Charging and Maintenance Guide

Introduction

Trojan Battery Company has been manufacturing lead-acid batteries for more than three generations. Our experience has shown that the key factor to achieving optimum performance and long battery life is a solid care and maintenance program. This brochure will focus on how to properly maintain and charge all Trojan lead-acid battery types.

While reading this brochure, please keep in mind that all battery systems are unique. Battery type, charger technology, equipment loads, cable size, climate, and other factors can all vary. Slight or significant, these differences will require battery maintenance to be adjusted. Therefore, use this brochure only as a guideline for proper battery care. Each particular system will always require a degree of customized attention.

Battery Type

Lead-acid batteries are generally classified by application (what they are used for) and by construction (how they are made). The primary application is automotive in which the battery is used for starting and lighting. Deep cycle is another major application but is usually broken down into more specific applications such as RV, golf cars, renewable energy, and marine.

There are two popular construction types, flooded batteries (wet) and VRLA batteries (Valve-Regulated Lead Acid). In the flooded types, the electrolyte is a solution of sulfuric acid and water that can spill out if tipped over. In VRLA batteries, the electrolyte is suspended in a gel or a fiberglass-mat (AGM technology), allowing these batteries to be mounted in a variety of positions. Before getting started, be sure to identify the type of battery involved. This brochure will address the charging and maintenance for both flooded and VRLA batteries.

Inspection

There are many tools that may help in properly caring for and maintaining batteries. Below is a list of basic items that Trojan recommends for this task:

Recommended Equipment

- Wrench
- Distilled Water
- Voltmeter
- Hydrometer
- Post Cleaner
- Baking Soda
- Vaseline
- Goggles & Gloves

CAUTION: Always wear protective clothing, gloves, and goggles when handling batteries and electrolyte. DO NOT SMOKE NEAR BATTERIES.

Batteries should be carefully inspected on a regular basis in order to detect and correct potential problems before they can do harm. It is a great idea to start this routine when the batteries are first received.

1. Examine the outside appearance of the battery.
   - Look for cracks in the container
   - The top of the battery, the posts, & connections should be clean, free of dirt, fluids, and corrosion..
   - Repair or replace any damaged batteries.
2. Fluids on or around the battery may be an indication that electrolyte is spilling, leaching, or leaking out.
   - Leaking batteries must be repaired or replaced.
3. Check all battery cables and their connections.
   - Look closely for loose or damaged parts.
   - Replace any cable that is broken or frayed.
4. Tighten all wiring connections to the proper specification (see below). Make certain there is good contact with the terminals.

Proper Torque Values for Connection Hardware

Automotive	50 to 70 in-lbs
Button	90 to 110 in-lbs
LT	100 to 120 in-lbs
Stud	120 to 180 in-lbs
Wingnut	95 to 105 in-lbs

WARNING: Do not ovetighten terminals. Doing so can result in post breakage, post meltdown, and fire.

Testing

Visual inspection alone is not sufficient to determine the overall health of the battery. Both open-circuit voltage and specific gravity readings can give a good indication of the battery's charge level, age, and health. Routine voltage and gravity checks will not only show the state of charge but also help spot signs of improper care, such as undercharging and over-watering, and possibly even locate a bad or weak battery. The following steps outline how to properly perform routine voltage and specific gravity testing on batteries.

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I. Specific Gravity Test

(Flooded batteries only)

1. Do not add water at this time
2. Fill and drain the hydrometer 2 to 4 times before pulling out a sample.
3. There should be enough sample electrolyte in the hydrometer to completely support the float.
4. Take a reading, record it, and return the electrolyte back to the cell.
5. To check another cell, repeat the 3 steps above.
6. Check all cells in the battery.
7. Replace the vent caps and wipe off any electrolyte that might have been spilled.
8. Correct the readings to 80° F:
   - Add .004 to readings for every 10° above 80° F
   - Subtract .004 for every 10° below 80° F.
9. Compare the readings.
10. Check the state of charge using **Table 1**.

The readings should be within the factory specification of 1.277 ± .007. If not, follow the steps below.

1. Check and record voltage level(s)
2. Put battery(s) on a complete charge.
3. Take specific gravity readings again.

If any specific gravity reading is still not within the factory specification, follow the steps below.

1. Check voltage level(s).
2. Perform equalization charge. Refer to the **Equalizing** section for the proper procedure.
3. Take specific gravity readings again.

If any specific gravity reading is still not within the factory specification of 1.277 ± .007 then one or more of the following conditions may exist:

1. The battery is old and approaching end of life.
2. The battery was left in a state of discharge too long.
3. Electrolyte was lost due to spillage or overflow.
4. A weak or bad cell is developing.
5. Battery was watered excessively previous to testing

Batteries in conditions 1 - 4 should be taken to a specialist for further evaluation or retired from service.

II. Open-Circuit Voltage Test

For accurate voltage readings batteries must remain idle (no charging, no discharging) for at least 6 hrs, preferably 24 hrs.

1. Disconnect all loads from the batteries.
2. Measure the voltage using a DC voltmeter.
3. Check the state of charge with **Table 1**.
4. Charge the battery if it registers 0% to 70% charged

If battery registers below the **Table 1** *values, the following conditions may exist:*

1. The battery was left in a state of discharge too long.
2. The battery has a bad cell.

Batteries in these conditions should be taken to a specialist for further evaluation or retired from service.

Percentage of Charge	Specific Gravity Corrected to 80° F	Open-Circuit Voltage				
		6V	12V	24V	36V	48V
100	1.277	6.37	12.73	25.46	38.20	50.93
90	1.258	6.31	12.62	25.24	37.85	50.47
80	1.238	6.25	12.50	25.00	37.49	49.99
70	1.217	6.19	12.37	24.74	37.12	49.49
60	1.195	6.12	12.24	24.48	36.72	48.96
50	1.172	6.05	12.10	24.20	36.31	48.41
40	1.148	5.98	11.96	23.92	35.87	47.83
30	1.124	5.91	11.81	23.63	35.44	47.26
20	1.098	5.83	11.66	23.32	34.97	46.63
10	1.073	5.75	11.51	23.02	34.52	46.03

Table 1. State of Charge as related to Specific Gravity and Open-Circuit Voltage

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Watering

(Flooded batteries only)

Flooded batteries need water. More importantly, watering must be done at the right time and in the right amount or else the battery's performance and longevity suffers.

Water should always be added after fully charging the battery. Prior to charging, there should be enough electrolyte to cover the plates. If the battery has been discharged (partially or fully), the electrolyte level should also be above the plates. Keeping the electrolyte at the correct level after a full charge will prevent having to worry about the level at other state of charge.

Depending on the local climate, charging methods, application, etc. Trojan recommends that batteries be checked once a month until you get a feel for how "thirsty" your batteries are.

Important things to remember:

1. Do not let the plates get exposed to air. This will damage (corrode) the plates.
2. The electrolyte level should not be up inside the fill well. This may cause the battery to overflow electrolyte during charging, resulting in a lost of capacity as well as causing a corrosive mess.
3. Do not use water with a high mineral content. Use distilled or deionized water only.

CAUTION: The electrolyte is a solution of acid and water so skin contact should be avoided.

Step by step watering procedure:

1. Remove the vent caps and look inside the fill wells.
2. Check electrolyte level; the minimum level is at the top of the plates.
3. If necessary add just enough water to cover the plates at this time.
4. Replace and tighten all vent caps.
5. Put the battery on a complete charge before adding any additional water (refer to the **Charging** section).
6. Once charging is completed, remove the vent caps and look inside the fill wells.
7. Add water until the electrolyte level is about 1/8" below the bottom of the fill well.
8. Clean, replace, and tighten all vent caps.

WARNING: Never add acid to a battery.

Cleaning

Batteries seem to attract dust, dirt, and grime. Keeping them clean will help one spot trouble signs if they appear and avoid problems associated with grime.

1. Check that all vent caps are tightly in place.
2. Clean the battery top with a cloth or brush and a solution of baking soda and water.
   - When cleaning, do not allow any cleaning solution, or other foreign matter to get inside the battery.
3. Rinse with water and dry with a clean cloth.
4. Clean battery terminals and the inside of cable clamps using a post and clamp cleaner.
   - Clean terminals will have a bright metallic shine.
5. Reconnect the clamps to the terminals and thinly coat them with petroleum jelly (Vaseline) to prevent corrosion.
6. Keep the area around the battery clean and dry.

Storage

Periods of inactivity can be extremely harmful to lead-acid batteries. When placing a battery into storage, follow the recommendations below to insure that the battery remains healthy and ready for use.

NOTE: Storing, charging or operating batteries on concrete is perfectly OK.

The most important things to avoid:

1. Freezing. Avoid locations where freezing temperature is expected. Keeping battery at a high state of charge will also prevent freezing. Freezing results in irreparable damage to battery's plates and container.
2. Heat. Avoid direct exposure to heat sources, such as radiators or space heaters. Temperatures above 80° F accelerate the battery's self-discharge characteristics

Step by step storage procedure:

1. Completely charge the battery before storing.
2. Store the battery in a cool, dry location, protected from the elements.
3. During storage, monitor the specific gravity (flooded batteries) or voltage. Batteries in storage

should be given a boost charge when they show a 70% charge or less. See **Table 1**.
4. Completely charge the battery before re-activating.
5. For optimum performance, equalize the batteries (flooded) before putting them back into service. Refer to the **Equalizing** section for this procedure.

Charger Selection

Most deep cycle applications have some sort of charging system already installed for battery charging (e.g. solar panels, inverter, golf car charger, alternator, etc.). However, there are still systems with deep cycle batteries where an individual charger must be selected. The following will help in making a proper selection.

There are many types of chargers available today. They are usually rated by their start rate, the rate in amperes that the charger will supply at the beginning of the charge cycle. When selecting a charger, the charge rate should be between 10% and 13% of the battery's 20-hour AH capacity. For example, a battery with a 20-hour capacity rating of 225 AH will use a charger rated between approximately 23 and 30 amps (for multiple battery charging use the AH rating of the entire bank). Chargers with lower ratings can be used but the charging time will be increased.

Trojan recommends using a 3-stage charger. Also called "automatic", "smart" or "IEI" chargers, these chargers prolong battery life with their well programmed charging profile. These chargers usually have three distinct charging stages: bulk, acceptance, and float.

Charger Voltage Setting	System Voltage				
	6V	12V	24V	36V	48V
Daily Charge	7.3– 7.4	14.6 – 14.8	29.2 – 29.6	43.8 – 44.4	58.4 – 59.2
Float	6.75	13.5	27.0	40.5	54.0
Equalize	7.75	15.5	31.0	46.5	62.0

Table 2. Charger Voltage Settings for Flooded Batteries

	Charger Voltage Setting	System Voltage			
		12V	24V	36V	48V
Gel Battery	Daily Charge	13.8 – 14.1	27.6 – 28.2	41.4 – 42.3	55.2 – 56.4
	Float	13.5	26.4	39.6	52.8
AGM Battery	Daily Charge	14.4 – 14.8	28.8 – 29.6	43.2 – 44.4	57.6 – 59.2
	Float	13.5 – 13.8	27.0 – 27.6	40.5 – 41.4	54.0 – 55.2

Table 3. Charger Voltage Settings for VRLA Batteries

Charging

Charging batteries properly requires administering the right amount of current at the right voltage. Most charging equipment automatically regulates these values. Some chargers allow the user to set these values. Both automatic and manual equipment can present difficulties in charging. **Tables 2 & 3** list most of the necessary voltage settings one might need to program a charger. In either case the original instructions for your charging equipment should also be referenced for proper charging. Here is list of helpful items to remember when charging.

1. Become familiar with the charger and follow the instructions issued by the charger manufacturer.
2. Batteries should be charged after each period of use.
3. Lead-acid batteries do not develop a memory and need not be fully discharged before recharging.
4. Charge only in well-ventilated area. Keep sparks or flames away from a charging battery.

5. Verify charger voltage settings are correct (**Table 2**)
6. Check electrolyte level (refer to the **Watering** section).
7. Tighten all vent caps before charging.
8. Do not overcharge the battery. Overcharging causes excessive gassing, heat buildup, and battery aging.
9. Do not undercharge the batteries. Undercharging causes stratification.
10. Do not charge a frozen battery.
11. Avoid charging at temperatures above 120° F.
12. Correct the charging voltage to compensate for temperatures above and below 80° F.

- Add .028 volt per cell for every 10° below 80° F
- Subtract .028 volt per cell for every 10° above 80° F

Additional VRLA Charging Instructions:

1. Become familiar with and follow the instructions issued by the charger manufacturer.
2. Verify charger has necessary VRLA setting
3. Set charger to VRLA voltage settings (**Table 3**)
4. Do not overcharge VRLA batteries. Overcharging will dry out the electrolyte and damage battery.

WARNING: Do not equalize VRLA batteries

Equalizing
(Flooded batteries only)

Equalizing is an overcharge performed on flooded lead-acid batteries after they have been fully charged. It reverses the buildup of negative chemical effects like stratification, a condition where acid concentration is greater at the bottom of the battery than at the top. Equalizing also helps to remove sulfate crystals that might have built up on the plates. If left unchecked, this condition, called sulfation, will reduce the overall capacity of the battery.

It is often recommended that batteries be equalized periodically, from once a month to once or twice per year. However, Trojan only recommends equalizing when low or wide ranging specific gravity (± .015) is detected after fully charging a battery.

Step by Step Equalizing:

1. Verify that the battery is of the flooded type.
2. Remove all loads from the batteries.
3. Connect battery charger.
4. Set charger for the equalizing voltage (**Table 2**).
5. Start charging batteries
6. Batteries will begin gassing and bubbling vigorously
7. Take specific gravity readings every hour
8. Equalization is complete when specific gravity values no longer rise during the gassing stage

NOTE: Many chargers do not have an equalization setting so this procedure can't be carried out.

Discharging

Discharging batteries is entirely a function of your particular application. However, below is list of helpful items:

1. Shallow discharges will result in longer battery life
2. 50% (or less) discharges are recommended
3. 80% discharge is the maximum safe discharge
4. Do not discharge flooded batteries 80% or more on a consistent basis. This will shorten the life of the battery.
5. Do not leave batteries in a state of discharged for any length of time.
6. Lead-acid batteries do not develop a memory and need not be fully discharged before recharging
7. Batteries should be charged after each period of use.
8. Batteries that charge up but cannot support a load are most likely bad and should be tested. Refer to the **Testing** section for proper procedure.