Care and Feeding of Motive Power Batteries

With a modicum of care and attention, batteries deliver years of troublefree service. Here is information for obtaining optimum performance and maximum life.

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The batteries that power electric lift trucks, tow tractors, pallet handlers, personnel carriers, and other mobile industrial equipment can, under normal operating conditions, be expected to provide dependable service for 2,000 work-shifts or charge/discharge cycles. With proper care and maintenance, even this long life can be extended.

Conversely, neglect can shorten battery life substantially. Failure to take immediate action when any abnormality is indicated can result in irreparable damage that might preclude the possibility of restoring the battery to optimum operating condition. Prompt action when an abnormality is indicated in a given cell can forestall further degradation, and can prevent the problem from infecting other cells of the battery.

How the Battery Is Constructed

A basic understanding of how motive power batteries are constructed helps in understanding why certain operating and maintenance procedures should be observed. Internal construction of a lead-acid motive battery is similar to that of the common automotive battery. The interior of the battery is compartmented into cells, with each cell containing a set of alternately spaced positive and negative plates. There is always one more negative plate than there are wrapped positive plates; a negative plate is contained at each end of the cell to achieve proper electrical balance. Separators are located between the plates to insulate each from the adjacent plates.

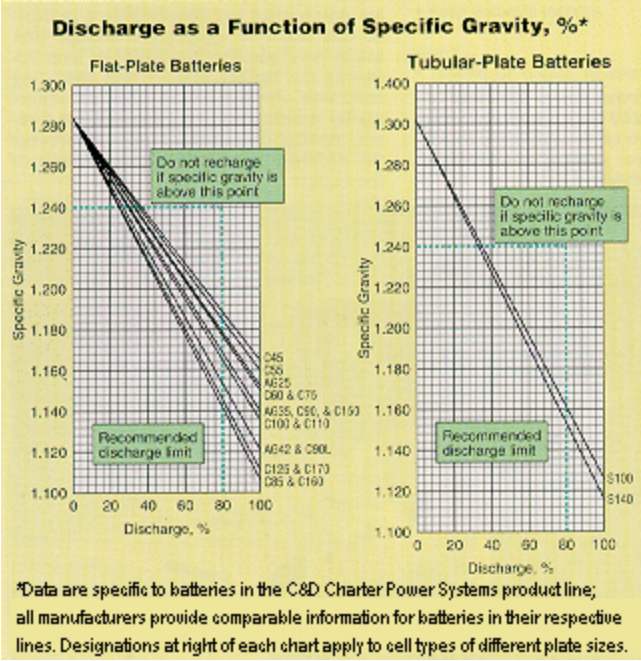
A positive and a negative terminal protrudes from the top of each cell. All of the positive plates are connected in parallel to the positive terminal. In like fashion, all negative plates are connected in parallel to the negative terminal of the cell. The entire assembly (referred to as an "element") is placed inside an acid-proof, high-impact-resistant container known as a "jar." Cell assembly is completed when a high-impact cover is sealed to the jar.

The number of cells that constitute a battery is dictated by the desired battery voltage. The cells are configured in a steel container known as the battery "tray." All of the individual cells are connected in series, and the completed unit is equipped with an appropriate connector. The cell elements are made operational by the addition of a sulfuric acid solution known the "electrolyte." Electrolyte level is such that the plates are fully submerged.

The completed battery is, for the most part, comparable to a typical 6-cell, 12-V automotive battery. Motive power batteries, however, are equipped with much larger cells, and are in all respects more rugged than automotive batteries. Industrial batteries are designed to handle much heavier loads, while lasting far longer than an automotive battery might be expected to last under less demanding conditions.

How the Battery Works

Until a battery is charged, it can do no work. Charging is performed by a charger that receives power from the utility supply, converts it to direct current, and feeds it into the battery under carefully controlled conditions. This force-feeding of energy into the battery develops an



electrochemical reaction that alters the chemical composition of the plates, and increases the specific gravity of the electrolyte. In service, the battery reverses the electrochemical reaction to release electrical energy.

In the discharge process, electrolyte strength is diminished, and its specific gravity decreases. The reduction in specific gravity is measured with a hydrometer. While the battery is in service and performing work, specific gravity continuously drops off, hour after hour. This is a normal process, and the electrolyte continues to lose strength until the battery is fully discharged.

A battery, however, should never be kept in service for as long as it continues to deliver power. A battery is rated by its manufacturer to deliver a specified number of ampere-hours before the battery has been discharged to a specified level. The battery should be removed from service and recharged when electrolyte acid concentration indicates the maximum recommended discharge level has been reached.

Daily Charging and Discharging Practices Discharging a battery beyond prescribed limits overworks the battery and makes recharging more difficult. More time is needed for recharging, with the additional time far out of proportion to the work delivered while the battery was being worked beyond its design capability. When this occurs, there might not be enough time to fully recharge the battery before it is needed again, and the battery might be returned to service before it is fully recharged -- setting in motion a problem that feeds on itself.

An undercharged battery going into a full work shift is likely to be overdischarged to an even greater extent by the end of the work shift. The vicious cycle set in motion can result in permanent battery damage.

If a battery is to deliver optimum performance and long life, it should be sized to deliver a full shift of work, while discharging to not more than 80% of total rated capacity. The charger is usually sized to fully recharge the battery in eight hours or less.

In cases where the battery is only slightly undersized, tolerable operation can sometimes be achieved by applying a boost charge during the work shift. This involves taking thee battery out of service briefly, and applying a short-duration, high-rate charge. Whenever boost charges are required, these possible causes should be considered:

- Battery is too small for the job
- Battery workload has increased
- Battery was taken off charge before the charge was complete
- Charger is not working properly
- Battery is approaching the end of its service life.

Specific gravity, as read at the end of the duty cycle, is an excellent indication of the amount of battery capacity that has been used. Battery manufacturers provide graphs for all batteries in their product lines to translate specific gravity into depth of discharge.

The manner in which one manufacturer presents this data is given in the section "Discharge as a Function of Specific Gravity." For flat-plate batteries in this product line, fully-charged cells have a specific gravity of 1.285 +/- 0.005. For tubluar-plate batteries in this product line, the full-charge specific gravity criterion is 1.310 +/- 0.005. As the cells discharge, electrolyte specific gravity reduces at slightly different rates for different-sized plates.

While overdischarging is detrimental, overcharging is not beneficial; overcharging can in no way increase the amount of battery work capability. Modern, electronically-controlled battery chargers comprise refined controls to ensure that the battery is safely charged to the proper level within the allotted charging time. Chargers can, however, get out of adjustment. Any of the following trouble signs indicate that the charger might be in need of adjustment.

- Unusual rise in battery temperature. The temperature of a battery undergoing charge should not rise more than 25 degrees F during an eight hour charge period. A higher temperature rise might mean that the charger is out of adjustment.
- Continuous running of charger. This condition is usually created by one of two factors -- failure of the charger automatic circuitry, or operating the charger at too low a charge rate.
- Continuous charging at high rate. In normal operation, the charger begins charging at a high current rate, and current drops off as the battery approaches full charge. Failure of the charge rate to taper off might mean charger control failure, or that the charger is out of adjustment.

Determining When Battery Is Fully Charged
Three indicators are used to determine if the battery has received its proper charge. First of these is voltage stabilization. During charging, voltage across the battery will continue to rise slowly. When the battery is fully charged, the voltage will level off.

Another indicator is leveling off of the rise in specific gravity. Specific gravity will continue to increase as the battery absorbs charge, but as the battery approaches full charge, there will be no further increase in specific gravity. In fact, there might even be a decrease in specific gravity, because of the temperature rise caused by continuing to charge a fully-charged battery.

The third indicator of full charge is leveling off of the charge current, as indicated on the charger ammeter or readings on a computerized control display.

Battery manufacturers usually supplement the specific gravity/percent discharge graphs for their product lines with simplified state-of-charge tables. The battery should retain its nominal full-charge specific gravity value throughout its service life. A gradual reduction in specific gravity can be expected, though, if the battery is exposed to the practice of overwatering or adding water before charge.

In the twilight of its life, a battery can experience internal short-circuiting and plate deterioration, which might be identified with reduced specific gravity. In such cases, it might be difficult to exceed 1.240 specific gravity after charging.

Weekly Equalizing Charge
An equalizing charge is a low-rate charge applied to ensure that all cells attain full charge with no appreciable difference between cells. It is simply a continuation of the regular charge, applied at a

low rate for an additional three hours. Applying an equalizing charge once a week is an effective means of maintaining electrical balance within the battery, thereby prolonging battery life.

Other Routine Maintenance Procedures

An effective battery maintenance program requires that attention be given to the charging equipment. Charging-rate controls and cutoff controls should always be checked before placing a battery on charge. A battery that is regularly overcharged requires frequent addition of water, and finishes its charge at a higher-than-normal temperature. If a battery is using an excessive amount of water, or if it develops excessive temperatures during charging, the charge rate should be lowered. This usually means adjusting the end-of-charge rate to somewhere between a normal finish rate and one-half the normal finish rate.

If proper care is taken in charging batteries and adding water, there is no reason batteries should not remain clean and dry. In dusty atmospheres, however, it might be necessary to clean off dust and dirt accumulations by brushing or blowing with low-pressure compressed air. It is essential to ensure that all vent plugs are securely in place any time that cleaning is undertaken.

If a battery is constantly wet, if might be due to overfilling or overcharging. Because spilled electrolyte corrodes steel, copper and other metal surfaces it contacts, electrolyte spills on a battery or overflow from inside a cell should be neutralized immediately with a solution of one pound of baking soda to a gallon of water. The solution should be applied with a paintbrush until all fizzing stops, taking care to work the solution under connectors, and brushing out grime. Residue should then be cleansed from the battery by rinsing with water from a low pressure hose.

A certain amount of internal loss of water in cells is normal. The lost water should be made up at the end of the charge, and never at the beginning of a charge. If water is added at the beginning of a charge, overflow might occur during charging. Subsequent replacement of the lost electrolyte with water results in dilution and an imbalance of acid and water. The specific gravity of the cell is lowered, resulting in less cell capacity.

It is very important that makeup water be either distilled or deionized water, or, if tapwater, certified by chemical laboratory testing as acceptable for battery use.

When adding water, it is better to underfill than overfill. If an automatic filling system is used to add water, it should be checked periodically to ensure that it is adjusted to terminate fill at the proper level. All cells of a battery should use about the same amount of water. If one cell is using more than the others, it might be losing water through a leaky jar or through the jar-to-cover seal. The leak should be located and repaired.

Recordkeeping

Electrically-powered vehicles in multi-shift service usually require more than one battery per vehicle. Each battery should be given a unique identity by painting an identifying number on the battery tray, and a service log should be kept for each battery. One cell in each battery should be identified as the pilot cell, with pilot cell designation rotated periodically among all cells of the battery.

Condition of the pilot cell can be presumed to represent condition of the battery as a whole. Pilot cell hydrometer readings should be taken and logged for each duty cycle. Logged information should contain the date of reading, before-charge and after-charge specific gravities, and addition of water.

Several times a year, a full set of voltage and specific gravity readings should be taken at the end of an equalizing charge. If voltage and specific gravity readings are uniform from cell to cell, the battery is in good condition. If variations in specific gravity exceed about 20 points, or if voltage

varies by more than about 0.15 volts per cell, there is reason to suspect that the battery is in trouble, and the reason for the variation should be investigated.

Some Do's and Don'ts	
Do… • Select and use batteries of proper capacity • Provide enough ventilation so that hydrogen released from batteries does not accumulate in concentrations greater than 1% by volume • Follow manufacturer recommendations • Wear protective equipment (goggles, face shield, rubber apron, and boots) when working on batteries • Keep open flames and sparks away from batteries • Read and observe all warnings posted in the battery room or published by the battery manufacturer • Take prompt action when a problem is indicated • Neutralize spilled electrolyte immediately with a solution of 1 lb. baking soda to 1 gal. of water • Apply an equalizing charge once a week • Keep accurate records	**Don't…** • Smoke or create sparks near batteries • Wear conductive jewelry when working around batteries • Lay tools on top of batteries • Overcharge batteries • Add water before charging; always add water at end of charge • Remove battery vent plugs