Trojan®
BATTERY COMPANY

TROJAN BATTERY USER'S GUIDE

Congratulations on your purchase from Trojan Battery Company, the manufacturer of the world's most trusted deep cycle batteries. The battery you purchased was engineered by Trojan to deliver superior power, performance, durability and reliability for use in a broad range of demanding applications.

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This User's Guide was created by Trojan's applications engineers and contains vital information regarding proper care and maintenance of your new battery. Please read through this user's guide carefully and completely before using your battery. It will help you achieve optimum performance and long life from your new investment.

1. Equipment Needed

- Goggles and gloves
- Distilled or treated water (i.e. de-ionized, reverse osmosis, etc.)
- Rubber-handled wrench
- Baking soda
- Post protector (i.e. petroleum jelly, anti-corrosion spray, etc.)
- Voltmeter (for flooded/wet, gel and AGM batteries)
- Hydrometer (for flooded/wet batteries)
- Discharge tester (if available)
- Battery charger

2. Battery Installation

To ensure you install your batteries properly and safely please use the following guidelines:

2.1. Safety

- Always wear protective clothing, gloves and goggles when handling batteries
- Do not smoke near batteries
- Keep sparks, flames and metal objects away from batteries
- Use a wrench with a rubber handle when making battery connections
- The electrolyte is a solution of acid and water, so avoid skin contact
- If acid contacts your skin or eyes, flush with water immediately
- Check that all cable connections to the terminal are properly tightened; connections that are too tight or too loose could result in post breakage, meltdown or fire
- To avoid short circuits do not lay objects on top of battery
- Charge batteries in a well-ventilated area
- Never add acid to a battery

2.2. Battery Connections

Battery cables provide the link between the batteries, equipment and charging system. Faulty connections can lead to poor performance and terminal damage, meltdown or fire. To ensure proper connections, please use the following guidelines for cable size, torque values and terminal protection.

2.2.1. Cable Size

Battery cables should be sized to handle the expected load. Refer to *Table 1* for the maximum current carrying capacity (amps) based on the cable/wire gauge size.

Table 1

Wire Gauge Size (AWG)	Ampacity (amps)
14	25
12	30
10	40
8	55
6	75
4	95
2	130
1	150
1/0	170
2/0	265
4/0	360

Table values are for cable lengths less than 6 feet (1829 mm). In series/parallel battery banks, it is preferable for all series cables to be the same length and all parallel cables to be the same length.

For more information refer to the National Electric Code for correct cable/wire size, which can be located at www.nfpa.org.

2.2.2. Torque Values

Tighten all cable connections to the proper specification to make sure there is good contact with the terminals. Over-tightening the connection to the terminal can result in terminal breakage and loose connections which can result in meltdown or fire. Refer to *Table 2* for the proper torque values based on the type of terminal on your battery.

Table 2

Terminal Type	Torque (in lbs)
AP	50 - 70
LT	100 - 120
LPT, HPT, WNT, DWNT, UT	95 - 105
ST	120 - 180

** For DT (Automotive Post & Stud) refer to AP or ST type*

WARNING: Use a wrench with a rubber handle when making battery connections.

2.2.3. Terminal Protection

Corrosion can build up on terminals if they are not kept clean and dry. To prevent corrosion apply a thin coat of petroleum jelly or terminal protector that can be purchased through your local battery dealer.

2.3. Ventilation

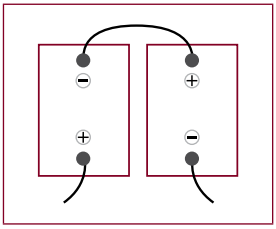
Flooded/wet lead acid batteries release small amounts of gas during usage, particularly during the charging process. Gel and AGM batteries generally do not release gas but can if too much pressure builds up during charging. It is critical to charge batteries in a properly ventilated area. For more assistance in calculating ventilation needs, please contact Trojan Battery Company's technical support engineers at 800-423-6569 or +1-562-236-3000.

2.4. Connecting Batteries to Increase System Power

2.4.1. Series Connections

To increase voltage, connect batteries in series. This will not increase the system capacity. Refer to *Diagram 1* for series connections.

Diagram 1



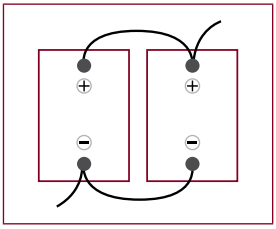
Example :
Two T-105, 6V Batteries rated at 225AH Connected in Series

System Voltage: 6V + 6V = 12V
System Capacity = 225AH

2.4.2. Parallel Connections

To increase capacity, connect batteries in parallel. This will not increase the system voltage. Refer to *Diagram 2* for parallel connections.

Diagram 2



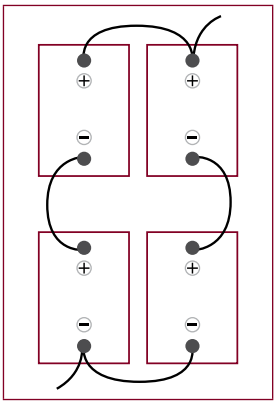
Example :
Two T-105, 6V Batteries rated at 225AH Connected in Parallel

System Voltage: 6V
System Capacity = 225AH + 225AH = 450AH

2.4.3. Series/Parallel Connections

To increase both voltage and capacity, connect additional batteries in series and parallel. Refer to *Diagram 3* for series/parallel connections.

Diagram 3



Example :
Four T-105, 6V Batteries rated at 225AH
Connected in Series/Parallel

System Voltage: 6V + 6V = 12V
System Capacity = 225AH + 225AH = 450AH

2.5. Battery Orientation

Flooded/wet batteries must be placed upright at all times. Fluid in the battery will spill if the battery is placed on its side or at an angle. Gel or AGM batteries are spill-proof so they can be placed either upright or on its side.

3. Preventative Maintenance

3.1. Inspection

- Examine the outside appearance of the battery. The tops of the batteries and terminal connections should be clean, free of dirt and corrosion, and dry. Refer to Cleaning *section 3.2*
- If fluids are on the top of a flooded/wet battery this may mean that the battery is being over-watered. Refer to Watering *section 3.3* for proper watering procedure. If fluid is on the top of a gel or AGM battery this means that the battery is being overcharged and the performance and life will be reduced
- Check battery cables and connections. Replace any damaged cables. Tighten any loose connections. Refer to Torque Values *section 2.2.2*

3.2. Cleaning

- Check that all vent caps are secured properly on the battery
- Clean the top of the battery, terminals and connections with a cloth or brush and a solution of baking soda and water. Do not allow cleaning solution to get inside the battery
- Rinse with water and dry with a clean cloth
- Apply a thin coat of petroleum jelly or terminal protector that can be purchased through your local battery dealer
- Keep the area around batteries clean and dry

3.3. Watering (flooded/wet batteries ONLY)

Water should never be added to gel or AGM batteries as they do not lose water during use. Flooded/wet batteries need to be watered periodically. The frequency depends upon battery usage and operating temperatures. Check new batteries every few weeks to determine the watering frequency for your application. It is normal for batteries to need more watering as they age.

- Fully charge the batteries prior to adding water. Only add water to discharged or partially charged batteries if the plates are exposed. In this case, add just enough water to cover the plates and then charge the batteries and continue with the watering procedure below
- Remove the vent caps and place them upside down so that dirt does not get on the underside of the cap or for Plus Series™ batteries, simply flip open the cap. Check the electrolyte level
- If the electrolyte level is well above the plates then it is not necessary to add more water
- If the electrolyte level is barely covering the plates, add distilled or de-ionized water to a level 1/8" (3 mm) below the vent well (this is the plastic shield inside the vent hole) for standard batteries and to the maximum (MAX) level indicator for Plus Series™ batteries
- After adding water, secure vent caps back on batteries
- Tap water may be used if the levels of impurities are within acceptable limits. Refer to *Table 3* for Water Impurity Limits

Table 3

Recommended Maximum Allowable Impurities In Water for Battery Use		
Impurity	Parts Per Million	Effects of Impurity
Color	Clear and "White"	-
Suspended Matter	Trace	-
Total Solids	100.00	-
Organic and Volatile Matter	50.0	Corrosion of positive plate
Ammonia	8.0	Slight self-discharge of both plates
Antimony	5.0	Self-discharge by local action, reduces life, lower on-charge voltage
Arsenic	0.5	Self-discharge, can form poisonous gas at negative
Calcium	40.0	Increase of positive shedding
Chloride	5.0	Loss of capacity in both plates, greater loss in positive
Copper	5.0	Increased self-discharge, lower on-charge voltage
Iron	3.0	Increased self-discharge at both plates, lower on-charge voltage
Magnesium	40.0	Reduced life
Nickel	None Allowed	Intense lowering of on-charge voltage
Nitrates	10.0	Increased sulfation at negative
Nitrites	5.0	Corrosion at both plates, loss of capacity, reduced life
Platinum	None Allowed	Violent self-discharge, lower on-charge voltage
Selenium	2.0	Positive shedding
Zinc	4.0	Slight self-discharge at negative

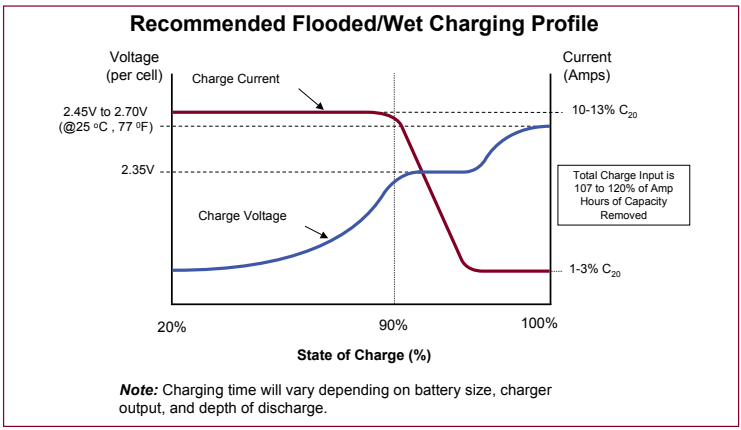
3.4. Charging and Equalizing

3.4.1. Charging

Proper charging is imperative to maximize battery performance. Both under- or over-charging batteries can significantly reduce the life of the battery. For proper charging, refer to the instructions that came with your equipment. Most chargers are automatic and pre-programmed. Some chargers allow the user to set the voltage and current values. Refer to *Diagram 4* for Trojan's recommended flooded/wet charging guidelines, *Diagram 5* for Trojan's recommended gel charging guidelines and *Diagram 6* for Trojan's recommended AGM charging guidelines.

- Make sure the charger is set to the appropriate program for flooded/wet, gel or AGM, depending on the type of battery you are charging
- Batteries should be fully charged after each use
- Lead-acid batteries (flooded/wet, gel and AGM) do not have a memory effect and therefore do not need to be fully discharged before recharging
- Charge only in well-ventilated areas
- Check electrolyte level to make sure plates are covered with water before charging (flooded/wet batteries only)
- Check that all vent caps are secured properly on the battery before charging
- Flooded/wet batteries will gas (bubble) towards the end of charge to ensure the electrolyte is properly mixed
- Never charge a frozen battery
- Avoid charging at temperatures above 120°F (49°C)

Diagram 4



Note: Charging time will vary depending on battery size, charger output, and depth of discharge.

Diagram 5

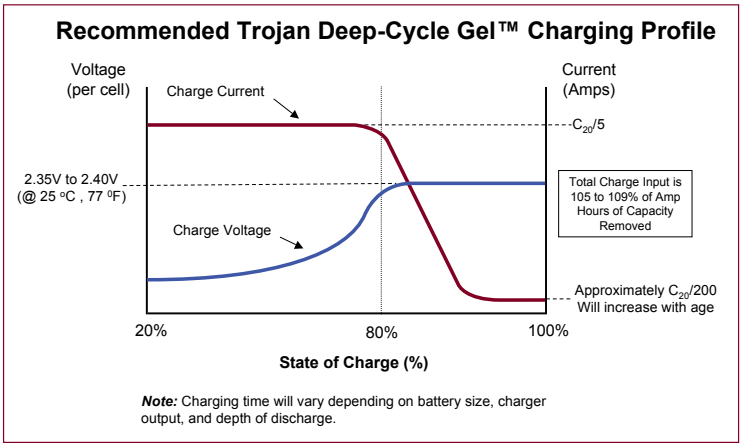
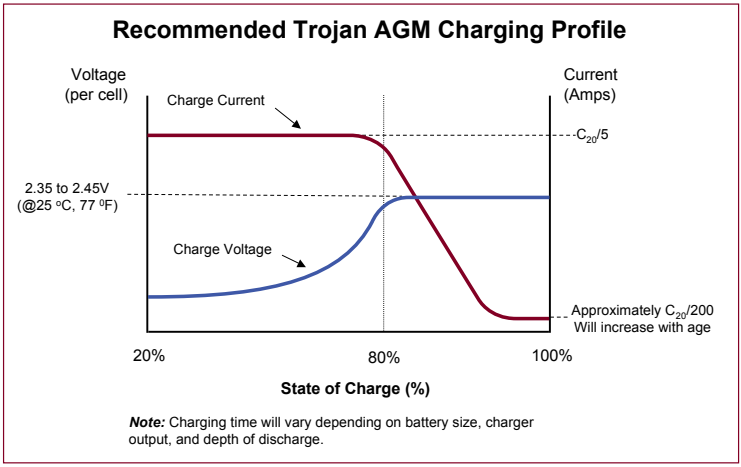


Diagram 6



3.4.2. Equalizing (flooded/wet batteries ONLY)

Equalizing is an overcharge performed on flooded/wet batteries after they have been fully charged. Trojan recommends equalizing only when batteries have low specific gravity, below 1.250 or wide ranging specific gravity, 0.030, after fully charging a battery. Gel or AGM batteries should never be equalized.

- Confirm that the batteries are flooded/wet
- Check electrolyte level to make sure plates are covered with water before charging
- Check that all vent caps are secured properly on the battery before charging
- Set charger to equalizing mode
- The batteries will gas (bubble) during the equalization process
- Measure the specific gravity every hour. Discontinue the equalization charge when the gravity no longer rises

WARNING: Do not equalize gel or AGM batteries.

4. Storage

- Charge battery before placing in storage
- Store in a cool, dry location, protected from the elements
- Disconnect from equipment to eliminate potential parasitic loads that may discharge the battery
- Batteries gradually self-discharge during storage. Monitor the specific gravity or voltage every 4-6 weeks. Stored batteries should be given a boost charge when they are at 70% state of charge (SOC) or less. Refer to *Table 4* for specific gravity and voltage measurements
- When batteries are taken out of storage, recharge before use

Table 4

State of Charge as a measure of Specific Gravity and Open-Circuit Voltage				
Percentage Charge	Specific Gravity	Open Circuit Voltage		
		Cell	6 Volt	12 Volt
100	1.277	2.122	6.37	12.73
90	1.258	2.103	6.31	12.62
80	1.238	2.083	6.25	12.50
70	1.217	2.062	6.19	12.37
60	1.195	2.04	6.12	12.24
50	1.172	2.017	6.05	12.10
40	1.148	1.993	5.98	11.96
30	1.124	1.969	5.91	11.81
20	1.098	1.943	5.83	11.66
10	1.073	1.918	5.75	11.51

4.1. Storage in Hot Environments (greater than 90°F or 32°C)

Avoid direct exposure to heat sources, if possible, during storage. Batteries self-discharge faster in high temperatures. If batteries are stored during hot, summer months, monitor the specific gravity or voltage more frequently (approximately every 2-4 weeks).

4.2. Storage in Cold Environments (less than 32°F or 0°C)

Avoid locations where freezing temperatures are expected, if possible, during storage. Batteries can freeze in cold temperatures if they are not fully charged. If batteries are stored during cold, winter months, it is critical that they are kept fully charged.

5. How To Maximize the Performance of Your Trojan Battery

- Follow all the procedures in this User's Guide for proper installation, maintenance and storage
- Do not discharge your battery more than 80%. This safety factor will eliminate the chance of over-discharging and damaging your battery
- If you have any questions or concerns about battery care, please contact Trojan Battery Company's technical support engineers at 800-423-6569 or +1-562-236-3000 before a problem develops

6. What to Expect from Your Trojan Battery

- A new battery will not deliver its full rated capacity. This is normal and should be expected as it takes time to "work the battery up"
- Trojan's batteries take between 50 – 100 cycles to work up to providing full, peak capacity
- When operating batteries at temperatures below 80°F (27°C) they will deliver less than the rated capacity. For example at 0°F (-18°C) the battery will deliver 50% of its capacity and at 80°F (27°C) it will deliver 100% of its capacity
- When operating batteries at temperatures above 80°F (27°C) they will deliver more than the rated capacity but the battery life will be reduced
- The life of a battery is difficult to predict as it will vary with application, frequency of usage and level of maintenance

7. Trouble-Shooting

These battery testing procedures are guidelines only for identifying a battery that may need to be replaced. Unique situations may be observed that are not identified within this procedure. Please contact Trojan Battery Company's technical support engineers at 800-423-6569 or +1-562-236-3000 for help interpreting the test data.

7.1. Preparation for Testing

- Check that all vent caps are secured properly on the battery
- Clean the top of the battery, terminals and connections with a cloth or brush and a solution of baking soda and water. Do not allow cleaning solution to get inside the battery. Rinse with water and dry with a clean cloth
- Check battery cables and connections. Replace any damaged cables. Tighten any loose connections. Refer to Torque Values *section 2.2.2*
- For flooded/wet batteries, check the electrolyte level and add water if necessary. Refer to Watering *section 3.3*
- Fully charge batteries

7.2. On-Charge Voltage Testing

- Disconnect and reconnect DC plug to restart charger
- While the batteries are on-charge record the current in the last ½ hour of charge (if possible) and measure the battery set voltage
- If the current at the end of charge is below 5 amps and the battery set voltage is above: 56V for a 48V system; 42V for a 36V system; 28V for a 24V system; 14V for a 12V battery; 9.3V for a 8V battery or 7V for a 6V battery, then proceed to the next step. Otherwise check the charger for proper output and recharge the batteries if necessary. If the set voltages are still low, you may have a failed battery
- While the batteries are on-charge measure the individual battery voltages
- If any battery voltage is below: 7V for 6V battery, 9.3V for 8V battery and 14V for 12V battery, and a voltage variation is greater than 0.5V for 6V battery or 1.0V for a 12V battery, from any other battery in set, it may be a failed battery

7.3. Specific Gravity Testing (flooded/wet batteries ONLY)

- Fill and drain the hydrometer 2-3 times before drawing a sample from the battery
- Measure specific gravity readings for all battery cells
- Correct specific gravity readings for temperature by adding 0.004 for every 10°F (5°C) above 80°F (27°C) and subtract 0.004 for every 10°F (5°C) below 80°F (27°C)
- If every cell in the battery set is below 1.250 the batteries may be undercharged; recharge batteries
- If any battery has a specific gravity variation of more than 0.050 between cells equalize the set
- If there is still a variation there may be a failed battery

7.4. Open Circuit Voltage Testing

This is the least preferred method of evaluating the performance of a battery.

- For accurate voltage readings, batteries must remain idle at least 6 hours (but preferably up to 24 hours)
- Measure the individual battery voltages
- If any battery voltage is greater than 0.3V from any other battery in set, equalize the set (flooded/wet batteries ONLY). Refer to equalizing *section 3.4.2*
- Remeasure the individual battery voltages
- If any battery voltage is still greater than 0.3V from any other battery in set you may have a failed battery

7.5. Discharge Testing

- Connect and start discharger
- Record the runtime (minutes) when discharge is complete
- Correct runtime minutes for temperature using the following formula (valid between 24°C (75°F) and 32°C (90°F):
    - Mc = Mr [1 – 0.009 (T - 27)] where Mc is the corrected minutes, Mr is the minutes recorded and T is the temperature at the end of discharge in °C
- If the discharge time is greater than 50% of the batteries' rated capacity then all the batteries are operational
- Reconnect the discharger to record the individual battery voltage while still under load (current being drawn)
- If the discharge runtime is less than 50% of the batteries' rated capacity, the batteries with a voltage that is 0.5V lower than the highest voltage may be a failed battery

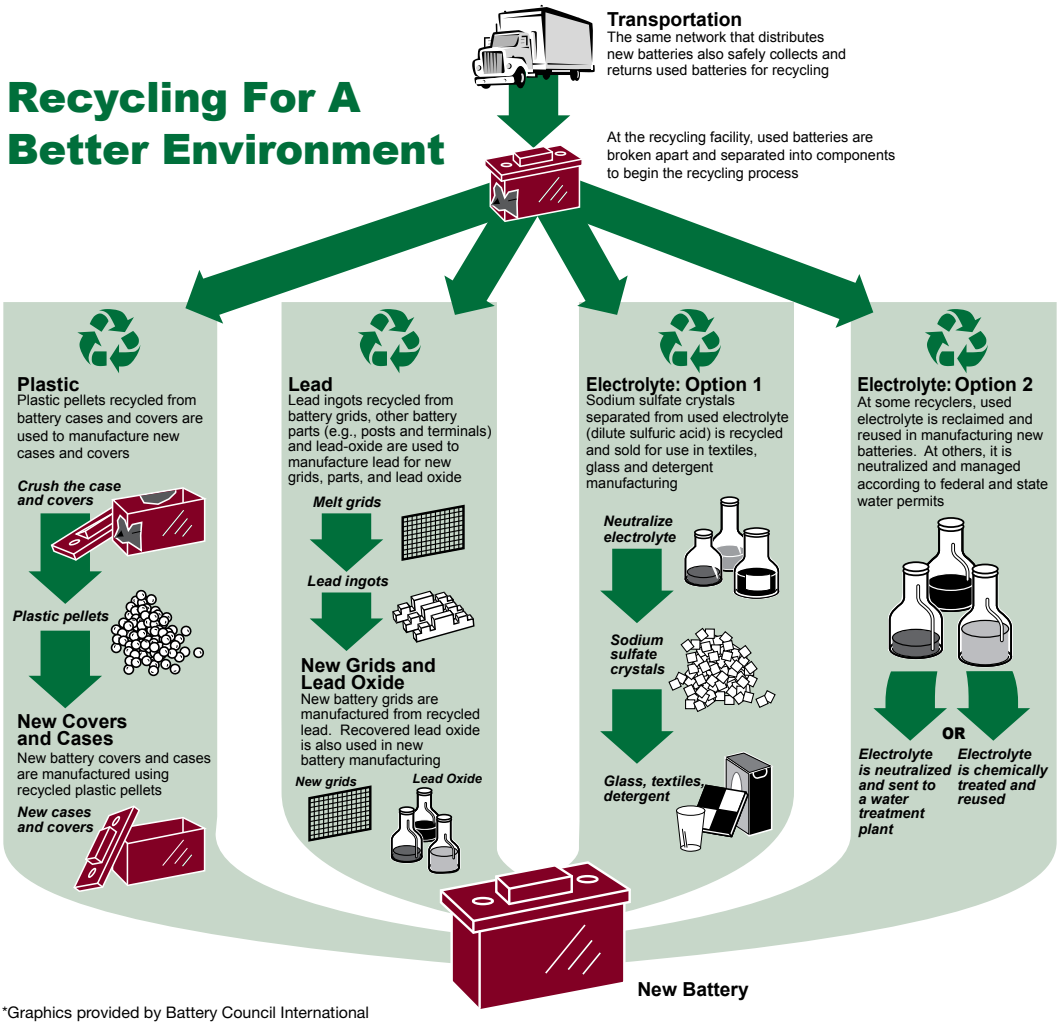
There are other methods of testing batteries including internal resistance (i.e. CCA testers) and carbon-pile discharge testers. However these are not suitable testing methods for deep cycle batteries.

8. Battery Recycling

Lead-acid batteries are the environmental success story of our time because more than 97 percent of all battery lead is recycled. In fact, lead-acid batteries top the list of the most highly recycled consumer products and Trojan Battery supports proper recycling of your battery to keep the environment clean.

Please contact your nearest Trojan Distributor, which can be located at www.trojanbattery.com, to properly recycle your batteries.

Below is the process in which your Trojan battery will be recycled:



*Graphics provided by Battery Council International

Trojan Battery Company would like to thank you for selecting our battery. With over 80 years of experience, Trojan Battery is the world's most trusted name in deep cycle battery technology backed by our outstanding technical support. We look forward to serving your battery needs.

Trojan Battery Company
12380 Clark St.
Santa Fe Springs, CA 90670 USA

Notes

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