Nickel-Cadmium Batteries

The **nickel–cadmium battery** (**Ni-Cd battery** or **Ni-Cad battery**) is a type of rechargeable battery using nickel oxide hydroxide and metallic cadmium as electrodes. The abbreviation *Ni-Cd* is derived from the chemical symbols of nickel (Ni) and cadmium (Cd): the abbreviation *NiCad* is a registered trademark of SAFT Corporation, although this brand name is commonly used to describe all Ni–Cd batteries.

Wet-cell nickel-cadmium batteries were invented in 1899 by Waldemar Jungner of Sweden. A Ni-Cd battery has a terminal voltage during discharge of around 1.2 volts which decreases little until nearly the end of discharge. Ni-Cd batteries are made in a wide range of sizes and capacities, from portable sealed types interchangeable with carbon-zinc dry cells, to large ventilated cells used for standby power and motive power.

Compared with other types of rechargeable cells they offer good cycle life and capacity, good performance at low temperatures, and work well at high discharge rates. However, the materials are more costly than types such as the lead acid battery, and the cells have higher self-discharge rates than some other types.

Ni-Cd cells were at one time and still widely used in portable power tools, photography equipment, flashlights, emergency lighting, and portable electronic devices. As well as numerous other devices we use on a daily basis.

Nickel-cadmium batteries are common for many reasons:

- Nothing is better (manufacture wise) better than a Ni-Cd battery. But it can also be the worst manufactured battery if not taken care of! Plain and simple.
- They were the mostly commonly available batteries at the time of production, with the ability to charge and discharge unlike an alkaline which once used is no longer of use anymore. This makes Ni-Cd perfect for applications such as your common household flashlights as well as drill packs or various other tools that require power packs. You might even find a Ni-Cd battery pack running your alarm panel at home too.
- At that time, the only direct competitor was the lead–acid battery, which was less physically and chemically robust. With minor improvements to the first prototypes, energy density rapidly increased to about half of that of primary batteries, and significantly greater than lead–acid batteries.
- In the past few decades, Ni–Cd batteries have had internal resistance as low as alkaline batteries. Today, all consumer Ni–Cd batteries use the "swiss roll" or "jelly-roll" configuration. This design incorporates several layers of positive and negative material rolled into a cylindrical shape. This design reduces internal resistance as there is a greater amount of electrode in contact with the active material in each cell.
- Ni–Cd batteries typically last longer, in terms of number of charge/discharge cycles, than other rechargeable batteries such as lead/acid batteries.

- You can “put away” a Ni-Cd battery with a little to no charge in it for storage, and still have it come back when you charge it prior to use again.

But that is not to say that Ni-Cd batteries are flawless. They have some disadvantages as well:

- Ni-Cd batteries can develop a memory effect. What’s a memory effect you ask? “Memory Effect” is when your battery thinks that it is fully charged but it isn’t. For example, let’s say your battery say it’s 70% charged, but it “thinks” that it is 100% charged. Under this condition, when installed on its charger it will stop recharging, because it is thinking that it is already full. When you start using your equipment, it will last shorter since it’s only in fact 70% charged.
- Memory effect develops because the cells itself, either weren’t completely discharged prior to recharge or were only partially charge prior to initial use. Thus making that initial charge the new “0%” when it may in fact have been at 40 or 50 %.
- Compared to lead–acid batteries, Ni–Cd batteries have a much higher energy density. A Ni–Cd battery is smaller and lighter than a comparable lead–acid battery. In cases where size and weight are important considerations (for example, aircraft), Ni–Cd batteries are preferred over the cheaper lead–acid batteries
- The terminal voltage of a Ni–Cd battery declines more slowly as it is discharged, compared with carbon–zinc batteries. Since an alkaline battery's voltage drops significantly as the charge drops, most consumer applications are well equipped to deal with the slightly lower Ni–Cd cell voltage with no noticeable loss of performance
- The primary trade-off with Ni–Cd batteries is their higher cost and the use of cadmium. This heavy metal is an environmental hazard, and is highly toxic to all higher forms of life. They are also more costly than lead–acid batteries because nickel and cadmium cost more. One of the biggest disadvantages is that the battery exhibits a very marked negative temperature coefficient. This means that as the cell temperature rises, the internal resistance falls. This can pose considerable charging problems, particularly with the relatively simple charging systems employed for lead–acid type batteries. Whilst lead–acid batteries can be charged by simply connecting a trickle charger to them, with a simple electromagnetic cut-out system for when the charger is stationary or an over-current occurs, the Ni–Cd battery under a similar charging scheme would exhibit thermal runaway, where the charging current would continue to rise until the over-current cut-out operated or the battery destroyed itself. This is the principal factor that prevents its use as engine-starting batteries. Today with alternator-based charging systems with solid-state regulators, the construction of a suitable charging system would be relatively simple, but the car manufacturers are reluctant to abandon tried-and-tested technology.

Inside a Ni-Cd Battery Pack or Cell

This battery uses nickel oxide in its positive electrode (cathode), a cadmium compound in its negative electrode (anode), and potassium hydroxide solution as its electrolyte.

The Nickel Cadmium Battery is rechargeable, so it can cycle repeatedly. A nickel cadmium battery converts chemical energy to electrical energy upon discharge and converts electrical energy back to chemical energy upon recharge.

In a fully discharged Ni-Cd battery, the cathode contains nickel hydroxide [Ni(OH)2] and cadmium hydroxide [Cd(OH)2] in the anode. When the battery is charged, the chemical composition of the cathode is transformed and the nickel hydroxide changes to nickel oxyhydroxide [NiOOH]. In the anode, cadmium hydroxide is transformed to cadmium. As the battery is discharged, the process is reversed. As shown in the following formula.

$$2Ni(OH)2+Cd(OH)2 \text{ <-- charge/discharge --> } 2NiO\ OH + Cd + 2H20$$

Ni–Cd cells have a nominal cell potential of 1.2 volts (V). This is lower than the 1.5 V of alkaline and zinc–carbon primary cells, and consequently they are not appropriate as a replacement in all applications. However, the 1.5 V of a primary alkaline cell refers to its initial, rather than average, voltage. Unlike alkaline and zinc–carbon primary cells, a Ni–Cd cell's terminal voltage only changes a little as it discharges. Because many electronic devices are designed to work with primary cells that may discharge to as low as 0.90 to 1.0 V per cell, the relatively steady 1.2 V of a Ni–Cd cell is enough to allow operation. Some would consider the near-constant voltage a drawback as it makes it difficult to detect when the battery charge is low.

Ni–Cd batteries used to replace 9 V batteries usually only have six cells, for a terminal voltage of 7.2 volts. While most pocket radios will operate satisfactorily at this voltage, some manufacturers such as Varta made 8.4 volt batteries with seven cells for more critical applications. 12 V Ni–Cd batteries are made up of 10 cells connected in series.

Sealed Ni–Cd cells may be used individually, or assembled into battery packs containing two or more cells (each cell containing 1.2 Volts). Small cells are used for portable electronics and toys, often using cells manufactured in the same sizes as primary cells. When Ni–Cd batteries are substituted for primary cells, the lower terminal voltage and smaller ampere-hour capacity may reduce performance as compared to the primary cell it would have contained.

Specialty Ni–Cd batteries are used in cordless and wireless telephones, emergency lighting, and other applications. With a relatively low internal resistance, they can supply high surge currents. This makes them a favourable choice for remote-controlled electric model airplanes, boats, and cars, as well as cordless power tools and camera flash units.

Nickel-Cadmium Cells

They are made of two thin plates of nickel oxy-hydroxide and cadmium which are flattened together and rolled up into a cylinder shape. The nickel oxy-hydroxide acts as the anode, and the cadmium acts as the cathode. The catalyst is the electrolyte fluid which fills the battery, known as potassium hydroxide. This causes an electrical charge to build between the anode and the cathode.