BATTERY CHARGING TUTORIAL

Current battery charging technology relies on microprocessors (computer chips) to recharge, using 3 stage (or 2 or 4 stage) regulated charging. These are the "smart chargers", and quality units generally are not found in discount stores. The three stages or steps in lead/acid battery charging are bulk, absorption, and float. Qualification, or equalization are sometimes considered another stage. A 2 stage unit will have bulk and float stages. It is important to use battery manufacturer's recommendations on charging procedures and voltages, or a quality microprocessor controlled charger to maintain battery capacity and service life.

The "smart chargers" are profiled with contemporary charging philosophy in mind, and also take information from the battery to provide maximum charge benefit with minimum observation. Some gel cell and AGM batteries may require special settings or chargers. Our units are selected for their suitability on the battery types they specify. Gel batteries generally require a specific charge profile, and a gel specific or gel selectable or gel suitable charger is called for. The peak charging voltage for Gel batteries is 14.1 or 14.2 volts, which is lower than a wet or AGM type battery needs for a full charge. Exceeding this voltage in a Gel battery can cause bubbles in the electrolyte gel, and permanent damage.

Most battery manufacturers recommend sizing the charger at about 25% of the battery capacity (ah = amp hour capacity). Thus, a 100 ah battery would take about a 25 amp charger (or less). Larger chargers may be used to decrease charge time, but may decrease battery life. Smaller chargers are fine for long term floating, e.g. a 1 or 2 amp "smart charger" can be used for battery maintenance between higher amp cycle use. Some batteries specify 10% of capacity (.1 X C) as the charge rate, and while this doesn't hurt anything, a good microprocessor charger of the appropriate charge profile should be fine up to the 25% rate. You talk to different engineers, even at the same company, you get different answers.

Three Stage Battery Charging

The **BULK** stage involves about 80% of the recharge, wherein the charger current is held constant (in a constant current charger), and voltage increases. The properly sized charger will give the battery as much current as it will accept up to charger

capacity (25% of battery capacity in amp hours), and not raise a wet battery over 125° F, or an AGM or GEL (valve regulated) battery over 100° F.

The **ABSORPTION** stage (the remaining 20%, approximately) has the charger holding the voltage at the charger's absorption voltage (between 14.1 VDC and 14.8 VDC, depending on charger set points) and decreasing the current until the battery is fully charged. Some charger manufacturers call this absorption stage an equalization stage. We don't agree with this use of the term. If the battery won't hold a charge, or the current does not drop after the expected recharge time, the battery may have some permanent sulphation.

The **FLOAT** stage is where the charge voltage is reduced to between 13.0 VDC and 13.8 VDC and held constant, while the current is reduced to less than 1% of battery capacity. This mode can be used to maintain a fully charged battery indefinitely.

Recharge time can be approximated by dividing the amp hours to be replaced by 90% of the rated output of the charger. For example, a 100 amp hour battery with a 10 % discharge would need 10 amps replaced. Using a 5 amp charger, we have 10 amp hours divided by 90% of 5 amps (.9x5) amps = 2.22 hour recharge time estimate. A deeply discharged battery deviates from this formula, requiring more time per amp to be replaced.

Recharge frequency recommendations vary from expert to expert. It appears that depth of discharge affects battery life more than frequency of recharge. For example, recharging when the equipment is not going to be used for a while (meal break or whatever), may keep the average depth of discharge above 50% for a service day. This basically applies to battery applications where the average depth of discharge falls below 50% in a day, and the battery can be fully recharged once during a 24 hour period.

Equalization

Equalization is essentially a controlled over charge. Some charger manufacturers call the peak voltage the charger attains at the end of the BULK mode (absorption voltage) an equalization voltage, but technically it's not. Higher capacity wet (flooded) batteries sometimes benefit from this procedure, particularly the physically

tall batteries. The electrolyte in a wet battery can stratify over time, if not cycled occasionally. In equalization, the voltage is brought up above typical peak charging voltage (to 15 to 16 volts in a 12 volt system) well into the gassing stage, and held for a fixed (but limited) period. This stirs up the chemistry in the entire battery, "equalizing" the strength of the electrolyte, and knocking off any loose sulphation that may be on the battery plates.

The construction of AGM and Gel batteries all but eliminates any stratification, and most all manufacturers of this type do not recommend it (advising against it). Some manufacturers (notably Concorde) list a procedure, but voltage and time are critical to avoid battery damage.

Battery Testing

Battery testing can be done in several ways. The most popular includes measurement of specific gravity, and battery voltage. Specific gravity applies to wet cells with removable caps, giving access to the electrolyte. To measure specific gravity, buy a temperature compensating hydrometer at an auto parts store or tool supply. To measure voltage, use a digital voltmeter in the DC voltage setting. The surface charge must be removed from a freshly charged battery before testing. A 12 hour lapse after charging qualifies, or you may remove the surface charge with a load (20 amps for 3 plus minutes).

State of Charge	Voltage		Specific Gravity
	12V	6V	
100%	12.7	6.3	1.265
75%	12.4	6.2	1.225
50%	12.2	6.1	1.190
25%	12.0	6.0	1.155
Discharged	11.9	6.0	1.120

Load testing is another method of testing a battery. Load testing removes amps from a battery (similar to starting an engine). Some battery companies label their battery with the amp load for testing. This number is usually 1/2 of the CCA rating. For instance, a 500 CCA battery would load test at 250 amps for 15 seconds. A load test can only be performed if the battery is at or near a full charge. Some electronic load

testers apply a 100 amp load for 10 seconds, and then display battery voltage. This number is compared to a chart on the tester, based on CCA rating to determine battery condition.

Sulphation of batteries starts when specific gravity falls below 1.225 or voltage measures less than 12.4 (12v Battery) or 6.2 (6 volt battery). Sulphation can harden on the battery plates if left long enough, reducing and eventually destroying the ability of the battery to generate rated volts and amps. There are devices for removing hard sulphation, but the best practice is preventing formation by proper battery care and recharging after a discharge cycle. Sulphation is the main reason a significant portion of lead acid batteries don't attain their chemical life span.

Charging Parallel Connected Batteries

Batteries connected in parallel (positive to positive, negative to negative) are seen by the charger as one large battery of the combined amp hour capacity of all the batteries. Thus, three 12 volt 100 amp hour (ah) batteries in parallel are seen as one 12 volt 300 ah battery. They can be charged with one positive and negative connection from one charger of the recommended amp output. They also can be charged with a multiple output charger, like a three bank unit in this case, with each battery getting its own connection at battery voltage. The charging amperage would be the sum of the individual output amps.

Charging Series Connected Batteries

Batteries connected in series are a different story. Three 12 volt 100 amp hour batteries connected in a series string (positive to negative, positive to negative, positive to negative) would make a 36 volt 100 ah battery pack. This can be charged across the pack with a 36 volt output charger of the appropriate amp output. They also can be charged with a multiple output charger, like a three bank unit in this case, with each battery getting its own connection at battery voltage (12 volts in this case). Either method is fine, **UNLESS** one or more of the batteries are tapped at lower than system voltage. An example would be tapping one of the batteries in this 36 volt string at 12 volts for a radio or some lights, etc. This imbalances the pack, and charging at system voltage (36V) doesn't correct the imbalance. The multiple bank

charger connecting to each battery is the correct way to deal with this series battery string, as it corrects the imbalance with every charge cycle.