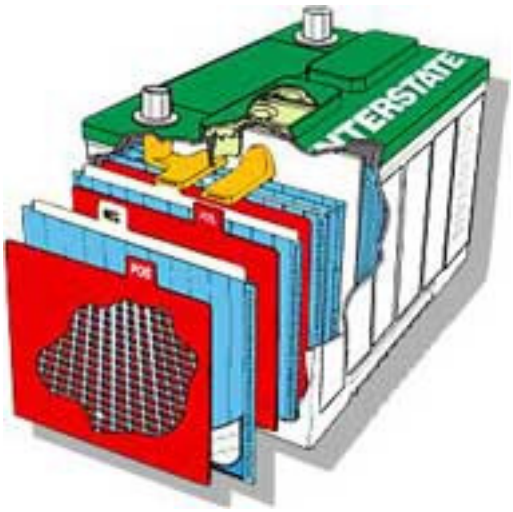

This Automotive Series
12-volt Lead Acid
BATTERY BASICS
has been developed by

Kevin R. Sullivan

Professor of Automotive Technology
Skyline College

v1.1

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THE AUTOMOTIVE BATTERY

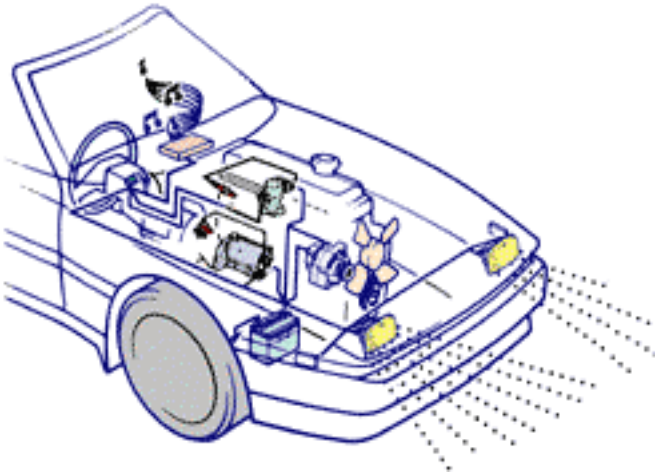
A lead-acid storage battery is an electrochemical device that produces voltage and delivers electrical current. The battery is the primary "source" of electrical energy used in vehicles today. It's important to remember that a battery does not store electricity, but rather it stores a series of chemicals, and through a chemical process electricity is produced. Basically, two different types of lead in an acid mixture react to produce an electrical pressure called voltage. This electrochemical reaction changes chemical energy to electrical energy and is the basis for all automotive batteries.

THE PURPOSE OF THE BATTERY
The battery supplies electricity when the:

ENGINE IS OFF: Electricity from the battery is used to operate lighting, accessories, or other electrical systems when the engine is not running.

ENGINE IS STARTING: Electricity from the battery is used to operate the starter motor and to provide current for the ignition system during engine cranking. Starting the car is the battery's most important function.

ENGINE IS RUNNING: Electricity from the battery may be needed to supplement the charging system when the vehicle's electrical load requirements exceed the charging system's ability to produce electricity. Both the battery and the alternator supply electricity when demand is high.



BATTERIES - Primary or Secondary

Batteries can either be **a primary cell**, such as a flashlight battery once used, throw it away, or a **secondary cell**, such as a car battery (when the charge is gone, it can be recharged).

PRIMARY CELL: Because the chemical reaction totally destroys one of the metals after a period of time, primary cells cannot be recharged. Small batteries such as flashlight and radio batteries are primary cells.

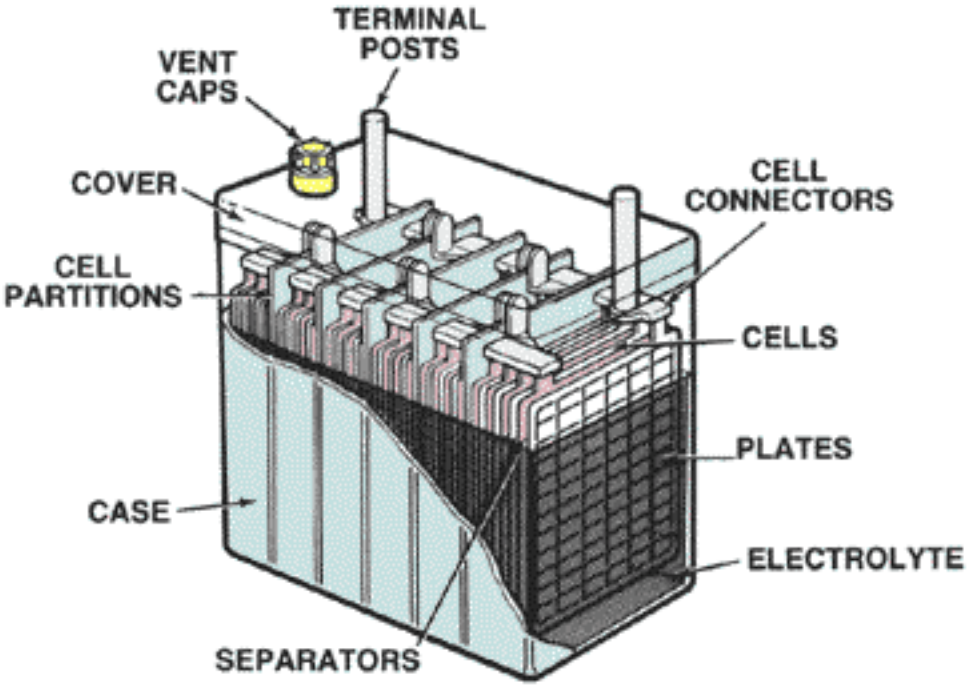
SECONDARY CELL: The metal plates and acid mixture change as the battery supplies voltage. As the battery drains the metal plates become similar and the acid strength weakens. This process is called discharging. By applying current to the battery in the reverse direction, the battery materials can be restored, thus recharging the battery. This process is called charging. Automotive lead-acid batteries are secondary cells and can be recharged.

BATTERIES - Wet or Dry Charged
Batteries can be produced as Wet-Charged, such as current automotive batteries are today, or they can be Dry-Charged, such as a motorcycle battery where an electrolyte solution is added when put into service.

WET-CHARGED: The lead-acid battery is filled with electrolyte and charged when it is built. During storage, a slow chemical reaction will cause self-discharge. Periodic charging is required. Most batteries sold today are wet charged.

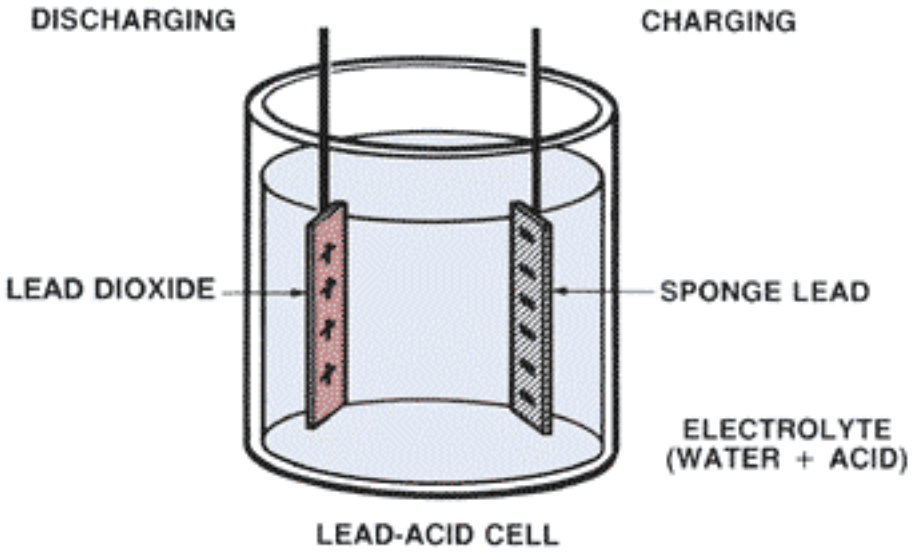
DRY-CHARGED: The battery is built, charged, washed and dried, sealed, and shipped without electrolyte. It can be stored for up to 18 months. When put into use, electrolyte and charging are required. Batteries of this type have a long shelf life. Motorcycle batteries are typically dry charged batteries.

BATTERY CONSTRUCTION
An automobile battery contains a diluted sulfuric acid electrolyte and positive and negative electrodes, in the form of several plates. Since the plates are made of lead or lead-derived materials, this type of battery is often called a lead acid battery. A battery is separated into several cells (usually six in the case of automobile batteries), and in each cell there are several battery elements, all bathed in the electrolyte solution.

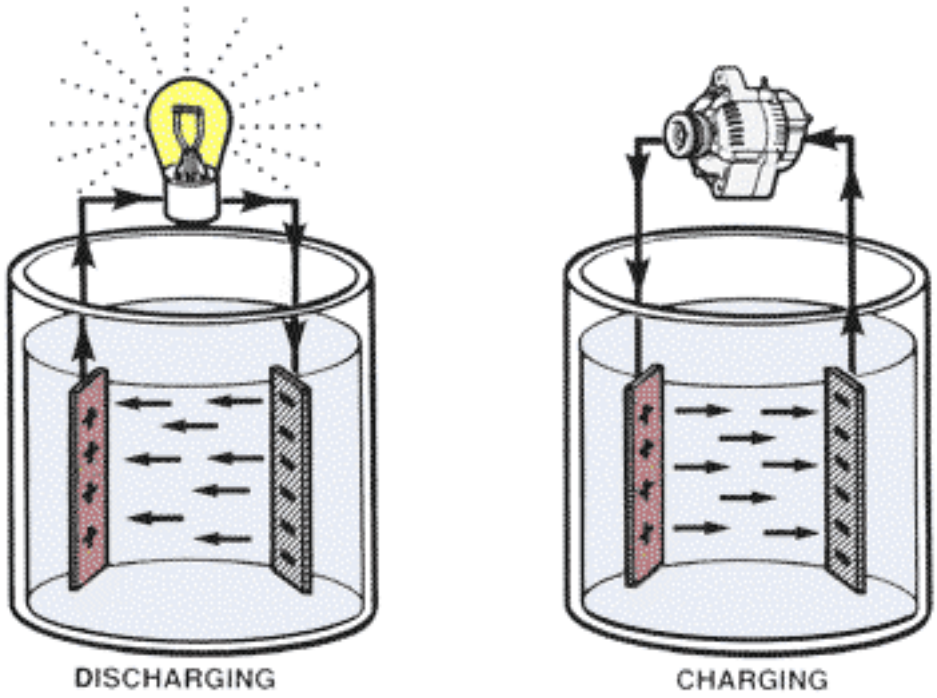


CELL OPERATION

Two dissimilar metals placed in an acid bath produce electrical potential across the poles. The cell produces voltage by a chemical reaction between the plates and the electrolyte. The positive plate is made of reddish-brown material such as Lead Dioxide (PBO2) while the negative plate is made of grayish material called Sponge Lead (PB). The acid bath is a mixture of sulfuric acid and water cell electrolyte. Together a cell element is formed.



CYCLING - The battery stores electricity in the form of chemical energy. Through a chemical reaction process the battery creates and releases electricity as needed by the electrical system or devices. Since the battery loses its chemical energy in this process, the battery must be recharged by the alternator. By reversing electrical current flow through the battery the chemical process is reversed, thus charging the battery. The cycle of discharging and charging is repeated continuously and is called "battery cycling".



DEEP CYCLING
Although batteries do cycle continuously, they do not cycle deeply. Deep cycling is when the battery is completely discharged before recharge.

Automotive batteries are not designed as deep cycle batteries. Automotive batteries are designed to be fully charged when starting the car; after starting the vehicle, the lost charge is replaced by the alternator. So the battery remains fully charged. Deep cycling an automotive battery will cause damage to the plates and shorten battery life.

Marine or golf cart batteries (Deep Cycle Batteries) on the other hand are designed to be completely discharged before recharging. Because charging causes excessive heat which can warp the plates, thicker and stronger plate grids are used. Normal automotive batteries are not designed for repeated deep cycling and use thinner plates.

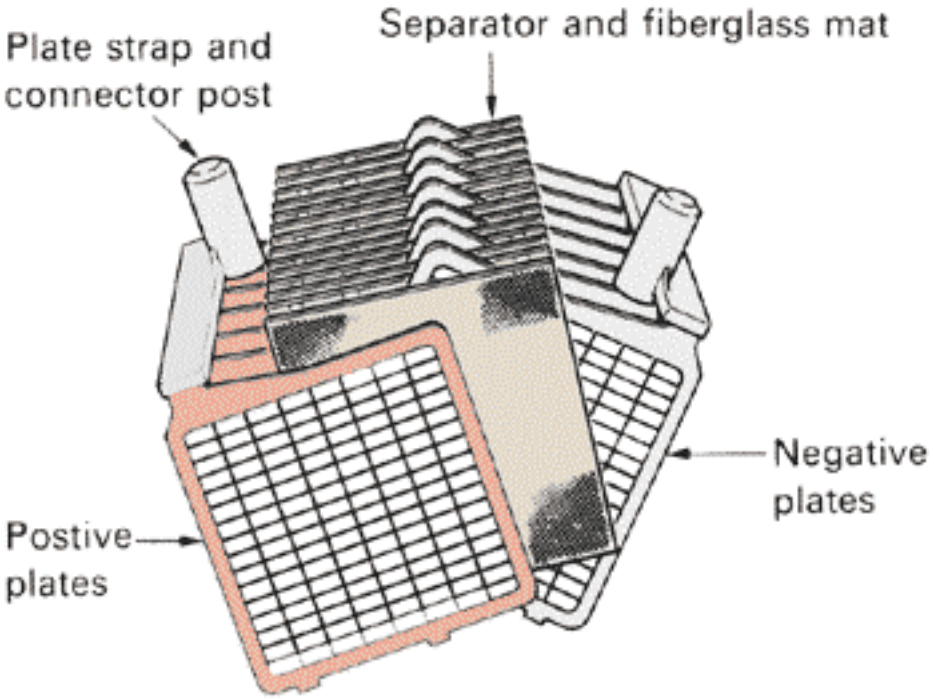
CELL VOLTAGE

Each cell element of the battery produces approximately 2.1 volts, regardless of the quantity or size of the plates. Automobile batteries have six cells that are connected in series, which produces a total voltage of 12.6 volts.

2.1 VOLTS X 6 CELLS = 12.6 VOLTS

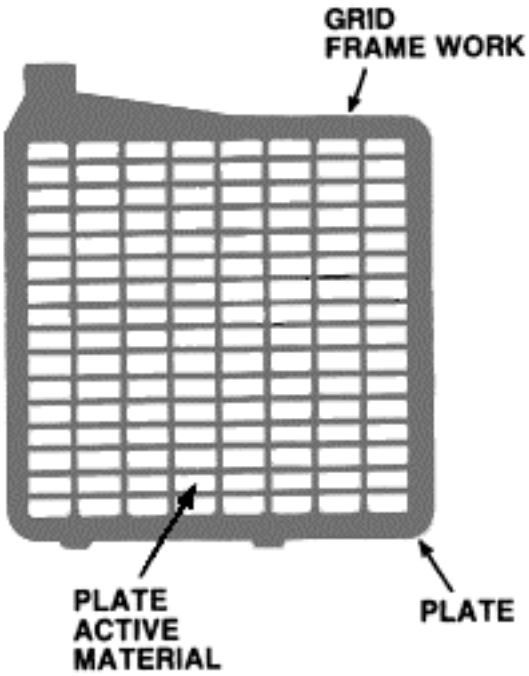
BATTERY CELL ELEMENT

The key to battery operation is the cell element. Positive plates and negative plates are each connected together by separate plate straps. These groups of positive and negative plates are then placed alternately, separated by micro-porous separators. Assembled together, the plates and separators form a battery cell element. Grouping the plates in this way serves to enlarge the surface area between the active materials and the electrolyte, thus allowing a greater amount of electricity to be supplied. In other words, the battery capacity is increased because of the increase in surface area. More plate surface area means the battery can deliver more current.



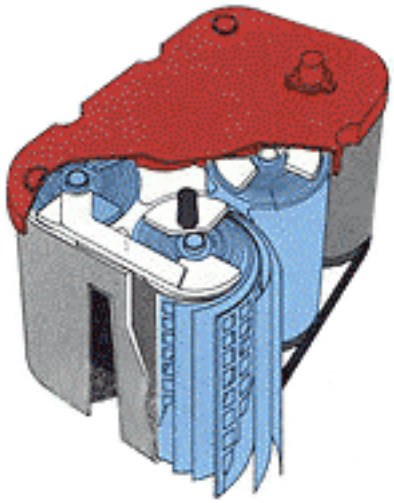
PLATES

Battery plates are constructed of a lead alloy containing a percentage of either Antimony or Calcium. The plates are designed as a thin flat grid, grids crossing at right angles (shown below) or grids crossing diagonally at different angles which reduces internal resistance. The grid provides the necessary framework for active material to be pasted onto the plate, making either a positive or a negative plate. The active material on a charged positive plate is a reddish-brown Lead Dioxide (PBO2), while the active material on a charged negative plate is a grayish Sponge Lead (PB).



GEL CELL BATTERIES

A gel battery design is typically a modification of the standard lead acid automotive. A gelling agent is added to the electrolyte to reduce movement inside the battery case. Many gel batteries also use one way valves in place of open vents, this helps the normal internal gasses to recombine back into water in the battery, reducing gassing. The spiral design provides more plate surface area and closer plate spacing resulting in a lower internal resistance. This low resistance provides more power in a smaller battery case and the ability to recharge much faster.



BATTERIES - Antimony, Calcium, or Gel
Several variations of the Lead -Acid battery are used today. Variations to the battery plate material and electrolyte solution provide different battery characteristics. Construction is basically the same; however, the materials used are slightly different.

1. Lead Antimony (Most commonly used).
Is commonly used in conventional lead acid battery which uses lead antimony cell plates.

Advantages:
1. Longer service life than Calcium batteries.
2. Easier to recharge when completely discharged.
3. Lower cost.

2. Lead Calcium (AC Delco maintenance free batteries).
Is a maintenance free lead acid battery which uses lead calcium cell plates.

Advantages:
1. Larger electrolyte reserve area above the plates.
2. Higher Cold Cranking Amp ratings.
3. Little or No maintenance.

3. Recombination (Gel Cell) (Optima batteries and some others).
Is a completely sealed lead acid battery which uses an electrolyte that is a gel (solid) rather than a liquid.

Advantages:
1. No liquid electrolyte to spill or leak.
2. Can be Deep Cycled several time without damage.
3. Totally corrosion and maintenance free.
4. Three to four times longer battery life than regular batteries.
5. More plate surface and closer plate spacing provides a compact case size.

LEAD ANTIMONY VS. LEAD CALCIUM

Lead-Antimony Cast Grid

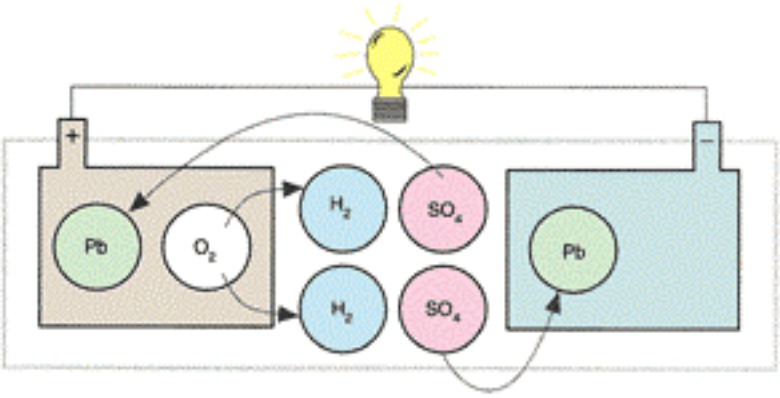
Conventional Low-Maintenance batteries use grids of Lead-antimony which is readily available, inexpensive, easy to cast, and provide a rechargeable battery that offers optimum efficiency and low cost. Lead antimony is used in **Low-Maintenance batteries.** Such batteries are built to reduce internal heat and water loss. Battery construction provides a deeper well area to allow a slight water loss over the life of the battery. Under normal conditions, the addition of water should not be required.

Lead-Calcium Grid

The maintenance-free batteries, such as Delco Freedom batteries, uses calcium. The lead-calcium grid is strong, more resistant to corrosion as well as overcharging, gassing, water usage, and self-discharge, all of which shorten battery life in conventional lead-acid batteries. Lead calcium is used in **Maintenance Free batteries**. Battery construction provides a deeper well area to allow a slight water loss over the life of the battery. No provision for adding water to the cells is provided because the battery is sealed.

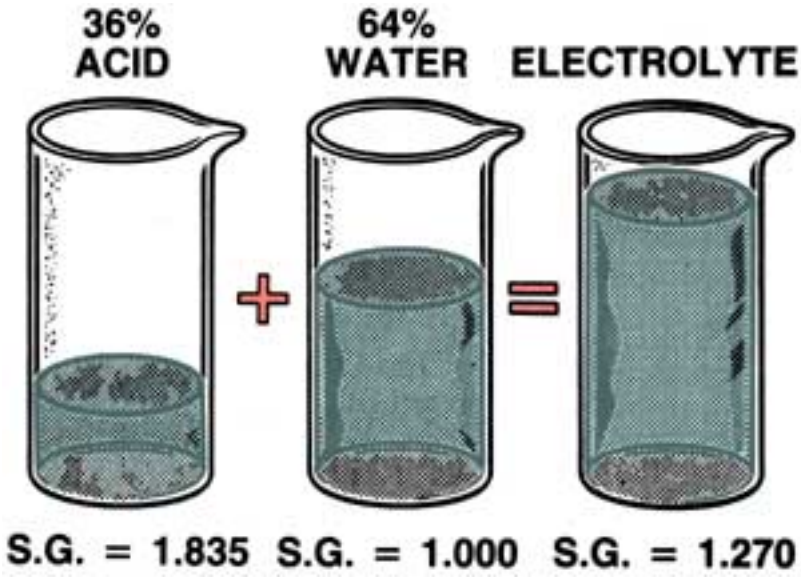
ELECTROLYTE

Battery electrolyte is a mixture of 36% sulfuric acid (SO4) and 64% distilled water (H20). Batteries today have an electrolyte with a specific gravity of 1.270 (at 20'C, 68'F) when fully charged. Specific Gravity is the weight of a given volume of liquid in comparison to the weight of the same volume of water. The higher the specific gravity of a liquid the denser (thicker) it is. Testing specific gravity will be discussed in the Battery Service Module.



SPECIFIC GRAVITY OF ELECTROLYTE

Specific gravity means exact weight. A "Hydrometer" or a "Refractometer" compares the exact weight of electrolyte with that of water. Electrolyte in a charged battery is stronger and heavier than 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, and the specific gravity of sulfuric acid is 1.835, which means the acid is 1.835 times heavier than the water. The battery electrolyte mixture of water and acid has a specific gravity of 1.270 and is usually stated as "twelve and seventy."



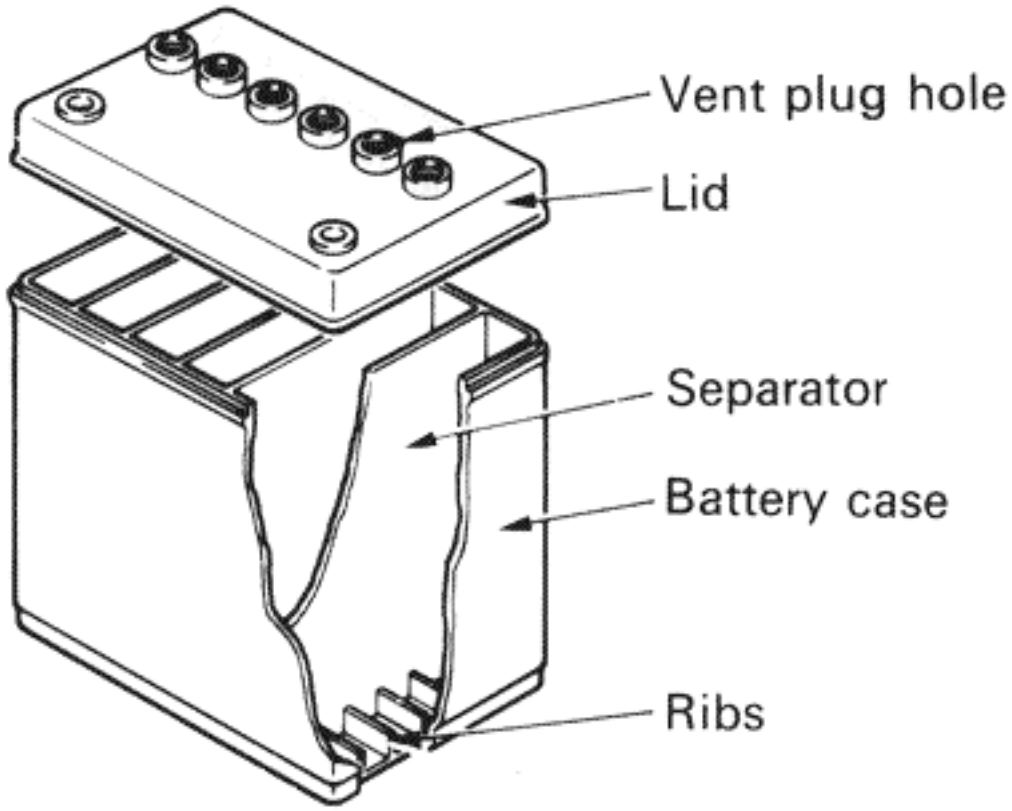
BATTERY SPECIAL HANDLING

The electrolyte inside the battery is a mixture of sulfuric acid and water. Sulfuric acid is very corrosive and can cause severe injury to your skin and eyes. Always wear protective goggles, gloves, and apron while servicing the battery. If it gets on your skin, flush with a large quantity of water immediately; if it gets in your eyes, flush with large quantities of water immediately (a mild solution of baking soda and water will neutralize the acid) and seek medical attention as soon as possible.

Because sulfuric acid will eat through clothing, it is advisable to wear proper work clothing when handling batteries. When charging the battery, hydrogen gas is released so it is extremely important to keep flames or sparks away from the battery to prevent explosion.

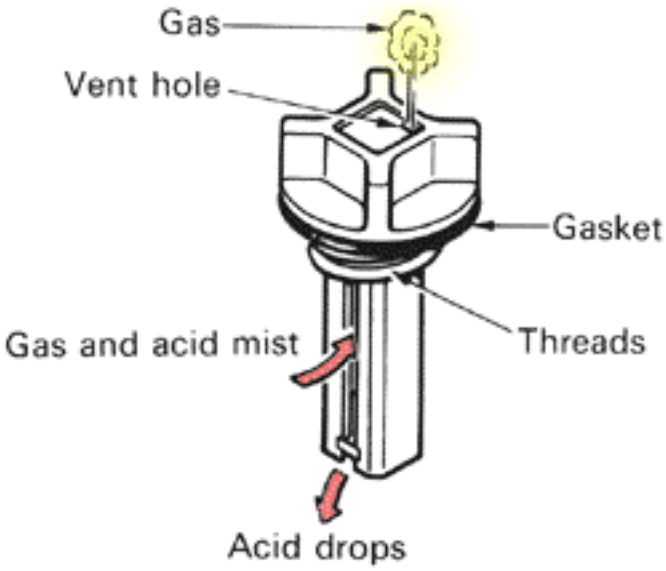
BATTERY CASE

The battery case holds the electrolyte and the individual battery cell elements. It is divided into six compartments or cells. The plates are raised up off the bottom of the case with ribs to prevent them from shorting out if any of the active materials (lead, etc.) should happen to fall from the plates. The case is made of polypropylene, hard rubber, and plastic base materials. Some battery manufacturers use translucent plastic cases which allow checking electrolyte level without removing vent caps. These cases often have "upper" and "lower" electrolyte level markers on the outside of the case.



VENT CAPS

Vent caps cover the holes that are used for adding electrolyte. They are also designed to separate the sulfuric acid mist and the hydrogen gas that forms when the battery charges. The caps are designed to the sulfuric acid mist to condense and drop back into the battery and allow hydrogen gas to escape through the vent holes to the atmosphere. Vent caps can cover each individual cell as shown below. Note:Many Gel Cell Batteries use a one way check valve enplane of vents.



VENT CAP STRIPS

Most batteries today use vent cap strips that cover multiple cells (shown below). The caps are are designed to allow hydrogen gas to escape and sulfuric acid mist to condense and drop back into the battery.

BATTERY TERMINAL DESIGN

Three design types of battery terminals are used; the Top (Post) Terminal, Side Terminal, and the "L" Terminal types. The **top terminal** design is the most popular among automotive batteries. Top post terminal batteries have tapered posts on the top of the battery. The **side terminal** design is used exclusively by General Motors, and the **"L" terminal** design is used in marine applications; both have internally threaded terminals.

BATTERY TERMINAL DESIGN

BATTERY TERMINAL IDENTIFICATION

Battery terminals are identified as either "**positive**" or "**negative**". Battery cases are marked with a "**+**" for the positive terminal, and a "**-**" on the negative terminal as shown below. The words "**POS**" or "**NEG**" are often used instead of the **+** or **-**. On top post terminal batteries, the positive post is slightly wider than the negative terminal post. This allow for easy identification.

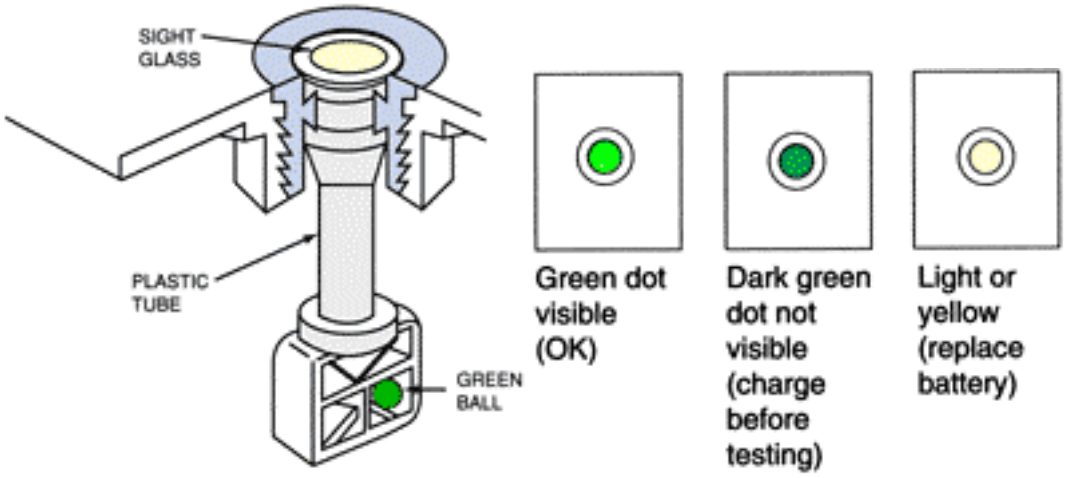
BATTERY TERMINAL CLAMPS

Battery cable clamps are can be made of steel or lead depending on the manufacturer. In addition, they can be attached to the cable by either crimp or bolt and nut. A crimped one piece battery cable with clamp is the most common used today.

STEEL

LEAD

BUILT IN SPECIFIC GRAVITY INDICATOR
Most maintenance free batteries use a built in single ball hydrometer that measures specific gravity in one cell, which is located on the top of the battery.



BATTERY HOLD DOWN / CARRIER
Battery hold downs are used to stop the battery from vibrating, moving, or spilling over while the car is in motion. Vibration will cause the battery to fail prematurely. Excessive vibration or sharp movement will cause active material to fall off the plates ruining the battery. The battery must always be secured. Additionally, a battery carrier or tray underneath the battery aids in securing the battery to the vehicle.

MANUFACTURER CODE / DATE CODE
A manufacturer's code is stamped onto the battery case at time of its manufacture. This manufacturers code contains information as to the date of manufacture, type, manufacturing plant, etc.

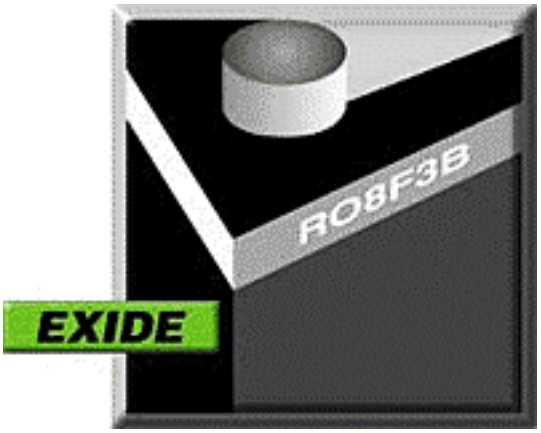
A two letter code (B0, A9, etc.) is also placed on the battery to make it easier for resellers and consumers to identify the production date. The code is on a sticker affixed to the battery or hot-stampded into the case cover along the top edge. The first letter represents the month, and the second number represents the year. The picture below shows B9, which is February 1999. Fresh batteries are always the best. Refer to the battery vendor or supplier for this information.

STICKER DATE CODES
A = January
B = February
C = March
D = April
E = May
F = June
G = July
H = August
J = September
K = October
L = November
M = December

DATE CODE EXCEPTIONS

DELCO - Freedom, Voyager, and some Sears brands:
The code dates are stamped on the cover, usually near the posts. The first character represents the year (0-9) and the second shows the month (A-M, skipping I). For example, 4CN1 would stand for 1994, March.

EXIDE - Napa Legend, Edge, Power-Tron and Titan:
The fourth or fifth character may be a letter code for the month and the following character a number code for the year (i.e. RO8F3B stands for June 1993).



BATTERY CAPACITY RATINGS
Several battery capacity ratings have been established by the Battery Council International (BCI) that determine the current capacity of a battery. The current capacity is an indication of the battery's ability to develop and deliver high amperage current to the starter and provide reserve power to the electrical system.

1) COLD CRANKING AMPS
The first battery rating is the **cold cranking amps (CCA) rating**. This rating indicates the ability of a battery to deliver a specified current at low temperature. The rating is determined by the amount of current a fully charged battery can supply for 30 seconds at 0'F (- 17.8'C) without having the battery terminal voltage fall below 7.2 V.

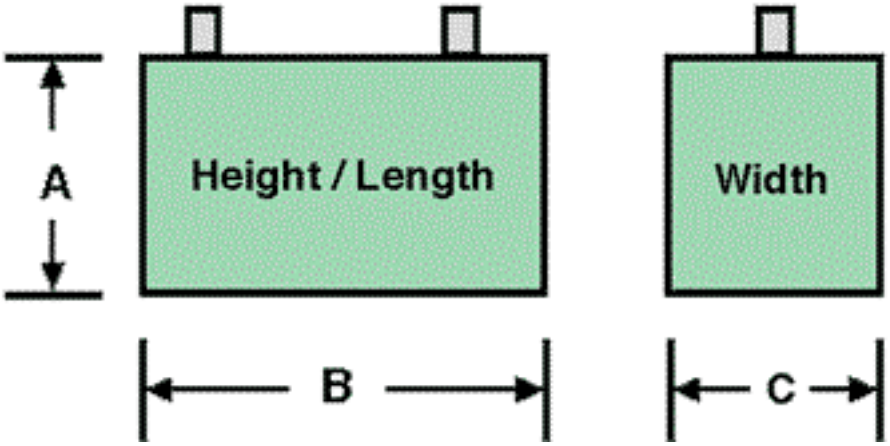
2) CRANKING AMPS
The second battery rating is the **cranking amps (CA) rating** (not to be confused with COLD Cranking Amps), which is the battery's ability to deliver a cranking current at 32' F. **This CA Rating is the same test as in the CCA rating, except it is calculated at a high temperature.** A battery with a CA rating of 800 may confuse a technician who may assume it is a CCA rating number. To convert CA at 32 'F to CCA at 0 'F, divide CA by 1.25. Example: a 650 CCA rated battery has the same current capacity as a 812 CA rated battery. This apparent marketing ploy may confuse the public into thinking they are purchasing a battery which is higher in capacity than it really is.

3) RESERVE CAPACITY
The third battery rating, the **reserve capacity rating,** is the time in minutes a vehicle can be driven after the charging system fails. This is roughly equivalent to the conditions after the alternator fails while the vehicle is being driven at night with the headlights on. The battery alone must supply current to the headlights and the computer/ignition system. The assumed battery load is a constant discharge current of 25 A. The reserve capacity rating is the length of time a fully charged battery that is at a temperature of 80'F (26.7'C) can supply 25 A before the terminal voltage falls below 10.5 V.

4) AMPERE HOUR
The fourth battery rating, the **ampere-hour rating** (expressed in ampere-hours, or Ah) is the amount of current a fully charged battery can supply for 20 hours without having the terminal voltage fall below 10.5 V. This test is made at a temperature of 80'F (26.7'C). If a battery can deliver 4 A under these conditions, it is an 80-Ah battery (4 A X 20 hours = 80 Ah).

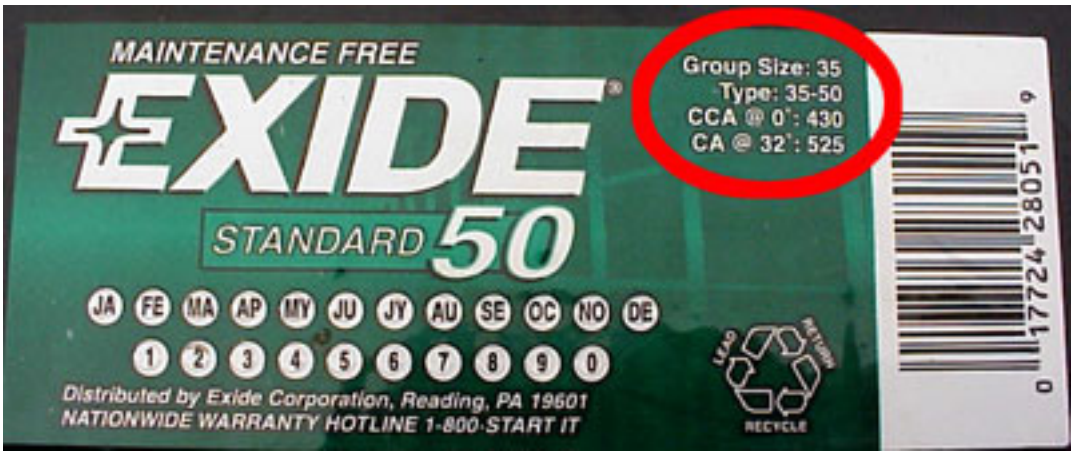
BATTERY GROUP SIZE

The Battery Council International (BCI) also determines the size group number. The BCI size group number identifies a battery in terms of its width, length, height, terminal design, and other physical features. Automotive manufacturers provide a designated amount of space in the engine compartment to accommodate the battery. Battery companies build batteries of various current-capacity ratings in a variety of sizes and shapes. A replacement guide is used when replacing a battery because the battery must fit into the space provided.



BATTERY INFORMATION LABEL

The capacity rating and group size information is usually located on the manufactures label. Additional information may also be provided.



36 VOLT BATTERIES

Soon you will find 36 volt batteries on new model vehicles. With the growing number of electrical devices on vehicles, the number of wires keeps growing. The advantage of 36 volt batteries will be the high voltage allows devices to operate with lower current flow, resulting in smaller wires, lightening the vehicle weight. What kind of charging system will the 36 volt battery need? A 42 volt charging system to begin with. The higher voltage output of the alternator will result in lower current from the alternator, resulting in smaller or equivalent size alternators used today. Look for these being first on the market from Mercedes or other high end cars.

