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CHARGING and KEEPING LIPO's SAFE

Lithium batteries are the preferred power sources for most electric modellers today. They offer high discharge rates and a high energy storage/weight ratio. However, using them properly and charging them correctly is no trivial task. There are many things to consider before using lithium cells for electric-flight. But none is more important than ***safety***.

1.0 Charging/Safety IMPORTANT!

Until you are willing to follow all safety precautions, DO NOT use lithium batteries. If you are type of person that prefers to push the limits of products, or be haphazard about following safety requirements. Lithium technology is not for you. Read on to find out why.

Lithium cells must be charged very differently than NiCad or NiMH. They require a special charger specifically designed to charge lithium cells. In general any charger that can charge lithium ion can charge lithium polymer, assuming that the cell count is correct. You must NEVER charge lithium cells with a NiCad or NiMH only battery charger. This is dangerous. Charging cells is the most hazardous part of using lithium batteries. EXTREME care must be taken when charging them. It is important to set your charger to the correct voltage or cell count. Failure to do this can cause the battery to spew violent flames. There have been many fires directly caused by lithium batteries. PLEASE BE RESPONSIBLE when charging lithium batteries.

2.0 Here are a few MANDATORY guidelines for charging/using LIPO's (Lithium Polymer Batteries).

2.1. Use only a charger approved for lithium batteries. The charger may be designed for Li-Ion or Li-Poly. Both batteries are charged in exactly the same. Some older cell phone chargers may charge the batteries .1 volt to low (4.1 vs. 4.2), but that will not harm the battery. However, inexpensive lithium chargers are widely available and the use of cell phone chargers is highly discouraged. ***OPTIPOWER™*** recommends **CellPro** Chargers as they are safe ACTIVE chargers.

2.2. Make certain that the correct cell count is set on your charger. Watch the charger very closely for the first few minutes to ensure that the correct cell count continues to be displayed. If you don't know how to do that, get a charger that you do know how or don't charge the batteries.

2.3. Check the Cell Voltages. Before you charge a new Lithium pack, check the voltage of each cell individually. Then do this after every tenth cycle thereafter. This is absolutely critical in that an unbalanced pack can explode while charging even if the correct cell count is chosen. If the cells are not within 0.1 volts of each

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other then charge each cell individually to 4.2 volts so that they are all equal. If after every discharge the pack is unbalanced you have a faulty cell and that pack must be replaced. Balance leads are provided on most new lithium packs. Balance connections give you the ability to check individual cell voltages and charge one cell at a time. Make sure and get the appropriate connector to go into your balance leads. Don't try to stick you volt meter probes in the balance connectors to measure voltage. They could slip and short your cells. Don't try to charge more than one cell (pack) at a time from the balance leads unless your charger is parallel rated and designed to do it.

4.20v = 100%
4.03v = 76%
3.86v = 52%
3.83v = 42% = typically used as a storage charge.
3.79v = 30%
3.70v = 11%
3.6?v = 0%

These are resting voltages - not under load voltages.

2.4. NEVER charge the batteries unattended. This is the number one reason for houses and cars being burned to a crisp by lithium fires.

2.5. Use a safe surface to charge your batteries on so that if they burst into flame no damage will occur. Vented fire safes, Pyrex dishes with sand in the bottom, fireplaces, plant pots, are all good options.

2.6. DO NOT CHARGE AT MORE THAN 1C unless specifically authorized by the pack vendor. I have personally had a fire in my home because of violating this rule. Today's highest discharge batteries can supposedly be safely charged at greater than 1C, however so far in all cases doing so shortens the life of the pack. Better to buy 3 packs than to try to charge 1 pack 3 times quickly.

2.7. DO NOT puncture the cell, ever. If a cell balloons quickly place it in a fire safe place, especially if you were charging it when it ballooned. After you have let the cell sit in the fire safe place for at least 2 hours. Discharge the cell/pack slowly. This can be done by wiring a flashlight bulb of appropriate voltage (higher is voltage is ok, lower voltage is no) up to your batteries connector type and attaching the bulb to the battery. Wait until the light is completely off, then throw the battery away.

2.8. If you crash with your lithium cells they may be damaged such that they are shorted inside. The cells may look just fine. If you crash in ANY way carefully remove the battery pack from the aircraft and watch it carefully for at least the next 20 min. Several fires have been caused by damaged cells being thrown in the car and then the cells catch fire later and destroy the car completely.

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2.9. Charge your batteries in an open ventilated area. If a battery does rupture or explode hazardous fumes and material will spew from the battery.

It can happen to you, do not think to yourself that "it won't happen to me" as soon as you do that it you'll be trying to rescue your kids from your burning house or car. I'm very serious about this.

Now that we have covered that important topic let's move on to lighter matters:

3.0 Lithium What?
Lithium Polymer batteries are used in many electronic devices. Cell Phone, Laptops, PDA's, Hearing Aids just to name a few. Most, if not all, lithium polymer batteries are not designed for RC use, we use them in different applications than they were designed for. They are similar to Lithium Ion batteries in that they each have a nominal voltage of 3.6 volts, but dissimilar in that they do not have a hard metal casing but rather a flexible material encloses the chemicals inside. The "normal" lithium polymer batteries are thin rectangle shapes with two tabs on the top one positive one negative. The reason we use Lithium cells is that they are significantly lighter than comparable NiCad or NiMH batteries, which makes our planes fly longer and better.

4.0. Voltage and Cell Count:
LiPolys act differently than NiCad or NiMH batteries do when charging and discharging. Lithium batteries are fully charged when each cell has a voltage of 4.2 volts. They are fully discharged when each cell has a voltage of 3.0 volts. It is important not to exceed both the high voltage of 4.2 volts and the low voltage of 3.0 volts. Exceeding these limits can harm the battery.
The way to ensure that you do not go below 3.0 volts while flying is to set the low voltage cut-off (LVC) of your electronic speed control (ESC). It important to use a programmable ESC since the correct voltage cut-off is critical to the life of your batteries. Use the ESC's programming mode to set the LVC to 3.0 volts per cell with a hard cut-off, or 3.3 volts per cell with a soft cut-off. If your ESC does not have hard or soft cut-off, use 3.0 volts per cell. You will know when flying that it is time to land when you experience a sudden drop in power caused by the LVC.
If your ESC has an automatic lithium mode. Use it, it will correctly sense the number of cells and set the auto cut-off appropriately.
If you have previously been flying with NiCad or NiMH batteries, switching over to lithium polymer will result in a different number of cells being used. If you had 6 to 7 round cells then 2 lithium polymer cells will correctly duplicate the voltage of those cells. If you had 10-11 cells then 3 lithium polymer cells would be right for you. There are a lot of 8 cell flyer's out there that are stuck between 2 and 3 cells. In my experience the best option is to determine how many watts you were using before and duplicate that with your LiPo's, Motor, and Prop. For example. If you were running 8 cells (9.6volts) at 10 amps then you have 9.6 x10, 96 watts. So if you went with 2 lithium polymer cells (7.2 volts nominal) then you'd need to

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change your prop such that you used 13 amps. If you went to 3 LiPoly's (10.8 volts nominal) then you'd need to reduce the amperage to 8.9 amps. These estimates are approximate, and some experimentation is required for best results but conserving Watts is a good way to start.

5.0.10C from 3S4P? Naming conventions explained.
How fast a battery can discharge is its maximum current capacity. Current is generally rated in C's for the battery. C is how long it takes to discharge the battery in fractions of an hour. For instance 1 C discharges the battery in 1/1 hours or 1 hour. 2 C discharges the battery in ½ or half an hour. All RC batteries are rated in mili Amp hours. If a battery is rated at 2000 mAh and you discharge it at 2000mA (or 2 amps, 1 amp = 1000mA) it will be completely discharged in one hour. The C rating of the battery is thus based on its capacity. A 2000mAh cell discharged a 2 amps is being discharged at 1C (2000mA x 1), a 2000mAh cell discharged at 6 amps is being discharged at 3C(2000mA x 3).

All batteries have limitations on how fast they can discharge. Because of this many LiPoly batteries are put in parallel to increase the current capacity of the battery pack. When 2 batteries are wired positive to positive and negative to negative they become like one battery with double the capacity. If you have 2 2000mAh cells and you wire them in parallel then the result is the same as 1 4000mAh cell. This 4000mAh cell has the same C rating as the original 2000mAh cells did. Thus if the 2000mAh cells could discharge at a maximum of 5C, or 10 amps then the new 4000mAh cell can also discharge at 5C or (4000mA x 5) 20 amps. This method of battery pack building allows us to use LiPoly batteries at higher currents than single cells could produce.

The naming convention that allows you to decipher how many cells are in parallel and how many are in series is the XSXP method. The number in front of the S represents the number of series cells in the pack so 3S means it's a 3 cell pack. The number in front of P means the number of cells in parallel. So a 3S4P pack of 2100mAh cells has a total of 12 cells inside. It will have the voltage of any other 3S pack since the number of cells in series determines the voltage. It will have the current handling of 4 times the maximum C rating of the 12 individual cells. So say our 3S4P pack had a maximum discharge of 6C. That means that it has a nominal voltage of 10.8 volts (3x3.6) and a maximum discharge rate of 50.4 amps (2100mAh x 6Cx4P).

6.0 Which battery should you buy?
With so many choices out there it is difficult to decipher what is marketing hype, what is brand loyalty, and what are outright lies. Battery manufacturers are constantly trying to one up one another. While capitalism can drive prices down, it also can give cause to false claims about products.

One great way to find out what the best battery is, is to look at graphs of the batteries performance. Looking at how low the voltage of the cell drops at various

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amperages will give you a metric to compare that battery to similar size/weight batteries. If graphs aren't your thing then simply look at what other people are using in successful setups that are similar to your application. If a lot of people are reporting long flight times and lots of power from airplane X, with power system Y, and battery Z and you do the same, then if your setup is similar the same battery will probably work well for you.

It pays to learn something about Watts, Volts, and Amps. Understanding these concepts is beyond the scope of this document, but can serve you well in not only figuring out what battery is best but also in your electric aircraft hobby.
I'm not convinced that a 30C battery is really any better than a 10 or 20C battery. Sure a higher C rating means it can discharge faster. But at the same time a battery discharged at 20C continuously will be empty in 3 minutes. Do you really only want to use the battery for 3 minutes? I love having burst power in helicopters and boats, but in almost all other applications actually running a battery at or above 20C is useless to me. I prefer to run batteries at 8-10 C and have a little headroom if I need it.

A final note on choosing a battery. Don't cheap out. Confirm that your batteries are capable of running that the amperage level you plan to use them at. Running a cell at a higher C rating than the battery can handle can not only damage your batteries, but it can also damage your speed control. Castle Creations has an excellent article on how using a weak battery can destroy a perfectly good speed control of any brand. Better to buy a bit better battery than you need than to destroy your electronics.

7.0. Dealing with temperature.
Lithium batteries like heat, but not too much. In the winter time, try to keep your batteries from the cold as much as possible. Leave them in the car while you're flying, or keep them in your fleece pocket... etc. At the same time don't let them heat up too much.

If your batteries are reaching 140F (60C) after use then something is wrong, identify the problem before next use, 60C will burn your hand.

8.0 Storage.
If you are not using a lithium cell it should be stored at what is known as the 'Storage' charge this is 3.84v/cell or around 42% of full capacity, good brands of charger have a 'storage' charge function. This will allow the cell to cope with temperature change whilst stored. Always try to keep cells in a fairly stable temperature environment and in a safe place in case were one too short. This would mean an environment where a cell fire would be contained, ideally a metal enclosure.

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Yours sincerely



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