RECHARGEABLE NI-CD BATTERIES

Responding to the Technological Revolution with Consistent Reliability!

Overview

Rechargeable Ni-Cd batteries are one type of alkaline storage battery, which is classified as a secondary battery. Ni-Cd batteries use nickel hydroxide as the positive electrode, cadmium as the negative electrode, and an alkaline electrolyte. They are designated by IEC 285 as alkaline secondary cells and batteries “Sealed nickel-cadmium cylindrical rechargeable single cells”. First invented by Jungner of Sweden in 1899, the basis for practical application of rechargeable Ni-Cd batteries was made possible about 50 years later by the development of the totally sealed cell by Neumann of France.

Ever since our development and practical application of rechargeable Ni-Cd batteries in 1961, for over 30 years Panasonic has continued to make innovations and improvements in order to meet the ever-increasing needs and demands of the market. As a result, our rechargeable Ni-Cd batteries are used for all types of applications throughout the world. Panasonic has also applied many original technological developments in our rechargeable Ni-Cd batteries, including the fabrication of the negative electrode by a pasted method, the fabrication of the positive electrode by a sintered method or by using a new foamed metal material, and the use of a new thin type separator, thus achieving ever-higher levels of reliability and performance. In particular, reflecting the needs of the market, our SM120 and SM80 Series were developed as a new High Capacity and Rapid Charge type, challenging the limits of Ni-Cd batteries to provide both rapid charge and approximately double the capacity of our standard type.

Because Ni-Cd batteries are made using the scarce natural resources of nickel and cadmium, Panasonic is making a positive effort for recycling them from the viewpoint of protecting the global environment and ensuring the efficient utilization of the earth’s natural resources.

Giving top priority to meeting the needs of our customers, Panasonic will continue to develop new products for providing power to the devices that are so important to today’s comfortable, enjoyable, and productive living.

Construction

Rechargeable Ni-Cd batteries are comprised of a positive electrode plate which uses nickel hydroxide as its main active material, a negative electrode plate which uses a cadmium compound as its main active material, a separator made of a thin non-woven fabric, an alkaline electrolyte, a metal case, a sealing plate provided with a self-sealing safety valve, and other components. The positive and negative electrode plates, isolated from each other by the separator, are rolled in a spiral shape inside the case and sealed by the sealing plate by means of an insulation gasket. In battery types which are designed for high-current discharge, such as the “P” Series, our unique collection system is used for the collectors of the positive and negative electrode plates. By making the side walls of the metal case thinner, it became possible for the battery to be lighter in weight and to have a larger internal volume than previous models.

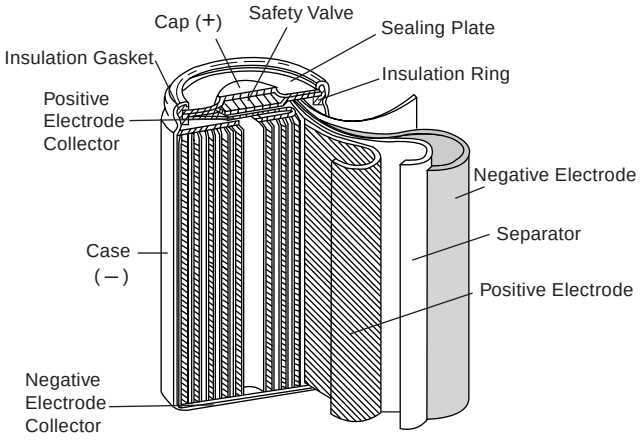


Figure 1 Construction

Battery Reactions

Generally, in rechargeable cells there are three different electro-chemical reactions: the discharge reaction which supplies electrical power to the load of the battery, the charge reaction which restores that electrical power, and the oxygen gas generation reaction resulting from the electrolysis of water on the positive electrode which occurs after the completion of charge, or, in other words, during overcharge. For rechargeable Ni-Cd batteries, the charge and discharge reactions are illustrated by the formula shown below.

The special characteristic of these reactions is that the alkaline electrolyte, for example, potassium hydroxide (KOH), does not apparently contribute directly to the reactions.

Positive Negative Discharge

$$2NiOOH + Cd + 2H_2O \rightleftharpoons 2Ni(OH)_2 + Cd(OH)_2$$

nickel oxyhydroxide; metal Cadmium; Water; Charge; Nickel hydroxide (1st); Cadmium hydroxide

The battery is designed so that the capacity of the negative electrode is larger than that of the positive electrode, and the gas generated at the positive electrode is absorbed by reacting with the unreacted part of the negative electrode, thus making it possible for the battery to be completely sealed. In this design, the reactions become as follows.

Positive $2OH^- \longrightarrow \frac{1}{2}O_2 + H_2O + 2e^-$

Negative $Cd + \frac{1}{2}O_2 + H_2O \longrightarrow Cd(OH)_2$

$Cd(OH)_2 + 2e^- \longrightarrow Cd + 2OH^-$

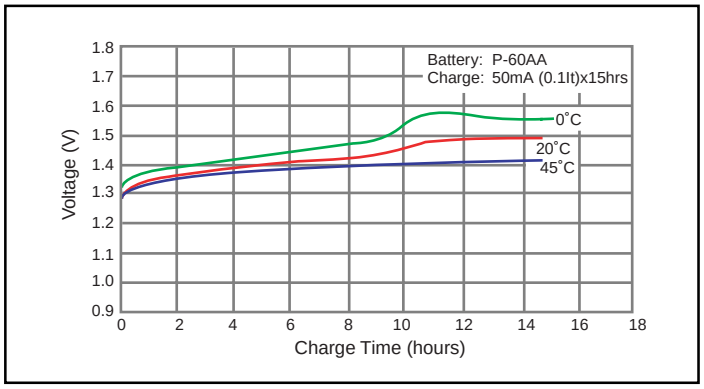
Five Main Characteristics of Ni-Cd Batteries

Ni-Cd batteries have five main characteristics: charge, discharge, cycle life, storage, and safety.

1. Charge Characteristics

The charge characteristics of Ni-Cd batteries are affected by the current, time, temperature, and other factors. Increasing the charge current and lowering the charge temperature causes the battery voltage to rise. Charge generates heat, thus causing the battery temperature to rise. Charge efficiency will also vary according to the current, time, and temperature. For rapid charge, a charge control system is required; refer to the following section on the charge methods for Ni-Cd batteries.

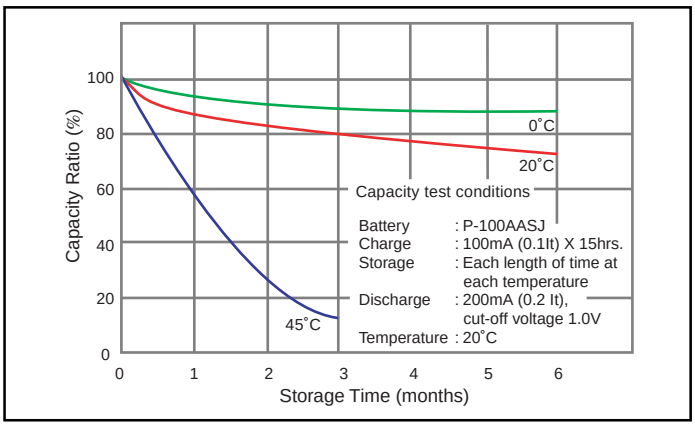
Typical Charge Characteristics



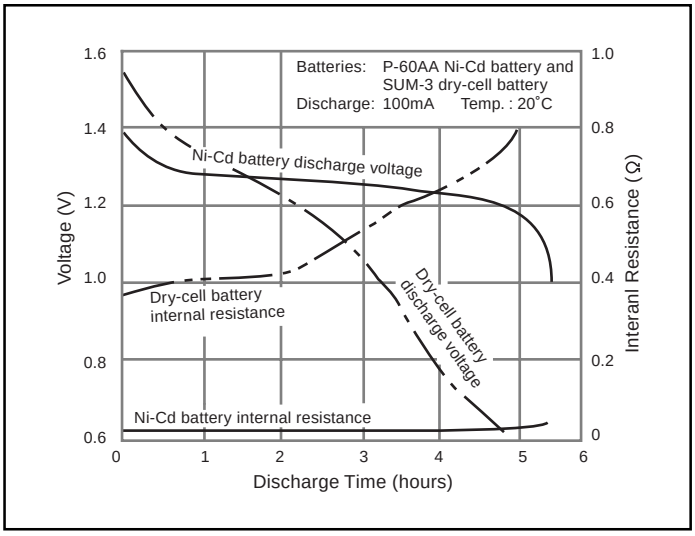
2. Discharge Characteristics

The discharge characteristics of Ni-Cd batteries will vary according to the current, temperature, and other factors. Generally, in comparison with dry-cell batteries, there is less voltage fluctuation during discharge, and even if the discharge current is high, there is very little drop in capacity. Among the various types of Ni-Cd batteries, there are models such as Panasonic's "P" type which are specifically designed to meet the need for high-current discharge, such as for power tools, and there are also models such as our new High Capacity and Rapid Charge type which are designed to meet the need for high capacity, such as for high-tech devices.

Typical Self-discharge Characteristics



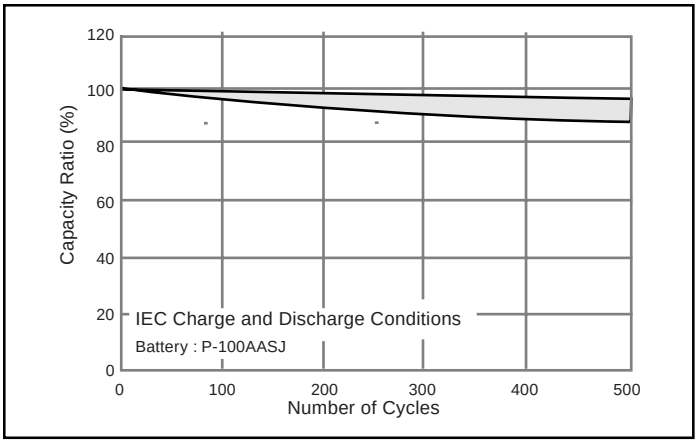
Typical Discharge Characteristics (Comparison with Dry-cell)



3. Cycle Life Characteristics

The cycle life of Ni-Cd batteries will vary according to the charge and discharge conditions, the temperature, and other usage conditions. When used in accordance with the IEC charge and discharge specifications, over 500 charge/discharge cycles are possible. The actual cycle life will vary according to which of the various charge formats is used, such as for rapid charge, and also according to how the device powered by the batteries is actually used.

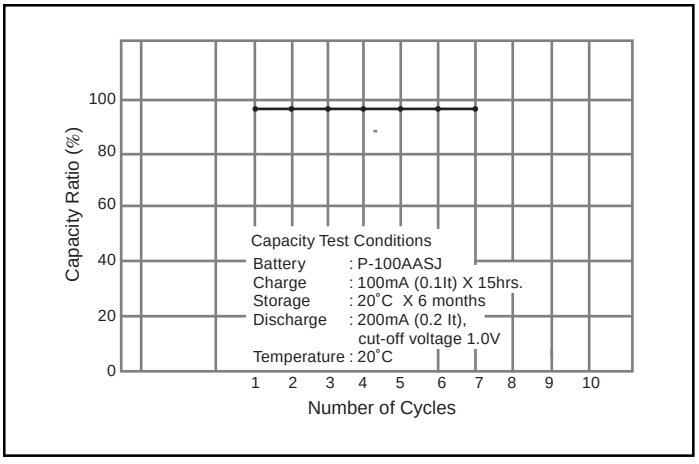
Typical Cycle Life Characteristics



4. Storage Characteristics

When Ni-Cd batteries are stored in a charged state, the capacity will gradually decrease (self discharge), and this tendency will be markedly greater at high temperatures. However, the capacity can be subsequently restored by charge. Even if the batteries are stored for an extended length of time, if the storage conditions are appropriate, the capacity will be restored by subsequent charge and discharge.

Typical Capacity Recovery After Storage



5. Safety

If pressure inside the battery rises as a result of improper use, such as overcharge, short-circuit, or reverse charge, a resetable safety valve will function to release the pressure, thus preventing bursting of the battery.