediately after discharge. The OEM's instruction manuals should show that over discharge should be avoided and that the battery should be charged immediately after discharge.

Check and Maintenance

It is advisable to periodically to do check and maintenance.

(1) Measure the total voltage of the batteries during trickle charge (or float charge). If the charge equipment provides a irregular (incorrect) read out, be sure to investigate the reason behind any deviations from the specified voltage range.
(2) Check the batteries for any sign of irregularities in appearance. If any damage such as a crack and deformation, or electrolyte leakage is found on the case, cover, etc., the batteries must be replaced with a new one. Also, clean the batteries if these are found to be dirty due to dirt and dust.

Safety

For any servicing of battery, preventive safety and caution must be followed. However, if a voltage over 150 volts exists between 2 terminals which can be touched simultaneously by inadvertance, it is necessary to use rubber insulated gloves as well as an insulated carpet, and to be accompanied by another person.

Exchange of the Batteries

(1) Exchange the batteries from current ones to the new ones, when there is any abnormality in appearance or characteristic of the batteries. When the batteries are connected in series, the batteries in one string should be exchanged at once.
(2) Exchange the batteries to new ones before they are used for the years shown on page 9 in trickle charge (or float charge) below 77°F(25°C) around them. The interval of this exchange should be shortened by temperature increase of every 50°F(10°C)

Storage

(1) Store the batteries in an upright position.
(2) Store the batteries starting from the fully charged state.
(3) Charge the batteries, at least once, every six months during storage below 77°F(25°C). Use the charging method which is shown on pages 7 & 9. The interval of this charge must be shortened to half by temperature rising of every 50°F(10° C).
(4) They should be used as quickly as possible.

Transportation

(1) Handle the batteries carefully to avoid injuries. They are heavy and must be handled properly.
(2) Avoid moisture or rain on the batteries.
(3) Keep the batteries in the upright position while in transportation. Avoid abnormally strong shock and/or vibration on the batteries.

Recycling

(1) Because of its importance, please consider placing written information of recycling the battery on: the product (application), the package, the carton and the battery, especially in countries where there are legal or voluntary regulations on recycling of batteries.
(2) When designing the product, make the battery easily removable, and accessible in order to make its replacement and recycling or proper disposal easy for the customer.

Other Cautions

(1) When cleaning the batteries, use soft cloth only. Use of organic solvents such as gasoline or thinner, and application or adherence of oil to the batteries must be avoided. Do not clean the batteries using cloth that contains organic solvents or oil. Also contact with soft polyvinyl chloride or the like must be avoided.
(2) Do not short batteries.
(3) Do not attempt to disassemble the batteries. Avoid contact with sulphuric acid leaked from the broken batteries.
(4) If eyes contact with sulphuric acid, wash eyes with a lot of clean water, and consult a physician immediately.
(5) Never dispose of the batteries in fire.
(6) Avoid mixed usage of the batteries differing in capacity, type, manufacturer or history of use (charge/discharge operation).
(7) Do not use the batteries for application other than those specified in this specification.
(8) In medical equipment, a back-up system other than the main battery should be built in, to provide power in the event that the main power or battery fails to work.
(9) When designing the charger, take battery damage modes into consideration, and provide protection against short-circuits, and/or protection for the charger output.
(10) When the batteries are used in vibration conditions, such as motor cycles, engine driven lawnmowers etc., proper cushion for protecting vibration should be prepared. Additionally the batteries should be mounted upright position.

Note: If the batteries are mounted side down position and/or up side down position, internal short circuit, internal breaks and/or electrolyte leakage might be occurred. Please contact your dealer for additional assistance, or for information not described in this handbook or specification.

NOTICE TO READERS

It is the responsibility of each user to ensure that each battery application system is adequately designed, safe and compatible with all conditions encountered during use, and in conformance with existing standards and requirements. The circuits contained herein are illustrative only and each user must ensure that each circuit is safe and otherwise completely appropriate of the desired application.

This technical handbook contain information concerning cells and batteries manufactured by the manufacturer. This information is generally descriptive only and is not intended to make or imply any representation guarantee or warranty with respect to any cells and batteries. Cell and battery designs are subject to modification without notice: All descriptions and warranties are solely as contained in formal offers to sell or quotations made by the manufacturer.

IT IS ADVISED TO KEEP A NOTEBOOK IN WHICH MEASURED TOTAL VOLTAGE VALUES CAN BE WRITTEN DOWN, AS WELL AS POWER CUTS ON MAINS BATTERY REQUIREMENTS (DISCHARGE DURATION AND INTENSITY)... ETC.