

BATTERY SERVICE



This Automotive Series
BATTERY SERVICE
has been developed by

Kevin R. Sullivan

Professor of
Automotive Technology
Skyline College

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BATTERY SERVICE

Battery services are routinely performed. These services include:

- 1. Testing**
- 2. Charging**
- 3. Cleaning**
- 4. Jumping a dead battery.**
- 5. Adding water.**



BATTERY TESTING

Battery testing has changed in recent years; although the three areas are basically the same, the equipment has improved.

1. Visual Inspection

2. State of Charge

- a. Specific Gravity
- b. Open Circuit Voltage

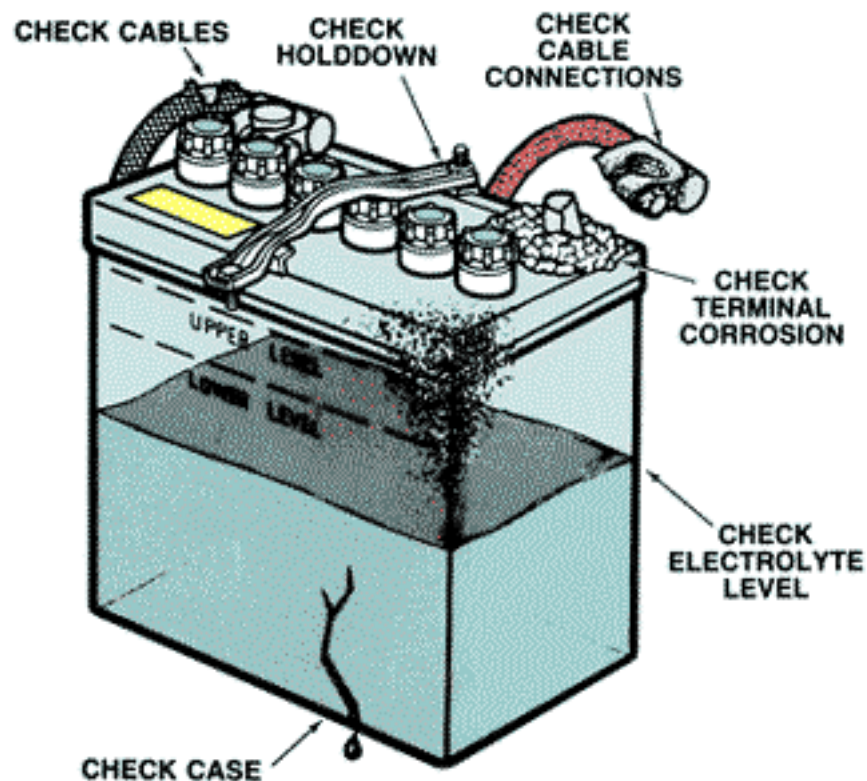
3. Capacity or Heavy Load Test

Note: This does not include the Midtronics battery tester which has a different test procedure and will be discussed later in this module.

VISUAL INSPECTION

Battery service should begin with a thorough visual inspection. This inspection may reveal simple, easily corrected problems.

- 1 . Check for cracks in the battery case and broken terminals. Either may allow electrolyte leakage, which requires battery replacement.
2. Check for cracked or broken cables or connections. Replace, as needed.
3. Check for corrosion on terminals and dirt or acid on the case top. Clean the terminals and case top with a mixture of water and baking soda. A battery wire brush tool is needed for heavy corrosion on the terminals.
4. Check for a loose battery hold-down or loose cable connections. Clean and tighten, as needed.



VISUAL INSPECTION CONTINUED

5. Check the electrolyte fluid level. The level can be viewed through the translucent plastic case or by removing the vent caps and looking directly into each cell. The proper level is 1/2" above the separators (about 1/8" below the fill ring shown below). Add distilled water if necessary. Do not overfill.

6. Check for cloudy or discolored electrolyte caused by overcharging or vibration. This could cause high self discharge. Correct the cause and replace the battery.



STATE OF CHARGE

The state of charge of a battery can be easily check in one of two ways:

Specific Gravity Test

Open Circuit Voltage Test

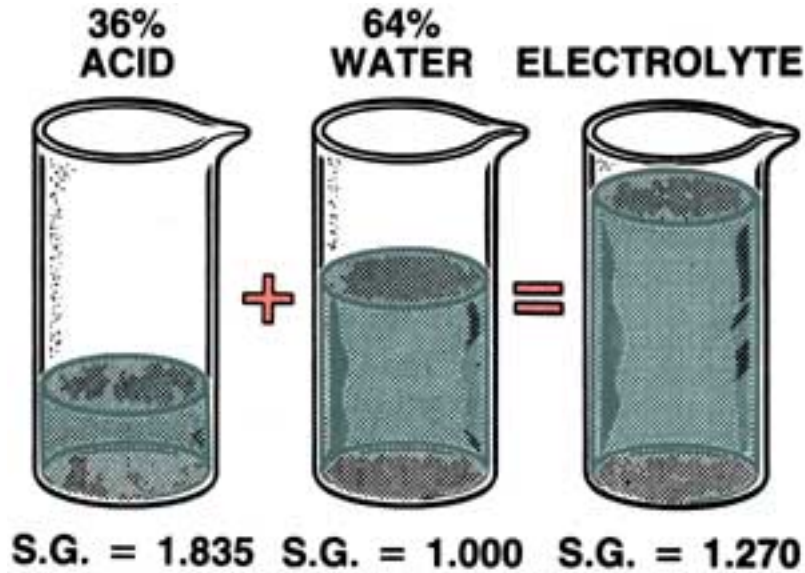
Note:

1: A state of charge test is required to determine if there is sufficient charge in the battery to properly perform a capacity test (explained later).

2: The only exception to this is the MIDTRONICS Battery Tester. This new state of the art capacitance tester will be discussed later in this module.

SPECIFIC GRAVITY

Specific gravity means exact weight. A "Hydrometer" or a "Refractometer" compares the exact weight of electrolyte with that of water. Strong electrolyte in a charged battery is heavier than weak electrolyte in a discharged battery. By weight, the electrolyte in a fully charged battery is about 36% acid and 64% water. The specific gravity of water is 1.000. The acid is 1.835 times heavier than water, so its specific gravity is 1.835. The electrolyte mixture of water and acid has a specific gravity of 1.270, usually stated as "twelve and seventy."



SPECIFIC GRAVITY READINGS

By measuring the specific gravity of the electrolyte, you can tell if the battery is fully charged, requires charging, or must be replaced. It can tell you if the battery is sufficiently charged for a capacity (heavy-load) test. The battery must be at least 75% charged to perform a heavy load test. (The heavy load test will be discussed later). In other words, each cell must have a specific gravity of 1.230 or higher to proceed.

CELL READINGS	PERCENT CHARGED
1.270	100 %
1.230	75%
1.190	50%
1.145	25%
1.100	0%

If the battery is less than 75% charged, it must be fully recharged before proceeding. If the battery is 75% or higher proceed to a heavy load test. A battery not sufficiently charged will fail because it is discharged.

SPECIFIC GRAVITY - EXCESSIVE CELL VARIATION READINGS

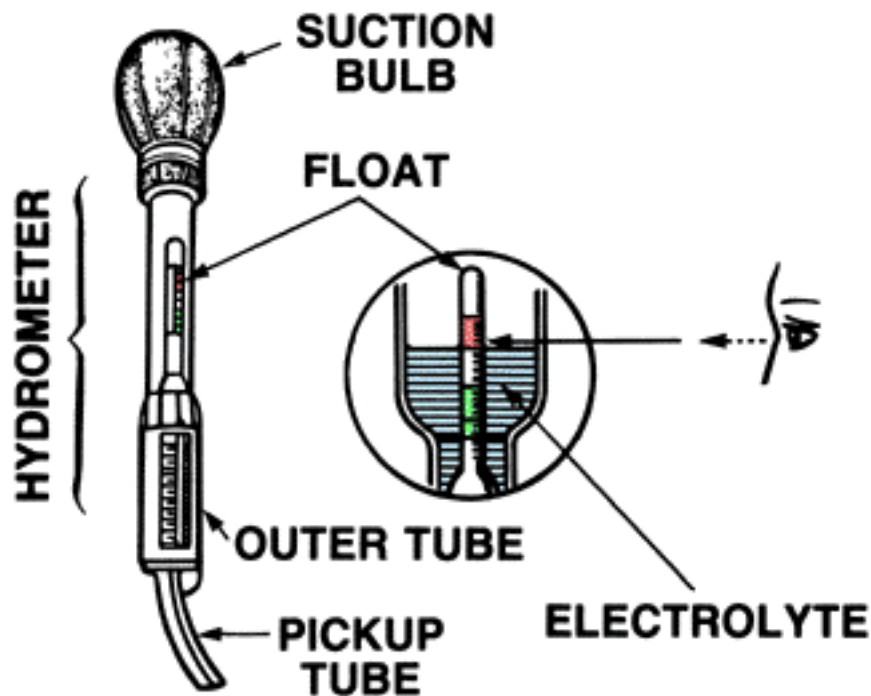
Variation in specific gravity among cells cannot vary more than 0.050. The variance is the difference between the lowest cell and the highest cell. A battery must be condemned for excessive cell variation if more that 0.050. In the example below, the highest SG reading is cell #1 (shown in green) while the lowest SG reading is cell #5 (shown in blue); the difference is 0.070 which requires battery replacement. Cell #5 if failing.

Cell #1	Cell #2	Cell #3	Cell #4	Cell #5	Cell #6
1.260	1.230	1.240	1.220	1.190	1.250

Many factors contribute to cell variation; for example, if water was just added to that cell, the cell is then diluted with water resulting is a lower specific gravity reading. Recharging the battery would correct this false reading. In some cases if a battery that has cell variation slightly over the specification and is only about 50% charge, charging the battery at a slow rate of charge (5A) may reduce the cell variation, thus saving the battery.

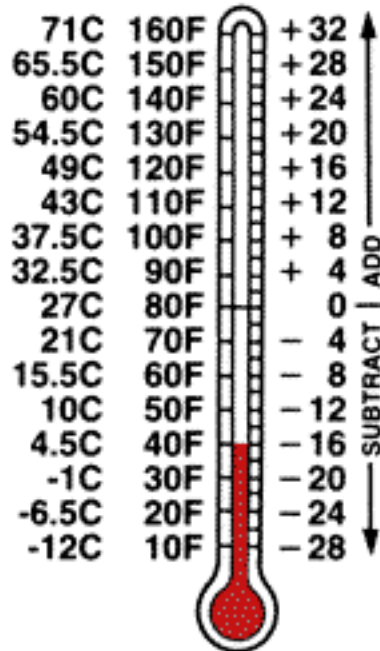
SPECIFIC GRAVITY TEST PROCEDURE (HYDROMETER)

1. Wear suitable eye protection.
2. Remove vent caps or covers from the battery cells.
3. Squeeze the hydrometer bulb and insert the pickup tube into the cell closest to the battery's positive (+) terminal.
4. Slowly release the bulb to draw in only enough electrolyte to cause the float to rise. Do not remove the tube from the cell.
5. Read the specific gravity indicated on the float. Be sure the float is drifting free, not in contact with the sides of top of the barrel. Bend down to read the hydrometer at eye level. Disregard the slight curvature of liquid on the float.
6. Record your readings and repeat the procedure for the remaining cells.



ADJUSTED SPECIFIC GRAVITY READINGS

Temperature correction is needed because specific gravity changes with temperature. Cold thickens the electrolyte and raises the specific gravity. Heat thins the electrolyte and lowers the specific gravity. Hydrometers are calibrated at 80°F (26.7°C). Electrolyte temperatures above or below 80°F must be adjusted. For every 10°F increment below 80°F, subtract 0.004 to the hydrometer readings, and for each 10°F increment above 80°F, add 0.004 to the readings. See the examples below.



EXAMPLE:

HYDROMETER READING.....	1.250
ELECTROLYTE TEMPERATURE.....	40F
SUBTRACT SPECIFIC GRAVITY.....	-.016
CORRECTED SPECIFIC GRAVITY IS....	1.234

EXAMPLE:

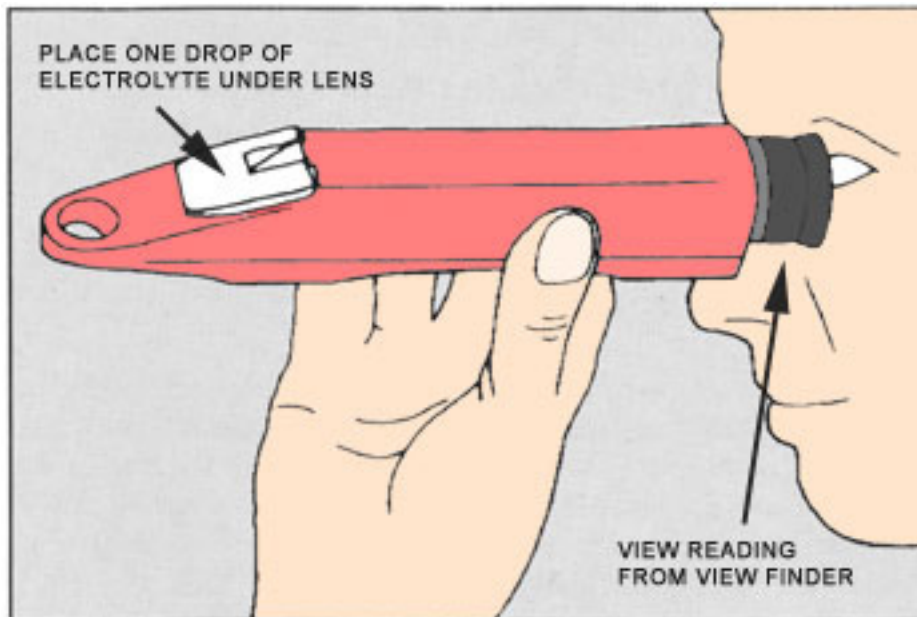
HYDROMETER READING.....	1.240
ELECTROLYTE TEMPERATURE.....	100F
ADD SPECIFIC GRAVITY.....	+.008
CORRECTED SPECIFIC GRAVITY IS....	1.248

A FULLY CHARGED BATTERY HAS A SPECIFIC GRAVITY OF ABOUT 1.265.

SPECIFIC GRAVITY TEST PROCEDURE (REFRACTOMETER)

A Refractometer optically measures the specific gravity. No temperature correction is needed.

1. Wear suitable eye protection.
2. Remove vent caps or covers from the battery cells.
3. Place one drop of electrolyte on the refractometer lens and close the prism.
4. Hold the refractometer up to the light and reading chart from view finder.
5. Record your readings and repeat the procedure for the remaining cells.



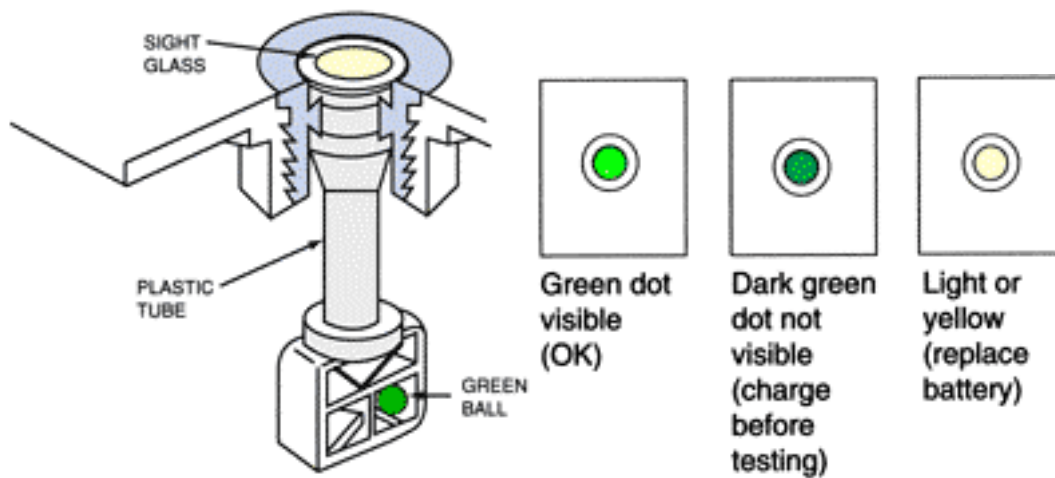
SPECIFIC GRAVITY TEST PROCEDURE (AC Delco Battery with built- in Hydrometer)

1. Wear suitable eye protection.
2. Observe the built-in hydrometer.

Green Dot is visible: the battery is sufficiently charged for further testing (Heavy Load Test).

Dark Green Dot is visible: the battery needs to be recharged before further testing.

Light or Yellow Dot is visible: replace the battery



OPEN CIRCUIT VOLTAGE

A digital voltmeter must be used to check the battery's open-circuit voltage. Analog meters are not accurate and cannot be used.

1. Turn on the headlamps' high beam for several minutes to remove any surface charge.
2. Turn headlamps off, and connect the digital voltmeter across the battery terminals.
3. Read the voltmeter. A fully charged battery will have an open-circuit voltage of 12.6 volts. On the other hand, a totally dead battery will have an open-circuit voltage of less than 12.0 volts.

Note: If the battery is 12.4v or higher, proceed to heavy load test. If the battery is less than 12.4v, the battery must be fully recharged before testing. **Be sure to remove the surface charge completely**; this is the number one mistake technicians make. If need be, place a load tester on the battery and load the battery for 10 seconds at approximately 200 amps. Allow a few minutes for the battery to recover then measure the open circuit voltage. This should remove the surface charge and allow an accurate open circuit voltage measurement. (Remember: a reading of 12.4 volts or higher load test the battery, 12.3 volts or less, recharge the battery.)

% of charge

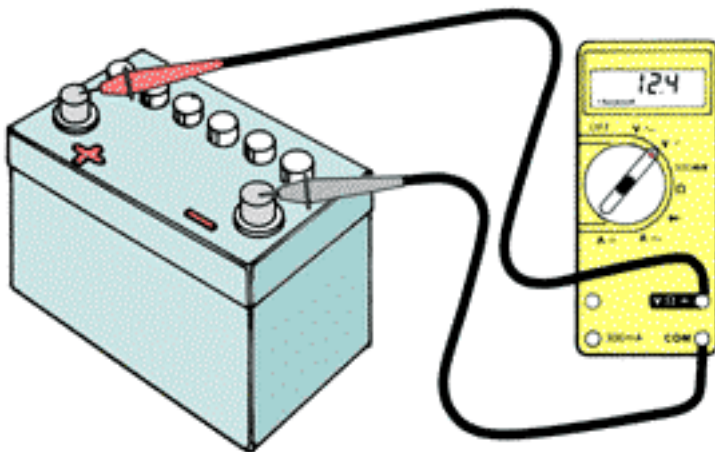
12.6v = 100%

12.4v = 75%

12.2v = 50%

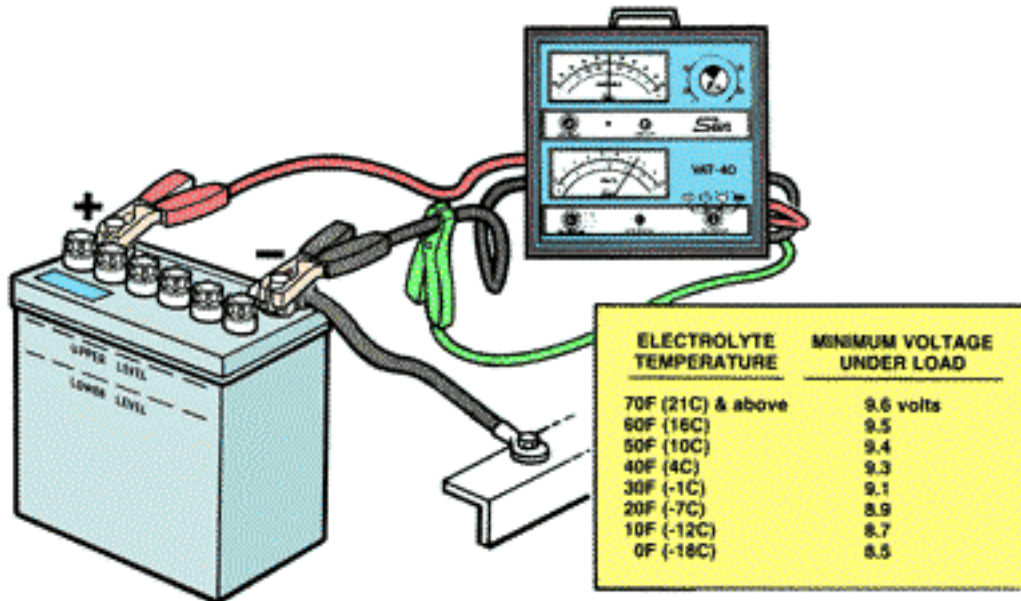
12.0v = 25%

11.9v = 0%



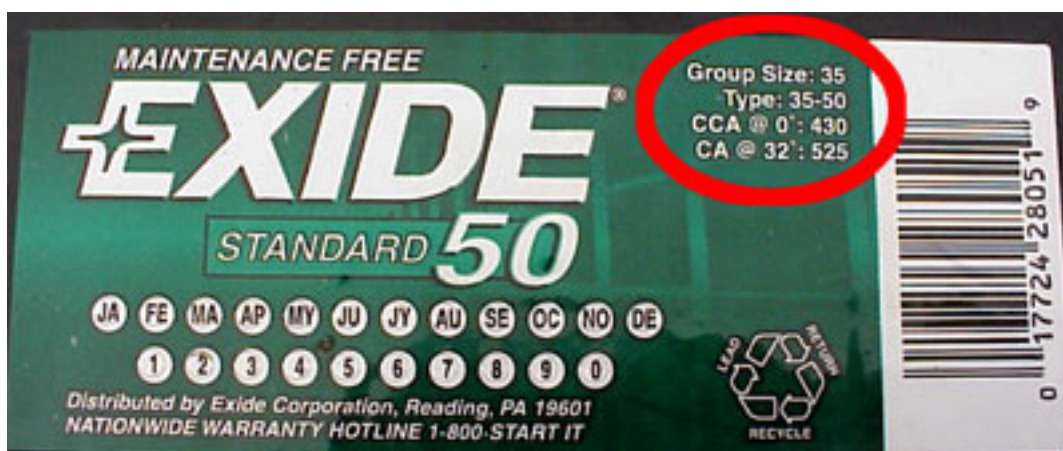
HEAVY LOAD TEST

While a State of Charge test determines the battery's state of charge, it does not measure the battery's ability to deliver adequate cranking power. A capacity, or heavy-load test measures the battery's ability to deliver current. A battery load tester such as a Sun VAT-40 is used. (Note: the battery must be at least 75% charged before a heavy test can be performed.)



DETERMINE CAPACITY RATING

The capacity rating is located on the battery label. Ratings can be expressed in CCA (Cold Cranking Amps), AH (Amp-Hour), or JIS (Japanese Industrial Standard.) JIS uses a six digit code (not shown). A conversion table is offered below that can be printed. If no rating is found on the battery, then use the OEM battery rating found in most repair manuals.



HEAVY LOAD TEST PROCEDURE

1. Install the load tester as shown in an earlier slide.
2. Load the battery by turning the Load Increase control until the ammeter reads 3 times the amp-hour (AH) rating or one-half the cold-cranking ampere (CCA) rating.
3. Maintain the load for no more than 15 seconds, and note the voltmeter reading.
4. If the voltmeter reading during the test is

9.6 volts or higher, the battery is good.

9.5 volts or below, the battery is defective and needs replacement.

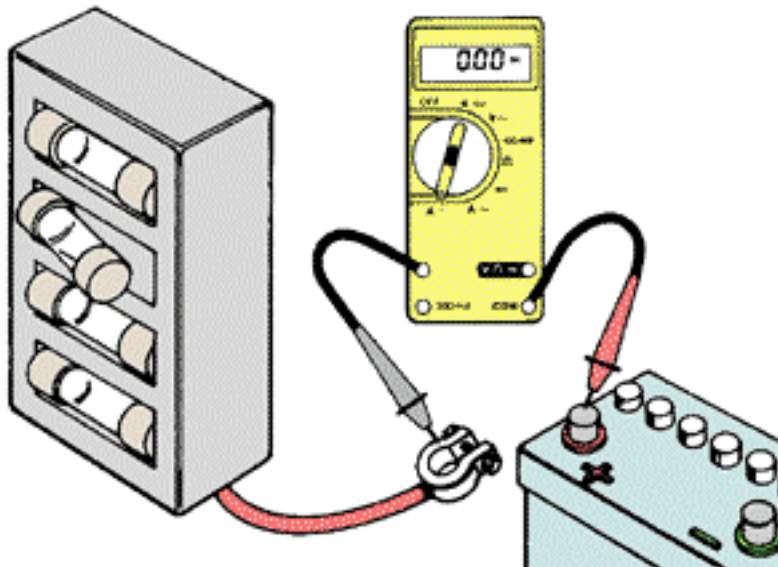
Note: Results will vary with temperature. Low temperatures will reduce the voltage reading, so the electrolyte should be at 70°F or above. If not, use the following conversion table:

Voltage	Temperature
9.6	70°F or above
9.5	60°F
9.4	50°F
9.3	40°F
9.1	30°F
8.9	20°F
8.7	10°F
8.5	0°F

CURRENT DRAINS

Parasitic drains are the small current drains required to operate various electrical systems, such as the clock, computer memory, or alarms, that continue to work when the car is parked and the ignition is off. All vehicles today have parasitic drains and over time will drain all batteries if not driven or charged periodically. The problem is when the parasitic drain becomes excessive, usually over 35 milliamps.

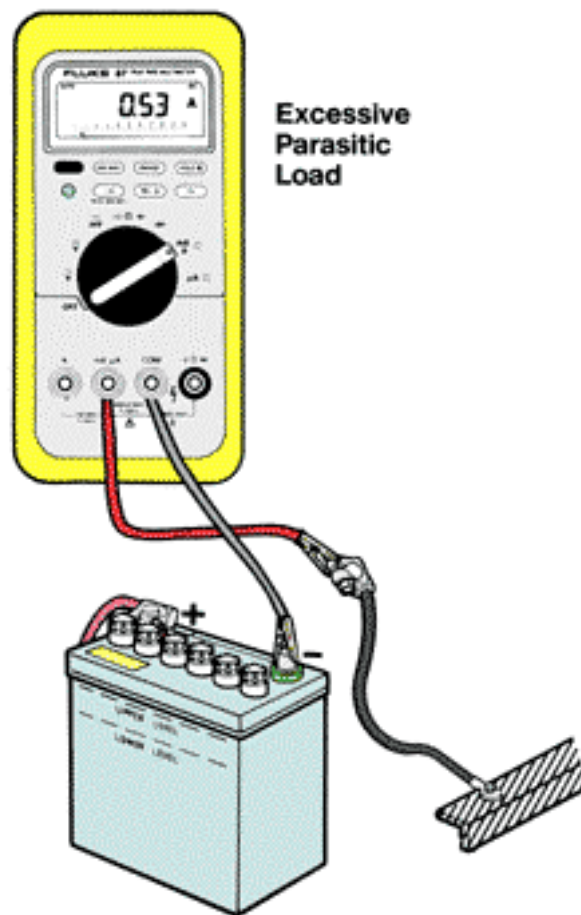
Unwanted battery drain can also be the reason why a battery keeps discharging. Unwanted battery drain can be a result of **excessive parasitic drain**, or if the top of the battery is wet or has excessive corrosion, it could create a path between the two battery posts, causing a current drain; usually 0.5 volt potential or higher will result in a battery discharge. This is called **Case Drain**.



PARASITIC DRAIN

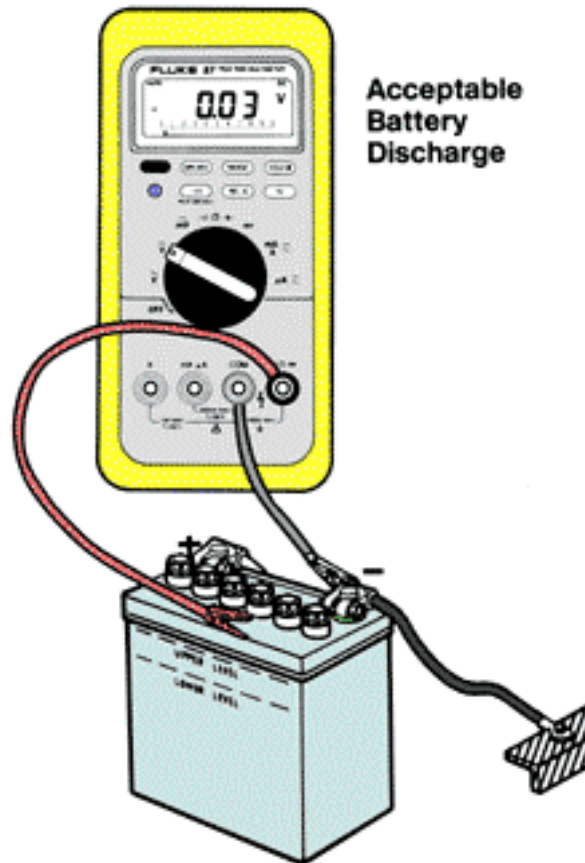
Check for excessive battery drain or parasitic loads using an ammeter. Make sure all electrical loads are off in the car, doors closed, and the key is out of the ignition switch . Disconnect one of the battery cables from the battery, placing an ammeter in series between the battery post and cable clamp. The current draw reading should be less than 35 milliamps. A reading higher than this (or manufacturer specifications) would indicate excessive battery drain. Something is "on", allowing current to flow running down the battery. Vehicles today typically will draw less than .020 amps (20 milliamps) of current to maintain electronic memories and circuits.

Note: If the battery is disconnected parasitic drains may temporarily increase. Circuits in the engine and body computers are activated and will run until internal timers run out. This reactivation period could be anywhere from a few seconds to almost 30 minutes. Whenever possible avoid disconnecting the battery while performing this test. It is possible to place one lead of the ammeter on the battery post and the other on the battery clamp, while at the same time lifting the battery clamp off the battery post. On side terminal batteries, connect the voltmeter with alligator clips and let sit until the timers run out.



BATTERY DISCHARGE / CASE DRAIN

Check for battery discharge (case drain) across the top of the battery using a digital voltmeter. Connect the negative (black) test lead to the battery's negative terminal post, and connect the positive (red) test lead to the top of the battery case. If the meter reads more than 0.5 volt, clean the case top using a solution of baking soda and water. Remove excess water from top of battery.



BATTERY CLAMP - POST RESISTANCE

Resistance between the battery terminal post and the clamp can account for the battery not being completely recharged and is often a problem. Although it may visually look all right, oxidation of the metal or slight corrosion can cause excessive resistance at the connection, thus creating a voltage drop and lowering current flow to the starter. Battery post and clamps should be cleaned at each battery inspection. To check for excessive resistance, perform a voltage drop between the battery terminal post and the clamp (shown below) while cranking the engine. The voltage drop reading should be 0.0 volts. Any voltmeter reading higher than "zero" volts requires cleaning the connection and rechecking.



MIDTRONICS BATTERY TESTER

Midtronics' test equipment is safe and simple to use while providing an accurate diagnosis in seconds. Midtronics battery testers are based on the measurement of battery conductance rather than a load test. Midtronics can even test a discharged battery to determine its condition. This tester is recommended by most automotive vehicle manufacturers. The 500 series model shown below not only can test the battery but the starting and charging systems as well.



MIDTRONICS OPERATION

Conductance is a measurement of the battery's ability to produce current. To measure conductance, the tester creates a small signal that is sent through the battery, then measures a portion of the AC current response. Conductance is a measure of the plate surface available in the battery which determines how much power the battery can supply. As a battery ages, the plate surface can sulfate or shed active material, which adversely affects its ability to perform. In addition, conductance can be used to detect cell defects, shorts, and open circuits, which will reduce the ability of the battery to deliver current.

MIDTRONICS BATTERY TEST PROCEDURE

1. Connect the tester to the battery.
2. Push a couple of buttons. (Enter information the unit requests, such as "in" or "out" of vehicle and rating method, such as CCA, CA, MCA, etc.
3. The automated test will take a few seconds giving accurate results.

Note: No load test is required and a state of charge test does not need to be done. No skill is required. Hook it up and go. Although the Midtronics is not 100% accurate, it have proven to be more reliable than human error.

BATTERY CHARGING

All battery chargers operate on the same principle: an electric current is applied to the battery to reverse the chemical action in the cells. Never connect or disconnect leads with the charger turned ON. Follow the battery charger manufacturer's instructions. DO NOT attempt to charge a battery with frozen electrolyte. When using a battery charger, always disconnect the battery ground cable first. This will minimize the possibility of damage to the alternator or electronic components in the vehicle. The battery can be considered fully charged when all cells are gassing freely and when there is no change in specific gravity readings for more than one hour.

A slow charge is 5 or 10 amps while a fast charge is generally 15 amps or higher. A slow charge is always preferred.

BATTERY CHARGER TYPES

Battery chargers are available in two classifications: Manual and Automatic.

Automatic chargers (typically the type consumers purchase) pulse and cycle the charge current and voltage rates. This automatic cycling rate protects the battery from damage and allows the charge rate to taper over time.

Manual chargers (shown below), also known as wheel chargers, are preferred by automotive professionals. These chargers do not cycle, but rather provide a constant non tapering charge. The constant charge rate allows the technician to accurately calculate the charge time to prevent overcharging of the battery.



Automatic Charger



Manual Charger

GENERAL RULES FOR CHARGING A BATTERY

Always leave the vent caps in place during charging.

Always follow the battery charger manufacturer's instructions.

Always charge batteries in a well ventilated area, and wear eye protection and protective clothing, such as a rubber apron and rubber gloves.

Always keep sparks or flames away from the battery. (Do not smoke near a battery)

Recharge the battery at the same rate at which it was discharged. If the discharge was slow, then charge at a slow rate; if the discharge was rapid, then charge at a higher rate. (When in doubt always use a slow charge.)

Never charge a battery that is connected to a vehicle. Disconnect the battery and charge. Excessive voltage can damage electrical circuits on the vehicle.

Recheck specific gravity readings periodically, determine if further charging is still required.

Periodically check the battery for excessive heat by placing your hand on the side of the battery. If it is hot (125°F) to the touch, interrupt the charging (turn off) until the battery cools and lower charge rate.

CHARGING PROCEDURE - AUTOMATIC CHARGER

1. Determine the type of battery... "sealed" or "accessible". If "sealed," the battery must be charged using a slow rate. (A "sealed" battery does not allow access to the cells or the addition of water or measuring specific gravity.) If "accessible," the battery may be charged at either the slow or fast rates.
2. Insure the charger is disconnected from the power source and/or the charger is turned off.
3. Connect the charger to the battery: positive cable to the positive terminal or negative cable to the negative terminal. (Insure a good connection by rocking back and forth.)
4. Plug in the charger. If there is a setting switch for "regular" or "deep cycle" batteries, use regular setting for regular (accessible) batteries and sealed/gel electrolyte batteries. Use deep cycle setting for standard deep cycle batteries and maintenance free batteries. Always refer to battery charger instruction manual before using battery charger.
5. Periodically check the battery for excessive heat by placing your hand on the side of the battery. If it is hot (125°F) to the touch, interrupt the charging (turn off) until the battery cools.
6. During the charge cycle, the charger senses the battery's state of charge and will input amps at the appropriate rate. As the battery approaches a full state of charge, the input amperage will decrease.
7. After charging is complete, verify the charger is turned off and disconnected from the power source before removing charger cables.

CHARGING PROCEDURE - MANUAL CHARGER

1. Determine the type of battery... "sealed" or "accessible". If "sealed," the battery must be charged using a slow rate. (A "sealed" battery does not allow access to the cells for the addition of water or measuring specific gravity.) If "accessible," the battery may be charged at either the slow or fast rates.
2. Insure the charger is disconnected from the power source and/or the charger is turned off.
3. Connect the charger to the battery: positive cable to the positive terminal or negative cable to the negative terminal. (Insure a good connection by rocking clamp back and forth.)
4. Plug-in the charger, set -the charge rate, and turn on the charger.
5. Periodically check the battery for excessive heat by placing your hand on the side of the battery. If it is hot 125°F to the touch, interrupt the charging (turn off) until the battery cools.
6. After charging is complete, insure charger is turned off and disconnected from the power source before removing charger cables.

CHARGING RATES - MANUAL CHARGER

The table below is used to calculate the charge rate and time of batteries of various strengths and states of charge using a manual (wheel type) charger.

Example: A battery with an RC (Reserve Capacity) rating of 80 RC and the state of charge is only 25% (specific gravity), first select the correct RC rating in the yellow column, 80 RC in our example. Now, select the charge rate (either 5 or 10 amps) under the state of charge column, 10 amps in our example. Where the two reading intersect (10 amps under 25% and 80 RC) will provide the amount of time in minutes (180) to charge the battery.

Note: If you are wondering where to get the RC rating of a battery that only has a CCA rating on it, refer to your battery vender for such information. It should be readily available from their product application book. If not, place battery on a low charge rate and check electrolyte specific gravity every 30 minutes until charged.

STATE OF CHARGE	75%		50%		25%		0%	
CHARGE RATE (AMPS)	5	10	5	10	5	10	5	10
50 RC	75	35	150	75	225	180	300	150
60 RC	90	45	180	90	270	135	360	180
70 RC	105	50	210	105	315	155	420	210
80 RC	120	60	240	120	360	180	480	240
90 RC	135	65	270	135	405	200	540	270
100 RC	150	75	300	150	450	225	600	300
110 RC	165	80	330	165	495	240	660	330
120 RC	180	90	360	180	540	270	720	360
BATTERY RESERVE (RC) CAPACITY RATING IN MINUTES	CHARGE TIME IN MINUTES							

CHARGING RATE - OPTIMA GEL CELL BATTERY

A Gel Cell Battery requires a shorter charge time. Optima recommends use of a voltage regulated charger set to the limits below.

Voltage: 13.8 to 15.0 volts

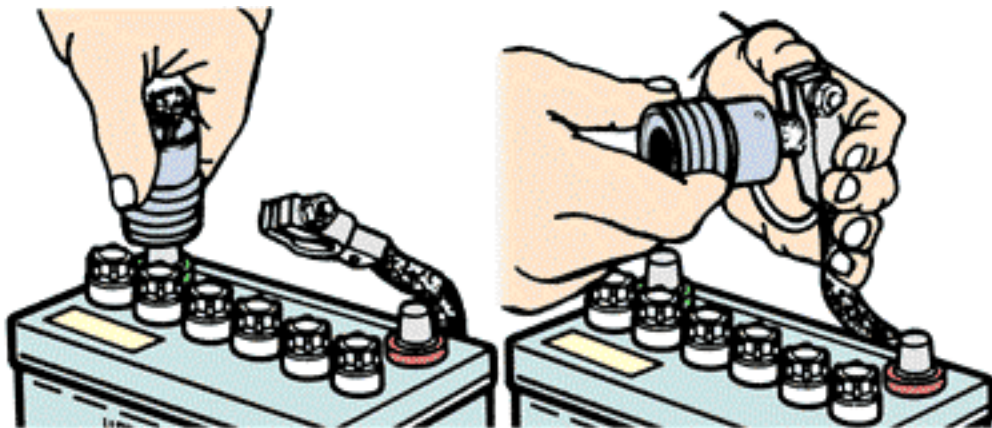
Current: 10 amps maximum

Time: 8 hours maximum

Note: Always use a voltage regulated battery charger with limits set to the above ratings. Overcharging can cause the safety valves to open and battery gasses to escape, causing premature failure. These gasses are flammable! You cannot replace water in sealed batteries that have been overcharged. Any battery that becomes very hot or makes a hissing sound while recharging should be disconnected immediately.

BATTERY TERMINAL CLEANING

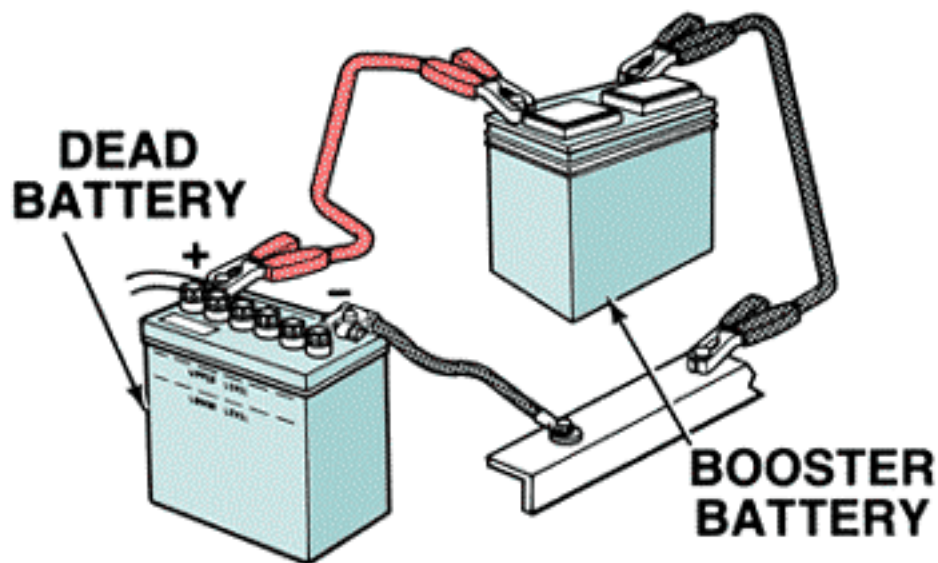
Over a period of time, sulfuric acid will corrode battery terminals, clamps, and hold-down. This corrosion adds resistance and lowers current flow to and from the battery. Corrosion can be easily cleaned with a mild solution of baking soda and water. Battery terminals and cables are routinely removed, cleaned, and reinstalled. A battery brush, which has both an external and internal brushes, is ideal for cleaning the terminal posts and the inside of clamp.



BATTERY JUMPING with Booster Cables

Jump starting a dead battery with a booster battery or battery in a car can be dangerous, so the proper sequence of connections will prevent sparks.

First, connect the two positive terminals, one from the good battery and the other to the dead battery. Next connect one end of the jumper cable to the negative terminal of the booster (Good) battery. Finally connect the other end to a good ground on the engine away from the dead battery. If a spark occurs, it won't be near the battery, thus reducing the chance for explosion. If the jump starting from another vehicle, start the vehicle, running the engine at 1500 RPM for a few minutes. While the engine is running, start the dead vehicle. Never jump start a frozen battery.



BATTERY JUMPING with Booster Pack

The portable booster pack is a lead-acid gel cell type battery. Typically capacity ranges from 250 - 1000 CCA ratings. Both consumer and professional versions are available. It contains an accessory plug and has a test button to verify its' own state of charge. Booster battery packs have proven to be a safe and effective in jump starting vehicles. To use: Connect the red booster pack cable to the positive terminal of the battery and the other cable end to a good ground on the engine away from the dead battery.



ADDING WATER

Under the rare occurrence of adding water to a battery, **use only Distilled water**. Minerals and chemicals that are commonly found in regular drinking water will react with the plate material and shorten battery life. Under normal conditions the addition of water should not be required. However, the addition of water may be necessary when the battery has been overcharged, for overcharging results in excessive evaporation of water from the electrolyte.

The water level should be no higher than 1/8 inch below the bottom of the vent well. To avoid permanent damage, make sure the electrolyte level never drops below the top of the plates. Also, avoid over filling, this may result in electrolyte overflow from the battery.