Technical Note

Batteries

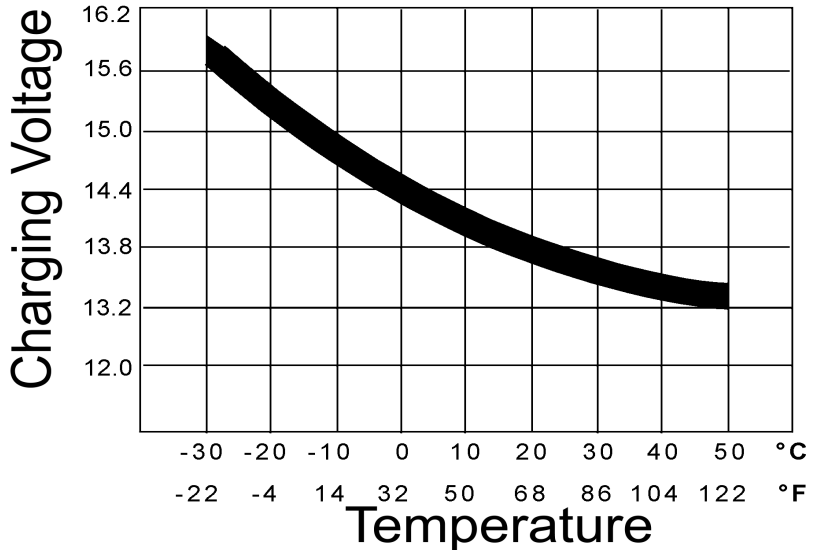
512-0101-01-01 Rev 1

Temperature Compensated Charging of Lead Acid Batteries

Introduction

To ensure optimum charging of lead acid batteries, the charge voltages should be adjusted to compensate for battery temperature. Battery temperature is affected by ambient temperature and by the battery's own internal resistance in conjunction with the amount of current passing through it. Generally, lower temperatures require higher charge voltages to ensure complete charging, while higher temperatures require lower charge voltages to prevent overcharging. The actual voltages used also depend on other factors including battery type (wet, gel, or Absorbed Glass Mat [AGM]), battery manufacturer's specifications, the state of charge of the battery and the resulting stage of operation that a multistage charger is in (bulk, acceptance or float). Figure 1 shows a typical gel battery voltage/temperature curve.

FIGURE 1: Typical voltage/temperature curve for gel cell batteries.



NOTE: To simplify explanation, all voltages used in this discussion will be related to a 12-volt battery. Divide any numbers by 2 for 6-volt systems, divide by 6 to obtain single cell voltages, and double all values for 24-volt systems.

Theory

As battery temperature changes, the gassing point of the battery changes. The gassing point is the voltage at which the battery will begin to generate significant amounts of oxygen and hydrogen gas when fully charged. This point drops to a lower voltage at higher temperatures. As mentioned above, temperature depends on internal and external factors. A deeply discharged battery for example will have a higher internal resistance and will draw more charge current and therefore will heat up quickly. A nearly charged battery will not draw much current so it

will heat up very little. External temperature depends on climate, season, and location of the batteries such as in an engine room.

In an ideal three-stage charging algorithm for wet cell batteries, the object is to take the voltage slightly above the gassing voltage during the bulk and acceptance charge cycles and hold it there until the battery is fully charged. Then, drop the voltage to a lower float voltage that is just below the gassing point to maintain the battery at full charge with minimal water loss. For gel and AGM batteries, the object is to approach the gassing voltage but not exceed it during the bulk and acceptance charge stages. Then the voltage should be dropped to a slightly lower float voltage once the battery is charged. The trick is to know where this gassing voltage point is at various temperatures for the various types of batteries.

Manual Temperature Compensation

Until recently, temperature compensation (if it was available at all) was manually set at the charger or alternator regulator based on a table defining the proper setting for wet or gel batteries at low or high temperatures (see Table 1 for example). More advanced systems allow for more control over the voltage/temperature set points (see Table 2). The manual temperature compensation method works well, but this requires proper system setup and manual adjustment when temperature conditions change.

Automatic Temperature Compensation

Newer, more intelligent charging systems are now incorporating automatic temperature compensation. These systems have one or more temperature probes mounted on the batteries to constantly monitor battery temperature and automatically regulate the voltages generated by the charging source. These probes should be mounted at points on the battery bank that are likely to be the warmest. This would include battery terminals and in between batteries.

Other Things To Consider

To minimize hot spots and improve heat dissipation in a bank it is a good practice to leave air space between batteries. It is also recommended that all cables connected to battery posts be of sufficient gauge and clean, tight connections maintained. Batteries that are deeply discharged should be recharged slowly to minimize heating, and never charge frozen batteries.

All batteries should always be in ventilated spaces so that the highly explosive oxygen/hydrogen gases will not accumulate.

Summary

To ensure long battery life and optimum performance during the battery's life, proper battery usage, proper maintenance and proper charging are all important. Suitable charging would include a multistage charging method, appropriate charger setup for the type of battery used, and the ability to temperature compensate the charge voltages.

TABLE 1: Battery type and temperature charge voltages (manual setting, above or below 80 degrees)

Battery Type and Temperature	Accept Voltage Maximum Time	Float Voltage	Equalize Voltage
12 Volt Wet Cell Warm Temperature	14.0 / 1 hr	13.1	15.8
12 Volt Wet Cell Cool Temperature	14.4 / 1 hr	13.5	16.3
12 Volt Gel Cell Warm Temperature	13.8 / 1 hr	13.3	13.8
12 Volt Gel Cell Cool Temperature	14.1 / 3 hr	13.6	14.1

TABLE 2: Manual temperature compensation charge voltages (10-degree increments)

		WET CELL		GEL CELL		
TEMP °F	°C	ACCEPT	FLOAT	ACCEPT	FLOAT	
120	49	13.4	12.5	13.9	13.3	
110	43	13.6	12.7	14.0	13.4	CAUTION ABOVE THIS TEMPERATURE
100	38	13.8	12.9	14.1	13.5	
90	32	14.0	13.1	14.2	13.6	
80	27	14.2	13.3	14.3	13.7	
70	21	14.4	13.5	14.4	13.8	DEFAULT SETTING
60	16	14.6	13.7	14.5	13.9	
50	10	14.8	13.9	14.6	14.0	
40	5	15.0	14.1	14.7	14.1	CAUTION BELOW THIS TEMPERATURE
30	-1	15.2	14.3	14.8	14.2	

TABLE 3: Automatic temperature compensation charge voltages

TEMPERATURE COMPENSATED CHARGING VOLTAGES					
TEMPERATURE		**WET CELL**	**GEL 1 (std.)**	**GEL 2 (fast chg.)**	**AGM**
Deg F	**Deg C**	**Accept Float**	**Accept Float**	**Accept Float**	**Accept Float**
120*	49	12.5 12.5	13.0 13.0	13.0 13.0	12.9 12.9
110	43	13.6 12.7	13.5 13.0	14.0 13.4	13.9 12.9
100	38	13.8 12.9	13.7 13.2	14.1 13.5	14.0 13.0
90	32	14.0 13.1	13.8 13.3	14.2 13.6	14.1 13.1
80	27	14.2 13.3	14.0 13.5	14.3 13.7	14.2 13.2
70	21	14.4 13.5	14.1 13.6	14.4 13.8	14.3 13.3
60	16	14.6 13.7	14.3 13.8	14.5 13.9	14.4 13.4
50	10	14.8 13.9	14.4 13.9	14.6 14.0	14.5 13.5
40	5	15.0 14.1	14.6 14.1	14.7 14.1	14.6 13.6
30	-1	15.2 14.3	14.7 14.2	14.8 14.2	14.7 13.7

* At 120 degrees, the charging source should drop to idle battery voltage so that it can continue to carry DC loads in the system, but at this high temperature, batteries should not be charging due to the risk of thermal run away condition.

The accuracy of the above voltages should be +/- 0.2 volts.

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