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

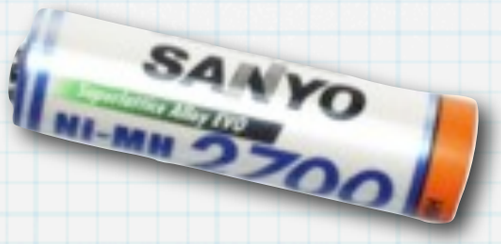
Pros

* 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

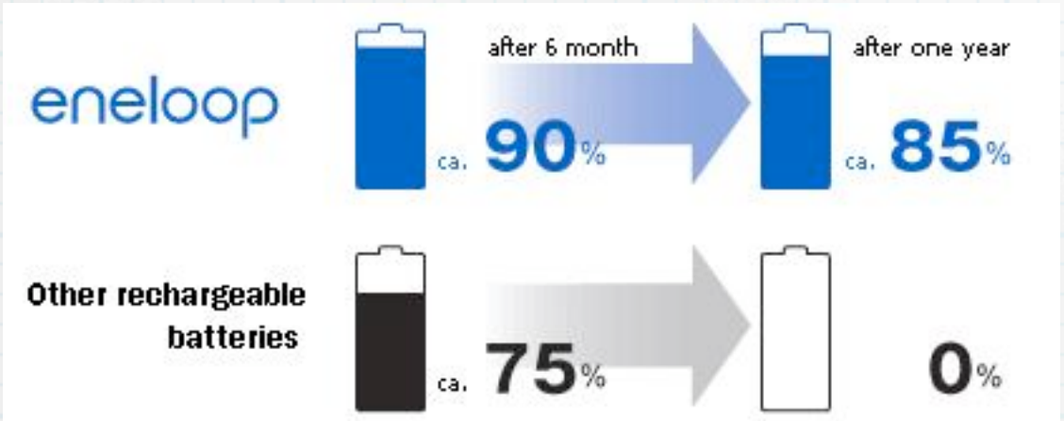
* Pros (vs. NiMH)

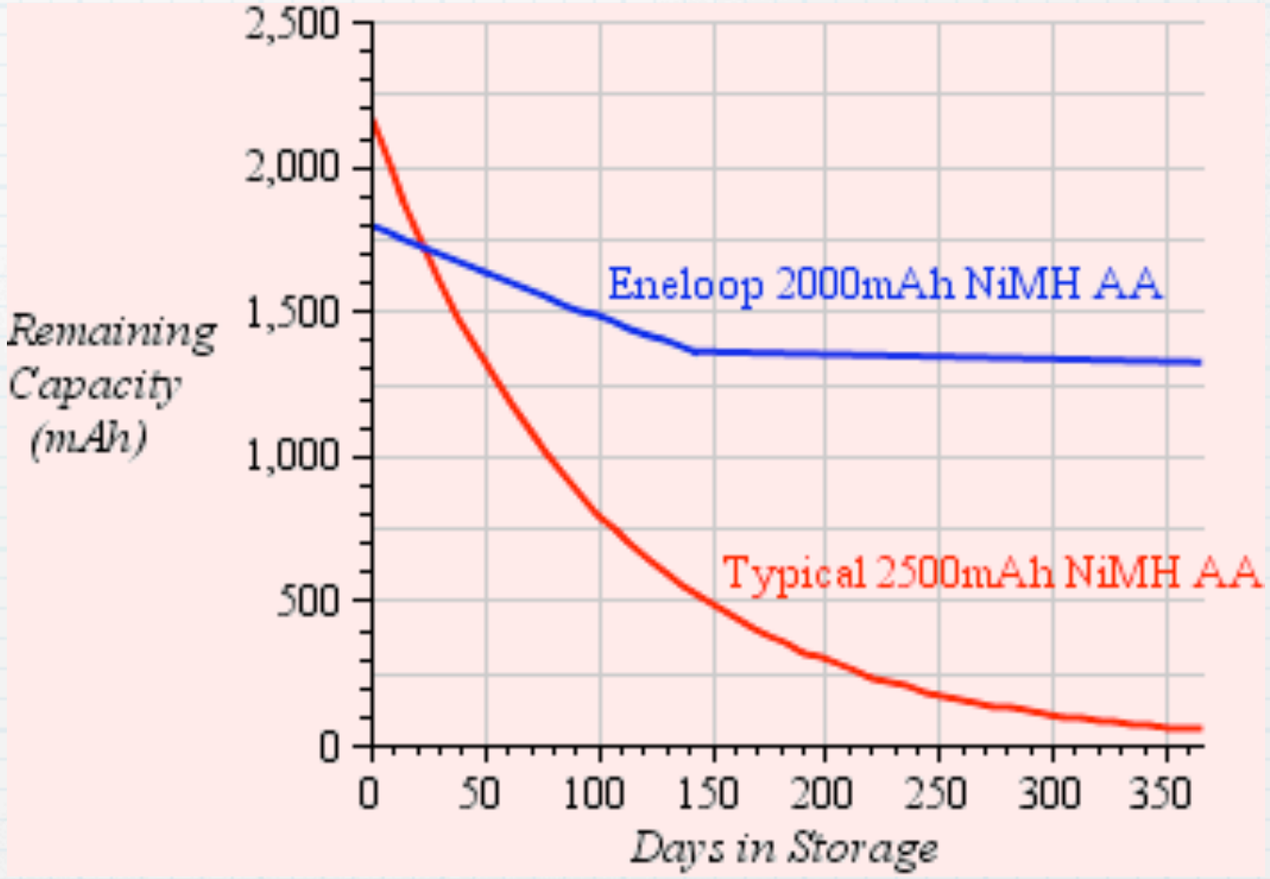
* Much longer shelf life
* Better cycle life
* Same environmentally friendliness

* Cons (vs. NiMH)

* Lower initial capacity
* Higher cost

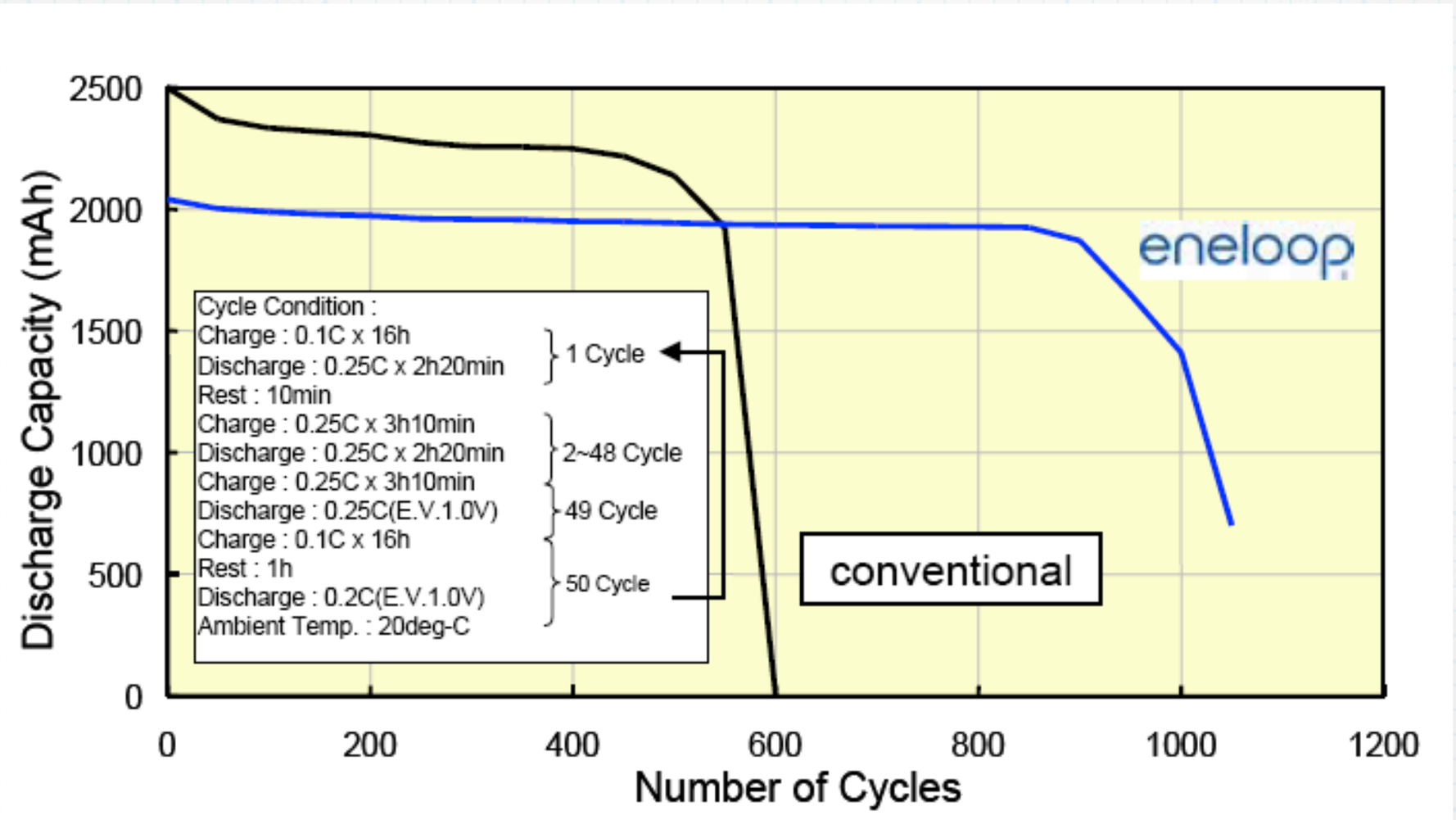
Shelf Life





- 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


2500
2000
1500
1000
500
0
Discharge Capacity (mAh)
0
200
400
600
800
1000
1200
Number of Cycles
eneloop
conventional
Cycle Condition :
Charge : 0.1C x 16h
Discharge : 0.25C x 2h20min
Rest : 10min
1 Cycle
Charge : 0.25C x 3h10min
Discharge : 0.25C x 2h20min
2~48 Cycle
Charge : 0.25C x 3h10min
Discharge : 0.25C(E.V.1.0V)
49 Cycle
Charge : 0.1C x 16h
Rest : 1h
Discharge : 0.2C(E.V.1.0V)
50 Cycle
Ambient Temp. : 20deg-C

Li-ion - Lithium Ion

* Pros

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

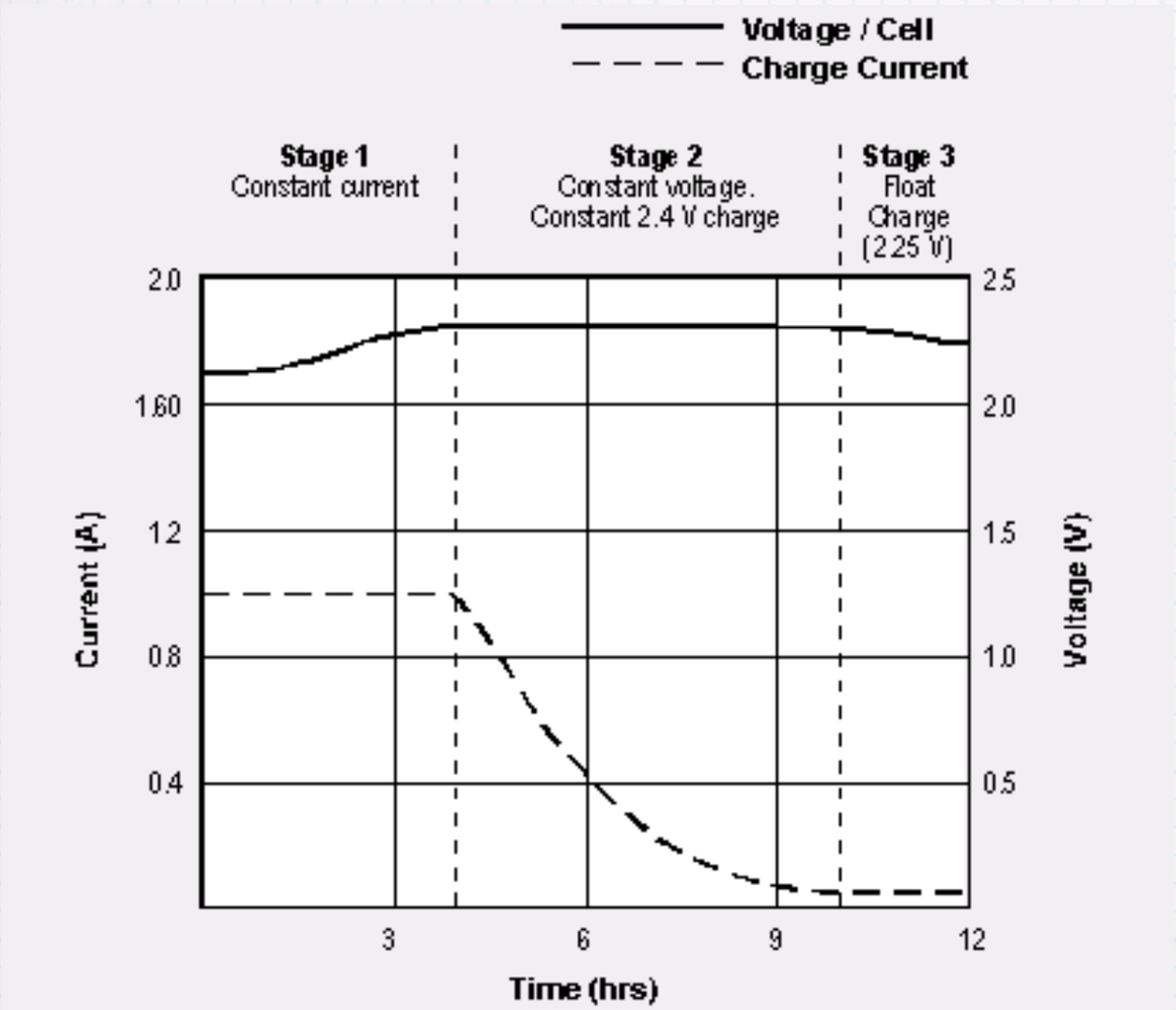
* Cons

* 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)

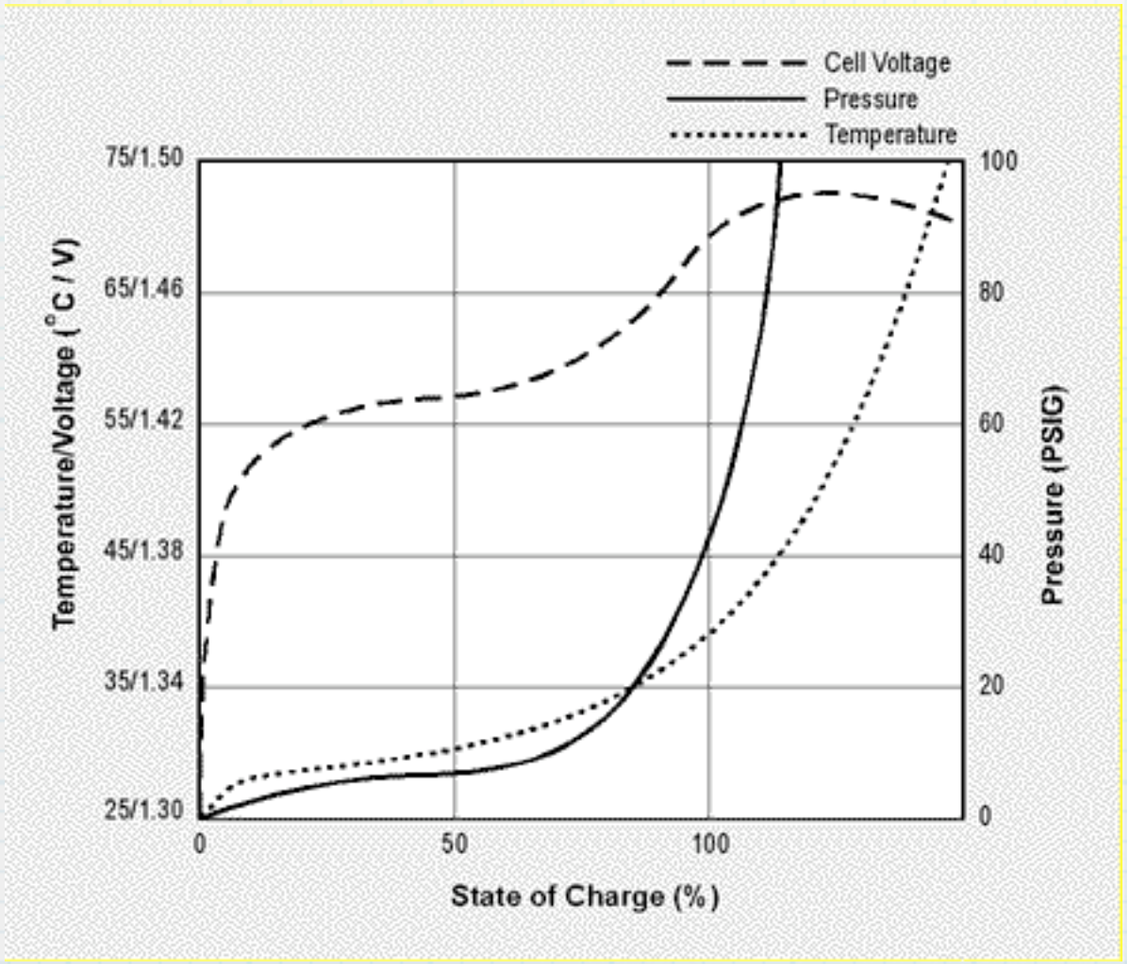


Stage 1: Constant Current between 0.1C and 0.3C

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

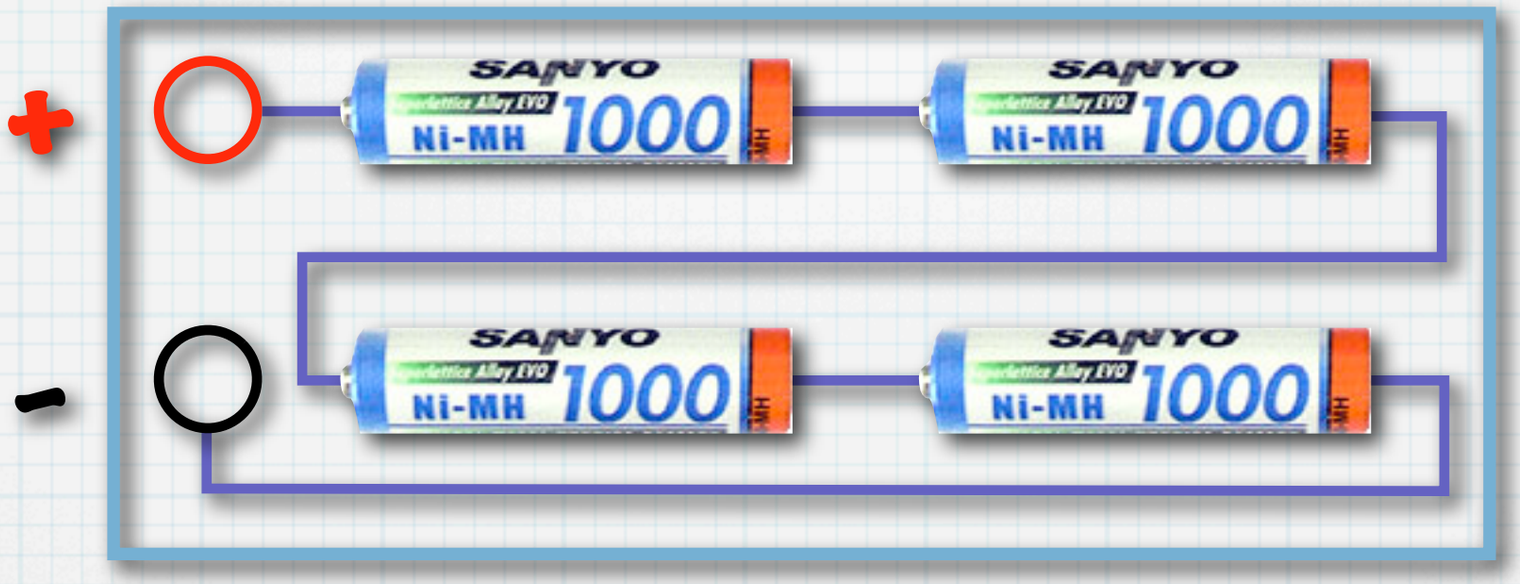


- Avoid high temperature during charging
- A charger for nickel-metal-hydride can also accommodate nickel cadmium, but not the other way around. A charger designed for nickel-cadmium would overcharge the nickel-metal-hydride battery.
- Nickel-based batteries prefer fast-charge. Lingering slow charges 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

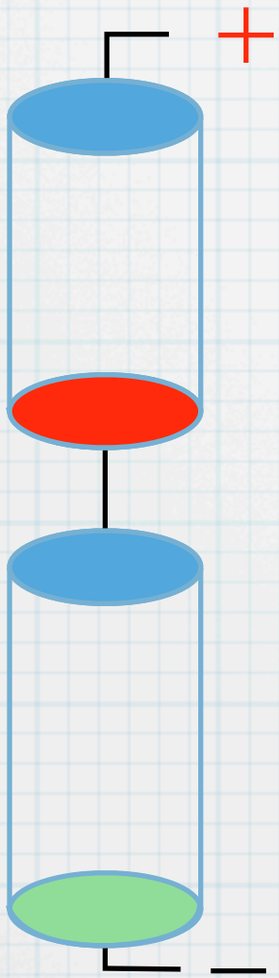
And why they often die young

Battery Pack



Made up of multiple cells in series

Two Cell Example



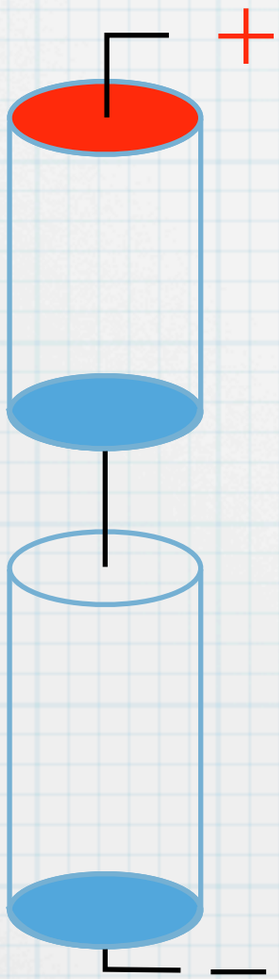
The upper cell has less capacity than the lower one

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

Displays & Modes

Charging Current:
Indicates mA charge rate

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

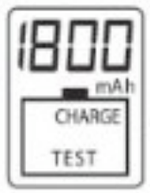
Discharging Current:
Indicates mA discharge rate

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

Time Elapsed:
Indicates charging time
(hh:mm)

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

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



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

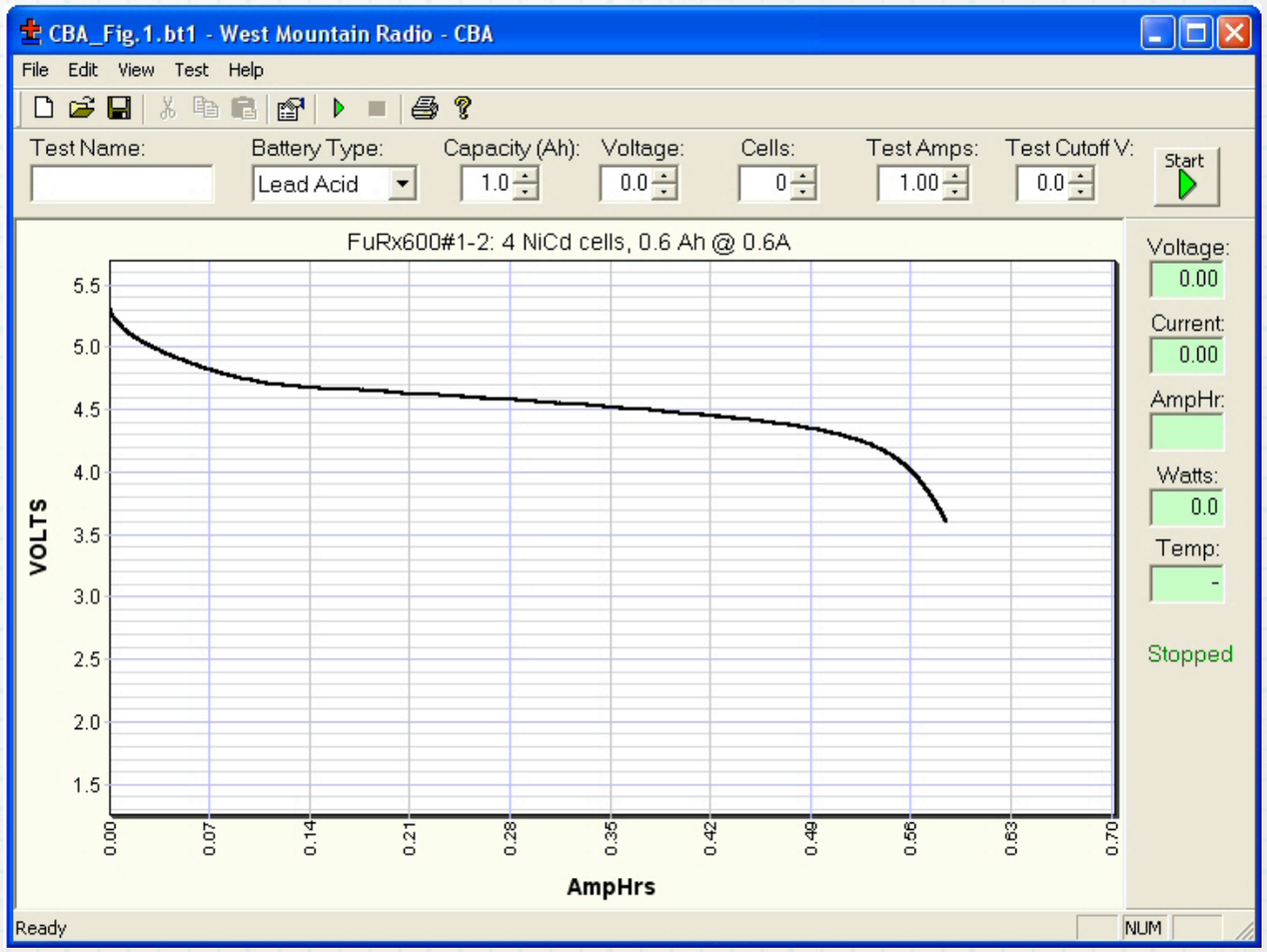
Terminal Voltage:
Measures battery voltage
(can be displayed in any mode)

All Modes
Automatically switches to Trickle Charge at the end of last charging cycle.

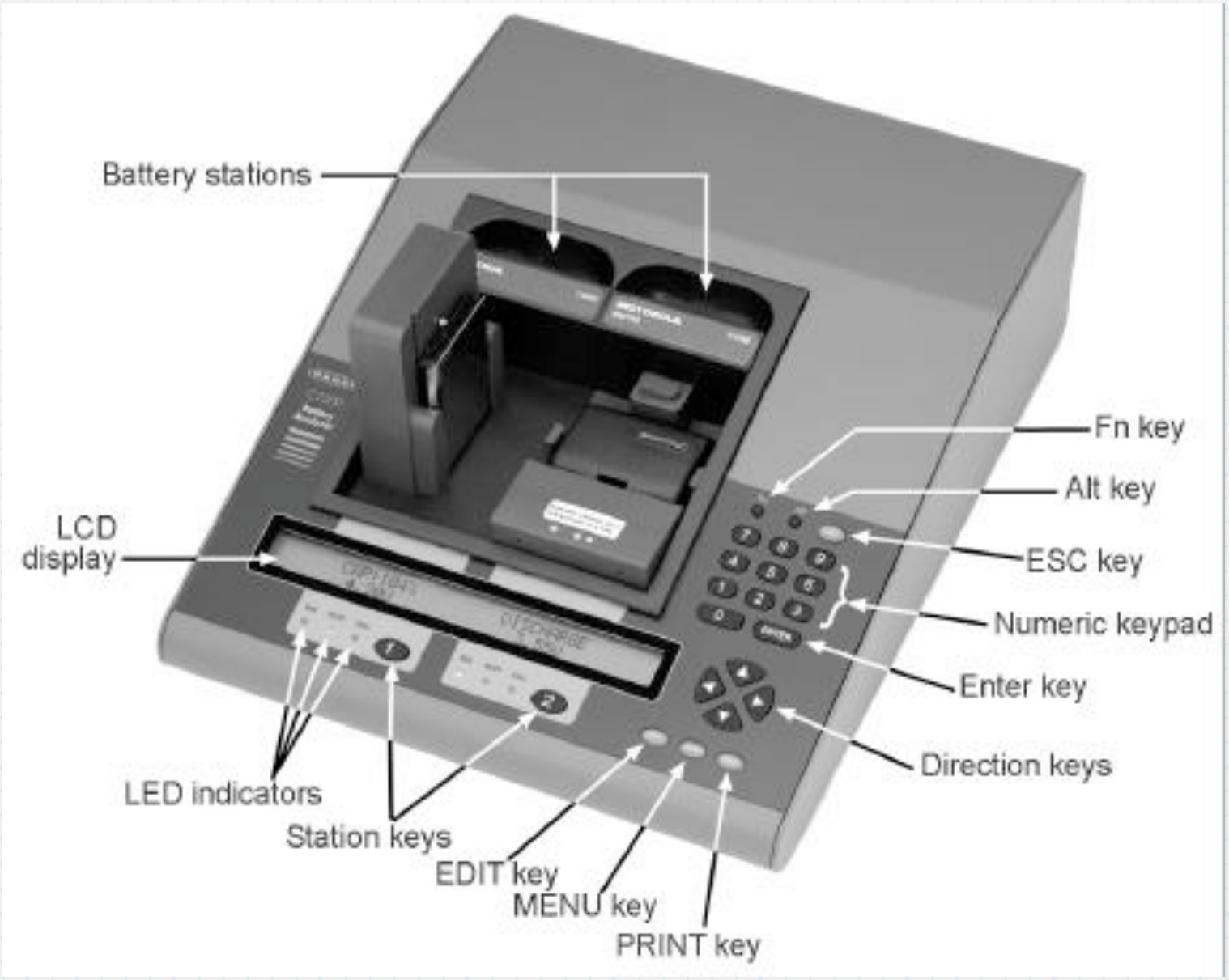
Battery Analyzers

For the truly committed

West Mountain Radio
CBA-II



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/
* http://www.westmountainradio.com/CBA_ham.htm
* http://www.cadex.com/