B4 BATTERIES

CAR BATTERIES

Lead-acid batteries

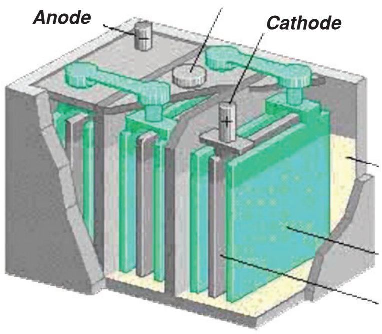
The modern lead-acid battery is by far the most familiar rechargeable storage cell technology. The lead-acid cell was invented in 1859 by a French physicist, Gaston Plante. It uses dilute sulfuric acid for an electrolyte, lead for the anode, and lead oxide for the cathode. The sulfuric acid dissociates into two hydrogen ions (protons) and a sulfate group. The sulfate group reacts with the lead anode to form lead sulfate and releases two electrons through the external circuit. Pb^0 is oxidised to Pb^{2+} and 2 electrons are released:

$$Pb + SO_4^{2-} \rightarrow PbSO_4 + 2e^-$$

At the cathode, the two electrons are taken up by the lead dioxide to form lead sulfate and water. Four H^+ ions also take part in this reaction. Pb^{4+} is reduced to Pb^{2+}:

$$PbO_2 + SO_4^{2-} + 4H^+ + 2e^- \rightarrow PbSO_4 + 2H_2O$$

As the reaction proceeds, lead sulfate deposits on the electrodes, and the current drops because the contact between the electrolyte and electrodes is reduced. Feeding a current of more or less 2A will reverse the reaction to break down the lead sulfate to form lead dioxide and produce sulfuric acid from the water, therefore recharging the cell.



The basic structure of a lead-acid battery

Source: Colorado College

A standard automotive battery consists of a box-shaped casing with internal divider walls to separate its series-connected cells. The electrodes in each cell are built as sets of interleaved plates to provide the maximum surface area for the electrochemical reaction. Each cell in a lead-acid battery provides about two volts. They usually consist of six cells in series to provide a total of 12 V. Lead-acid batteries usually have large capacities, though they tend to run down quickly.

They can be recharged hundreds of times until their electrodes are too eroded to allow the battery to hold a charge. They have indefinite shelf lives if stored without electrolyte. Lead-acid batteries are cheap and effective, and at present the battery of choice where high power capacities are required at sensible cost.

A new type of lead-acid battery was introduced in the late 1990s and operates on the same chemical principles, but has a radically different construction. The electrodes are formed as thin plates, with the electrolyte stored in a separator sheet between the plates, and stored in a sealed can in a "wound" or "jelly-roll" configuration. The improved battery configuration provides higher energy density, though the environmental issues remain much the same. This is about the only significant innovation in lead-acid battery design in over a century of the technology's existence.

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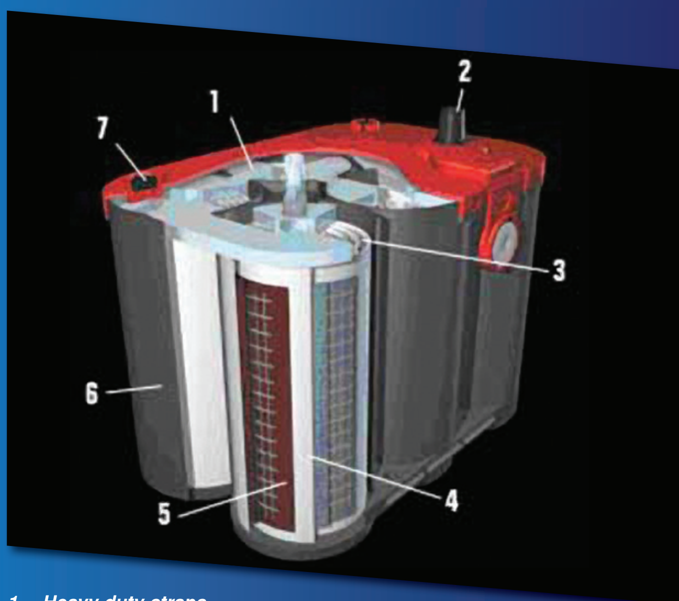
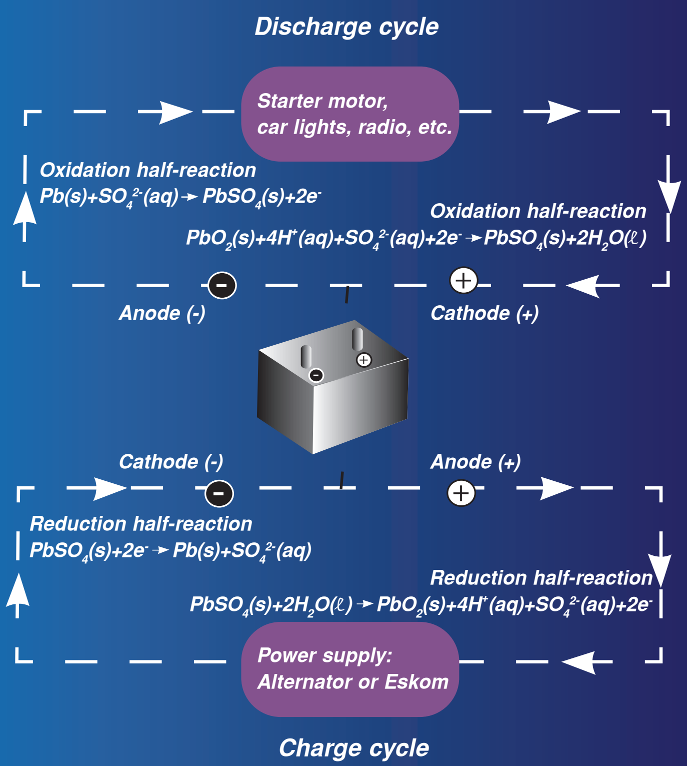
Latest design for lead-acid batteries using the Optima patented Spiralcell Technology



1 Heavy duty straps
2 Corrosion resistant terminals
3 SpiralCell construction
4 Absorbent glass mat separator holds electrolyte like a sponge
5 High purity lead grids for long life
6 Impact resistant polypropylene case
7 Resealable pressure relief valve with flame trap

Source: Optima Battery



The reactions that occur during discharge can be reversed. The discharge reaction is spontaneous and when charging, an external power supply is used to drive a non-spontaneous reaction.

What's the best battery for the electric vehicle?

The electric vehicle will gain public acceptance as soon as a battery emerges that is inexpensive and provides 10 years of reliable service. The high cost and limited cycle life of the batteries used in hybrid vehicles negate the savings achieved in burning less fuel. The current benefits are environmental in nature rather than in cost savings. Higher fuel prices could force a shift towards battery powered vehicles.

Nickel and lithium-based batteries have been tried but both chemical reactions have problems with durability and stability. Lithium-ion has an advantage in weight but this gain is offset by a high price. Similarly, nickel-metal-hydride used for the hybrid vehicle is expensive and requires forced air-cooling. No battery manufacturer is willing to commit to a 10-year warranty. After excursions into new battery chemistries, design engineers always come back to the old but proven lead-acid battery.

The fuel cell may still be two decades away before offering a viable alternative for cars. An executive from Ford stated recently that it may never be feasible to replace the internal combustion engine with fuel cells. Cost and longevity remain major drawbacks.

This material was obtained from Batteryuniversity.com. Learners - if you use any part of it you need to write it in your own words and include the following in your reference list: Buchmann, I. 2005. Batteryuniversity.com - What's the best battery for wheeled and stationary applications? [Online]. Available: www.batteryuniversity.com/parttwo-40.htm. [27 July 2010].

Sodium-sulfur battery

In contrast to the traditional battery, which houses solid electrodes and liquid (or slurried) electrolyte, this design incorporates liquid electrodes separated by a solid electrolyte. Molten sodium (Na) (melting point 98°C) is the anode, and molten sulfur (S) (melting point 113°C) is the cathode (mixed with powdered graphite to improve conductivity). The sodium loses electrons, which pass through the external circuit (wire and stainless-steel electrode housing) and reduce the sulfur (S) to polysulfide ions (S_n^{2-}). The electrolyte is β-alumina, a mixture of metal (Na, Mg, Al) oxides that allows sodium ions to pass through and reach the sulfur ions.

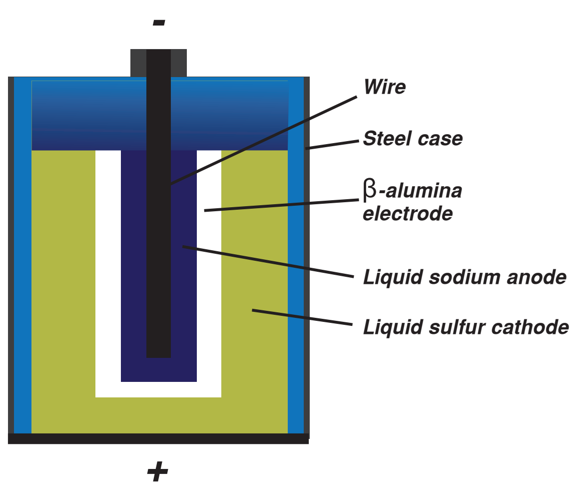
Advantages: Na-S batteries can provide four to five times the energy per unit mass and undergo about three times as many discharge-recharge cycles as lead-acid batteries.

Disadvantages: Moderate speed and short discharge time: a BMW powered by a 265-kg Na-S battery had a top speed of 96 km·h^{-1} and a cruising range of 160 km; earlier versions had long recharge times (16 h). A temperature of 350°C must be maintained to keep reactants and products molten and a high sodium conductivity in the β-alumina.

$2Na(\ell) \rightarrow 2Na^+(\ell) + 2e^-$

$S(\ell) + 2e^- \rightarrow S_n^{2-}(\ell)$

$2Na + 4S \rightarrow Na_2S_4 \quad E_{cell} = 2\ V$



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DID YOU KNOW?

A lead-acid battery self-discharges at only ~5% per month or ~50% per year.