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General Battery Overview

General Overview of Battery Chemistries

Unlike mass-market, single-use batteries, rechargeable batteries vary in chemistry, construction and size. Designs vary according to the usage requirements, such as power draw, form factor and operating temperatures, of the device for which they are designed. Some battery designs accommodate fast charging better than others, but charging speed can be limited by the size of the power supply available to provide sufficient current for a faster charging rate.

What is a battery?

A battery is a device that generates an electrical current by chemical reaction.

How does a battery work?

Batteries operate on a simple theory: two dissimilar metals in contact with an electrolyte will produce a flow of electrons (electricity) when all elements are in contact with each other.

What are the different categories of batteries?

Batteries fall into two general categories -- primary batteries and secondary batteries.

Primary batteries cannot be recharged or "brought back to life" once they have used up their power. Examples of primary batteries include alkaline batteries that are commonly used in flashlights, portable radios and miscellaneous consumer electronics devices.

Secondary batteries, also known as storage batteries, are capable of being recharged and reused up to 500 times (charge/discharge cycles). Nickel Cadmium, Nickel-Metal Hydride and Li-Ion batteries (used in many portable electronic devices such as two-way radios and bar code scanners) are examples of this type (belong to this category).

What are the different battery chemistries?

The following are the three most common chemistries utilized in battery cells. Their general characteristics and primary uses are noted below (See Appendix for more information):

Nickel Cadmium (Ni- CD)

Nickel Cadmium is one of the most rugged rechargeable batteries. They are very suitable for use in small, portable devices such as two-way radios and power tools. Ni-CD batteries perform well in the rigorous conditions such as low temperatures, can be re-charged immediately even after long periods of storage, and are economically priced. However, if a

battery is not maintained properly (i.e. not fully discharged after each use) it develops a condition known as 'memory effect'.

For decades, NiCd batteries have been the “workhorse” of the portable industry. Compared to other battery types, NiCd costs the least per cycle to operate, and can last more cycles – from 300-600 under normal conditions. The drawbacks to NiCd batteries is their heavier weight, their susceptibility to the memory effect, which decreases capacity, and their cadmium content, which means they must be disposed as hazardous chemicals. NiCd batteries can be charged in as little as 1-2 hours, but most NiCd chargers take three to 16 hours to deliver a full charge. The factor limiting charge time for every battery is the amount of polarization that develops. The polarization results from different mechanisms, including mass transport and diffusion limitations. **DEW** technology has successfully increased charging speed to meet the electrochemical state of the battery, and achieved more than 2000 cycles on average with NiCd batteries.

Nickel Metal Hydride (Ni- MH)

The Nickel Metal Hydride (Ni-MH) battery is a rechargeable battery chemistry that can be used to replace Ni-CD's in certain applications. Ni-MH shows significant improvements over Ni-CD rechargeable batteries in terms of performance (significantly reduced 'memory effect' when compared with Ni-CD), increased energy density, environmental friendliness, and lighter weight.

NiMH batteries have replaced NiCds in many applications where weight and capacity impact the marketability of the portable device. NiMH use is increasing in countries with strict environmental codes, as NiMH is believed to have fewer toxic disposal limitations than NiCd. NiMH can cost about twice as much as a NiCd battery, and has somewhat better weight and volume energy density than NiCd. However, NiMH evolves more heat than NiCd during charging, has a higher rate of self-discharge and is more difficult to terminate at full capacity during charging.

Lithium Ion (Li- Ion)

Among the three basic chemistries, this is the most advanced .The Lithium Ion (Li-Ion) battery is a very high energy density rechargeable chemistry, has low self- discharge, and no memory effect. This chemistry is ideal when smaller and lighter weight batteries are required such as cell phones and laptop computers.

The Li-Ion battery is fast becoming the portable battery of choice on the market today. However, high costs and fewer charge/discharge cycles have limited its application to very portable, premium products such as laptops, medical devices, and cellular phones that require lighter weight and extended run time. Since lithium is a highly reactive metal, extra precautions must be taken to ensure the batteries are fully charged without being overcharged. Although standards of Li Ion batteries have improved, safe handling is a priority. Overcharging and overheating can result in damage to the battery and its associated device. With standard chargers, Li Ion batteries are charged in 3-6 hours and last about 300 cycles. **DEW** technology charges Li on batteries in less than 90 minutes and averages 1800 cycles.

What is Volt?

Volt (V) can be explained as the “Pressure” that is created by the electric source such as a cell phone or two way radios (i.e.: garden hose water pressure).

What is Amperage?

Ampere (Amps) = the “Quantity” of electron flow (i.e.: gallons of water available)

What is milliampere-Hours (mAH)?

Volts x Amps = Watts. Usually expressed in milliampere-hours (mAH) when less than 1000 and ampere-hours (AH) when 1.0 or higher. To summarize, ‘mAH’ can be explained as the ‘capacity’ of the battery, i.e. the amount of power that is packed into the battery. Higher ‘mAH’ rating results in longer battery life between charges.

What is “Memory Effect”?

Capacity decrease and voltage drop in a battery caused by continuous charging and incomplete discharging. This process causes a battery to hold less charge over time. Ni-CD batteries tend to suffer from memory effect more than the Ni-MH ones. For instance, when a battery is used for a few hours it depletes some of its capacity but say it still leaves around 50% of its capacity intact. If this partially charged battery is re-charged repeatedly without being fully discharged first, it will gradually develop a “memory” that will degrade the capacity to 50% of its true value because of poor battery maintenance.

What is cycle life?

Cycle life is the number of times a battery can be charged and discharged before it runs out of its energy. One cycle is defined as a full charge followed by discharge.

What is self- discharge?

A reversible capacity loss in Ni-CD and Ni-MH batteries; it occurs when the batteries are not in use for extended periods of time. Most batteries lose 1% to 2% of their energy every day, depending on humidity and temperature of the storage place.

What charging precautions should be taken when charging a battery pack?

Clean contacts: To achieve optimum charge contact, be sure both charger and battery contacts are clean. Dirty contacts can result in a charger/battery malfunction.

Optimum charging temperature: Ni-CD batteries are designed to be operated and charged at 65°F. Charging batteries in high temperatures causes the battery to reach a point where the battery discharges, due to faster chemical reactions caused by higher temperatures. Thus a battery never reaches full charge giving ‘memory effect’. Conversely, chemical reactions slow with cold ambient temperatures. At cold temperatures, the cells may not be able to accept the charge current. This builds pressure and creates the potential for cell rupture. As a rule, never charge a battery when the ambient temperature is warmer than 120°F or colder than 40°F.

What steps should be followed for the initial charge cycle to maximize battery performance?

All batteries are shipped uncharged. Initially, all new batteries must be charged for 14 - 16 hours continuously. All batteries require a "break-in" period, so don't be alarmed if your battery doesn't hold a full charge right away. A new battery may show false full charge as indicated on your charger. Also the battery may not power up the device because of low voltage.

It is recommended that for the first 5 to 10 cycles one must charge the battery fully and drain it fully before recharging. This will properly condition the battery and will ensure that it will operate at its maximum capacity. This is recommended for all batteries. You can discharge most batteries by unplugging the charger and leaving the battery in the device (e.g. two-way radio) and leaving the device turned on until completely discharged.

What precautions should be taken when storing battery packs?

It is very important that batteries be stored in cool dry places away from heat and metal objects.

How should batteries be charged after they have been in storage (or un-used) for over three months?

It is recommended to use a slow trickle charge for batteries that have been stored for more than 3 months. After the first slow charge, a rapid charge may be used.

It is also recommended that periodic battery analyzing and conditioning should be considered to prolong battery life while assuring the battery has enough capacity to run the equipment for the necessary time period.

APPENDIX: Highlights of Battery Chemistries

•NiCd

<u>Plus</u>	<u>Minus</u>
Inexpensive / Mature	Moderately Heavy
High Current Draw	Environmental Issues
High Cycle Life	Memory Effect
Wide Temp Range	Moderate Self Discharge
-20 to 60C Operating	1000 - 2400 mAh cap.
-30 to 50C Storage	
5 to 30C Charge	
Fastest Charge	
Store Discharge for 5+ years	

NiMh

<u>Plus</u>	<u>Minus</u>
25 to 30% Smaller & Lighter than NiCd	More Expensive

Fewer Environmental Issues ?
Less Memory Effect
2000 to 2800 mAh Capacity

Lower Cycle Life
Limited Current Draw
Impedance creep
Limited Temp Range
0 to 40C Operating
-20 to 30C Storage
Greater Self Discharge

●Li-ion (et al)

<u>Plus</u>	<u>Minus</u>
Light and Smaller	Expensive
Low Self Discharge	Slow Charge Rate
Packaging Options	Sensitive to Overcharge
2500 to 3500 mAh Cap.	Reacts with oxygen
Consistent Current Draw	Low (est) Cycle Life
	Prefers partial Discharges

Summary of ACT iCHARGE Product Line Advantages:

- Fastest Charger - 30 minutes for 1200mAh
- Fewer bays required per radio
- Greatest possible availability
- Conditions Battery to a Like New Condition / each charge
- Eliminates Memory Effect
- No Heat - Batteries are not cooked
- Two to Three Times Life Improvement
- Patented process, reduces battery expenses
- Last Battery Charger You Will Ever Purchase
- Universal Adapters for Most Radios
- Field Upgradeable