
CHATHAM AERONAUTS
EST:1955
FLYING CLUB INC.

Battery Charging

There’s more to it than just plug in and wait.

Presenter: Jeff Vince

Overview

- Part two in mini series on batteries.
- This month we'll talk Care and Feeding (storage and charging) for the four most used battery chemistries we talked about last month:
  - NiCd
  - NiMH
  - LiIon/LiPo
  - LiFePo4/A123

Charging NiCd Batteries.

- Most manufactures recommend a slow charge over 16-24 hours especially for first charge. This lets all the cells in the pack equalize as the charged cells can dissipate the heat from being trickle charged while the others top up.
- This method can also be used to float or trickle charge NiCd batteries. Keeping charge current at 0.05C (C/20) to 0.1C (C/10). This will compensate for the NiCd's self discharge rate and keep it "toped up"

Fast charging NiCd

- You can charge NiCd by temperature, cutting off current when cell reaches 45-50 Celsius. This can be risky as the internal temp will be higher than what you can measure from the outside.
- Better temperature based charges will use “Delta Temperature over Delta Time”. Basically it looks for a rapid increase in temp over a short time (1 degree rise in 1 minute) and terminates charging.
- The best way to charge NiCd is NDV (negative delta voltage). Battery voltage will rise until the cell is full, then fall off slightly. Better charges can use this fall off to detect the pac/cell is full.
- This will allow charging as fast as 4C, 1C charging is always recommended.

What causes the NDV?

- When the NiCd is fully charged, oxygen starts being generated at the nickel electrode.
- This oxygen moves through the separator and forms Cadmium Hydroxide when it interacts with the cadmium electrode.
- This causes the cell voltage to drop, the charger can detect this drop to indicate the charge cycle is complete.

Reverse load or “burp” charging

- Sophisticated chargers will add a slight load or discharge cycle every minute or so to the charge.
- This helps with recombination of gasses generated in the cell during charging reducing the cell temperature and stress.
- Can also assist with reducing the “memory effect”
- You’ll commonly see this as 50 or 55 second of charging each minute with 5 or 10 seconds of moderate load.

Care of NiCd batteries

- NiCd cells don’t fully perform until they’ve had a few cycles. Don’t expect top performance until you’re 5-10 cycles in.
- Performance can start to drop off as early as 100 cycles under moderate use.
- NiCd cells will vent if abused (over temp usually). This happens around 1000-1400kPa (150-200psi). You’ll see white powder form on the cell near the vent. Venting will dry out the electrolyte and damage the cell.
- NiCd self discharge fairly quickly (compared to say LiIon) so expect to top them off before use or use a very low current (0.05-0.1C) charge to float the pack fully charged.

What’s considered full vs drained?

- A fully charged NiCd cell will be around 1.45 Volts. Right off the charger it can be slightly higher.
- Fully discharged voltage will be 0.9 to 1.0 volts.
- Nominal voltage is 1.2V.
- NiCd self-discharge at a rate is similar to NiMH. Often 10-15% in the first 24 hours, then 10-15%/month after.

How fast can I charge

- NiCd manufactures prefer the slow C/10 charge, but some cells are designed for “quick charge”. This usually means C/5 or even C/3 on smaller batteries.
- This translates into an 8 or 5 hour charge.
- Now you’re saying “but C/3 is just three hours right?”, it is but there’s a catch:
  - The charging efficiency of the NiCd is around 83%. So for every 100mAh you put in, only about 80 of it makes it to the battery.
- Many cells can be fast charged at 1C. So just over an hour (remember the efficiency above) but you have to do it carefully. Using Negative Delta Time and temperature sensing is often recommended.

Charging NiMh

- Unlike NiCd that run right from the box, NiMH requires a forming charge when new. If not, you likely won't get full capacity.
  - Forming charge is 1/10 of C (C/10) rating. Best to use a wall wart charger and run it long enough to hit 120% of the packs capacity. The extra is blown off as heat, so don't let them sit and cook forever.
- Like NiCd, NiMh can be trickle charged at C/10 but this can lead to heat build up. Many manufactures recommend C/30 or even C/40 to slow charge.
- NiMh can be "floated" at a charge level right around it's self discharge level. Duracell, for example, recommends C/300 to hold cells at full charge

Fast Charging NiMH

- NiMh benefits from the Delta Voltage method of charging like NiCd, only the delta is much smaller. Your charger must be sensative enough to detect the 5-10mV/cell drop.
- You can also detect charge completion by temperature, looking for a delta of 1 degree per minute with an absolute maximum of 60 Celsius.
- Even then, fast charging means 1C and for larger cells (1000mah+) most manufacturers recommend not exceeding 1Amp charge current.

What’s considered full vs drained?

- A fully charged NiMh cell will be around 1.4 Volts. Right off the charger it can be slightly higher.
- Fully discharged voltage will be 1 to 1.1 volts.
- Nominal (rated) voltage like a NiCd is 1.2v.
- Standard NiMH self-discharge at a rate of 5-20% the first day, then 0.5-4% per day after that at room temperature. As the temperature rises so does the discharge rate.

Storage/Care of NiMh

- Voltage depression or “Memory” effect is possible, but can be resolved usually with a few charge and discharge cycles.
- Deep discharge can damage cells. Particular if differences in the cells within the pack allows one cell to go to 0 volts. The other cells will reverse charge it irreparably damaging the cell.
- Like NiCd, NiMh is designed to vent gas if the pressure gets too high. The interesting thing is while NiCd vent oxygen, NiMh vent hydrogen when charged too quickly or over-charged.

Charging Lithium batteries

- No temperature or slow trickle options here. It’s all about Constant Current - Constant voltage.
- Charger will keep current constant (at 1C usually) until voltage reaches 4.2/cell. Then will reduce current.
- Once the current falls to near zero, and voltage remains at 4.2/cell, charge is complete.
- This hard limit of 4.2V and how quickly the cells will be damaged if charged beyond that is why you must use a balancing charger. Without it one cell in a two cell pack could be 4.3 volts while the other is 4.1 by the time the charger sees the 8.4 it’s looking for to know the charge is done.

How does balancing work

- Each cell cannot exceed 4.2 volts.
- Charge current is coming in via main lead (usually, there are exceptions) so current flows through all cells.
- Once a cell reaches 4.2, but the others have not, the charges switches a resistor in parallel with that cell. Essentially “burning off” the current that it would receive.
- Balancing can take a while if there is a lot of difference between the cells. This is because the resistor(s) used by the charger can only dissipate the heat so quickly without being damaged.

Fast charging LiPo

- Most manufactures recommend not charging faster than 1C. This seems pretty well accepted as the default fast charge rate.
- Some “fast charge” cells can take 2 or even 3C rates.
- A fair bit of research has shown slower charge rates helps maintain the number of possible cycles. If you have the time, consider charging at C/2 or even slower.

Storage/Care of LiPo/LiIon

- Trickle charging is not possible. With low self-discharge this isn't much of an issue.
- In fact, some manufactures state that charging to 100% can reduce the life span of the battery. They recommend 80-90% for routine use.
- The debate rages on what level you should store batteries at. Most accept that storing at full charge or full discharge harms cell life, so 60% is recommended unless you plan to use the battery within a day or so.
- That said, this seems to be based on old research that new technologies have made obsolete. So in the end, best to hedge your bets and store at 60%?

What’s considered full vs drained?

- Full charge is 4.2 volts. Any higher can damage the cells. High Voltage Graphene batteries can actually go to 4.35.
- Fully discharged is 3.0volts per cell. Any lower can cause damage.
- Nominal voltage is 3.7V. This is why we see them listed as “7.4v” packs rather than “8.4” for 2S.

Charging LiFePo4/A123 batteries

- Like LiIon it’s all about constant current then constant voltage.
- Constant current charge will take the cell to 95% charged; 3.5volts.
- Constant voltage then adds the last 5% taking it to 3.65.
- Some LiFeP04 cells are tolerant of fast charge (particularly cells from A123) at rates of up to 5C. This means practical charging in less than 15 minutes.

Storage/care of LiFePo4

- Many users still run the cells to 60% for long term storage.
- Some evidence has been observed that storing for long periods at 100% charge can lead to degradation of the cells.
- However, some manufactures and many users are storing over the winter at 100% charge without issue.
- LiFePo4 will lose up to 3% per month from self discharge.

What’s considered full vs drained?

- Fully charged is 3.65 volts per cell.
- Fully discharged is 2.0 volts.
- Nominal voltage (rating you’ll see on the pack) is 3.2 volts.

References

- http://batteryuniversity.com/learn/article/charging_nickel_based_batteries
- http://www.powerstream.com/NiCd.htm
- https://en.wikipedia.org/wiki/Nickel%E2%80%93metal_hydride_battery
- http://batteryuniversity.com/learn/article/elevating_self_discharge
- https://www.rcgroups.com/forums/showthread.php?209187-Complete-Guide-to-Lithium-Polymer-Batteries-and-LiPo-Failure-Reports
- https://rogershobbycenter.com/lipoguide/
- http://www.propwashed.com/lipo-storage-voltage/
- http://www.powerstream.com/LLLF.htm