Lithium Batteries in Racing Presenters Notes

By: Matthew Chin

I want to start with a story. A few years ago the company I was working for; Braille Battery had gotten to contract with Indycar to design, develop, and build a spec 12v battery that would be used for the series. This was exciting! Every single car in the field would be using OUR batteries, we couldn't mess this up…but we were navigating into uncharted waters, lithium was new, lithium was unproven in such abusive conditions. Everything in testing was successful, and the season was well on its way with no issues. And then this happened….

Now, I don't have the actual picture but there was an accident on a super oval where the left side (where our battery sat) of the car scrapped the wall for over 1000 feet. My heart stopped…was the driver ok? Was our battery going to cause a fire? What if the driver is unconscious?...The car came to a screeching haut after what felt like forever, and I sat there waiting, but nothing happened. I breathed a sigh of relief after the driver was out of the car and the corner workers (thanks to those guys!) were cleaning up the car off the course. We had it written in our contract for any accident over 4g to get the battery back for testing and inspection, so now I got excited waiting for this battery to get back to us. Few days later it comes from the team, we open it with nervousness and excitement. First thing we notice is that the case, that we had designed was scrapped heavily almost all the way through, but not quiet. Next we took it to our lab to test and disassemble. We check the stats of the battery against when we first sent it out. It was within 3% of new. We starting taking it apart to check the internal component's, they were just as when they left our hands the first time. We were ecstatic! We had successfully designed, developed, built and tested…in the real world, a safe lithium battery for racing! To this day every single Indycar is using the same basic battery.

In this presentation I will go over all the basics of lithium ion batteries in racing, everything needed to know how to tech, what to look out for, why you will see more of them, and some of the performance advantages of lithium batteries.

Can anyone name some OEM manufactures who are putting lithium batteries into their cars?

More and more manufactures are selling cars with lithium batteries as either standard or optional equipment. These 3 cars, the Mclaren MP4-12C, BMW M4, and Porsche GT3 are just some of the cars using lithium ion batteries from the factory…And of course this one [tesla] is also using lithium batteries and are becoming a part of local autoXs and HPDEs, and I imagine soon part of club and professional racing. So what are the issues? What do we need to look out for to make sure that these cars don't end up like the Boeing 787 Dreamliner.

Lithium is the future in racing

Like I spoke about before, every single Indycar is using lithium batteries. Roughly 85-90% of the IMSA weather tech series is using lithium batteries Nascar, F1, Australian V8 Supercar, and DTM ALL use lithium 12v batteries. More and more people looking for ways to reduce weight are starting to see the benefit of lithium batteries in their race car. This means as the nations leading racing organization we need to be prepared and knowledgeable on the technology of the future. We will also see more full electric/hybrid cars based on lithium technology systems coming in on the next few years. Lets start with the basics…

So, true or false.

A lithium battery can be put on the same circuit as a lead acid battery?

This is false,

Since lithium actually has a higher floating and charging voltage than a lead acid battery damage will occur to both batteries if they are put on the same circuit. You want to make sure to use a lithium charger to recharge a dead battery instead of "jumping" it with a lead acid battery like you normally would. Lets go over some of the safety concerns of lithium batteries.

I want to say that a properly made lithium ion battery is safe. As safe as a lead acid battery. However they are not bullet proof, the same safety standards should be adhered to as a lead acid battery.

As any battery holds a fair bit of energy the tie down for the battery must be secure. However I recommend a system that can be used to quickly remove the battery from the vehicle.

Battery Cutoff Switch must be working correctly. Incase there is an issue with the battery you will want to make sure you can quickly and safely disconnect the battery from the electrical system

Since the battery is non-spill able (no liquid) under normal working condition they can be mounted in any direction safely, just like an AGM battery

The big one is to make sure there is nothing around the battery that can cause a short. Lithium batteries can release a massive amount of amperage very quickly which can cause a very dangerous situation

You want to make sure that there is no physical damage to the battery case or terminals. I have seen where a lose terminal (on the physical post of the battery is lose. This could lead to a short internally so verify with a solid grip on the terminal to make sure it is solid

Also all battery manufactures should be able to produce a Data sheet on the battery. This will tell you the chemistry of the battery, any certifications the battery has, such as IP rating or CE rating. Type of cells, capacity, maximum amp draw, if it has a BMS, or at a minimum cell balancing. Many of the manufactures actually have a built in short circuit cutoff. Information like that can be vital.

The dangers of lithium.

The biggest danger to a lithium battery is thermal runaway. This is when one cell fails inside the battery and the heat causes the next cell to fail and so on and so forth. That is the runaway situation.

What causes this situation you might ask?

This is most often cause by a short within the cell pack. Each lithium battery is comprised of multiple individual cells placed in series and parallel at the same time, well what we have seen is if the voltage in the cell becomes too low it will actually flip polarity (positive/negative) which then creates an internal short.

Lithium batteries are very good at giving off large amounts of energy very quickly, very very quickly. And like anything else especially in racing we know that when there are large transfer of energy there is a large creation

of heat. Think of glowing brakes, or a turbocharged engine running at full song. Heat management is a key factor in racing successfully!

So what happens in this situation? What do you need to look out for?

A failing Li-ion begins to hiss, bulge and leak electrolyte. Remember these batteries are designed to be sealed, so if you see anything coming out. Its not good.

The electrolyte consists of lithium salt in an organic solvent (lithium hexafluorophosphate) and is highly flammable. This material is held in sealed steel containers, but burning electrolyte can ignite combustible material in close proximity.

In the rare case there is an issue with the lithium battery. First all non-emergency responding personnel (including the driver) should be removed from the situation (duh).

If at all possible the battery should be removed from the vehicle and placed in a spot away from any combustible material. This is why I said it is advisable to have a quick disconnect (such as an Andersen connector for the battery, and a pin system holding the battery in)

If the battery cannot be removed then:

Dowse Li-ion fire with water, use a standard ABC fire extinguisher, or if applicable the halon fire system in the car, the combustible electrolytes need oxygen to create the fire. Only use a Class D fire extinguisher for lithium-metal fires because of the reaction of water with lithium. (Li-ion contains little lithium metal reacting with water.)

If a Class D extinguisher is not available, douse a lithium-metal fire with water to prevent the fire from spreading.

For best results during a Li-ion fire, use a foam extinguisher, CO2, ABC dry chemical, powdered graphite, copper powder or soda (sodium carbonate) as you would extinguish other combustible fires. Reserve the Class D extinguishers for lithium-metal fires only.

If the fire propagated away from the battery, such as an engine fire all effort should be put to keeping the fire either away from the battery or try to remove the battery from the situation. Again there is a large amount of energy inside these batteries which on their own won't cause an issue but if the fire burns hot enough around the battery it could add fuel to the fire! (pun intended)

****Be aware of cell propagation as each cell might be consumed on its own time table when hot. Place a seemingly burned-out pack outside for a time.***

Although new types of Lithium batteries are coming out, the most popular for automotive usage are:

LiFeP04- Lithium Iron Phosphate - Li-phosphate is more tolerant to full charge conditions and is less stressed than other lithium-ion systems if kept at high voltage for a prolonged time.

Thermal runaway270°C (518°F) Very safe battery even if fully charged

Lithium Manganese Oxide - These three active metals, as well as the silicon enhancement can conveniently be chosen to enhance the specific energy (capacity), specific power (load capability) or longevity

Thermal runaway250°C (482°F) typical. High charge promotes thermal runaway And thus is not the recommended style of lithium batteries for race cars.

There are 2 main styles of lithium cells. Each have their advantages and disadvantages.

Lets start with the preferred style for racing. Cylindrical cells, these units are the gold standard for the needs of racing. They can handle the high heat, high abuse situations of racing. From the G-forces to the constant charge from the alternator. They also are safer since they are steal encased and have a “blowoff point” if an issue ever arises. But the are not as efficient with their space as other cells, and are a bit heavier due to the steel case.

The other style is prismatic cells, these are pouch style lithium cells that can be stacked together giving you more “amp hours and cranking power in a smaller package. They are also lighter than cylindrical cells.

But I do not recommend using these types of cells for racing application because they don’t deal with heat as well, they can end up bulging causing issues or a “Release” of the materials inside.

So, there are a couple of things that I want to bring up to make sure that the batteries are being used successfully.

- Lithium batteries don’t like the cold. Damage can be done if the battery is CHARGED under 32F. They can be discharged under 32F AND will actually heat itself up to above 32F if the battery is allowed to discharge for a while.
- If the battery is charged below 32F the electrolytes will crystalize and it will puncture the membranes within the cell which will cause a short and then the battery will fail.
- I wouldn’t recommend putting the battery next to the exhaust or the head but anywhere else is a safe place (temperature wise) for the battery to live.
- Over time the battery can be susceptible to excess vibrations so it helps to put a vibration barrier between it and the car. Something simple like a foam pad. Many brands of batteries actually put foam inside for vibration dampening.

Since there is such a high amount of energy in lithium batteries I do not recommend allowing home build lithium batteries while racing. Just the same you would not allow someone to use a homebuilt fuel pump there is too high of a risk with lithium batteries. However there are many brands that have been proven and are safe for competition use. All of these brands are known to use cylindrical cells.

- Braille Battery
- Super Bee
- A123
- Lithium pro
- Antigravity
- GreenLiFE Battery
- All of these brands have been proven to be safe in racing conditions. However new brands are coming out all the time and information between the different chapters should be shared if any problems are seen with ANY brand battery.

So now that we have talked about how to handle lithium situations lets talk about why you will start seeing them more often…

We as racers, or race fans are always trying to find ways to be faster. Now most of us know that reducing weight (or getting to class minimum) is one of the best ways to improve performance. But I think we can all agree we would rather lose it on the car than ourselves.

Lithium batteries generally weigh 50-75% lighter than a comparable lead acid battery, when a car use to need a 30-40lb battery can now be replaced with a 8-10lb lithium battery!

This is probably the quickest and easiest way to reduce pounds in an overweight car.

And you guys with SRF, after repairing your car with 10lbs of fiberglass and resin can remove the weight again using a lithium battery

Lithium batteries contain a massive amount of power.

Have you ever spun out on track and had a hard time restarting the car after a stall? Not with lithium. There is a ton of cranking power for their size and weight.

Let me tell you a story. Most of you are familiar with this car [Corvette Racing C7.R] We got to talk to Dan Binks after they switch to lithium ion batteries. He said he use to run 2 12v AGM batteries in parallel for hot starts during endurance races, and the car would still have issues at times causing their pit stops to be longer. He switched to a single lithium ion battery that weighs 8.3lbs, and the engine fired so much quicker that over the course of the 24 Hours of Daytona it saved the team around 45 seconds. Tell me where else you can drop in a part and improve race performance that quickly!

Because who doesn't like even MORE POWER!

But what I mean by this is that the resting voltage is actually higher than lead acid batteries. Most 12v designed electrics actually perform better with a little higher voltage. Fuel pumps become more efficient, spark is a little hotter, lights a bit brighter. This is why most alternators put out over 14v while running! This actually gives some people the chance to run a lithium battery as a total loss system for sprint races!

It is also a "cleaner source" of power. I am sure most of you have heard of electrical interference with voltage drops which can cause havoc trying to trace down an issue. Lithium racing batteries maintain their voltage much steadier than any lead acid making sure that all your electronics work as intended.

Lithium Batteries can be much, much smaller than a comparable lead acid battery in racing. So cars, like Formula Ford, Formula Continental, and others that have space constraints, Lithium can help free up some of that space and still provide you with all the power you need.

So we have gone over some of the points of lithium, but what about the costs?

For club racing these batteries are fairly expensive. Ranging from $400-$1200+ dollars.

However compared to the cost for some of the other products we purchase for racing. It is actually fairly reasonable for the benefits.

A typical lithium battery should, if taken care of last roughly 8-10 years.

Many can be rebuilt and verified by the manufactures to make sure they are in top shape.

Over time the batteries actually become less expensive and this main stream for the everyday grassroots racer,

We have gone over some of the more important parts of lithium batteries.

Hopefully I have given you a better understanding of this new technology that is coming into the SCCA's future.

I want to remind you not to be afraid of new technology, it is what pushes up forward into the future. There was a time when people were afraid of gasoline and how flammable it is. That is why garages when they were first made were separate from the house.

The lithium technology used for 12v batteries is very different than those used in cellphones and hover boards and are vastly safer.

Lead is dead and here's to the future of racing in the SCCA and lithium batteries to power it!