Silent Wings Soaring Association

March 2015

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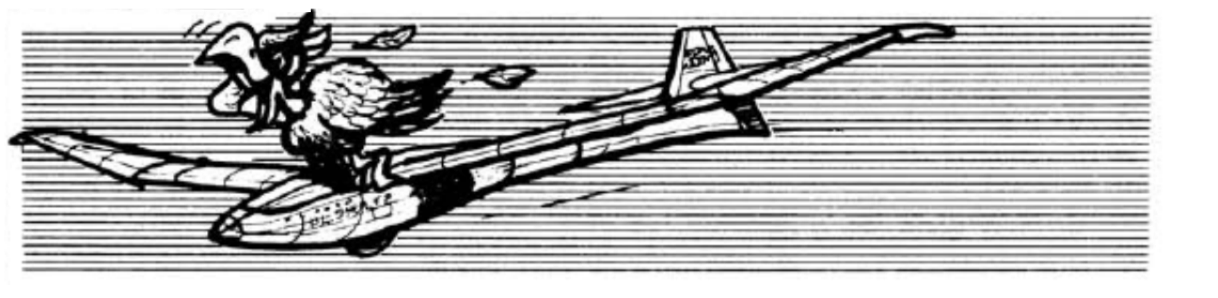
Soaring



Keith **Kindrick** **March** 2015

Over the last couple years new batteries have surfaced making the choices for the right application a little confusing. Many people have been using 5 cells to make the servos faster. Some people like the 4 cell packs just because it is a standard solution with wall chargers available to support them. Manufacturers have been slow to adopt new battery types because they have to be sure anything new works with a high degree of certainty. You see a few of the current radios with new cell types. It's not always easy to convert transmitters from the NiCad/NiMh cells to a LiFe/LiPo due to the space needed. Another drawback might be the charging of them. Transmitters have charge circuits in them to prevent over charging NiCad/NiMh cells. New cells have higher voltage and require you to remove them for charging which is not always convenient.

When I look back at the last decade my batteries were all NiCad's which lasted easily 4 years. Once I started to switch to the new (at the time) NiMh cells I had problems keeping them at full capacity for 3 years.

Since most of us need a certification course to get up to speed let's go to Batteryuniversity.com to get the education we need for battery types and uses.

Nickel-cadmium (NiCd)

The nickel-cadmium battery, invented by Waldmar Jungner in 1899, offered several advantages over lead acid, but the materials were expensive and the early use was restricted. Developments lagged until 1932 when attempts were made to deposit the active materials inside a porous nickel-plated electrode. Further improvements occurred in 1947 by trying to absorb the gases generated during charge. This led to the modern sealed NiCd battery in use today.

For many years, NiCd was the preferred battery choice for two-way radios, emergency medical equipment, professional video cameras and power tools. In the late 1980s, the ultra-high-capacity NiCd rocked the world with capacities that were up to 60 percent higher than the standard NiCd. This was done by packing more active material into the cell, but the gain was met with the side effects of higher internal resistance and shorter cycle.

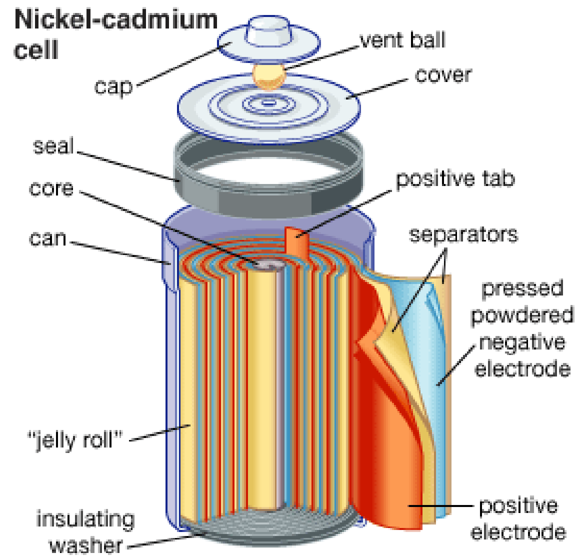
The standard NiCd remains one of the most rugged and forgiving batteries but needs proper care to attain longevity. It is perhaps for this reason that NiCd is the favorite battery of many engineers.

Advantages

- Fast and simple charging even after prolonged storage
- High number of charge/discharge cycles; provides over 1,000 charge/discharge cycles with proper maintenance
- Good load performance; rugged and forgiving if abused
- Long shelf life; can be stored in a discharged state
- Simple storage and transportation; not subject to regulatory control
- Good low-temperature performance
- Economically priced; NiCd is the lowest in terms of cost per cycle
- Available in a wide range of sizes and performance options

Limitations

- Memory effect; needs periodic full discharges
- High self-discharge; needs recharging after storage



Nickel-metal-hydride (NiMH)

Research of nickel-metal-hydride started in 1967; however, instabilities with the metal-hydride led scientists to develop the nickel-hydrogen battery (NiH) instead. Today, NiH is mainly used in satellites.

New hydride alloys discovered in the 1980s offered better stability and the development of NiMH advanced in earnest. Today, NiMH provides 40 percent higher specific energy than a standard NiCd, but the decisive advantage is the absence of toxic metals.

The advancements of NiMH are impressive. Since 1991, the specific energy has doubled and the life span extended.

NiMH also has high self-discharge and loses about 20 percent of its capacity within the first 24 hours, and 10 percent per month thereafter. What is of ongoing concern to the consumer using rechargeable batteries is the high self-discharge, and NiMH behaves like a leaky basketball or bicycle tire. A flashlight or portable entertainment device with a NiMH battery gets "flat" when put away for only a few weeks. Having to recharge the device before each use does not sit well. The Eneloop NiMH by Sanyo has reduced the self-discharge by a factor of six. This means that you can store the charged battery six times longer than a regular NiMH before a recharge becomes necessary. The drawback is a slightly lower specific energy compared to a regular NiMH. Other NiMH manufacturers such as ReCyko by GP claim similar results.

There are strong opinions and preferences between battery chemistries, and some experts say that NiMH will serve as an interim solution to the more promising lithium systems. There are many hurdles surrounding Li-ion also and these are cost and safety. Li-ion cells are not offered to the public in AA, AAA and other popular sizes in part because of safety. Even if they were made available, Li-ion has a higher voltage compared to nickel-based batteries.

Advantages

- 30–40 percent higher capacity than a standard NiCd
- Less prone to memory than NiCd
- Simple storage and transportation; not subject to regulatory control
- Environmentally friendly; contains only mild toxins
- Nickel content makes recycling profitable

Limitations

- Limited service life; deep discharge reduces service life
- Requires complex charge formulas
- Does not absorb overcharge well; trickle charge must be kept low
-
- Generates heat during fast-charge and high-load discharge
- High self-discharge; chemical additives reduce self-discharge at the expense of capacity
- Performance degrades if stored at elevated temperatures; should be stored in a cool place at about 40 percent state-of-charge

Figure 1 below gives you the visual image of how the Eneloop NiMh performs at a higher voltage over time at a continuous discharge at 500mah at 77 Deg F (25C).

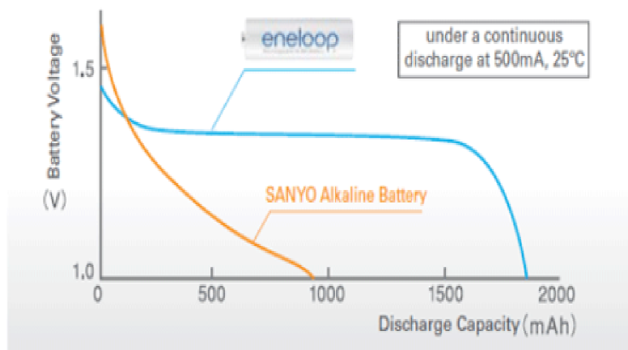


Figure 1

Silent Wings Soaring Association
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Types of Lithium-ion
Become familiar with the many different types of lithium-ion batteries.

The casual battery user may think there is only one lithium-ion battery. As there are many species of apple trees, so do also lithium-ion batteries vary and the difference lies mainly in the cathode materials. Innovative materials are also appearing in the anode to modify or replace graphite. Scientists prefer to name batteries by their chemical name and the material used, and unless you are a chemist, these terms might get confusing. The table below offers clarity by listing these batteries by their full name, chemical definition, abbreviations and short form. family.

Chemical name	Material	Abbreviation	Short form	Notes
Lithium Cobalt Oxide[1] Also Lithium Cobalate or lithium-ion-cobalt)	$LiCoO_2$ (60% Co)	LCO	Li-cobalt	High capacity; for cell phone laptop, camera
Lithium Manganese Oxide[1] Also Lithium Manganate or lithium-ion-manganese	$LiMn_2O_4$	LMO	Li-manganese, or spinel	Most safe; lower capacity than Li-cobalt but high specific power and long life. Power tools, e-bikes, EV, medical, hobbyist.
Lithium Iron Phosphate[1]	$LiFePO_4$	LFP	Li-phosphate	
Lithium Nickel Manganese Cobalt Oxide[1], also lithium-manganese-cobalt-oxide	$LiNiMnCoO_2$ (10–20% Co)	NMC	NMC	
Lithium Nickel Cobalt Aluminum Oxide[1]	$LiNiCoAlO_2$ 9% Co)	NCA	NCA	Gaining importance in electric powertrain and grid storage
Lithium Titanate[2]	$Li_4Ti_5O_{12}$	LTO	Li-titanate	

Lithium Iron Phosphate ($LiFePO_4$) ***(what most of us know as LiFe)***

In 1996, the University of Texas (and other contributors) discovered phosphate as cathode material for rechargeable lithium batteries. The key benefits are enhanced safety, good thermal stability, tolerant to abuse, high current rating and long cycle life. Storing a fully charged battery has minimal impact on the life span. As trade-off, the lower voltage of 3.3V/cell reduces the specific energy to slightly less than Li-manganese. In addition, cold temperature reduces performance, and elevated storage temperature shortens the service life.

Li-polymer Battery: Substance or Hype?

The *polymer* hype of the early 2000s is still going strong, however, most users cannot distinguish between a regular Li-ion and one with polymer architecture. Lithium-polymer differs from other battery systems in the type of electrolyte used. The original polymer design dating back to the 1970s uses a solid (dry) polymer electrolyte that resembles a plastic-like film.

To make the modern Li-polymer battery conductive at room temperature, gelled electrolyte is added. All Li-ion polymer cells today incorporate a micro porous separator with moisture. The correct term is “Lithium-ion polymer” (Li-ion polymer or Li-polymer for short). Li-polymer can be built on many systems, such as Li-cobalt, NMC, Li-phosphate and Li-manganese. For this reason, Li-polymer is not considered a unique battery chemistry. Most Li-polymer packs for the consumer market are based on Li-cobalt.

With gelled electrolyte added, what then is the difference between a normal Li-ion and Li-ion polymer? As far as the user is concerned, the lithium polymer is essentially the same as the lithium-ion battery. Both use identical cathode and anode material and contain a similar amount of electrolyte. Although the characteristics and performance of the two systems are alike, the Li-polymer is unique in that a micro porous electrolyte replaces the traditional porous separator. The gelled electrolyte becomes the catalyst that enhances the electrical conductivity. Li-polymer offers slightly higher specific energy and can be made thinner than conventional Li-ion, but the manufacturing cost increases by 10–30 percent. Despite the cost disadvantage, the market share of Li-polymer is growing.

Li-polymer cells also come in a flexible foil-type case (polymer laminate or pouch cell) that resembles a food package. While a standard Li-ion needs a rigid case to press the electrodes together, Li-polymer uses laminated sheets that do not need compression. A foil-type enclosure reduces the weight by more than 20 percent over the classic hard shell. Furthermore, thin film technology liberates the format design and the battery can be made into any shape, fitting neatly into stylish cell phones and laptops to make them smaller, thinner and lighter. Li-polymer can be made very slim to resemble a credit card.

Charge and discharge characteristics of Li-polymer are identical to other Li-ion systems and do not require a special charger. Safety issues are also similar in that protection circuits are needed. Gas buildup during charge can cause some Li-polymer in a foil package to swell. Li-polymer in a foil package may be less durable than Li-ion in the cylindrical package. Li-polymer is not limited to a foil package and can also be made into a cylindrical design.

Advantages

- High energy density
- Relatively low self-discharge; less than half that of NiCd and NiMH
- Low maintenance. No periodic discharge is needed; no memory.

Limitations

- Requires protection circuit to limit voltage and current
- Subject to aging, even if not in use (aging occurs with all batteries and modern Li-ion systems have a similar life span to other chemistries)
- Transportation regulations when shipping in larger quantities

Cycling Performance

(How NiCd, NiMH and Li-ion perform when put to the test)

To compare older and newer battery systems, Cadex tested a large volume of nickel-cadmium, nickel-metal-hydride and lithium ion batteries used in portable for communication devices. Preparations included an initial charge, followed by a regime of full discharge/charge cycles at 1C. The tables show the capacity in percent, DC resistance measurement and self-discharge obtained from time to time by reading the capacity loss incurred during a 48-hour rest period. The tests were carried out on the Cadex 7000 Series battery analyzers.

Nickel-cadmium

In terms of life cycling, nickel-cadmium is the most enduring battery. Figure 2 illustrates the capacity, internal resistance and self-discharge of a 7.2V, 900mA pack with standard NiCd cells. Due to time constraints, the test was terminated after 2,300 cycles. The capacity remained steady; the internal resistance stayed low at 75mWand the self-discharge was stable. This battery receives a grade “A” rating for almost perfect performance.

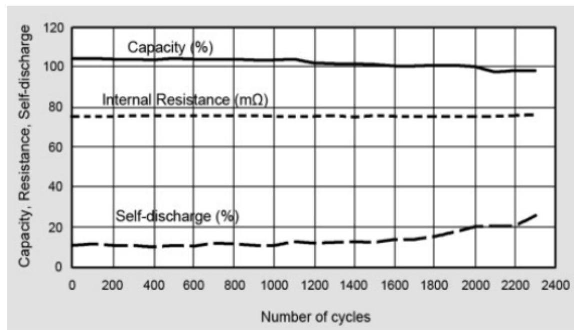


Figure2

Nickel-metal-hydride

Figure 3 examines NiMH, a battery that offers high specific energy but loses capacity after the 300-cycle mark (Blue Triangle). There is also a rapid increase in internal resistance after cycle count 700 (Red Triangle) and rise in self-discharge after 1000 cycles. The test was done on an older generation NiMH. *(this clearly shows the reason why I had problems when I switched over to these cells – KK)*

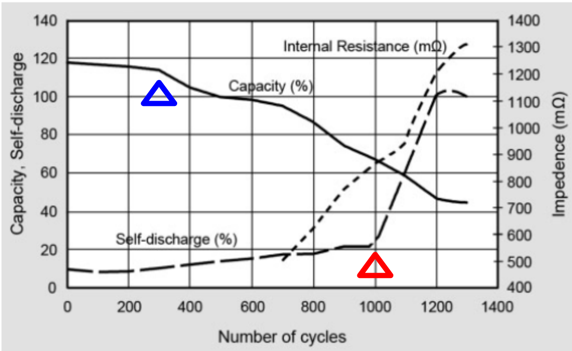


Figure 3

Lithium-ion

Figure 4 examines the capacity fade of a modern Li-ion Power Cell at a 2A, 10A 15A and 20A discharge. Stresses increase with higher load currents, and this also applies to rapid and ultra-fast charging.

Li-ion manufacturers often do not specify the rise of internal resistance and self-discharge as a function of cycling. Advancements have been made with electrolyte additives to keep the resistance low through most of the battery life. The self-discharge of Li-ion is low and is in par with lead acid.

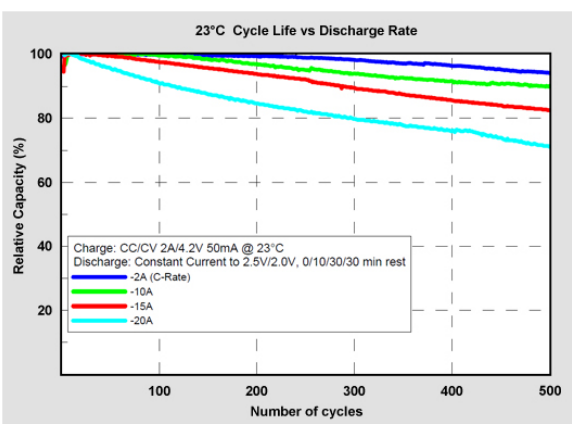


Figure 4

A good reason for changing the way you select a battery type is for voltage and self-discharging. NiMh cells for me do not last nearly as long unless you manage them all the time through a trickle charge. Digital servos have a need for a higher voltage to maintain their performance. Figure 5 shows what happens when you remove the battery from the charger and start using it. A123 cells (LiFe @ 3.3 volts nominal) came on line as a way to solve the need for higher sustained power. In figure 5 you can clearly see these cells stabilize off the charger at a higher voltage than the NiMh cells do. This however, creates another problem with receivers and servos not rated to handle this higher voltage. I found out early on before the 6 volt servos appeared you could easily damage servos without regulating the voltage to a lower level. Figure 6 shows how to wire a Battery Eliminator Circuit (BEC) 10 amp peak voltage regulator from Castle http://www.castlecreations.com/products/ccbec.html I'm very impressed with all of the Castle products and this BEC is no exception because you can have adjustable voltage from 4.8 to 9.0 volts (I typically run at 5.6 volts for the receiver inside my gliders).

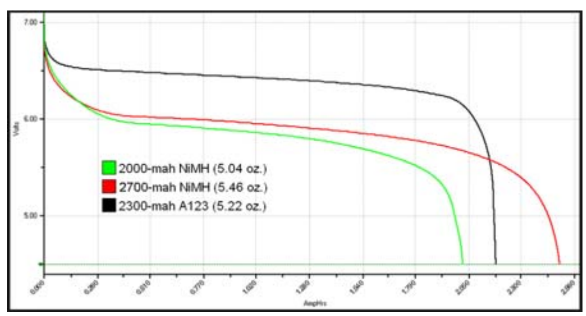


Figure 5

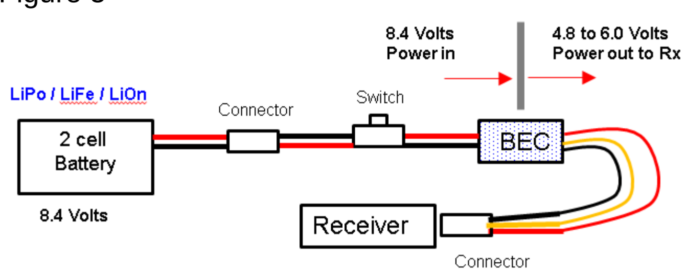


Figure 6

When you use a BEC there is no limit to what type of battery cell you use. It will safely lower the voltage down to the receiver prior to entering it as long as you set the correct voltage.

Ultra-fast Chargers

Ultra-fast chargers have been around for many years. Most NiCd and specialty types of Li-ion batteries, can be charged at a very high rate up to 70 percent state-of-charge (SoC). At a rate of 10C or 10 times the rated current, a 1A battery could theoretically be charged in six minutes, but there are limits. To apply an ultra-fast charge, the following conditions must be observed:

- The battery must be designed to accept an ultra-fast charge. Current handing poses limitation with many pack designs.
- Ultra-fast charging only applies during the first charge phase. The charge current must be lowered when the 70 percent state-of-charge threshold is reached.
- All cells in the pack must be balanced and in good condition. Older batteries with high internal resistance will heat up; they are no longer suitable for ultra-fast charging.
- Ultra-fast charging can only be done under moderate temperatures. Low temperature slows the chemical reaction, and energy that cannot be absorbed causes gassing and heat buildup.
- The charger must include temperature compensations and other safety provisions to halt the charge if the battery gets unduly stressed. Failure to heed to these conditions could cause rapid disintegration of the battery and fire.

An ultra-fast charger can be compared to a high-speed train that is capable to travel 300km per hour (188 mph) on a track built for it. The tracks, and not the machinery, govern the maximum speed. Adding power to a charger is relatively simple; the intelligence lies in assessing the condition of the battery and applying the right amount of maximum charge. A properly designed ultra-fast charger will lower the current when certain conditions occur. In essence, only newer batteries can be ultra-fast charged.

Do not ultra-fast charge batteries if possible and charge at a more moderate rate of 1C or less. Figure below compares the cycle life of a lithium-ion battery when charged and discharged at 1C, 2C and 3C. A 1C charge and discharge cycle causes the capacity drop from 650mAh to 550mAh after 500 cycles, reflecting a decrease to 84 percent. A 2C accelerates capacity fade to 310mAh, representing a decrease to 47 percent, and with 3C the battery fails after only 360 cycles with 26 percent remaining capacity.

As seen figure 5 the harder you drive the cells the worse their performance will be.

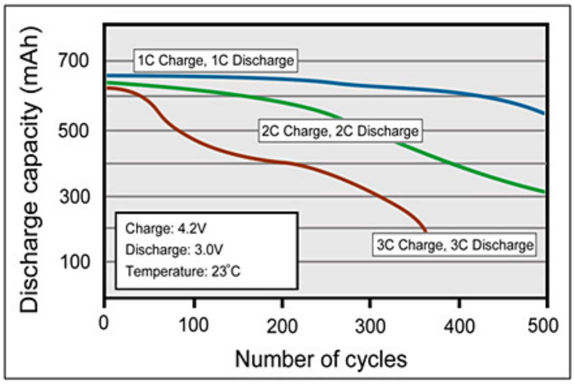


Figure 5

Balancing Cells

Most of the new chargers have a way to balance each cell. Battery balancing and battery redistribution refer to techniques that maximize a battery's capacity to make all of its energy available for use and increase the battery's longevity. A battery balancer or battery regulator is a device in a charger that performs battery balancing. Typically, the individual cells in a battery have somewhat different capacities and may be at different levels of state of charge (SOC). Without redistribution, discharging must stop when the cell with the lowest capacity is empty (even though other cells are still not empty); this limits the energy that can be taken from and returned to the battery.

Without balancing, the cell of smallest capacity is a "weak point", it can be easily overcharged or over-discharged while cells with higher capacity undergo only partial cycle. For the higher capacity cells to undergo full charge/discharge cycle a balancer should “protect” the weaker cells; so that in a balanced battery, the cell with the largest capacity can be filled without overcharging any other (i. e. weaker, smaller) cell, and it can be emptied without over-discharging any other cell. Battery balancing is done by transferring energy from or to individual cells, until the SOC of the cell with the lowest capacity is equal to the battery's SOC.

Battery redistribution is sometimes distinguished from battery balancing by saying the latter stops at matching the cell's state of charge (SOC) only at one point (usually 100% SOC), so that the battery's capacity is only limited by the capacity of its weakest cell. Figure 6 shows how the battery cells are wired internally to accomplish this in LiPo / LiOn / LiFe battery pack.

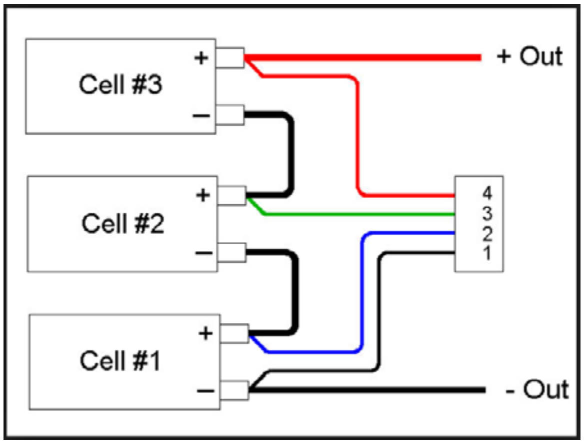


Figure 6

What have we learned?

Nickel-cadmium (NiCd)

- ✓ NiCd remains one of the most rugged and forgiving batteries but needs proper care to attain longevity.
- ✓ It is perhaps for this reason that NiCd is the favorite battery of many manufacturers.

Nickel-metal-hydride (NiMH)

- ✓ 30–40 percent higher capacity than a standard NiCd.
- ✓ Less prone to memory than NiCd. NiMH also has high self-discharge and loses about 20 percent of its capacity within the first 24 hours, and 10 percent per month thereafter.

Lithium Iron Phosphate($LiFePO_4$)

- ✓ High energy density.
- ✓ Relatively low self-discharge; less than half that of NiCd and NiMH.
- ✓ Low maintenance.
- ✓ No periodic discharge is needed; no memory.
- ✓ Requires protection circuit to limit voltage and current.
- ✓ Subject to aging, even if not in use

Cycling Performance

- ✓ In terms of life cycling, nickel-cadmium is the most enduring battery.
- ✓ NiMH as battery that offers high specific energy but loses capacity after the 300-cycles. There is also a rapid increase in internal resistance after 700 cycles. A rise in self-discharge after 1000 cycles.
- ✓ Li-ion Power Cells at a 2A, 10A 15A and 20A discharge rates have increased stress with higher load currents, and this also applies to rapid and ultra-fast charging. (Li-ion manufacturers often do not specify the rise of internal resistance and self-discharge as a function of cycling. Advancements have been made with electrolyte additives to keep the resistance low through most of the battery life)
- ✓ The self-discharge of Li-ion is low and is in par with lead acid.

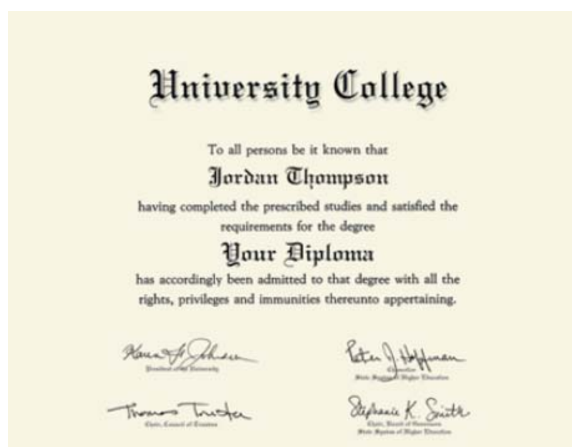
Ultra-Fast Chargers

- ✓ Do not ultra-fast charge batteries if possible and charge at a more moderate rate of 1C or less.
- ✓ A 1C charge and discharge cycle causes the capacity drop from 650mAh to 550mAh after 500 cycles, reflecting a decrease to 84 percent.
- ✓ A 2C accelerates capacity fade to 310mAh, representing a decrease to 47 percent.
- ✓ At 3C the battery fails after only 360 cycles with 26 percent remaining capacity.

Balancing Cells

- ✓ Without balancing, the cell of smallest capacity is a "weak point", it can be easily overcharged or over-discharged while cells with higher capacity undergo only partial cycle.

That concludes our certification course for Battery University! Congratulations!



Silent Wings Soaring Association

March 2015

Let's ALL Fly!

That is it for this month.

Thermals to all ~ Keith

Take a look back in time during the golden years of sailplane design with Part 2 of a 4 Part series by the master of sailplanes Dave Thornburg.

This is CLASSIC information located at the end of this newsletter.

2015 Contest Schedule

DATE	EVENT	CD
Sunday **March 8, 2015**	**SWSA CLUB**	John Barr
Sunday **April 12, 2015**	**SWSA CLUB**	Frank Corsaro
Friday **May 1, 2015**	**CVRC ALES**	CVRC
Saturday & Sunday **May 2-3/2015**	**CVRC Bent Wing**	CVRC
Saturday **May 9, 2015**	**SWSA CLUB**	Henry Rodriguez
Sunday **June 14, 2015**	**SWSA CLUB**	Harvey Jenkins
Saturday & Sunday **June 20-21**	Sacramento	SVSS
Sunday **July 12, 2015**	**SWSA CLUB**	TBD
Sunday **August 9, 2015**	**SWSA CLUB**	Bruce Averson
Sunday **Sept 13 , 2015**	**SWSA CLUB**	James **Smith**
Sunday **Sept TBD, 2015**	**Wilson Cup**	CVRC
Saturday & Sunday **Oct 3-4, 2015**	**VISALIA FSF**	CVRC
Sunday **Oct 11, 2015**	**SWSA CLUB**	Keith **Kindrick**
Sunday **Nov 8, 2015**	**SWSA CLUB**	TBD
TBD **December 2015**	**SWSA Year End Party**	

Silent Wings Soaring Association

March 2015

2015 SC2 Contest Schedule

Sunday March 22	SULA	Field of Dreams
Sunday April 26	SWSA	SWSA
Sunday May 17	VVRC	VVRC
Sunday June 28	Harbor Soaring	Harbor Soaring
Sunday July 19	Inland Soaring	Inland Soaring
Sunday August 23	TOSS	TOSS
Sunday September 20	Club SULA	Location Field of Dreams
Sunday October 18	TPG	TPG
Sunday November 15	Rain Date	

More Information @ www.sc2soaring.com

If you have any events let me know

SILENT WINGS SOARING ASSOC.

2015 Holidays and Observances

Apr 5	**Easter Sunday**
Apr 13	**Thomas Jefferson's Birthday**
May 10	**Mothers' Day**
May 25	**Memorial Day**
Jun 21	**Fathers' Day**
Jul 3	**'Independence Day' observed**
Jul 4	**Independence Day**
Sep 7	**Labor Day**
Oct 12	**Columbus Day (Most regions)**
Oct 31	**Halloween**
Nov 11	**Veterans Day**
Nov 26	**Thanksgiving Day**
Dec 24	**Christmas Eve**
Dec 25	**Christmas Day**
Dec 31	**New Year's Eve**