Care and Feeding of Rechargeable Batteries

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Battery Types

* Lead Acid
* Nickel-Based
  * NiCd
  * NiMH
* LSD
* Li-ion
Battery Charging

- Lead Acid
- Nickel-based
- Battery Packs
- Analyzers & Chargers
Before We Begin

Some Definitions

Battery capacity is rated in Amp-hours (Ah)

- It is the number of amperes times the number of hours that the battery can supply
- A 20 Ah battery can supply 1 A for 20 hours, 4 A for 5 hours, etc.

The letter ‘C’ is used to represent the capacity of a battery

- Often used in describing charge rates
- To charge a 1 Ah battery at a 0.5C rate means to charge with 500 mA
Battery Types

Different Chemistries
Sealed Lead Acid (SLA)

7 Ah

26 Ah

40 Ah
Sealed Lead Acid (SLA)

**Pros**
- Inexpensive and simple to manufacture
- Mature, reliable and well-understood technology
- Self-discharge is among the lowest of rechargeable batteries
- Capable of high discharge rates

**Cons**
- Low energy density - poor weight-to-energy ratio limits use to stationary and wheeled applications.
- Cannot be stored in a discharged condition - the cell voltage should never drop below 2.10V.
- Allows only a limited number of full discharge cycles - well suited for standby applications that require only occasional deep discharges.
NiCd - Nickel Cadmium
NiCd - Nickel Cadmium

* **Pros**
  * Fast and simple charge
  * High number of charge/discharge cycles - over 1000 cycles
  * Good load performance
  * Good low temperature performance
  * One of the most rugged rechargeable batteries.
  * Economically priced

* **Cons**
  * Relatively low energy density
  * Memory effect - nickel-cadmium must periodically be exercised (discharge/charge) to prevent memory
  * Environmentally unfriendly - nickel-cadmium contains toxic metals
  * Relatively high self-discharge - needs recharging after storage
NiMH - Nickel Metal Hydride
**NiMH - Nickel Metal Hydride**

**Pros**
- 30-40% higher capacity than standard nickel-cadmium
- Less prone to memory than nickel-cadmium
- Environmentally friendly - contains only mild toxins

**Cons**
- Limited discharge current - heavy load reduces the battery's cycle life.
- More complex charge algorithm needed
- Trickle charge settings are critical
- High self-discharge - typically 50% higher than nickel-cadmium
- High maintenance - nickel-metal hydride requires regular full discharge to prevent crystalline formation
LSD - Low Self Discharge

Also known as ‘Hybrid’
LSD - Low Self Discharge

**Pros (vs. NiMH)**
- Much longer shelf life
- Better cycle life
- Same environmentally friendliness

**Cons (vs. NiMH)**
- Lower initial capacity
- Higher cost
After only three weeks of storage, the Eneloops have more capacity remaining.

After about 3.5 months, the Eneloops will have twice the capacity of the traditional cells.
Cycle Life

Discharge Capacity (mAh) vs. Number of Cycles

Cycle Condition:
- Charge: 0.1C x 16h
- Rest: 10min
- Charge: 0.25C x 3h10min
- Discharge: 0.25C x 2h20min
- Charge: 0.25C x 3h10min
- Discharge: 0.25C(E.V.1.0V)
- Charge: 0.1C x 16h
- Rest: 1h
- Discharge: 0.2C(E.V.1.0V)
- Ambient Temp.: 20deg-C

conventional
Li-ion - Lithium Ion

**Pros**
- Highest energy density available
- Good cycle life - 500 cycles

**Cons**
- Risk of FIRE if abused
- Only available packaged with safety circuit
- Complex, tightly controlled charger
- High cost
Battery Charging

Different Procedure for Each Chemistry
Sealed Lead Acid (SLA)

Stage 1: Constant Current between 0.1C and 0.3C

Stage 2: Constant Voltage at 2.4V/cell (14.4V for a 12V battery) for 5 hours

Stage 3: Float Charge at 2.25V/cell (13.5V for a 12V battery)
Nickel-Based

- Avoid high temperature during charging
- A charger for nickel-metal-hydride can also accommodate nickel cadmium, but not the other way around. A charger designed for nickel-cadmium would overcharge the nickel-metal-hydride battery.
- Nickel-based batteries prefer fast-charge. Lingering slow charges cause crystalline formation (memory).
- If not used immediately, remove the battery from the charger and apply a topping-charge before use. Do not leave nickel-based battery in the charger for more than a few days, even if on trickle charge.
Battery Packs

And why they often die young
Battery Pack

Made up of multiple cells in series
Two Cell Example

- The upper cell has less capacity than the lower one.
- During discharge it will empty first.
- The lower cell still has some capacity left.
- If discharge is continued, the upper cell will be damaged.
Two Cell Example

A similar problem occurs during charging.
During charging the upper cell will reach full charge first.
If charging continues, the upper cell will be damaged.
Continuing charge/discharge cycles further damage the upper cell and the pack dies.
Solution

* Use a battery pack made from individual rechargeable cells

* AA battery pack

* Charge the cells individually outside of the pack

* Do not run the pack all the way down
Battery Chargers

Why to spend a little extra
Considerations

* Charge cells individually
* Capable of fast charge
* Voltage and temperature monitoring
* Capacity analysis
### LaCrosse Alpha BC-900

**Charging Current:** Indicates mA charge rate

**Discharging Current:** Indicates mA discharge rate

**Time Elapsed:** Indicates charging time (hh:mm)

**Accumulated Capacity:** Indicates battery’s full capacity (mAh or Ah)

**Terminal Voltage:** Measures battery voltage (can be displayed in any mode)

### Displays & Modes

- **Charge Mode**
  - Within 4 seconds charging automatically begins at 200mA, or select 500, 700, 1000, 1500 or 1800 mA settings for faster charging times.

- **Discharge Mode**
  - Reduce memory effect in rechargeable batteries by discharging completely then recharging to full capacity in one cycle. User selectable mA.

- **Refresh Mode**
  - Batteries will be discharged and recharged 20 cycles or until batteries are refreshed to maximum capacity. User selectable mA.

- **Test Mode**
  - Batteries are charged to full capacity, discharged completely to measure capacity for display in mAh or Ah, then recharged to full capacity.

**All Modes**
- Automatically switches to Trickle Charge at the end of last charging cycle.
Battery Analyzers
For the truly committed
West Mountain Radio
CBA-II

Computerized Battery Analyzer
CBA II

![Image of CBA-II](image_url)

![Graph showing battery discharge characteristics](image_url)
Cadex Battery Analyzer
Acknowledgements & Links

* Battery University
  * http://www.batteryuniversity.com
* http://www.stefanv.com/electronics/sanyo_eneloop.html
* http://www.eneloop.info
* http://www.lacrossetechnology.com/900/
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