LONGER LIFE. LOWER COST.

HB

BATTERY CARE & MAINTENANCE GUIDE

HARRIS
BATTERY COMPANY

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We attempt to ensure the correctness of the product descriptions and specifications contained herein. We reserve the right to change designs and specifications without notice or obligation.

It is the responsibility of the reader of this information to verify any and all information presented herein.

Do not mix battery disposal with other industrial or household waste.

Batteries with this symbol can be recycled. Contact your Harris Battery representative for proper battery return and recycling.

Do not expose batteries to flames or sparks as it may cause an explosion. No Smoking when working around batteries.

Risk of explosion and fire. Battery terminals and connector are always under voltage. Do not place tools or other metal objects on the battery. Avoid short circuits.

Keep away from children.

Electrolyte is highly corrosive. Always wear protective gear and avoid spills.

Read instructions carefully and place them close to the battery.

Use protective glasses, gloves and clothing when working on batteries. Always make safe working practices a priority.

Batteries and cells are heavy. Ensure secure installation. Use only suitable handling equipment and lifting gear.

EXPLODING BATTERY DANGERS

Starting, Lighting and Ignition batteries contain sulfuric acid and produce explosive mixtures of hydrogen and oxygen. Because self-discharge action generates hydrogen gas even when the battery is not in operation, make sure batteries are stored and worked on in a well ventilated area. ALWAYS wear ANSI Z87.1 (U.S. standard) approved safety glasses and face shield or splash proof goggles when working on or near batteries:

- Always wear proper eye, face and hand protection.
- Keep all sparks, flames and cigarettes away from the battery.
- Never try to open a battery with nonremovable vents.
- Keep removable vents tight and level except when servicing electrolyte.
- Make sure work area is well ventilated.
- Never lean over battery while boosting, testing or charging.
- Exercise caution when working with metallic tools or conductors to prevent short circuits and sparks.
- Always read and follow all precautionary labels on the product.

HANDLING BATTERY ACID

Battery acid, or electrolyte, is a solution of sulfuric acid and water that can destroy clothing and burn the skin. Use extreme caution when handling electrolyte and keep an acid neutralizing solution—such as baking soda or household ammonia mixed with water—readily available. When handling battery acid:

- **Always wear proper eye, face and hand protection.**
- If the electrolyte is splashed into an eye, immediately force the eye open and flood it with clean, cool water for at least 15 minutes. Get prompt medical attention.
- If electrolyte is taken internally, drink large quantities of water or milk. **DO NOT** induce vomiting. Call a physician immediately.
- Neutralize with baking soda any electrolyte that spills on a vehicle or in the work area. After neutralizing, rinse contaminated area clean with water.

To prepare electrolyte of a desired specific gravity, always pour the concentrated acid slowly into the water; **DO NOT** pour water into the acid. Always stir the water while adding small amounts of acid. If noticeable heat develops, allow the solution to cool before continuing to add acid.

CHARGING

SAFE CHARGING

Never attempt to charge a battery without first reviewing the instructions for the charger being used. In addition to the charger manufacturer's instructions, these general precautions should be followed:

- Always wear proper eye, face and hand protection.
- Always charge batteries in a well-ventilated area.
- Keep vents tight and level.
- Turn the charger and timer "OFF" before connecting the leads to the battery to avoid dangerous sparks.
- Never try to charge a visibly damaged or frozen battery.
- Connect the charger leads to the battery; red positive (+) lead to the positive (+) terminal and black negative (-) lead to the negative (-) terminal. If the battery is still in the vehicle, connect the negative lead to the engine block to serve as a ground. Be sure the ignition and all electrical accessories are turned off. (If the vehicle has a positive ground, connect the positive lead to the engine block.)
- Make sure that the charger leads to the battery are not broken, frayed or loose.
- Set the timer, turn the charger on and slowly increase the charging rate until the desired ampere value is reached.
- If the battery becomes hot, or if violent gassing or spewing of electrolyte occurs, reduce the charging rate or turn off the charger temporarily.
- Always turn the charger "OFF" before removing charger leads from the battery to avoid dangerous sparks.
- Always read and follow all precautionary labels on the product.

REMEMBER!

Always wear safety glasses and face shield or splashproof goggles when working on or near batteries.

SAFETY FIRST.

DETERMINING THE STATE OF CHARGE

The state of charge of a lead acid battery is determined by its weight compared to water, or specific gravity of the electrolyte. This is measured with a hydrometer or determined by stabilized voltage. Refer to the chart below for state-of-charge levels.

USING A HYDROMETER

A hydrometer is a float-type device used to determine the state of charge of a battery by measuring the specific gravity of the electrolyte (i.e. the concentration of sulfuric acid in the electrolyte). The hydrometer will extract electrolyte from the cell. A glass float in the barrel is calibrated to read in terms of specific gravity. The lower the float sinks in the electrolyte, the lower its specific gravity. The correct method for reading a hydrometer:

- Hold the barrel vertically so the float is not rubbing against the side of it.
- Draw an amount of acid into the barrel so that with the bulb fully expended, the float will be lifted free, touching neither the side, top or bottom stopper of the barrel.
- You should be eye-level with the surface of the liquid in the hydrometer barrel.
- Keep the float clean, checking it often to be sure it is not cracked.

STATE OF CHARGE	SPECIFIC GRAVITY	12V	6V
100%	1.265	12.65	6.32
75%	1.225	12.45	6.21
50%	1.190	12.24	6.12
25%	1.155	12.06	6.02
DISCHARGED	1.120	11.89	5.93

** This table assumes a fully charged specific gravity of 1.265 at 80˚F (26.7˚C)*

BATTERY CHARGING GUIDE

6-Volt and 12-Volt Batteries – Recommended rate and time for fully discharged condition ("at discharged")

Rated Battery Capacity (Reserve Minutes)	Slow charge (Overnight, 10-16 hours)	Fast Charge
80 minutes or less	15 hours @ 3 ampere	2.5 hours @ 20 amperes OR 1.5 hours @ 30 amperes
Above 81 to 125 minutes	21 hours @ 4 ampere	3.75 hours @ 20 amperes OR 1.5 hours @ 50 amperes
Above 126 to 170 minutes	15 hours @ 3 ampere	2.5 hours @ 20 amperes OR 1.5 hours @ 30 amperes
Above 171 to 250 minutes	23 hours @ 6 ampere	7.5 hours @ 20 amperes OR 3 hours @ 50 amperes
Above 250 minutes	24 hours @ 10 ampere	6 hours @ 40 amperes OR 4 hours @ 60 amperes

BATTERY CHARGING

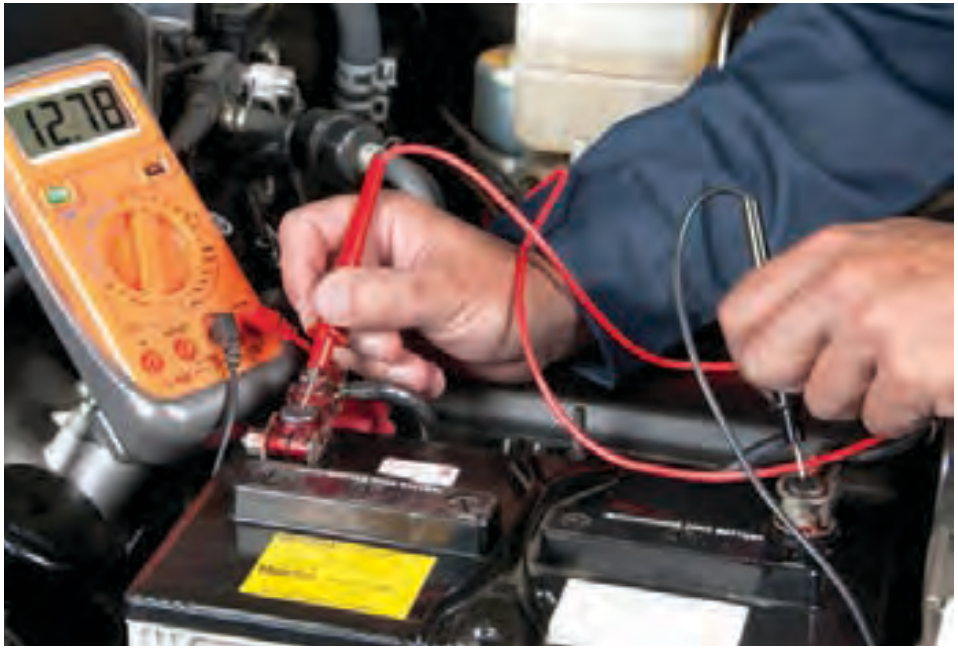
A discharged battery can be recharged. Follow the charging guides of the battery charger if available. If they are not available, use the rates shown in the “Battery Charging Guide” above.

Observe the following safety rules before beginning:

- Wear safety goggles or glasses when charging a battery.
- Keep flames or sparks away from the battery.
- Identify the polarity of the battery to be recharged.
- Clean the battery terminals.
- Unplug or turn off the charger before attaching or removing clamp connectors.
- Carefully attach the positive (+) (usually red in color) charger clamp to the positive terminal of the battery and negative (-) (usually black in color) charger clamp to the negative terminal of the battery.
- When applicable keep the safety vent caps firmly in place.
- Ventilate the area where the battery is to be charged.
- Do not charge a frozen battery. Allow the battery to come to 60° F (15.5°C) before placing it on charge.
- Do not charge a dried out battery. When applicable, refill the battery with distilled water before charging.
- When charging a battery in a vehicle, be sure that the vehicle’s electrical system has protection against over-voltage or be sure that the charger will not have high charging voltages which may damage the vehicle’s electrical system.

If a battery is to be recharged overnight (10-16 hours), refer to the specified slow charge rate. Lower rates must be used if a battery problem is suspected.

Don’t overcharge sealed batteries, as this increases water loss. The “Battery Charging Guide” (previous page) tells you approximately how much recharge a fully discharged battery requires. Or follow the below steps:



- Determine the state-of-charge of the battery with a hydrometer or voltmeter. An excess of electrolyte will result in a higher specific gravity reading than normal when the battery is discharged. Lower than normal specific gravity readings will be obtained if the battery is “acid starved.”
- When recharging a discharged battery, it is recommended that the battery receive 20% more charge than the exact charge it requires.
- Measure the specific gravity of a cell once per hour to ensure it is properly charged. The battery is assumed to be fully charged when there is less than 0.003 change in specific gravity occurs over a three-hour period.
- When any battery is being charged, periodically measure the temperature of the electrolyte. If the temperature exceeds 125°F (51.6°C), or if violent gassing or spewing of electrolyte occurs, reduce the charging rate or stop charging to avoid damaging the battery.

Battery testing should be performed periodically, whether or not a starting problem has occurred. Use the following methods to test your battery:

TESTING WITH ADJUSTABLE LOAD TESTER/HYDROMETER

VISUAL INSPECTION

- Visually inspect the battery for container, cover or terminal damage. If any damage found, replace the battery.
- Check the electrolyte level in each cell. If the level is below the top of the plates in any cell, top off with water just above the top of the separators and charge for 15 minutes at 15-25 amps.

HYDROMETER TEST

- Measure the specific gravity in each cell with a hydrometer. Refer the figure instead of figure X in the “Charging” section to determine the state-of-charge and whether the battery needs to be charged. If you cannot achieve a specific gravity of 1.225 or greater by charging, replace the battery.

ADJUSTABLE LOAD TEST

- Disconnect the battery cables, ground cable first.
- Measure the temperature of a center cell. If the instrument has an integral temperature compensator, use the attached probe. Cover battery with a damp cloth.
- Connect the voltmeter and load test leads to the appropriate battery terminals. Be sure the terminals are free of corrosion.
- Connect the current transducer (if necessary) to the appropriate lead.
- Apply a test load equivalent to 50% of the Cold Cranking Performance at 0˚F (-17.8˚C) rating of the battery for 15 seconds.
- Read and record the voltage at 15 seconds; remove the load.
- Refer to the Voltage Chart on this page to determine the minimum passing voltage based on the battery’s test temperature.
- If test voltage is above the minimum, return the battery to service.
- If test voltage is below the minimum, replace the battery.

VOLTAGE CHART

Estimated Electrolyte Temperature	Minimum required voltage under load @ 15 seconds (Use 1/2 these values for 6V batteries.)
70˚F (21˚C)	+ 9.6
60˚F (16˚C)	9.5
50˚F (10˚C)	9.4
40˚F (4˚C)	9.3
30˚F (-1˚C)	9.1
20˚F (-7˚C)	8.9
10˚F (-12˚C)	8.7
0˚F (-17.8˚C)	8.5

TESTING WITH FIXED LOAD TESTER/OPEN CIRCUIT VOLTMETER

VISUAL INSPECTION

- Visually inspect the battery for container, cover or terminal damage. If found, replace the battery.
- Check the electrolyte level in each cell. If the level is below the top of the plates in any cell, top off with water just above the top of the separators and charge for 15 minutes at 15-25 amps.

FIXED LOAD TEST

- Disconnect the battery cables, ground cable first.
- Measure the temperature of a center cell and set the temperature dial on the tester to the proper setting. If the tester has a temperature probe, place it in a center cell.
- If present, set the battery size selector to the range appropriate to the CCA of the battery being tested. Read the scale on the meter appropriate to the CCA of the battery being tested.
- Connect the voltmeter and load test leads to the appropriate battery terminals. Be sure the terminals are corrosion-free.
- Apply the test load for 15 seconds.
- Read and record the battery performance from the instrument meter at 15 seconds; remove the load.
- If the battery passed the load test, it can be returned to service.
- If the battery failed the load test, conduct Open Circuit Voltage Test.

OPEN CIRCUIT VOLTAGE TEST

Use this test to determine state-of-charge if a hydrometer is not available.

- Allow at least 10 minutes after the load test for the voltage to stabilize.
- Determine the approximate state of charge from the chart at right (battery temperature 60-100˚F).
- The change in voltage is small and must be measured using a digital meter or an analog meter with an expanded scale.
- If the state of charge is 75% or greater, and the battery failed the load test, it should be replaced.
- If the state of charge is less than 75%, the battery should be charged at the recommended rate and time shown in the “Battery Charging Guide” and the load test repeated. If it passes, return to service. If it fails the load test again, replace it.

VOLTAGE CHART

Open Circuit Volts	Percent Charge
12.6 or greater	100%
12.4-12.6	75-100%
12.2-12.4	50-75%
12.0-12.2	25-50%
11.7-12.0	0-25%
11.7 or less	0%

**Table assumes a fully charged specific gravity of 1.265.*

BATTERY STOCK MAINTENANCE

A responsible service person should be given the responsibility of the designated battery storage area and inventory maintenance. Duties, and the appropriate safety procedures, should be clearly explained. The proper tools and equipment should be provided and an understanding of their use should be required.

Equipment should include a slow charger, a fast charger, battery connectors, hydrometers, and thermometers. A carrying strap, terminal cleaner, water filler and a supply of baking soda for the neutralization of acid, should also be available.

The battery room, or area, should be equipped with an adequate exhaust fan. Safety equipment such as eye protection, rubber gloves, safety shoes, acid proof clothing, etc., should be provided. An eye-wash sink should also be available in case of emergencies. All batteries should be stored in a cool, dry place in an upright position.

STOCK ROTATION

Product stock must be rotated on a strict, first-in, first-out basis. Date codes are stamped on batteries and on the shipping pallet to accomplish this important rotation rule. The main cause for selling a dated, discharged replacement battery, is failure to follow the “first-in, first-out” rotation rule.

STORAGE TIPS

Roller racks are best for storing and ensuring proper battery rotation. If roller racks are not available, wooden shelving can be used. Never pile batteries on top of one another unless they are in cartons. Only stack batteries three-high, or two-high if they are heavy commercial batteries. Check the state of charge of stored batteries every 30 days. If a wet battery becomes severely discharged, the electrolyte can freeze if it is stored below 20°F (-7°C). A battery that is at 75% state of charge or greater is in no danger of freezing. It is best to maintain 75% of charge at all times. Refer to the State of Charge chart in the “Battery Charging” section.

SELF-DISCHARGE

All flooded lead acid wet batteries will slowly lose charge when not in service, called self-discharge.

Standard maintenance free batteries containing certain grid alloys, self-discharge at a lower rate than deep cycling batteries. The rate of self-discharge increases with increasing temperature; this is true for both maintenance free and deep cycle batteries. Allowing batteries to stand for an extended period of time without recharging them, will result in reduced performance and service life. To preserve optimum battery performance and life, recharge batteries in storage when the open circuit voltage drops to 12.4 volts.

BOOSTING CHARGE

To make up for self-discharge while in stock, a boosting charge should be given to batteries whenever they fall .040 points in specific gravity, corrected to 80°F (26.7°C). The boosting charge should be administered regardless if the batteries are to remain in stock or are being prepared for sale. This boost charge will normally be required after about 15-40 weeks of storage at 30°F (-1.12°C). The specific gravity drop will occur faster at elevated temperatures and slower at reduced temperatures. Observe the level of electrolyte before putting a battery on charge, and if necessary, add water to the cells to bring them to proper level.

A charge rate of 3% of the Reserve Capacity rate should be used to charge the battery. The charging should continue until the specific gravity of the electrolyte, corrected to 80°F

STORAGE

(26.7°C), is constant over three successive readings taken at one hour intervals.

Some batteries may be sealed in a way that does not allow the specific gravity to be checked. The charging rate for these batteries is also 3% of the Reserve Capacity rate. The length of charge should be one half of the Slow Charge time on the Battery Charging Guide. For example, a battery rated at 100 minutes of Reserve Capacity and reading 12.4 volts should be charged at 3 amps for 10 hours.

Storing batteries for long periods of time without recharging them may accelerate grid corrosion and form boundary layers of non-conductive material between the grid wires and the active materials. This can result in a loss in capacity and early battery failure.

DRY CHARGED BATTERIES

Dry charged batteries contain no electrolyte until activated for service. These batteries should be stored in a cool, dry place. The ambient temperature should be as uniform as possible. Large temperature fluctuations will cause air to enter batteries as they cool (even though they are sealed) and expel air as they become warm. It is very important to rotate the stock on a “first-in, first-out” basis. The length of time these batteries can be stored depends upon the original processing of the plates and separators, the exposure to temperature variations, and the humidity conditions during storage. Under adverse conditions, batteries may lose their charge in a few months; under ideal conditions, the charge retention may last for a few years.

The main advantage of dry charged batteries is that they can be stored for long periods of time without permanent damage. They do not experience appreciable deterioration such as sulfation or corrosion while in storage. This is not true for a wet battery.

INSTALLATION

PREPARATION OF WET BATTERIES

All batteries should be fully charged before installation. Be sure the specific gravity is at least 1.250 or higher and that battery voltage is at least 2.1 volts per cell.

REMOVING OLD BATTERY

Check the owner’s manual for specific instructions.

- Locate the positive battery terminal and mark the polarity on the positive cable before removing the battery.
- Remove the “ground” cable connector first.
- Use the proper size box, or open end wrench, when removing cables.
- Inspect the battery tray for possible damage or corrosion. Corroded parts may be cleaned with water (with added household ammonia or baking soda) and scrubbed with a stuff brush. Cleaned parts should be dried and painted. Do NOT paint battery terminals.
- Examine the cables to be sure they are correct size, that insulation is intact and that the terminal connectors and bolts are not corroded.

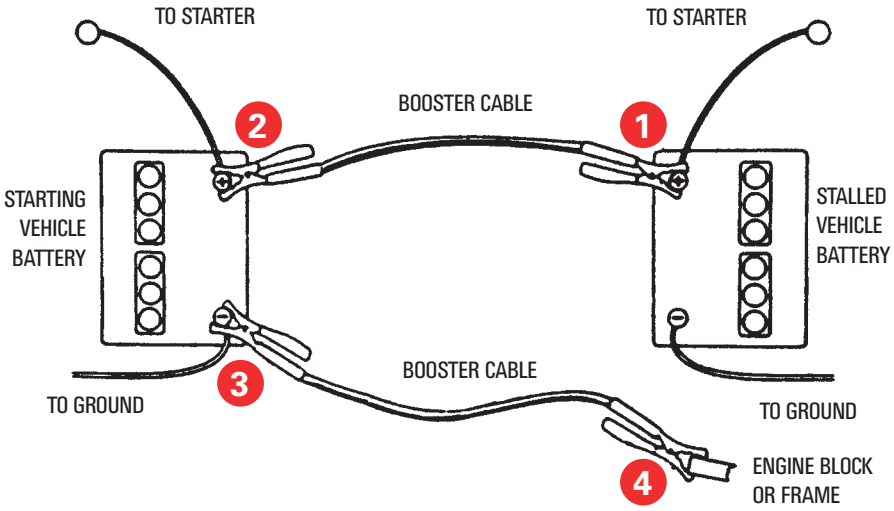
AVERAGE CABLE SIZES

No. 6: Passenger cars/light trucks/vans with 12V systems
No. 4: Larger engines (400 CID+), or specified by manufacturer
No. 1: Passenger cars/light vehicles with 6V systems
No. 0: Systems with large engines

INSTALLATION

Check the owner’s manual for specific instructions.

- Remove any foreign objects from the tray and insert the battery, making sure it rests level.
- Tighten the holddown until it is snug, but not too tight that it cracks the battery cover/case.
- Clean cable terminals before connecting. Connect the positive (+) cable first and the “ground” cable last.
- Apply a thin coating of high-temperature grease or petroleum jelly on the posts and cable clamps to prevent corrosion.



SAFE BOOSTER CABLE OPERATION

A battery that's discharged — from leaving your headlights on or from a damaged alternator — can be recharged to its full capacity. But a battery that's at the end of its service life can't be recharged enough to restore it to a useful power level.

If the battery is discharged, not dead, you can jump-start it from another fully charged battery. About 30 minutes of driving should allow the alternator to charge your battery until you take it to a service station for a full charge. If the alternator or another part of the electrical system in your car is damaged, they won't be able to recharge your battery. So if your battery keeps discharging, before you replace it, have your electrical system checked.

What looks like a bad battery could be an electrical system problem. If you have a bad component in the electrical system, it will keep draining a new battery, and you'll be stranded again and again.

The following are tips for safe booster cable operation:

- When jump-starting a vehicle, **always wear proper eye protection** and never lean over the battery.
- Inspect both batteries before connecting booster cables. Do not jump start a damaged battery.
- Be sure vent caps are tight and level.
- Make certain that the vehicles are not touching and both ignition switches are turned to the OFF position.
- Refer to the vehicle owners' manual for other specific information.

To jump-start the battery see corresponding diagram:

1. Connect positive (+) booster cable to positive (+) terminal of discharged battery.
2. Connect other end of positive (+) cable to positive (+) terminal of assisting battery.
3. Connect negative (-) cable to negative (-) terminal of assisting battery.
4. Make final connection of negative (-) cable to engine block of stalled vehicle, away from battery and carburetor.
5. Start vehicle and remove cables in REVERSE order of connections.

SIZING AND INSTALLATION

DETERMINE BATTERY CAPACITY

- Battery type and battery size strongly affect the performance of your inverter. First identify the type of loads your inverter will be powering and how much you will be using them between charges. Once you know how much battery capacity you will be using, you can determine how much battery capacity you will need. AT 50% DOD.
- The more deeply the battery is discharged on each cycle, the shorter the battery life will remain. Therefore, using more batteries than the minimum will result in longer life for the battery bank.
- Keep in mind that batteries lose capacity as the ambient temperature lowers. If the air temperature near the battery bank is lower than 77°F (25°C), more batteries will be needed to maintain the required capacity.

FORMULAS AND ESTIMATIONS

- Watts = Volts x Amps
- Battery capacity is expressed by how many Amps for how many hours a battery will last - Amp-Hour (AH.) capacity.
- For a 12-Volt inverter system, each 100 Watts of the inverter load requires approximately 10 DC Amps from the battery.
- For a 24-Volt inverter system, each 200 Watts of the inverter load requires approximately 10 DC Amps from the battery.
- The first step is to estimate the total Watts (or Amps) of load, and how long the load needs to operate. This can be determined by looking at the input electrical nameplate for each appliance or piece of equipment and adding up and adding up the total requirement. Some loads are not constant, so estimations must be made. For example, a full-sized refrigerator (750-Watt compressor), running 1/3 of the time would be estimated at 250 Watts-per-hour.
- After the load and running time is established, the battery bank size can be calculated. The first calculation is to divide the load (in Watts) by 10 for a 12-Volt system or by 20 for a 24-Volt system resulting in the number of Amps required from the battery bank.

INSTALLATION & CABLING GUIDELINES

- Do not install the inverter in the same compartment as batteries or in any compartment used for storage of flammable liquids like gasoline. Off-gassing of batteries can cause damage to the Inverter, and risk of explosion.
- Do not use excessive DC cable lengths as they increase wire resistance and reduce input power.
- Ensure that each cable between the Inverter and the battery(s) is no longer than 6 feet.
- Have all wires and cables terminated with correct and appropriately sized connectors.
- Do not use aluminum. It has about 1/3 more resistance than copper of the same size and is difficult to make good low-resistance connections.

VOLTAGE DROP PER FOOT OF DC CABLE

	INVERTER OUTPUT(W):	600	1000	1500	3000
	Current(A):	60	100	150	300
WIRE SIZE (AWG)	RESISTANCE (ohms/ft)@ 77°F	**VOLTAGE DROP Per FOOT:**			
4	0.000253	0.0152	0.0253	0.0380	0.0759
3	0.000201	0.0121	0.0201	0.0302	0.0603
2	0.000159	0.0096	0.0159	0.0239	0.0477
1	0.000126	0.0076	0.0126	0.0189	0.0378
0	0.000100	0.0060	0.0100	0.0150	0.0300
2/0	0.000079	0.0048	0.0079	0.0119	0.0237
3/0	0.000063	0.0038	0.0063	0.0095	0.0189
4/0	0.000050	0.0030	0.0050	0.0075	0.0150

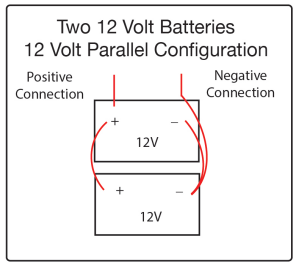
NOTE* Voltage drop per foot = Current Value X Resistance Value

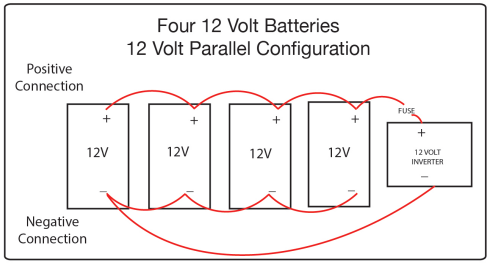
FUSING/CIRCUIT BREAKERS

To properly protect your electronics you are required to install DC -rated fused that can safely withstand the short-circuit batteries can produce.

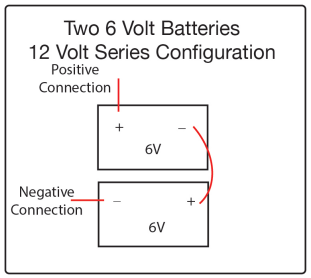
- Determine the total cold cranking amp rating for your battery(s). The cold cranking amp rating of each battery is normally displayed on the label. If not, contact the battery manufacturer to find out.
- If you are using one battery to power your inverter and its rating is 500, the total cold cranking amp rating is 500. If you are powering your inverter with two batteries in parallel, an each has a rating of 500, the total cold cranking amp rating is 1000.
- CCA : The cold cranking rating refers to the number of amperes a lead-acid battery at 0°F can deliver for 30 seconds, while maintaining at least 7.2 Volts (1.2 VPC)

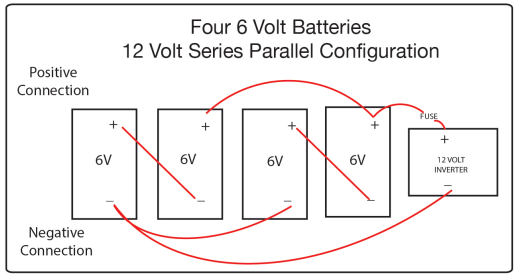
PARALLEL BATTERY CONFIGURATIONS





SERIES BATTERY CONFIGURATIONS





PERFORMANCE TIP

- Always keep your house batteries fully charged when not in use, and ensure that maximum Depth of Discharge is not exceeded on your house bank.

HARRIS
BATTERY COMPANY

OHIO	5425 Warner Rd, Valley View, OH 44125
PENNSYLVANIA	604 Drum Ave, Somerset, PA 15501
	701 Ashland Ave, Folcroft, PA 19032
MICHIGAN	17612 Commerce St, New Boston, MI 48164
CALIFORNIA	2030 Lynx Place, Ontario, CA 91761

POWERFUL ANSWERS®

1.800.367.7670

Corporate Headquarters
10708 Industrial Parkway NW
Bolivar Ohio 44612

HARRISBATTERY.COM