General Car Lipo FAQ

By Shawn Palmer

Q: There are a lot of concerns and conflicting information about Lipo packs floating about on the internet. What is the real truth regarding the safety of this technology?

A: Many people have reservations about using lipos or allowing them at their track because of the outdated and often third hand stories floating around about packs "spontaneously combusting" without warning and for no apparent reason. The real truth is that a lipo pack is just like any other electron storage device: They don't do anything "spontaneously all by themselves". For a pack to fail destructively, the user has to do something to it first. It must have been damaged previously, or currently in the process of being seriously abused to fail destructively. If you follow the lipo rules below and never abuse the pack, it will provide you with many hundreds of worry free and consistent cycles. Like any other battery technology, lipos have been constantly evolving and improving in all areas. Safety, performance, and resistance to damage have all made very large advances over the last five years. Modern packs made specifically for the car industry (ROAR approved) represent the latest and most stable technology. It is actually extremely difficult to induce a failure involving flames *even when these packs are intentionally and repeatedly abused.*

Q: So what are these "rules for lipo" to make sure I safely get the best performance and longest life from my lipo packs?

A: The Lipo Rules:

A Lipo pack is damaged when any of the following rules are broken. The damage is cumulative and cannot be reversed, so you want to make sure none of these are ever broken to get the longest life and best performance from your packs.

Followed rules = hundreds of consistent cycles and a happy pack.

Unfollowed rules = less and less cycles before the pack does not perform anymore, and may result in a destructive failure depending on how many times and how deeply the rules are violated.

Rule #1) Proper cutoff voltage.
With modern car packs, it's best to have a cutoff set on your ESC (or separate cutoff device) at 6.0 to 6.4v for a 2 cell (7.4v) pack. Most common speed

controls won't give you the option to set a cutoff voltage, but some products from Novak, and all products from Speed Passion and Castle have the proper option built into them.

Damage always occurs to 7.4v packs when they are at any lower voltage than 6.0 volts, regardless of whether the pack is under a discharge load or not. If the resting voltage is below 6 volts the pack has been seriously damaged because the voltage when it was under a discharge load was actually much lower. The lower the voltage and the longer it stays low, the more damage is occurring. Sometimes just one time well below 6 volts is enough to permanently damage a 7.4v pack to the point where it will no longer charge or perform. It just depends how far below, and how many times previously it's been below 6 volts.

If your ESC doesn't have a setting for cutoff voltage, DO NOT use any lipo pack unless you have a secondary device to cut off the motor at the correct voltage. By the time the pack "feels soft" or you notice any decrease in power, the pack has already been damaged.

Rule #2) Maximum Temperature.
Any temperature measured on any part of the pack exceeding 60degC/140degF will cause damage. Generally the pack temp will INCREASE for about 5-10mins after the run is over, so temp the pack immediately after the run and then again about 10mins later if you think it's close to the maximum

In an electric system, amps = heat. The more amps you're drawing in the system, the hotter the batteries, ESC and motor will get. In cars, amps come from top speed. The faster the car is at full throttle (actual full throttle, not just full throttle with the radios endpoints turned down) the more amps the motor is drawing, the battery is delivering, and the ESC is flowing. I mention "actual full throttle" because of the way ESC's work. It doesn't matter very much heat (amp) wise, if you turn down the throttle endpoint on your radio to slow down the car if it's too fast, or use all of the throttle (speed). It will heat up (use amps) just like its being run mostly wide open. It's very highly recommended to simply gear for the top speed you need for your track or running area, and not "dial out" throttle throw to slow the car down. You'll have a much cooler running (and longer lasting) power system.

The less capable the pack (lower capacity and lower C rating), the more it will heat up with the same load (think IB4200's vs. NiCad 2400's on a mod motor). Most ROAR approved 4000-5000mah packs actually have much more safe output capability than most any 10^{th} scale ESCs and motors can handle! Generally in cars, if your pack is gaining more than 20deg above ambient/starting temperature after your race – you might consider a pack with more capacity or better discharge performance.

Rule #3) Charging
Always charge your lipo packs at a 1C rate. "1C" means use the same charge rate as the Mah capacity of the pack. So for a 5000mah (5.0 amp hours) pack, the 1C charge rate would be 5 amps. For a 3200mah pack, the safe charge rate is 3.2 amps

Charging at more than 1C will reduce the cycle life and overall performance of your packs. I know you've heard all sorts of things about how it's OK, and maybe even from the ill informed suppliers themselves, but this type of damage is still poorly understood at this time. Mostly because as the output "C" rate goes up with better generations of lipos, they are becoming more resistant (not impervious – just more resistant) to damage from "quick charging" at 2C, 3C, and above. However, ALL real world data at this time still shows that even the most modern cells will still suffer 100% from decreased cycle life when more than a 1C charge rate is used. It's just as simple as that – more than 1C charge will damage your packs.

More than 1C charging provides ZERO advantages as well. It will NOT increase the output (voltage under load) performance, and actually over time the output performance of packs charged at more than 1C will decrease. Due to the charging algorithm of lipo chargers, the time to fully charge the pack from empty to full using a greater than 1C charge rate usually only reduces the charge time by **about 5 minutes**. 2C charging will NOT fully charge a pack in half the time! So you can see there are zero benefits and quite a few negatives to charging at more than 1C.

Lipo packs must ONLY be charged with a charger that uses the standard CC/CV (constant current/constant voltage) charging style. Your charger should specifically say if it charges Lithium chemistry packs. If it does not say so, do NOT charge your lipo pack with it. Charging lipo packs on any other battery chemistry mode (NiMH, NiCad, Lead Acid) will quickly destroy the pack and possibly induce a destructive pack failure the FIRST TIME it's done.

One last word on charging: When the pack is full (a 2cell car lipo pack is full when the resting voltage of the pack is 8.40v) it is full – there is no need to "top off" lipo packs. In fact – charging or bumping voltage any higher than 8.4v will immediately damage the pack and make a destructive failure likely to happen either immediately, or at any point further in the pack's life.

Rule #4) Storage
If you have lipo packs that will not be run for more than a month or two, you must store them at about 1/2 charge. Do NOT store them fully charged and DO NOT store them near fully discharged (down to 6.0v).

The best way to know the charge state of a lipo is to use a mah reporting device either when charging from fully discharged (read the Mah into the pack from your charger if capable). For a 5000mah pack driven all the way to the proper lipo cutoff, charge it until you have 2500mah back into the pack and disconnect it from the charger for storage. Using a whattmeter (from www.astroflight.com), or the discharge function on your charger, discharge a fully charged pack to 1/2 of its capacity. So for a fully charged 5000mah pack, discharge 2500mah from it before storage. Each pack is different, but generally a ½ charged pack will show a voltage of about 7.4 to 7.6v.

Most lipo packs require no special storage or transport containers. You can use your normal battery cases or drawers in a hauler bag. A LipoSack (www.liposack.com) is a highly recommended accessory though for transportation and storage, as well as a safety precaution when charging. They are designed to contain any flame within the special bag material if a destructive failure occurs. DO however keep your Core packs near room temperature (not out in the freezing cold or burning hot garage or car) for best performance and longest life. Remember that the maximum temperature is 140degF – a car parked in the sun can easily exceed that, and so can non climate controlled garages in the summer.

Q: So how is a Lipo pack different than my old 6 cell NiMH packs?

A: Construction

A single lipo cell has a higher voltage than a single NiMH cell. Two lipo cells in series have a fully charged and nominal voltage that are similar to a 6 cell NiMH pack. So your Core 7.4v pack has very similar voltage than a 6 cell NiMH pack, but is actually made up of only two battery cells.

Voltage

Just like NiMh, the number of cells in the pack determines the pack voltage. Each lipo cell is 4.2v fully charged. Most folks are comfortable with the fact that each cell in an average NiMH/NiCad pack is around 1.5v fully charged. A six cell NiMh pack is around 9.0v fully peaked. It is named a 7.2v pack (1.2v/cell) for its "nominal" voltage. A two cell lipo pack is 8.4v fully charged, and is named a 7.4v pack (3.7v/cell) for its "nominal" voltage.

As you can see, "nominal" voltage is fairly arbitrary in both cases, as it's neither the fully charged voltage, nor the fully discharged voltage, but somewhere in between. Since a 6 cell NiMH pack and 2 cell Lipo pack have such similar

nominal and fully charged voltages, you can expect the overall performance of your car and motor to be similar as well.

Performance:

Your Core lipo packs are subject to the same rules of performance as any other battery. They are still an electron storage device, but in a different looking package and configuration than you're used to seeing. The main parameter controlling any battery's performance is its internal resistance. The lower the internal resistance, the more amps (speed/punch) it can deliver, the higher the voltage (speed/punch) it will maintain during that delivery and the cooler it will be at the end of the delivery.

In general, a 4000-5000mah ROAR approved lipo pack will maintain a very similar or higher average voltage under load than even the best hand zapped, pushed, tweaked, and matched NiMH pack. This corresponds to ***both*** more power and speed on tap, ***and*** longer runtimes.

The most profound difference between a good lipo and NiMh packs is that the output performance of the lipo pack is exactly consistent from the first pull of the trigger to the last during a run. There is no “peak” to get over in the first few laps, and no “sag” in the later stages of the run as the NiMh pack starts to get soft. Your lipo pack will also give you consistent performance run after run for its entire lifespan. Good quality packs will generally last you 300-400 consistent top performance cycles if they are never abused. Once you finally notice the performance is not quite what it used to be, there is usually a rapid decline and it’s best to dispose of the pack properly at the point at which it clearly has reached the end of it’s life. No more relegating expensive NiMH packs to “practice only” after just a few runs!

Mah Capacity

One of the most interesting things about lipos is that as the Mah of the pack goes up - so does the output performance as well as the runtime. The higher the capacity, generally the more punch and lower the internal resistance will be. So even if the claimed C rating is lower on a 5000mah pack, in most cases it still is capable of delivering more actual output amps than a lower capacity pack with a higher claimed C rating. To find output capacity, simply multiply the pack capacity (in amp hours, so divide the mah capacity by 1000) by the claimed C rating to get amp delivery: 5000mah pack = 5 amp hour pack X 22C = 110 amps of capability. Compared to a 30C 3200mah pack (3.2 X 30) = 96 amps of capability. Not only will the 5000 run longer, but it will have more power capability (speed/punch) than the higher rated 3200 pack. This formula is completely dependent on the accuracy of the claimed C rating of the pack, so I’ll have more on claimed C ratings below.

Memory:

Lipo has no memory effect at all. This is beneficial because you can use the same pack for bashing, track practice and racing. The performance will always be the same regardless of how you use it.

Resting Time:

Your Core lipo pack needs no 24 hour “rest” between cycles to maintain peak performance. If you have enough time to recharge between rounds, you can even use one single pack for an entire day of practice, heats and mains! I bring one pack and one charger for each car I’m racing with, and charge back up between heats. This can be a significant cost and time savings over having to have multiple NiMH packs for every car.

"Can I use my lipo pack with a regular brushed motor and brushed ESC?"

Most standard ESCs are not capable of providing the correct cutoff voltage to keep the packs from being damaged or destroyed from being drawn down too far. An overdrawn pack will be damaged and must be watched closely for the rest of it’s cycle life or be disposed of properly. Any overdischarged pack can be a fire hazard when it's put back on a charger. Maybe not the first time, maybe not until the second or fifth time (if it lasts that long) but it's an absolute danger.

The good news is that there are devices you can have inline to either provide the correct cutoff directly, or sound an audible and/or LED warning indirectly to let you know when it's time to stop running. You MUST use one of these devices if you use a lipo pack with an ESC that does not have a proper lipo cutoff setting. By the time you notice the power falling off, it is FAR TOO LATE and the voltage is already too low and the pack has been damaged.

Due to the fully charged peak voltage of a good 6cell NiMH pack actually being extremely close to a 2cell lipo pack, your ESC and motor are in no danger from excess voltage. You may want to temp your motor the first few runs with a new lipo pack and re-gear for the track as needed (because there is likely to be more punch and speed on tap with the lipo pack), but just going from a high quality 6cell NiMH to a 2cell lipo pack shouldn't make any huge differences to the ESC and motor. The pack will be maintaining a higher voltage under load, so you will notice quicker acceleration and possibly higher top speed as well.

Q: Why are ROAR approved lipo packs in a hard plastic case?

A: Exposed (non hard case) Lipo cells can be very vulnerable to physical damage. If the thin silver cell envelope gets the slightest scrape, puncture or tear, the pack must then be immediately disposed of properly. An impact resistant plastic case is required to protect the pack from external physical damage to

ensure it has a long useful life. Bashing and racing with a non-encased lipo pack can be a serious safety risk, not to mention the potential to be an expensive replacement cost with any crash or loose battery strap!

Q: Every battery type has it's "tweaks" to improve performance. Can I:

Zap the cells/pack?
Absolutely not. Zapping (forcing an instantaneous but extremely high voltage through a NiMH cell) lowers the internal resistance of NiMH cells by destroying the inner insulating layers of the cell, but at the cost of reducing the performance life significantly. Any such procedure attempted on a lipo pack would surely end in an immediate and catastrophic pack failure.

"Bump" or charge to more than 8.4 volts?
Absolutely not. Lipo packs are especially sensitive and intolerant of overcharging. Any charging over 8.4v will immediately and permanently damage your pack, and may lead to the destructive failure of the pack at any time afterwards.

"Re-Peak" the pack just before the race?
As long as you are using a Lipo capable charger in lipo mode, there is no harm in trying to squeeze more Mah into it, but there are zero benefits to "re-peaking" a lipo because **they are either fully charged, or they are not.** In most cases the charger will see the voltage already at 8.4v and not even begin the charge cycle. When a lipo pack is at 8.4v at rest – it is fully charged. There is no "peak" to the charging process at all. The charger simply applies less and less current to the pack when it reaches 8.4v, until it maintains 8.4v by itself.

Q: So what *CAN* I do to tweak the performance?

A: Starting Temperature
Like most batteries, lipos all have an "ideal output temperature". When run with a starting temperature of around 100degF, the internal resistance is at its lowest. So you get best voltage under load AND least amount of heat built up during the run if you start the pack out at 100degF. Starting the run at room temperature may show a slight decrease in power output, but only with very high performance setups. A very cold pack (<50degF) can show noticeably poor performance in most setups until it warms up with use.

In the winter time or in cold climates, it's best to store packs in a heated indoor living space rather than in a cold garage so they're ready for use at a moments notice.

For outdoor racing in cold climates, you can get an edge on the competition by pre-warming your packs to 90-100degF before the race. But remember – 140F is

the maximum safe temperature, and the pack may still increase in temperature with use, so exercise caution with any battery heating procedures.

Also – this is the optimal temp for output performance, and when the pack is being charged it makes little difference what temperature it is. Other than extreme cold which may allow the pack to overcharge, or if it's over 140degF which may cause a destructive failure while charging.

Quality Connectors

Your battery can only flow as much juice as the connector allows. You can actually see the performance difference between beefy low resistance connectors (Deans, Traxxas, 4mm gold plugs) and the white plastic stock connectors that come on most RC electronics. Quality connectors made for high amperage use will allow your pack to deliver its full power potential.

Good Soldering Skills
Installing good connectors and wiring up electric systems involves soldering, and a bad solder joint or two can ruin your whole day (not to mention potentially ruining electronics and batteries). The BEST solder joint is where the wire looks like it's just barely coated silver and you can still see all the wire strand detail. Use just barely enough solder to make sure you don't have bare wire strands hanging around. The best solder joint is NOT where there is a smooth silver blob encasing everything. If you can't see the individual strands of copper that make up the wire, you have used too much solder.

A final word on "claimed" C ratings:
Firstly lets define "C" rating:
Oh wait - that's right, no one has a standard definition of what that number actually means or how to determine it! (and I'm being completely serious)

To ME: The C rating means that the pack can output "X" many amps for the duration of it's capacity (usually about 80% of the total pack capacity) WITHOUT doing either of two things:
1) dropping below 3.0v/cell, AND
2) heating up beyond 140degF

The C rating comes from the following math, using a made up pack as an example: A 5000mah pack is supposedly 20C, which means it can theoretically be discharged at 20 times its capacity. 20 times 5000mah = 100,000mah or 100 amp continuous discharge capability.

First, you must actually have and use some serious discharging equipment including voltage and current monitoring/reporting along with a temp gun or thermal probe. Hook up the pack, and throw a 100 amp load on it and report/graph the voltage and temperature over the time of the discharge. If the

pack dips below 6v (2 cell pack) or reaches 140degF before a minimum of 80% of the capacity is discharged out of it, it's not really a 20C pack. Again, this is going by my OWN C rating criteria because there is no real standardized "test" to determine C rating claims and no real definition of how that figure on the label is arrived at.

For this case lets say the pack just stayed above 6v and just below 140F at 75 amps. So we take 75a and divide that by 5 amp hours (pack capacity) and we get 15. So I'd call this pack a 15C pack. If it could be discharged fully at 110 amps and hold voltage and not overheat, then we have 110 divided by 5 = 22C

And here's where the problem lies (whoops - did I just say lies?).
1)Not many folks have access to 100A+ discharging and graphing equipment. Therefore extremely few people really actually KNOW what their own, or other packs out there are really capable of, and whether or not what's on the label is accurate, what it really means, or if its just plain made up.

2)If we look at it from a marketing perspective, a racer may have the choice between two packs with similar pricing and Mah capacity, and one is labeled 20C and the other is labeled 23C, obviously everyone would buy the 23C pack. Its simple marketing and psychology directing that purchase.

3) There's no real universally accepted testing/performance standard either in the lipo industry, or the hobby industry. The lipo factories that do supply performance graphs always supply them for single cells – never in the form that we're using them as a pack of two cells inside a hard case. So even that data has to be looked at with some level of suspicion.

So when you add up all three of the above items, you begin to realize what the racers are really facing right now. What does 15-20-25-30C really mean???? By what (and who's) definition was that C rating determined? Were *packs* actually discharge tested? Are the brands just using whatever the factories happen to tell them the C rating is? (and again - by what standards are the factories using - and aren't all the factories competing with each other too in order to offer the highest performance at the best price to the brand resellers? Doesn't it pay for them to fudge their #s a little bit too?) Are they all just flat out making up numbers higher than anyone else's just to sell packs?

When it comes right down to it - If I wasn't restricted by my own morals and professional integrity, I could advertise the brand of 5000mah pack that I sell as 45C and probably sell 10x more than we already do right now. Think about it - WHO out there is an unbiased party AND has discharge equipment capable of 225 amps to prove that it's not?

In the real world of ROAR approved lipo packs, MY ratings system says there is nothing better out there right now than true 20 to 22C packs. There are plenty of

C rating claims way higher than that, and they seem to climb by the week don't they? Of course they do, because each brand has to claim something higher than everyone else in order to get attention and sell packs. Plus as above – who's going to prove their claims wrong?

So the moral of the story here is what I say to our customers when they ask about lipo and what ours is "rated at" (because I rarely discuss what my own actual rating for our packs are and I refuse to buy into marketing hype promotional methods). I ask them: Do you trust who you are dealing with/buying them from? Do they have years and years of experience specifically using them in car applications as well as industry experience with the lipo products they're selling? Do they really know everything about it in order to support you with accurate advice, accurate performance claims and safe usage guidelines? Have they been asked exactly what their C ratings mean, and by exactly what method and criteria they were determined?