NiMH Technology

A Generic Overview

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Cell Fundamentals

- **A Hybrid Technology...**
  - The Nickel-Metal Hydride cell chemistry is a hybrid of the proven positive electrode chemistry of the sealed nickel-cadmium cell with the energy storage features of metal alloys developed for advanced hydrogen energy storage concepts.
  - The heritage in a positive limited cell design, results in batteries providing enhanced capacities while retaining the well characterised electrical and physical design features of the sealed nickel-cadmium cell design.

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Electrochemistry

- The electrochemistry of the nickel-metal hydride cell is generally represented by the following charge and discharge reactions
- **Charge:**
  - At the negative electrode, in the presence of the alloy and with an electrical potential applied, the water in the electrolyte is decomposed into hydrogen atoms, which are absorbed into the alloy, and hydroxyl ions as indicated below:
  - Alloy + H20 + e\` ⇔ Alloy (H) + OH\`
  - At the positive electrode, the charge reaction is based on the oxidation of nickel hydroxide just as it is in the nickel-cadmium couple
  - $Ni(OH)_2$ + OH\` ⇔ NiOOH + $H_2O$ + e\`

Electrochemistry

- **Discharge**
  - At the negative electrode, the hydrogen is desorbed and combines with a hydroxyl ion to form water while also contributing and electron to the circuit
  - Alloy (H) + OH` ⇔ Alloy + H2O + e`
  - At the positive electrode, nickel oxyhydroxide is reduced to it's lower valence state, nickel hydroxide.
  - NiOOH + H_2O + e` ⇔ $Ni(OH)_2$ + OH`

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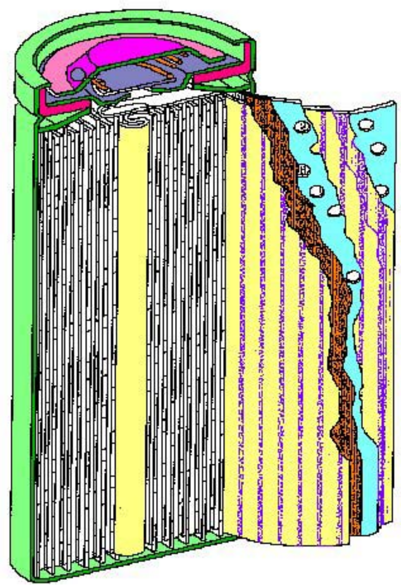
➢Cell Components...

- **Nickel-metal hydride cells, with the exception of the negative electrode, use the same general types of components as the sealed nickel-cadmium cell**
  - Negative Electrode
  - Positive Electrode
  - Electrolyte
  - Separator



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...Cell Components...

- **Negative Electrode**
  - The basic concept of the nickel-metal hydride cell negative electrode emanated from research on the storage of hydrogen for use as an alternative energy source in the 1970's. Certain metallic alloys were observed to form hydrides that could capture (and release) hydrogen in volumes up to nearly a thousand times their own volume.
  - By careful selection of the alloy constituents and proportions, the thermodynamics could be balanced to permit the absorption and release process to proceed at room temperatures and pressures. The general result is shown schematically in figure 1 where the much smaller hydrogen atom is shown absorbed into the interstices of a bimetallic alloy crystal structure

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...Cell Components...

- **Negative Electrode (continued...)**
  - Two general classes of metallic alloys have been identified as possessing characteristics desirable for battery cell use. These are rare earth/nickel alloys generally based around $LaNi_5$ (the so-called AB_5 class of alloys) and alloys consisting primarily of titanium and zirconium (designated as AB_2 alloys).
  - In both cases, some fraction of the base metals is often replaced with other metallic elements. The AB_5 formulation appears to offer the best set of features for commercial nickel-metal hydride cell applications

...Cell Components...

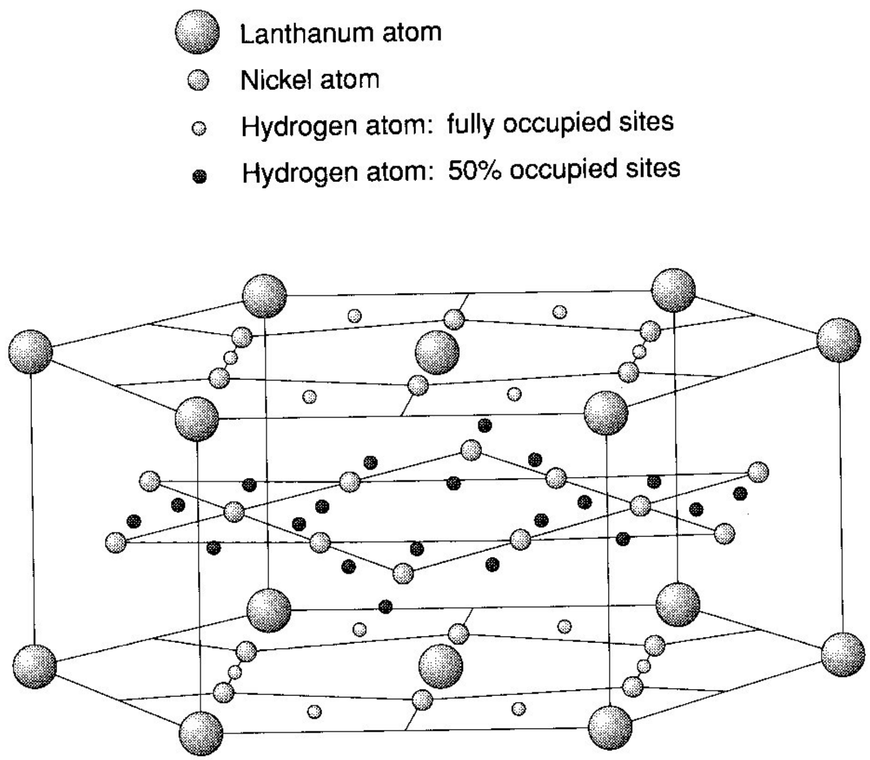

Figure 1.
Schematic of metal-Alloy Crystal Structure Within Nickel-Metal Hydride Negative Electrode

- **The metal hydride electrode has a theoretical capacity approximately 40 percent higher than nickel cadmium electrode in a nickel-cadmium couple. As a result, nickel-metal hydride cells provide energy densities that are 20-40 percent higher than the equivalent nickel-cadmium cell.**

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...Cell Components...

- **Positive Electrode**
  - The NiMH positive electrode design draws heavily on the experience with NiCd electrodes. Electrodes that are economical and rugged exhibiting excellent high-rate performance, long cycle life, and good capacity include pasted and sintered-type positive electrodes.
  - The balance between the positive and negative electrodes is adjusted so that the cell is always positive limited as illustrated in figure 2. This means that the negative electrode possesses a greater capacity than the positive. The positive will reach full capacity first as the cell is charged. It will then generate oxygen gas that diffuses to the negative electrode where it is recombined. This oxygen cycle is a highly efficient way of handling moderate overcharge currents.

...Cell Components...

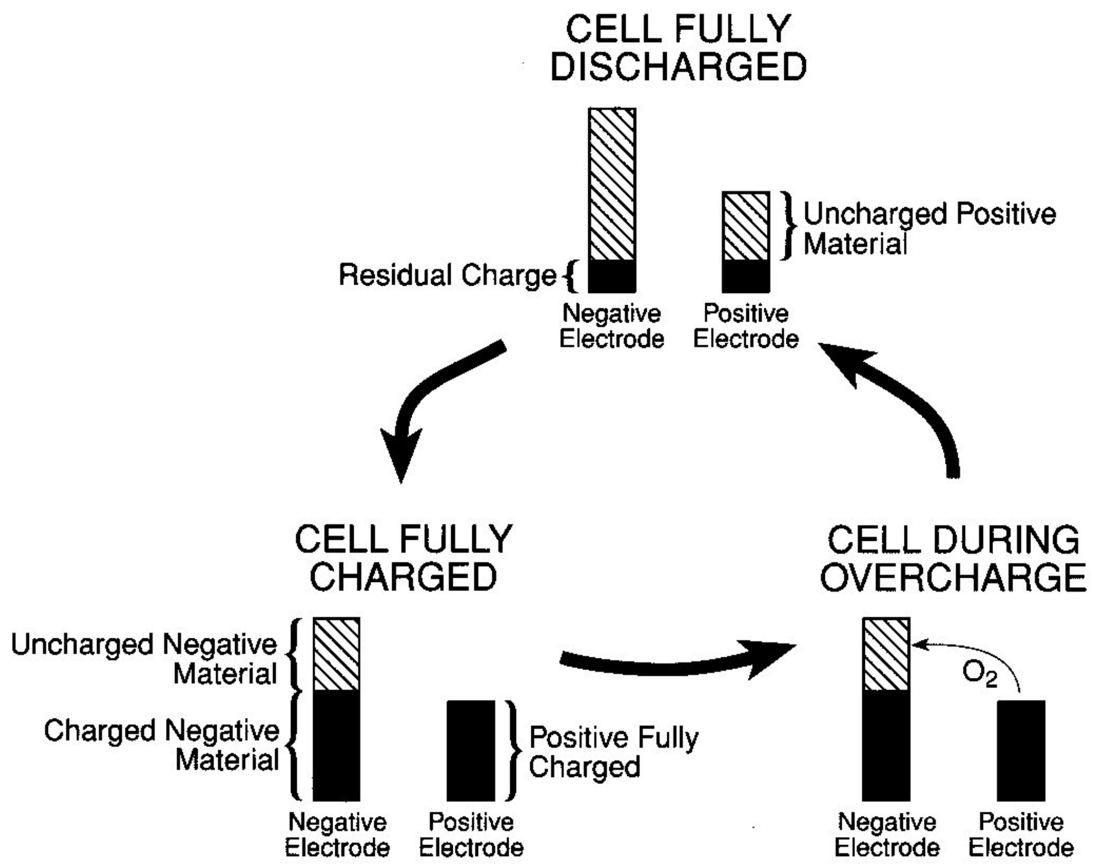

Figure 2.
Relative Electrode balances For Nickel-Metal Hydride Cell During Discharge/Charge/Overcharge

...Cell Components

- **Electrolyte**
  - The electrolyte used in the nickel-metal hydride cell is alkaline, a dilute solution of potassium hydroxide* containing other minor constituents to enhance cell performance.

- **Separator**
  - The baseline material for the separator, which provides electrical isolation between the electrodes while still allowing efficient ionic diffusion between them is a nylon* blend similar to that currently used in many nickel-cadmium cells.

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* Note: See “High temperature NiMH Development” presentation for changes made to these materials in Moltech's EMT Series of NiMH cells.

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➢Cell Construction...

- The NiMH couple lends itself to the wound construction shown in figure 3, which is similar to that used by present-day cylindrical nickel-cadmium cells. The basic components consist of the positive and negative electrodes insulated by separators. The sandwiched electrodes are wound together and inserted into a metallic can that is sealed after an injection of a small amount of electrolyte.
- Cylindrical cell designs are typically two piece designs, with metallic cases containing the electrode assembly serving as the negative terminal of the cell, and metallic top cover assemblies containing the vent mechanism serving as the positive terminal of the cell. These two parts are electrically isolated from each other by means of a seal ring.

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Cell Construction

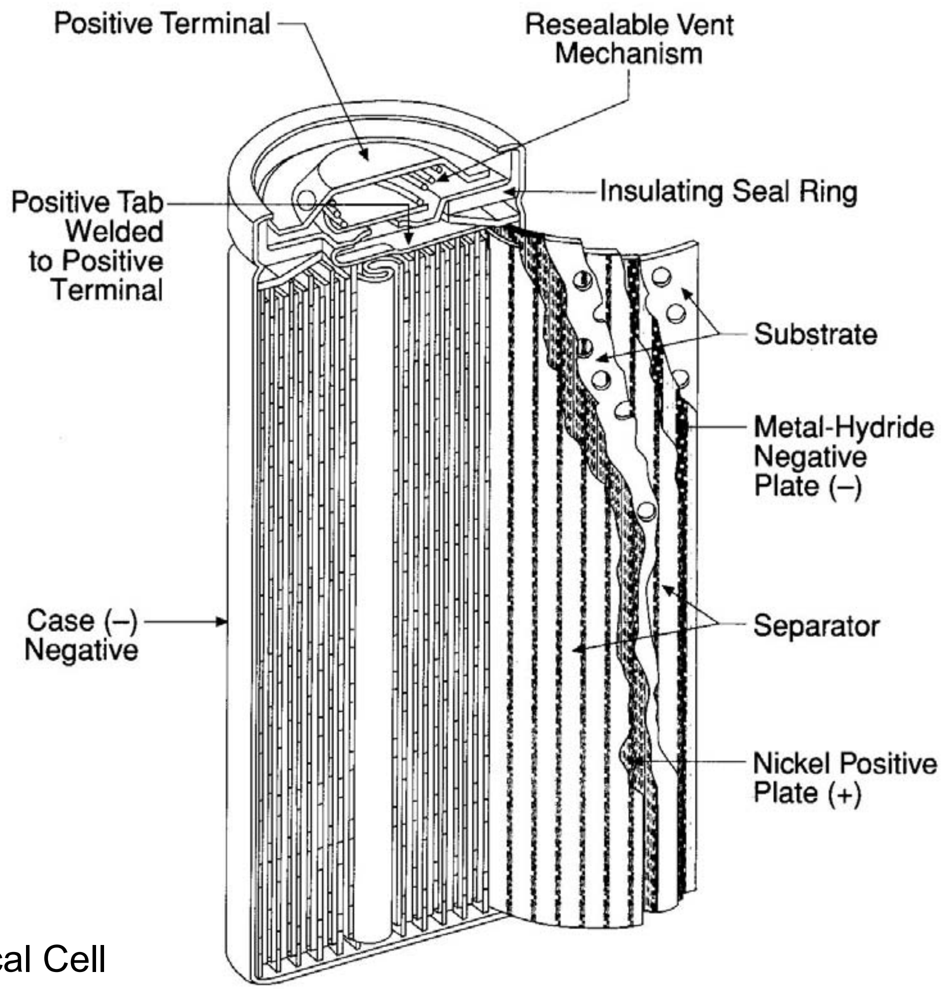

Figure 3.
Schematic Of Cylindrical Cell Construction

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Cell Construction

- Nickel-Metal Hydride cells contain a resealable safety vent built into the top as illustrated in figure 4. the nickel-metal hydride cell is designed so the oxygen recombination cycle described earlier is capable of recombining gases formed during overcharge under normal operating conditions, thus maintaining pressure equilibrium within the cell.
- However, in cases of charger failure or improper cell / charger design for the operating environment, it is possible that oxygen, or even hydrogen, will be generated faster than it can be recombined. In such cases the safety vent will open to reduce the pressure and prevent cell rupture. The vent reseals once the pressure is relieved.

Cell Construction

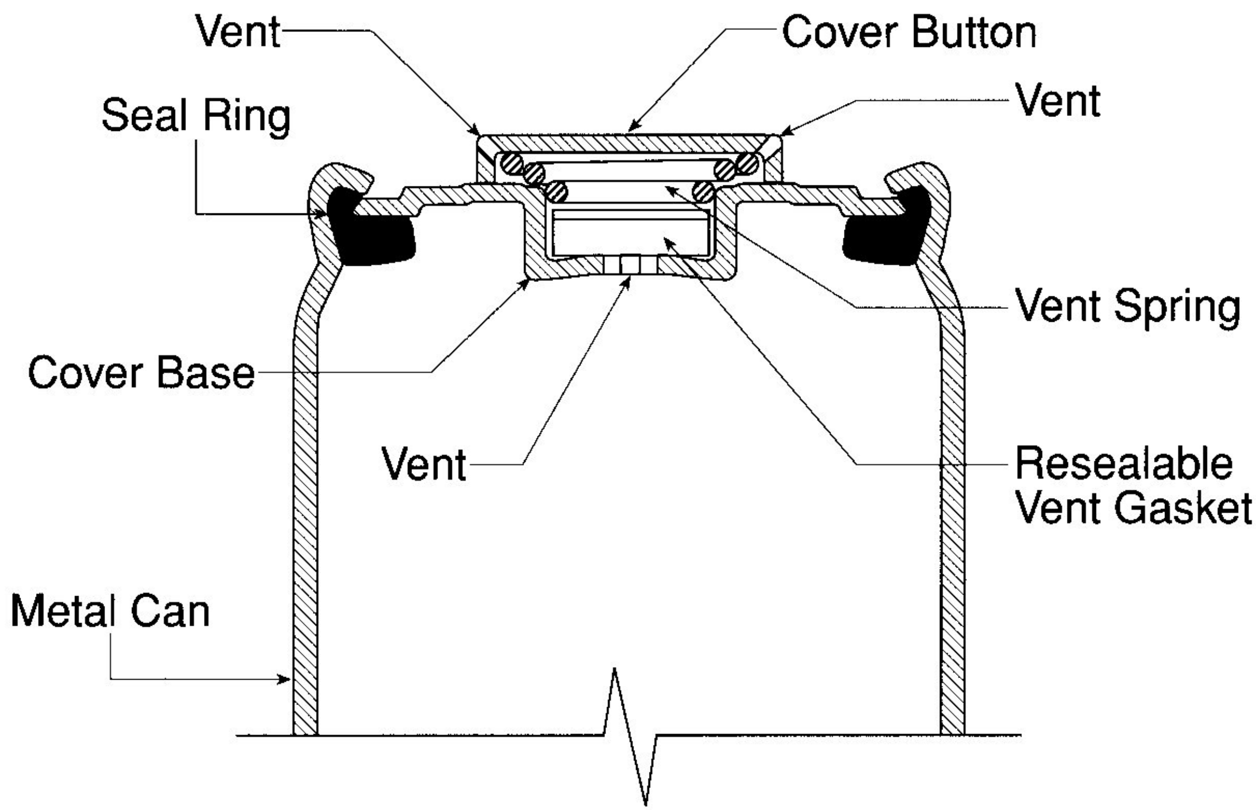

Figure 4.
Schematic Of Resealable Vent Mechanism

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