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Chapter: 3

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Composition and Chemistry

A rechargeable battery is based on the principle that the **charge/discharge** process is reversible, that is, the **energy** delivered by the battery during discharge can be replaced or restored by recharging.

3.1 Active Components: Positive and Negative Electrodes

Nickel oxyhydroxide (NiOOH) is the active material in the positive **electrode** of the nickel-metal hydride battery in the charged state, the same as in the nickel-cadmium battery.

The negative active material, in the charged state, is hydrogen in the form of a metal hydride. This metal **alloy** is capable of undergoing a reversible hydrogen absorbing/desorbing reaction as the battery is charged and discharged, respectively.

The unique attribute of the hydrogen storage alloy is its ability to store hundreds of times its own volume of hydrogen gas at a pressure less than atmospheric pressure. Many different intermetallic compounds have been evaluated as electrode materials for nickel-metal hydride batteries. Typically, these fall into two classes: **AB₅** alloys, of which LaNi₅ is an example,

and **AB₂** alloys, of which TiMn₂ or ZrMn₂ are examples.

DURACELL nickel-metal hydride battery technology is based on the use of **AB₅** instead of **AB₂** alloys. **AB₅** alloys offer better corrosion resistance characteristics, resulting in longer **cycle life** and better rechargeability following storage. The composition of the metal alloy is formulated for optimal stability over a large number of charge/discharge cycles. Other important properties of the alloy include:

- Large hydrogen storage capability for high energy density and battery capacity.
- Favorable kinetic properties for high rate capability during charge and discharge.
- Low hydrogen pressure alloy and high purity materials to minimize **self-discharge**.

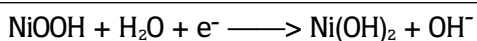
3.2 Electrolyte

An aqueous solution of potassium hydroxide is the major component of the **electrolyte** of a nickel-metal hydride battery. A minimum amount of electrolyte is used in this sealed cell design, with most of

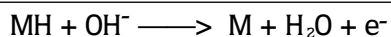
this liquid being absorbed by the **separator** and the electrodes. This “starved electrolyte” design facilitates the diffusion of oxygen to the negative electrode at the end-of-charge for the “oxygen recombination” reaction.

3.3 Cell Reactions

During discharge, the nickel oxyhydroxide is reduced to nickel hydroxide



and the metal hydride (MH) is oxidized to the metal alloy (M).



The overall reaction on discharge is:

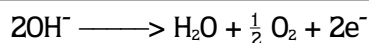


The process is reversed during charge.

Composition and Chemistry (cont.)

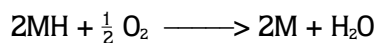
The sealed nickel-metal hydride cell uses the “oxygen-recombination” mechanism to prevent a build-up of pressure that may result from the generation of oxygen towards the end of charge and **overcharge**. This mechanism requires the use of a negative electrode (the metal hydride/metal electrode) which has a higher effective capacity than the positive (nickel oxyhydroxide/nickel hydroxide electrode) electrode. A schematic drawing of the electrodes is shown in **Figure 3.3.1**.

During charge, the positive electrode reaches full charge before the negative electrode which causes the evolution of oxygen to begin:



The oxygen gas diffuses through the separator to the negative electrode, a process which is facilitated by the “starved-electrolyte” design and the selection of an appropriate separator system.

At the negative electrode, the oxygen reacts with the metal hydride and oxidizes or discharges the metal hydride to produce water:



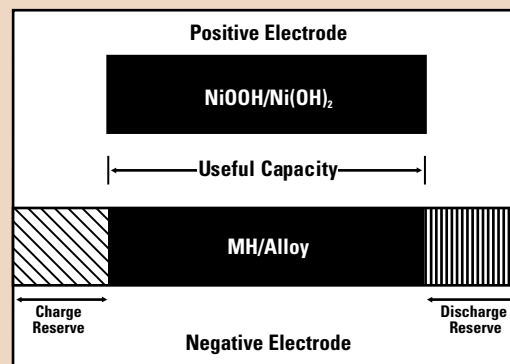
Thus, the negative electrode does not become fully charged and pressure does not build up.

The charge current, however, must be controlled at the end of charge and during overcharge to limit the generation of oxygen to below the rate of recombination. Thus, **charge control** is required to prevent the build-up of gases and pressure. Duracell recommends that continuous overcharge not exceed C/300 for optimal performance.

As shown in **Figure 3.3.1**, the nickel-metal hydride cell is designed with a discharge and charge reserve in the negative electrode. The discharge reserve minimizes **gassing** and degradation of the cell in the event of **overdischarge**. The charge reserve ensures that the cell maintains low internal pressure on overcharge.

The negative electrode has excess capacity compared to the positive electrode and is used to handle both overcharge and overdischarge. Thus, the useful capacity of the battery is determined by the positive electrode.

FIGURE 3.3.1



Schematic representation of the electrodes, divided into useful capacity, charge reserve and discharge reserve.