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 booklet will focus on how to properly maintain and charge all Trojan lead-acid battery types.

While you read this brochure, please understand all battery systems are unique. Battery type, charger technology, equipment loads, cable size, and climate can all vary. Slight or significant, these differences will require battery maintenance to be adjusted. So please keep in mind this booklet is only a guideline for proper battery care. Your particular system will always require a degree of customized attention.

Battery Type

Lead-acid batteries are generally classified by application and by construction (what they are used for & how they are made). The primary application is car batteries, sometimes called automotive. Deep cycle is also a major application but is usually broken down into more specific applications such as RV, golf cars, floor scrubbers, renewable energy, marine, and so on.

There are two popular construction types: Flooded batteries (Wet) and VRLA batteries (Valve-Regulated Lead Acid). Flooded types contain a wet electrolyte (acid in water) which can spill if tipped over. However, in VRLA batteries, the electrolyte is suspended in a gel or a fiberglass-mat (AGM technology). These batteries are non-spillable. Before getting started understand which battery type you are involved with. This booklet will address the charging and maintenance for both types.

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

CAUTION: Always wear protective clothing, gloves, and goggles when handling batteries and electrolyte

Just like looking under the hood of your car and examining the engine will help you find trouble spots that need maintenance. Your batteries should also 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 you first receive your batteries. Here is a guideline on what to look for:

- ❑ Examine the outside appearance of the battery.
- ❑ Look for cracks in the container
- ❑ Repair or replace any damaged batteries.
- ❑ The top of the battery, the posts, & connections should be clean, free of dirt, fluids, and corrosion.
- ❑ If batteries are dirty, refer to the **Cleaning** section for the proper cleaning procedure.
- ❑ Any fluids on or around the battery is an indication that electrolyte is spilling, leaching, or leaking out.
- ❑ Leaking batteries must be repaired or replaced.
- ❑ Check all battery cables and their connections.
- ❑ Look closely for loose or damaged parts.
- ❑ Battery cables should be intact; broken or frayed cables can be extremely hazardous.
- ❑ Replace any cable that looks suspicious.
- ❑ 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

Flooded	65 to 75 in-lbs
VRLA	90 to 100 in-lbs

WARNING: Do not overtighten 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 voltage and specific gravity readings of each cell will 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 (like undercharging, overwatering, etc.) and possibly even locate a bad or weak battery. The following steps outline how to properly perform routine voltage and specific gravity testing on your batteries.

I. Specific Gravity Test

(Flooded batteries only)

(Do not add water at this time)

1. Fill and drain the hydrometer 2-4 times before pulling out a sample.
2. There should be enough sample electrolyte in the hydrometer to completely support the float.
3. Take a reading, record it, and return the electrolyte back to the cell.

- ❑ To check another cell, repeat the 3 steps above.
- ❑ Check all cells in the battery.
- ❑ Replace the vent caps and wipe off any electrolyte that might have been spilled.
- ❑ Correct the readings to 80° F:
  - Add .004 to readings for every 10° above 80° F
  - Subtract .004 for every 10° below 80° F.
- ❑ Compare the readings.
- ❑ Check the state of charge using **Table 1**.

The readings should be at or above the factory specification of 1.277 (± .007). If any specific gravity readings register low, then follow the steps below.

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

If any specific gravity readings still register low then follow the steps below.

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

If any specific gravity reading still registers lower than 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 (n charging, no discharging) for at least 6 hrs, preferably 24.

- ❑ Disconnect all loads from the batteries.
- ❑ Measure the voltage using a DC voltmeter.
- ❑ Correct the readings to 80° F:
  - Add .028 per cell for every 10° above 80° F
  - Subtract .028 per cell for every 10° below 80° F.
- ❑ Check the state of charge with **Table 1**.
- ❑ Charge the battery if it registers 0%-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

Watering
(flooded batteries only)

Just like cars need oil, flooded batteries need water. More so, watering must be done at the right time and in the right amount or else the battery's performance and longevity suffers. There are two levels for a batteries water. First, when a battery is discharged (partially or fully)……the water only needs to cover the plates. Second, after fully charging the battery,…….the best level is just below the end of the plastic filling well. Keeping the water of the 2nd level will prevent having to worry about the 1st level.

The most important things to avoid:

1. Don't let the plates get exposed to air. This will damage (corrode) the plates.
2. Don't fill the water level up the filling well to the cap. This most likely will cause the battery to overflow acid, consequently losing capacity and making a corrosive mess.
3. Do not use water with a high mineral content. Use distilled or deionized water only.

How often do I water my batteries?

This depends on your climate, charging methods, appplication, etc. Trojan simply recommends that to check the batteries once a month until you get a feel for how thirsty your batteries are.

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

Step by step watering procedure:

- Minimum electrolyte level is at the top of the plates.
- Open the vent caps and look inside the fill wells.
- If necessary add just enough water to cover the plates at this time.
- Put batteries on a complete charge before adding any additional water (refer to the **Charging** section).
- Charge batteries completely
- Open the vent caps and look inside the fill wells.
- Add water until the electrolyte level is 1/8" below the bottom of the fill well.
- A piece of rubber can be used safely as a dipstick to help determine this level.
- 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.

- Check that all vent caps are tightly in place.
- 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.
- Rinse with water and dry with a clean cloth.
- Clean battery terminals and the inside of cable clamps using a post and clamp cleaner.
- Clean terminals will have a bright metallic shine.
- Reconnect the clamps to the terminals and thinly coat them with petroleum jelly (Vaseline) to prevent corrosion.
- Keep the area around batteries clean and dry also.

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 temp. 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. Temp's above 80 deg. F accelerate the battery's self-discharge characteristics

Step by step storage procedure:

- Completely charge the battery before storing.
- Store the battery in a cool, dry location, protected from the elements.
- During storage, monitor the specific gravity (flooded) or voltage. Batteries in storage should be given a boost charge when they show a 70% charge or less. See **Table 1**.
- Completely charge the battery before re-activating.
- 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	7.2 – 7.4	14.4 – 14.8	28.8 – 29.6	43.2 – 44.4	57.6 – 59.2
Float	6.6	13.2	26.4	39.6	52.8
Equalize	7.8	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.

- Become familiar with and follow the instructions issued by the charger manufacturer.
- Batteries should be charged after each period of use.
- Lead-acid batteries do not develop a memory and need not be fully discharged before recharging.
- Charge only in well-ventilated area. Keep sparks or flames away from a charging battery.
- Verify charger voltage settings are correct (**Table 2**)
- Check water level (see the **Watering** section).
- Tighten all vent caps before charging.
- Prevent overcharging the batteries. Overcharging causes excessive gassing (water breakdown), heat buildup, and battery aging.
- Prevent undercharging the batteries. Undercharging causes stratification.
- Do not charge a frozen battery.
- Avoid charging at temperatures above 120° F.

<u>Additional VRLA Charging Instructions:</u>

- Become familiar with and follow the instructions issued by the charger manufacturer.

- Verify charger has necessary VRLA setting
- Set charger to VRLA voltage settings (**Table 3**)
- 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.

How often do I equalize ?

Many experts recommend that batteries be equalized periodically. Ranging anywhere from once a month to once or twice per year. However, Trojan only recommends equalizing when low or wide ranging specific gravities (+/-.015) are detected after fully charging a battery.

Step by Step Equalizing:

- Verify the battery(s) are flooded type.
- Remove all loads from the batteries.
- Connect battery charger.
- Set charger for the equalizing voltage (**Table 2**).
- Start charging batteries
- Batteries will begin gassing and bubbling vigorously
- Take specific gravity readings every hour
- 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:

- Shallow discharges will result in a longer battery life
- 50% (or less) discharges are recommended
- 80% discharge is the maximum safe discharge
- Do not fully discharge flooded batteries (80% or more). This will damage (or kill) the battery. Equivalent to overheating a car's engine, extent of damage unknown.
- Many experts recommend operating batteries only between the 50% to 85% of full charge range. A periodic equalization charge is a must when using this practice.
- Do not leave batteries deeply discharged for any length of time.
- Lead-acid batteries do not develop a memory and need not be fully discharged before recharging
- Batteries should be charged after each period of use.
- Batteries that charge up but cannot support a load are most likely bad and should be tested. Refer to **Testing** section for proper procedure.