How to maintain NiMH Battery?

NiMH battery outperforms other rechargeable batteries and has higher capacity and less voltage depression. These properties make them ideal for use in high drain devices like digital camera.
The toxic **Cadmium** is absent in NiMH battery so it is the most **Eco friendly** one.

The NiMH battery is similar to NiCd cells in structure but it uses a **hydrogen absorbing alloy** as negative electrode instead of cadmium. The positive electrode is a **nickel oxy hydroxide (NiOOH)**.Alkaline batteries have approximately **3000 mAh capacity** with a 1000 mA load. Digital camera with LCD and flash light can draw over **1000 mA** quickly and depleting the alkaline batteries after a few shots. NiMH batteries on the other hand can easily handle the high current levels and maintain their full capacity. AA type NiMH cells have a nominal capacity (C) ranging from **1000 mAh to 2700 mAh** at 1.2 volts with a discharge rate of 0.2C / hour.

What is inside?

The NiMH battery has a special chemistry.There is an **'Inter metallic compound in the NiMH battery'**. Most NiMH cells use **AB5 or AB2** type metallic compounds. The common one is AB5 where **'A'** represents a rare earth mixture of **lanthanum, cerium, neodymium, praseodymium or titanium.** The **'B'** represents **nickel, cobalt, manganese etc**. But some NiMH cells use higher capacity negative materials based on AB2 compounds. Here 'A' represents titanium or vanadium and 'B' is nickel modified with chromium, cobalt iron etc. The metallic compound reversibly forms a mixture of **'metal hydride compound'**. When the battery is undergoing charging process, hydrogen ions are forced out of potassium hydroxide electrolyte solution by the charging voltage. This avoids the formation of gas inside. During the discharge process, the same ions are released to participate in the reverse reaction. When over charged at low current, oxygen produced at the positive electrode passes through the separator and recombines at the surface of the negative electrode. Hydrogen production is suppressed and the charging energy converts to heat. This makes the NiMH battery maintenance free.

Features of NiMH Battery

Voltage

Typical NiMH battery is rated **1.2 volts/cell**. This is the nominal voltage of the cell that is discharging at the rate of **C/10 at 25 degree** centigrade to an end voltage of 1 volt. The battery pack has three 1.2 volt cells making a total **3.6 volts**. When a fully charged battery is used, the discharge voltage starts from 1.5 volts followed by a sharp drop to 1.3 volts. The voltage in the cell remains 1.3 volts to 1.2 volts until another voltage drop occurs during a deep discharge. The nominal voltage of the battery can be calculated by dividing the battery power by its capacity

Nominal voltage = Wh / Ah. That is Watt hour / Ampere hour

Charge Efficiency

It is the ratio (in percentage) of the charge removed from the battery during discharge compared to the energy used during charging to restore the original capacity. It is also called**' Charge Acceptance'or'Coulombic Charge'.** Charge efficiency is adversely affected by temperature. Low temperature reduce charge acceptance and increase charge time.

Rate capacity

It is the maximum rate a battery cell can charge or discharge. **'Capacity'** refers to the electric current in the battery which is expressed in **Ampere-Hour(Ah) or MilliAmpere-Hour(mAh)**.Abbreviation **'C'** represents the rated capacity of the battery. That is the battery charge or discharge **CmA for one hour or 2C for 30 minutes.** In NiMH cells, the capacity is usually represented in **mAh**. The 'rated capacity' of the battery can be calculated by multiplying the time taken to discharge the battery to the end voltage by the rate of discharge current. For example, a 1500 mAh battery takes 1 hour to attain 1 volt per cell if it is discharged at the rate of 150 mA. The rate current denoted as 'C' is either charge or discharge current in the battery. If 1500 mAh is discharging at the rate of C/2 will have a discharge current of 750 mA per hour. The rated capacity of the battery is not the capacity obtained for use but its charging/discharging rate.

Internal impedance

When battery provides current, a resistance develops inside the battery. This is called internal impedance. It includes both dc and ac resistance. The internal impedance of NiMH battery is too small and the electrode easily becomes polarized and a polarization resistance will be produced while measuring the dc resistance. So that it is difficult to measure the accurate value .

Self discharge

A fully charged battery loss it capacity when not in use for long time. The self discharge rate of NiMH battery is 5-10% on the first day. Self discharging property makes NiMH battery unsuitable for many light duty uses such as digital clocks, remote control devices etc where battery would normally be expected to last many months. Temperature at which the battery is stored is very important. Higher temperature above 55 degree increases self discharge rate.

Memory effect

'Memory effect' which causes the battery to **'remember'** how much charge was released on previous discharge. So that the same amount of energy is released with every charge/discharge cycle. The battery then keeps the ‘memory’ of the primary platform and considers it as the end of discharge for the next cycle even though the battery can be discharged further. If a ‘memory effect’ develops, during the next discharge cycle, battery only remembers this. **Memory effect is less in NiMH battery**

Voltage depression

When the battery is discharged below 0.8 volt per cell, one weaker cell may goes to zero volt first. If the battery is deeply discharged, it charges in the ‘reverse’ direction. This creates “Voltage depression” and the battery performance suddenly drops. So in order to avoid this problem, it is necessary to charge the battery when it holds less than 5% of C.

Over charge

When the battery is charging continuously after it gets fully charged, the positive capacity becomes higher than the negative, resulting in oxygen generation from the positive which passes to the negative side. If the charge current is too high or charging time is prolonged, the generated oxygen cannot be used up in time. This creates high internal pressure leading to battery distortion and damage.

Over discharge

When the battery attains the specified voltage, it still posses the ability to discharge the stored current. In NiMH cells, the safe ‘end voltage’ limit of individual cell in the pack is 1 volt at 0.2C to 2C. If the cell is discharging below this end voltage, say for example 0.8 volt per cell at 3C or more, over discharge takes place.

Short circuit

If the NiMH battery terminals are shorted with a conductive material (even moisture), the electrolyte pressure and internal gas pressure increases suddenly, and the electrolyte leak out from the battery and in extreme cases battery will explode.

Charging Method

If it is properly maintained, the life of the battery NiMH battery can be extended up to 2 years depending on the use. The basic parameters involved in NiMH battery charging are

Charge current

NiMH battery is a high current device holding more than **3000 mAh current**. So charging current and voltage are very important aspects. Current required for the battery depends on its capacity’C’ which is expressed in Ah or mAh in the battery specification. For example, if the ‘C’ value of the battery pack is **1300 mAh**, it requires **1.3Ah** (1300 mAh)**current to get fully charged.** The charging current can be calculated using the formula

0.1C / mAh

If the capacity C is 1300 mAh, then the required current for normal charging is
0.1C / 1300. That is 130 mA.
1C of 1300 mAh battery equals 1300 mAh current

Charge voltage

About 1.4 to 1.6 volt per cell is needed for NiMH battery pack for charging. A fully charged cell measures 1.35 to 1.4 volts in the unloaded condition. During discharge the cell can provide 1.2 volts down to 1 volt. If the voltage level decreases below 0.8 volts, the cell may be permanently damaged.

What happens during charging?

Charging is the' pumping' of electrical energy in the chemical content of the cell. Continuous pumping of current faster than the chemical reaction to accept the charge can reduce the **'charge accepting property'** of the chemicals inside the battery cell. This leads to polarization, overheating and corrosion of electrodes etc. The reason for this is that here is a 'reaction gradient' exists between the electrodes in the electrolyte. The electrolyte close to the electrode 'charge' first and then the electrolyte far away from the electrode.

Two important chemical changes take place during charging. These are **'Charge transfer' and 'Mass transport'**. In charge transfer, actual chemical reaction takes place in the electrolyte close to the electrodes. Mass transport is the movement or diffusion of materials formed during charge transfer from the surface of electrodes. So that further molecules can take part in the chemical reaction. Charge transfer is a fast process while mass transport is a relatively slow process continuing till all the materials in the electrolyte are transformed.

The time required for charge transfer is very low. That is 1 minute or less. But mass transport requires several hours to complete. These two phenomena are applicable in charging and discharging. Continuous pumping of current in fast or quick charge, causes 'quick charge transfer' so that there will not be sufficient time for mass transport. This will adversely affect the battery chemistry leading to passivation of electrolyte, crystal formation, gas accumulation, polarization etc. These **"Parasitic effects"** reduce the charge acceptance of the cell leading to poor performance. The best method to balance the charge transfer and mass transport is to provide **'rest periods'** during the charging process. This can be done by interrupting the charging current for one or more times for a short period to stabilize the chemical reaction.

Better care – better performance

It is important to consider the following to keep the NiMH battery in top condition.
NiMH cells are good for 500 to 1000 cycles if properly charged. A new battery needs full charging (Reforming) before use. It should be `charged and discharged minimum 5 times to attain full charge capacity. When a new NiMH battery is charged and connected to equipment, it will show full charge only for 10-15 minutes. If this occurs, remove the battery and allow it to cool for 15 minutes and then charge. Fast charging with 100%C should be terminated after 1.5 hours. Charger should be switched off if the battery temperature rises above 55 degree centigrade. Do not discharge the entire cells in the battery pack below 0.8 volt per cell to avoid voltage depression. NiMH cells do not accept full charge and discharge if the temperature is above 50 degree and below 0 degree. NiMH cells like 0-40 degree temperature. NiMH cells can hold full charge for a month if stored in normal temperature. If it is kept near hot objects or exposed in sunlight for hours, the charge will drop in one day. 'Condition' the battery once in a month. This is done by completely discharging the battery by running the equipment in battery power and then allows to charge completely.

If the battery is not used for long periods, first charge the battery fully and then remove it from the equipment and store in a cool dry place. Recharge again once in a month. Do not charge NiMH battery using raw DC (12or 24 V) available from the outlets of car or aircrafts since the voltage and current are not regulated. If emergency charging is required from such power sources, use a voltage and current regulator circuit in the charger. Do not 'flatten' the battery below 0.8V/cell and do not over charge beyond 100%C