



USER'S GUIDE ***FLOODED DEEP CYCLE***



RELIABLE POWER. GREAT VALUE

 **Made in
USA**
of U.S. and imported parts


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1 SAFETY

Since batteries deliver large amounts of power that can cause injury and even death, observing safety rules is of paramount importance. For your safety and the safety of those around you, please observe the following checklist when working on or around batteries.

Always	Never
Always charge batteries in well-ventilated areas	Never charge a flooded battery without securing vent caps on the cells
Always wear protective clothing, gloves, and safety goggles	Never smoke near batteries
Always use insulated tools when working on batteries	Never wear jewelry or other metal objects when working on or around batteries
Always check connections for proper torque	Never make direct contact with the electrolyte (sulfuric acid). If this occurs, flush with large amounts of water.
Always keep sparks and flames away from batteries	Never place objects on top of batteries
Always use short cables of appropriate size to minimize voltage drop	Never add acid to a battery
Always ensure plates are covered in water before charging	Never charge a frozen battery
Always make sure charger is set for the appropriate battery type (flooded)	Never charge a battery when the temperature is above 122°F (50°C)
Always charge batteries before installing	Never store batteries unless they are fully charged
Always neutralize small spills with baking soda and water. For large spills, contact the appropriate first responders.	Never leave an acid spill unattended

 **WARNING!** Risk of fire, explosion, or burns. Do not disassemble, heat above 158°F (70°C), or incinerate.

2 EQUIPMENT NEEDED

Before installation or maintenance of your batteries, have the following equipment available:

- Proper personal protective equipment (eye protection and acid resistant gloves)
- Distilled or deionized water
- Insulated tools
- Baking soda
- Terminal protector spray
- Voltmeter
- Hydrometer (flooded/wet batteries)
- Battery charger
- Discharge tester (if available)

3 BATTERY INSTALLATION

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

3.1. BATTERY CONNECTIONS


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

3.2. TERMINAL TYPES

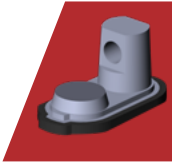
Figure 1 illustrates various terminal types found on Pacer batteries. Refer to the appropriate terminal type when determining proper torque in *Section 3.5*.

FIGURE 1 – TERMINAL TYPES

TERMINAL SPECIFICATIONS^E



TYPE	ELPT
DESCRIPTION	EMBEDDED LOW PROFILE TERMINAL
HEIGHT INCHES (mm)	1.22 (31)
TORQUE POUNDS (Nm)	95-105 (11-12)
BOLT	5/16"



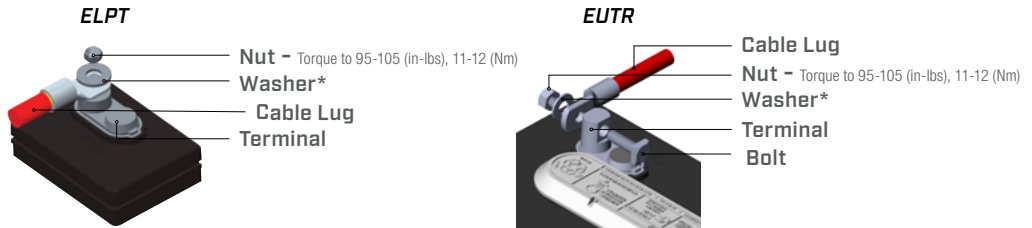
TYPE	EUTR
DESCRIPTION	EMBEDDED UNIVERSAL TERMINAL REVERSE
HEIGHT INCHES (mm)	1.10 (28)
TORQUE POUNDS (Nm)	95-105 (11-12)
BOLT	HOLE SIZED FOR 5/16" - 18 BOLT

3.3. CORRECT HARDWARE INSTALLATION

If using flat washers, it is very important to ensure the battery cable lug is contacting the lead surface of the terminal, and the washer is placed on top of the lug. Do not place a washer between the battery terminal and the lug, as this will create high resistance and cause excessive heating of the connection and terminal. It is important that fasteners be tightened to the appropriate torque for each terminal type, as defined in *Table 2*.

FIGURE 2

Flooded Battery Terminal Configurations



3.4. CABLE SIZE

Battery cables should be sized to handle the expected load. Refer to Table 1 for the maximum amperage based on the cable/wire gauge size.

TABLE 1

<i>Cable/Wire Gauge Size, AWG (mm²)</i>	<i>Ampacity (amps)</i>
14 (2.08)	20
12 (3.31)	25
10 (5.26)	35
8 (8.36)	50
6 (13.3)	65
4 (21.1)	85
2 (33.6)	115
1 (42.4)	130
1/0 (53.5)	150
2/0 (67.4)	175
4/0 (107)	230

Table values are from NEC Table 310.15(B)16 for copper cables rated at 167°F (75°C), operating at an ambient temperature of no more than 86°F (30°C). Lengths in excess of 6 feet (1829 mm) may require heavier gauge wire to avoid unacceptable voltage drop. 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 Electrical Code for correct cable/wire size, which can be located at www.nfpa.org.

3.5. TORQUE VALUES

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

TABLE 2

<i>Terminal Type</i>	<i>Dry Torque (in-lb)</i>	<i>Dry Torque (Nm)</i>
ELPT, EUTR	95 - 105	11 - 12

 **WARNING!** Use an insulated wrench when making battery connections.

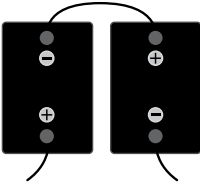
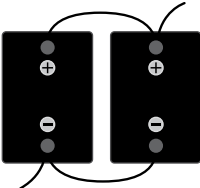
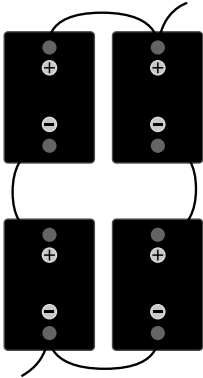
3.6. TERMINAL PROTECTION

Corrosion can build up on terminals if they are not kept clean and dry. To prevent corrosion, after tightening the fasteners, apply a thin coat of terminal protector spray that can be purchased through your local battery dealer.

3.7. CONNECTING BATTERIES IN BANKS

You can increase capacity and voltage, or both, by configuring your batteries as shown in *Table 3*.

TABLE 3

	SERIES CONNECTION	PARALLEL CONNECTION	SERIES/PARALLEL CONNECTION
			
			Note: maximum of three parallel strings
	To increase voltage, connect batteries in series. This will not increase the system capacity.	To increase capacity, connect batteries in parallel. This will not increase the system voltage.	To increase both voltage and capacity, connect additional batteries in series and parallel.
EXAMPLE	Two P-105, 6V Batteries rated at 220Ah Connected in Series	Two P-105, 6V Batteries rated at 220Ah Connected in Parallel	Four P-105, 6V Batteries rated at 220Ah Connected in Series/Parallel
	System Voltage = $6V + 6V = 12V$ System Capacity = 220Ah	System Voltage = 6V System Capacity = $220Ah + 220Ah = 440Ah$	System Voltage $6V + 6V = 12V$ System Capacity = $220Ah + 220Ah = 440Ah$

3.8. VENTILATION

Deep-cycle flooded/wet lead acid batteries release small amounts of gas during usage, particularly during the charging process. **It is critical to charge batteries in a properly ventilated area.**

3.9. BATTERY ORIENTATION

Deep-cycle 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.

3.10. BATTERY ENVIRONMENT

Batteries should be stored and installed in a clean, cool and dry place, keeping water, oil, and dirt away from the batteries. If any of these materials are allowed to accumulate on the batteries, tracking and current leakage can occur, resulting in self-discharge and possible short-circuits. Battery chargers should also be installed in well-ventilated, clean areas that are easily accessible. Relative humidity should be <90%.

3.11. TEMPERATURE

The recommended operating temperature range is -4°F to 113°F (-20°C to 45°C). It is important to minimize temperature variations between the cells. Therefore, avoid restricting airflow by tightly packing batteries together. The batteries should have a minimum of 0.50" (12.7 mm) of space between them to allow for adequate airflow.

4 PREVENTIVE MAINTENANCE

4.1. INSPECTION

- Examine the outside appearance of the battery. The tops of the batteries and terminal connections should be clean, dry, and free of corrosion. Refer to Section 4.3, Cleaning.
- If fluids are present on the top of a deep-cycle flooded/wet battery, it may mean that the battery is being overwatered or overcharged. Refer to Section 4.2, Watering, for the proper watering procedure.
- Check battery cables and connections. Replace any damaged cables and tighten any loose connections. Refer to Section 3.5, Torque Values.

4.2. WATERING (FLOODED/WET BATTERIES ONLY)

Deep-cycle flooded/wet batteries need to be watered periodically. The frequency depends on battery usage, charging and operating temperature. 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.

- Use only distilled or deionized water. Tap water can contain contaminants that will damage the battery. Also, be aware that water can pick up impurities from containers, piping, and fixtures. Table 4 contains the limits for impurities to avoid damaging batteries.
- 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. Once completed, continue with the watering procedure below.
- Check the electrolyte levels by removing the vent caps and placing them upside down so that dirt does not accumulate on the underside of the cap.
- If the electrolyte level is barely covering the plates, add distilled or deionized water to the proper level.
- After adding water, secure vent caps back onto batteries.

FIGURE 5



Standard Vent Well

TABLE 4

WATER IMPURITY LIMITS		
Impurity	Parts Per Million	Effects of Impurity
Color	Clear and "White"	-
Suspended Matter	Trace	-
Total Solids	100	-
Organic and Volatile Matter	50	Corrosion of positive plate
Ammonia	8.0	Slight self-discharge of both plates
Antimony	5.0	Increased self-discharge, reduces life, lower on-charge voltage
Arsenic	0.50	Self-discharge, can form poisonous gas at negative plate
Calcium	40	Increase of positive plate shedding
Chloride	5.0	Loss of capacity in both plates, greater loss on the positive plate
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	Reduced life
Nickel	None Allowed	Substantial lowering of on-charge voltage
Nitrates	10	Increased sulfation on the negative plate
Nitrites	5.0	Corrosion of both plates, loss of capacity, reduced life
Platinum	None Allowed	Increased self-discharge, lower on-charge voltage
Selenium	2.0	Positive plate shedding
Zinc	4.0	Slight self-discharge of negative plate

4.3. CLEANING

Check the battery for cleanliness at regular intervals and keep terminals and connectors free of corrosion. Terminal corrosion may adversely affect the performance of the battery and present a safety hazard.

- For flooded batteries, check that all vent caps are secured properly on the battery.
- Clean the top of the battery, terminals, and connections with a cloth or non-metallic brush, and a solution of baking soda and water comprised of 1 cup of baking soda to 1 gallon of water (60 ml of baking soda per liter of 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 terminal protector spray which can be purchased through your local battery dealer.
- Keep the area around batteries clean and dry.

5 CHARGING & EQUALIZING

5.1. INITIAL CHARGING

Due to the potential for self-discharge during shipping and storage, batteries should be given a full charge prior to first use. See the next section for details on proper charging.

5.2. NORMAL CHARGING

Proper charging is imperative to maximize battery performance. Both under- or over-charging batteries can significantly reduce the life of the battery. Most chargers are automatic and pre-programmed, while others are manual and allow the user to set the voltage and current values.

- **Charge only in well-ventilated areas.**
- Batteries should be fully charged after each use. "Use" is defined as 30 minutes or more of runtime.
- Before charging, make sure the charger is set to the appropriate program for deep cycle flooded/wet batteries.
- Charging time will vary depending on battery size, charger output, and depth of discharge.
- Lead-acid batteries do not have a memory effect and should not be fully discharged prior to charging.
- Temperature compensated charging is desirable. Temperature compensation coefficients raise the voltage/cell for temperatures below 77°F (25°C), and lower the voltage/cell for temperatures above 77°F (25°C).
- Never charge a frozen battery.
- Avoid charging at temperatures above 122°F (50°C).

5.2.1. CHARGING FLOODED BATTERIES

- Prior to charging, check electrolyte levels to verify that the plates are covered with electrolyte. If plates are exposed, add enough water (distilled or deionized) to just cover the plates prior to charging.
- Make sure that vent caps are in place and are properly secured.
- Pacer recommends a 3-phase I-V-I profile for charging its flooded batteries
 - Phase 1: Constant current bulk charge
A constant current equal to 10-13% of C20 is applied as the voltage slowly increases.
The bulk phase ends when the voltage rises to the absorption voltage.
 - Phase 2: Constant voltage absorption charge
A constant voltage equal to 2.35-2.45 V/cell is applied as the current slowly declines.
The absorption phase ends when the current falls to the finish current.
 - Phase 3: Constant current finish charge
A constant current equal to 1-3% of C₂₀ is applied as the voltage increases. The finish phase ends when the battery is fully charged. **Flooded batteries will gas (bubble) toward the end of the finish phase to ensure proper mixing of electrolyte.**
 - Refer to *Table 5* and *Figure 6* for system charging parameters and typical voltage and current profiles.
 - In applications where batteries are infrequently used, it is desirable to compensate for self-discharge by keeping a low charging voltage on the batteries. This is called the float voltage. Avoid using continuous float charging on flooded batteries that are charged more than once/week.

When float charging is used, it is started immediately after the end of the finish stage.
- Following charge completion, add water if required as directed in *Section 4.2*.

TABLE 5

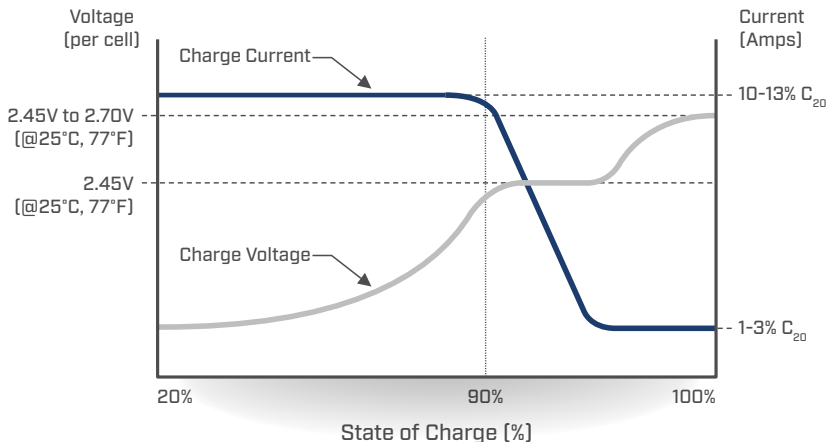
FLOODED/WET BATTERIES - NORMAL CHARGING PARAMETERS @ 25°C [77°F]							
Pacer Battery Line	Maximum Charge Current* (% of C ₂₀)	Absorption Voltage** (V/cell)	Maximum Absorption Phase Time (hours)	Finish Current (% of C ₂₀)	Equalization Voltage (V/cell)	Float Voltage (V/cell)	Temperature Compensation (V/cell)
Flooded/Wet	13%	2.45	4	1-3%	2.70	2.25	Fahrenheit: -2.8 mV x (T _{battery} -77) Celsius: -5 mV x (T _{battery} -25)

*If charging time is limited contact Pacer Technical Support for assistance.

**In cases where the charger has a bulk voltage setting rather than a current, use the above absorption settings.

FIGURE 6

Recommended Deep-Cycle Flooded/Wet Charging Profile



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

5.3. EQUALIZING (FLOODED/WET BATTERIES ONLY)

When batteries are used in a battery bank, over time some of the batteries can drift to a lower state of charge than others. This charge imbalance can lead to sulfation and premature battery failure.

In order to ensure that these charge imbalances are corrected, a process called “equalization” is used.

Equalizing is an overcharge performed after fully charging deep-cycle flooded/wet batteries. An equalizing charge prevents electrolyte stratification and reduces sulfation, which are leading causes of battery failure. Pacer recommends equalizing for 2-4 hours in the following situations:

- Periodically (every 30 days)
- When batteries have a low specific gravity after charging (<1.235), or
- When the range of specific gravities between cells is > 0.030 points
- Reference *Section 9.3* for instructions on specific gravity measurement.

Equalization can be performed either automatically (as programmed on the charger) or by following the procedure below:

- Check the battery's electrolyte level in each cell to make sure the plates are covered 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 specific gravity no longer rises.

6 STORAGE

The following tips will help ensure that your batteries emerge from storage in good condition:

- Charge batteries before placing them in storage.
- Store in a cool and dry location, protected from the elements.
- Disconnect from equipment to eliminate potential parasitic loads that may discharge the battery.
- Batteries gradually self-discharge during transit and storage, so monitor the specific gravity or open-circuit voltage of flooded batteries every 4 - 6 weeks.
- Batteries in storage should be charged when they decline to the following state of charge (SOC):
 - o Flooded batteries: 70% SOC
- Refer to *Table 7* for the relationship between SOC, specific gravity (flooded only) and open-circuit voltage. If charging is needed, follow the normal charging procedure outlined in *Section 5.2*.
- When batteries are taken out of storage they should be given an initial charge as outlined in *Section 5* prior to use.

6.1. STORAGE IN HOT ENVIRONMENTS

Storage in hot environments (greater than 90°F or 32°C) can negatively impact batteries. Avoid direct exposure to heat sources, if possible, during storage. Batteries self-discharge faster at high temperatures. If batteries are stored during hot summer months, monitor State-of-Charge on a regular basis as follows:

- Flooded batteries: check specific gravity or voltage every 2 - 4 weeks.

6.2. STORAGE IN COLD ENVIRONMENTS

If possible, avoid locations where freezing temperatures are expected during storage. Batteries can freeze in cold temperatures (less than 32°F or 0°C) if they are not fully charged. If batteries are stored during cold winter months, it is critical that they be kept at a high state of charge as outlined above.

Freezing Point of Electrolyte		
Specific Gravity	Temperature	
	°C	°F
1.280	-68.9	-92.0
1.265	-57.4	-71.3
1.250	-52.2	-62.0
1.200	-26.7	-16.0
1.150	-15.0	-5.0
1.100	-7.2	19
Source: BCI Service Manual © 1995		

TABLE 7

FLOODED/WET STATE OF CHARGE AS A FUNCTION OF SPECIFIC GRAVITY AND OPEN-CIRCUIT VOLTAGE					
STATE OF CHARGE (%)	SPECIFIC GRAVITY	CELL	6 VOLT	8 VOLT	12 VOLT
100	1.277	2.122	6.37	8.49	12.73
90	1.258	2.103	6.31	8.41	12.62
80	1.238	2.083	6.25	8.33	12.50
70	1.217	2.062	6.19	8.25	12.37
60	1.195	2.04	6.12	8.16	12.24
50	1.172	2.017	6.05	8.07	12.10
40	1.148	1.993	5.98	7.97	11.96
30	1.124	1.969	5.91	7.88	11.81
20	1.098	1.943	5.83	7.77	11.66
10	1.073	1.918	5.75	7.67	11.51

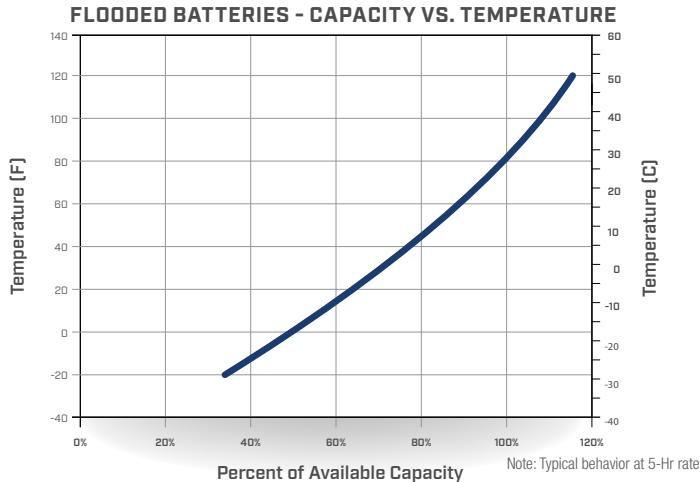
7 MAXIMIZING THE PERFORMANCE OF YOUR PACER BATTERY

- Follow all the procedures in this User's Guide for proper installation, maintenance and storage.
- Do not discharge your battery to more than 80% depth of discharge.
This safety factor will eliminate the chance of over-discharging and damaging your battery.

8 WHAT TO EXPECT FROM YOUR PACER BATTERY

- A new deep-cycle battery will not immediately deliver its full rated capacity. This is normal and should be expected since it takes time for a deep-cycle battery to reach 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 battery life will be reduced.
- The life of a battery is difficult to predict and will vary by application, frequency of usage and level of maintenance.

FIGURE 9



9 TROUBLESHOOTING

These battery testing procedures are guidelines only for identifying a deep-cycle battery that may need to be replaced. Unique situations may be observed that are not identified within this procedure.

9.1. PREPARATION FOR TESTING

- If applicable, 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 [1 cup of baking soda to 1 gallon of water (60 ml of baking soda per liter of 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 with an insulated wrench. Refer to *Torque Values Section 3.5*.
- For deep-cycle flooded/wet batteries, check the electrolyte level and add water if necessary. Refer to *Watering Section 4.2*.
- Ensure batteries are fully charged before discharge testing to obtain accurate results.

9.2. VOLTAGE TESTING WHILE CHARGING

- Disconnect and reconnect DC plug to restart charger.
- While the batteries are charging, record the current in the last ½ hour of the charge cycle (if possible), and measure the battery set voltage.
- If the current at the end of the charge is below 5 amps, and the battery set voltage is above the readings shown in *Table 8*, proceed to the step below to measure the on-charge voltages:

Table 8						
System/Battery Voltage	48V	36V	24V	12V	8V	6V
End-of-Charge Threshold Voltage	56V	42V	28V	14V	9.3V	7V

- If the end-of-charge voltage does not exceed these values, check the charger for proper output and recharge the batteries. If the set voltages are still low, you may have a failed battery.
- While the batteries are on-charge, measure the individual battery voltages.
- Compare each voltage to the proper entry in *Table 9*. If any battery is below the appropriate Minimum Voltage Threshold and the variation between all of the voltages is greater than the Allowable Variation, the low battery may have failed.

TABLE 9

ON-CHARGE TEST THRESHOLDS		
NOMINAL BATTERY VOLTAGE	MINIMUM VOLTAGE THRESHOLD	ALLOWABLE VARIATION WITHIN A SET
6V	7V	0.5V
8V	9.3V	0.7V
12V	14V	1.0V

9.3. SPECIFIC GRAVITY (FLOODED/WET BATTERIES ONLY)

- Use a reliable, high-quality hydrometer for specific gravity measurements.
- 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 1.235, the batteries may be undercharged and require recharging.
 - If any battery has a specific gravity variation of more than 0.030 between cells, equalize the set.
 - If there is still a significant variation, there may be a failed battery.

Hydrometer



9.4. OPEN CIRCUIT VOLTAGE TESTING

- For accurate voltage readings, batteries must remain idle at least 6 hours, and preferably up to 24 hours.
- Measure and record the individual battery voltages.
- If any recorded voltage differs from another one by more than 0.3V, equalize the set (deep-cycle flooded/wet batteries ONLY). Refer to *Section 5.3, Equalizing*.
- Measure the individual battery voltages again.
- If any recorded voltage differs from another one by more than 0.3V, compared to any other battery in the set, you may have a failed battery.

9.5. DISCHARGE TESTING

- Follow the procedure below to determine battery capacity.
- Ensure the battery set has been fully recharged before testing.
- Prior to running a discharge test, ensure that all charging sources and loads are disconnected from the batteries.
- Connect and start discharger.
- Record the runtime (minutes) when discharge is complete.
- Correct runtime minutes for temperature using one of the following formulas*.

- o For temperature measurements in Fahrenheit

$$M_c = M_r [1 - 0.005 \times (T_1 - 80)]$$

- o For temperature measurements in Celsius

$$M_c = M_r [1 - 0.009 (T_1 - 27)]$$

Where M_c = Corrected discharge time corrected to 80°F (or 27°C)

M_r = Recorded discharge time

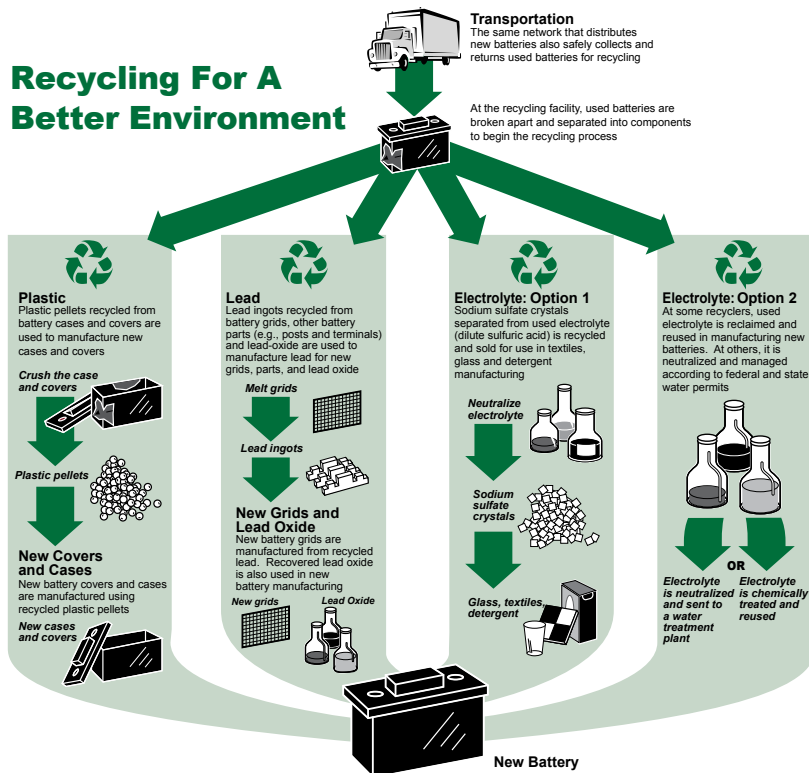
T_1 = Battery temperature at end of discharge (°F or °C)

- If the corrected discharge time is greater than 50% of the batteries' rated capacity at that discharge rate, then battery performance is considered acceptable.
- Restart the discharger to record the individual battery voltages while still under load (current being drawn).
- If the discharge runtime is less than 50% of the batteries' rated capacity, the battery with a voltage that is 0.5V lower than the highest voltage may be a failed battery.
 - o There are other methods of testing batteries including internal resistance (i.e. C.C.A. testers) and carbon pile discharge testers. However, these are not suitable testing methods for deep-cycle batteries.

*These formulas are only valid for battery temperatures between 75°F (24°C) and 90°F (32°C).

10 BATTERY RECYCLING

Lead acid batteries are the environmental success story of our time. Per the International Lead Association, in Europe and the USA, 99% of all battery lead is recycled. In fact, lead acid batteries top the list as the most highly recycled consumer products.



Graphics provided by Battery Council International

11 BATTERY ABBREVIATIONS

A	Ampere	EUTR	Embedded Universal Terminal Reverse
Ah	Ampere-hour	°F	Degrees Fahrenheit
AWG	American Wire Gauge	M_c	Minutes Corrected
°C	Degrees Celsius	M_r	Minutes Recorded
C.C.A.	Cold Cranking Amps	SOC	State of Charge
DD	Depth of Discharge	T	Temperature
ELPT	Embedded Low Profile Terminal	V	Volt

Notes

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PACER[®]

FLOODED DEEP CYCLE



RELIABLE POWER. GREAT VALUE



Manufactured with Quality System
Certified by Pacer Battery Company

Designed in compliance with applicable BCI standards.
Tested in compliance to BCI standards.



 **Made in USA**
of U.S. and imported parts

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