THEORY OF OPERATION

The basic electrochemical reaction equation in a lead-acid battery can be written as follows:

Pb	$2H_2SO_4$	PbO_2	Discharging	$PbSO_4$	$2H_2O$	$PbSO_4$
(porous lead)	(sulfuric acid)	(porous lead dioxide)	$\rightleftharpoons$	(lead sulfate)	(water)	(lead sulfate)
active material	electrolyte	active material	Charging	active material	electrolyte	active material
of negative plate		of positive plate		of negative plate		of positive plate

Discharge

During the discharge portion of the reaction, lead dioxide (positive plate) and lead (negative plate) react with sulfuric acid to create lead sulfate, water and energy.

Charge

During the recharge phase of the reaction, the cycle is reversed: the lead sulfate and water are electro-chemically converted to lead, lead oxide and sulfuric acid by an external electrical charging source.

Oxygen Recombination

To produce a truly maintenance-free battery, it is necessary that gases generated during overcharge are recombined in a so-called “oxygen cycle”. Should oxygen and hydrogen escape, a gradual drying out would occur, eventually affecting capacity and battery life. During charge, oxygen is generated at the positive and reacts with and partially discharges the sponge lead of the negative. As charging continues, this oxygen recombines with the hydrogen being generated by the negative, forming water. The water content of the electrolyte thus remains unchanged unless the charging rate is too high.

In case of rapid generation of oxygen gas exceeding the absorbing capacity of the negative plate, the pressure relief valve will open to release excessive gas.

Deep Discharge

The Power-Sonic battery is protected against cell shorting by the addition of a buffering agent that insures the presence of acid ions even in a fully discharged state. The need for expensive circuitry in the design of a system to prevent deep discharge and possible cell shorting is thereby reduced considerably.

Power-Sonic defines “deep discharge” as one that allows the battery voltage under load to go below the cut-off (or “final”) voltage of a full discharge. The recommended cutoff voltage varies with the discharge rate for a 6 volt battery, for example, it is 5.25V at the 20-hour (0.05C) rate, 5.10V at the 4-hour (0.2C) rate, and 4.5V at the 1/2- hour(1.0C) rate.

It is important to note that deep discharging a battery at high rates for short periods is not nearly as severe as discharging a battery at low rates for long periods of time. To clarify, let’s, analyze two examples:

- Battery A is discharged at the 1C rate to zero volts. “C” for a 4 AH battery, for example, is 4 amps. Full discharge is reached after about 30 minutes when the battery voltage drops to 1.5V/cell. At this point, only 50% of rated capacity has been discharged (1C amps x 0.5 hrs = 0.5C Amp. Hrs.) Continuing the discharge to zero volts will bring the total amount of discharged ampere-hours to approximately 75% because the rapidly declining voltage quickly reduces current flow to a trickle. The battery will recover easily from this type of deep discharge.

- Battery B is discharged at the 0.01C rate to zero volts. 0.01C for a 4 AH battery is 40mA. Full discharge is reached after 100+ hours when the terminal voltage drops to 1.75 V/cell. At this point, the battery has already delivered 100% of its rated capacity (0.01 x 100 hrs = 1C Amp. Hrs.). Continuing the discharge to zero volts will keep the battery under load for another 4-5 days(!), squeezing out every bit of stored energy.

This type of “deep” discharge is severe and is likely to damage the battery. The sooner a severely discharged battery is recharged, the better its chances to fully recover.