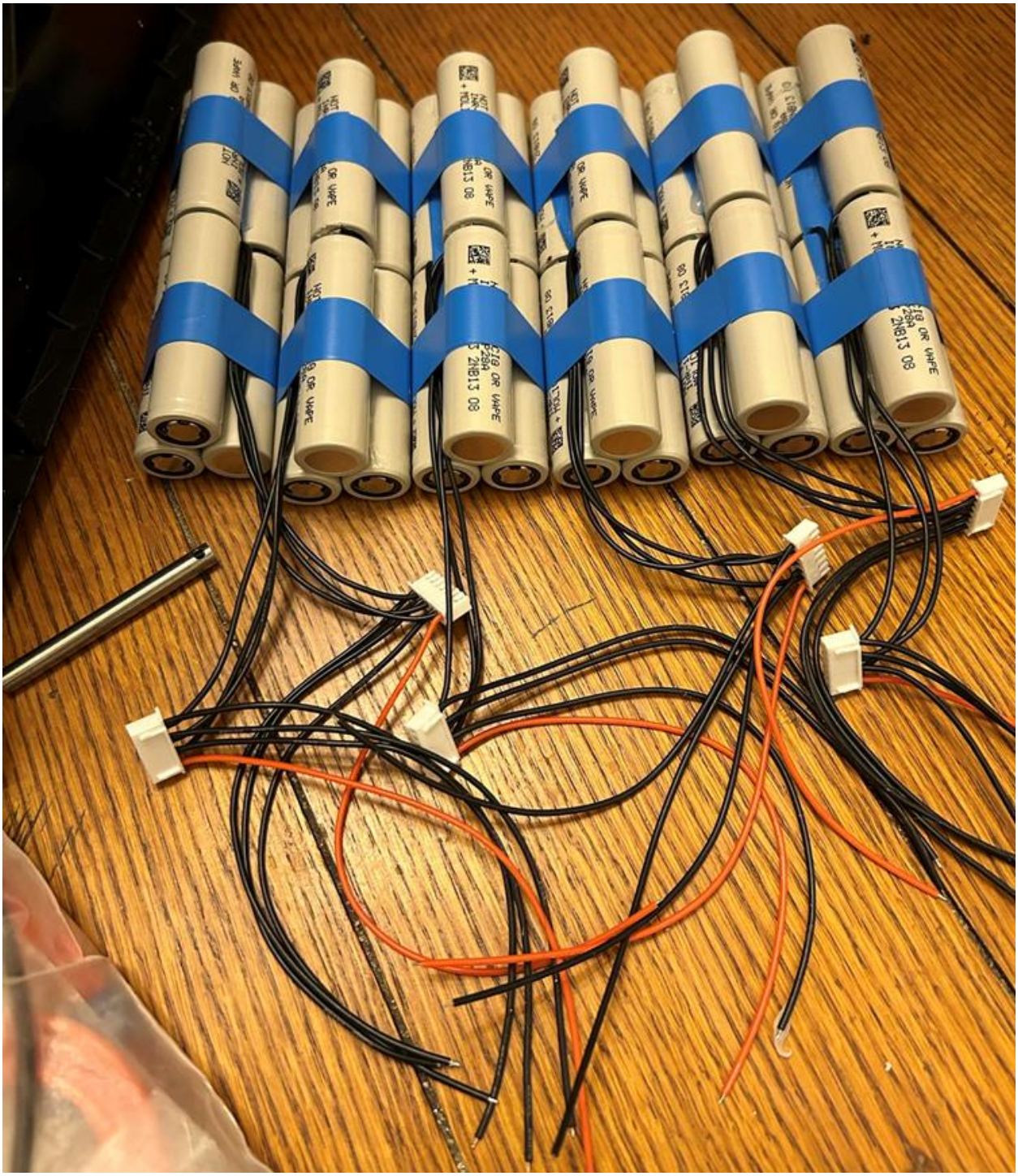
So You Want to Make Lithium-Ion Battery Packs?

Written by: Dennis S. Nunes – April 2025



Li-Ion batteries before applying shrink wrap (Photo by Dane Martin)

I'm off to see the Wizard, the Wonderful Wizard of…

I'm sure that most people have heard these famous words from the movie, *The Wizard of Oz* during their lifetime. As a small kid watching this movie for the first time, the Wicked Witch of the West scared me to death! At 70+ years of age, she still scares me! What does this line have to do with making Lithium-Ion (Li-Ion) battery packs for a control line model airplane? Let me try to explain…

When Dorothy was swept up by a tornado, came back down to earth, woke up in the Land of Oz, she had no idea where she was, what to do, or where to go. That's pretty much how I felt when it came to making Li-Ion battery packs.

Finished 6S 2800 Li-Ion Batteries made by Dane Martin (Photo by Dennis Nunes)

Back in August of 2019 I decided to build my first electric powered control line precision aerobatic model airplane, a profile, known as *Circulas 46e IIe*.

This led me to write the article entitled, *"Turning to the Dark Side – The Building of Circulas 46IIe – An Electric Profile"*. You can view and/or download a copy of this article from the *Flying Lines* website. But beware, a lot of things have changed since then and will continue to change. It hard to believe, but that was almost 6 years ago. Time sure flies when you're having fun!

Back then, I started with *Thunder Power* 5S 2800 mAh Lithium Polymer (Li-Po) batteries. These batteries were the lightest (10.5 oz.) and worked very well with a 2-

blade propeller. However, when I started to experiment with the 3-blade propellers, I soon found out that I didn't have enough battery capacity to handle these type of props.

Circulas 46 IIe at the 2021 AMA NATs

It was clear I needed to move up to a Thunder Power 6S 2800 mAh battery (12.5 oz.). Buying a new set of Li-Po batteries can get very expensive, especially if you purchase them when they are not on sale. Currently, one 6S 2800 mAh battery with a XT-60 connector will set you back $86.00 plus tax and shipping. So for a set of (6) batteries, you're looking at almost $600.00! The cost savings is tremendous if you can wait and hold out for a *Thunder Power* sale. During some of the holidays, you can get discounts from 25% to 45%. Believe me, it's worth waiting for a holiday to purchase their batteries!

Back then, due to my lack of experience, I learned that charging Li-Po batteries at a high charge rate can shorten the life of the battery. I found myself ruining batteries and losing one plane in the process. A very valuable lesson and a very expensive one.

If you treat and take proper care of your Li-Po batteries, they will serve you well and last a long time. *Thunder Power* batteries are expensive, but they are light, come in a variety of cells and capacities, and are easy to obtain.

A New Sheriff (Battery) in Town:

At the 2021 NATs, Paul Walker used Li-Ion batteries and wrote about them in a post on Stunthanger.com. There are a couple of *advantages* that Li-Ion batteries have over Li-Po batteries:

- The biggest advantage is weight. A 6S 2800 mAh Li-Ion battery weighs 10.5 oz. This is 2 oz. lighter than a 12.5 oz. *Thunder Power* 6S 2800 Li-Po battery. A considerable savings in weight!
- Li-Ion batteries are supposedly safer to use than Li-Pol batteries. *You still need to exercise caution when charging or using any type of lithium battery.*
- Another advantage is the price. Several year ago you could buy a 6S 2800 Li-Ion battery for $50.00 each!
- The life cycle of Li-Ion batteries is about twice, if not more, than Li-Po batteries.
- Li-Ion batteries can withstand operating at higher temperatures than Li-Po batteries.
- Li-ion batteries can run or be brought down to a lower voltage than Li-Po batteries.

But there are some *disadvantages* of Li-Ion batteries that need to be considered:

- The biggest disadvantage, is that you or someone you know, needs to "make" these battery packs. Unlike Li-Po's, Li-Ion batteries are not available commercially.
- Li-Ion batteries run hot and may require additional cooling in order to keep the battery and other electrical components cool. This may require rerouting or redirecting air to the battery compartment and/or components.
- Also, the shape and size of the battery is different. In most cases a different type of battery mount is needed.
- It is recommended that you only charge Li-Ion batteries at 1C. Which it now takes me a little over an hour to fully charge (6) 2800 mAh Li-Ion batteries.
- From my experience, I've found that battery capacity is weakened when the temperature gets below 45°F or less. I've "run out of battery" on a couple of flights due to cold, damp weather conditions. Once the temperature rises to about 45°F, the problem disappears. This can be a common problem when flying in cold weather conditions. For further information on keeping batteries warm see the article, *"A Battery Warmer – Really?"* This article is available on the Flying Lines website.

WARNING:

Before we go any further, a warning. This is not meant to scare anyone, but there are risks involved in handling and working with Li-Ion batteries.

My grandfather, who taught me to use power tools, told me when it comes using power tools, *"Do not be afraid of them, but show them respect. The minute you fail to give them the respect, is when they bite you"*. The same can be said when it comes to Li-Po or Li-Ion batteries *and then some.* Notice the warning below:

> *WARNING: Improper handling or misuse of Li-Ion batteries can result in **FIRE, EXPLOSION, or THERMAL RUNAWAY**, causing personal injury, property damage, or death! – Please read the "Important Safety Warning" section at the end of this article for further information.*

Can You Make Your Own Batteries?

Will DeMauro sent me a link to his pictures on how he made his battery packs. In talking with Will and from the pictures, it didn't appear to be too difficult. *But could "I" make them?*

Well, rather than build my first set of Li-Ion batteries, I decided to purchase (6) 6S 2800 mAh Li-Ion batteries from Dane Martin. These batteries are well made, have worked well and still do. The individual cells used in these battery packs are the *Molicel* INR-18650-P28A 2800. However, when flying in cold weather, as mentioned earlier, battery

capacity is reduced. In my situation, I ran out of battery near the end of the 4-leaf clover. So I know that I'm right on the edge when it comes to capacity, *especially in cold weather*. Warm weather, there are no problems at all, plenty of battery capacity. As batteries age, capacity will decline. How much? Time will tell.

I wanted to try and make a new set of batteries. Strangely enough, I wasn't the only one wanting to do this. Several of us on the west coast wanted to make them, for various reasons, but we were not quite sure what was involved. Talking with Will and looking at his pictures helped. *"A picture may be worth a thousand words", – but they don't tell you everything!*

Then someone, I believe it was Jim "Uncle Jimby" Aron, suggested that we get together for a brainstorming/building session and try to learn how to build our own Li-Ion battery packs. Thankfully, there were a couple of individuals who have made Li-Ion packs and were willing to share their experience and knowledge with us. So a call went out (actually an email) to see who was interested in getting together. What a response we received! Chris Cox, Fred Underwood and Randy Ling who had experience at making battery packs, agreed to attend and help. Howard Rush, Jim Aron, Dave Fitzgerald, and I also wanted to be there.

So, the next thing we needed was a place where we could gather and attempt to build some battery packs. Howard stepped up to the plate and graciously offered his huge workshop in Olympia, Washington as the gathering spot.

***Batterypalooza* was born:**

I believe it was Howard who coined the name —– *Batterypalooza!* At least that's what the subject line stated in the plethora of emails that followed.

About a month prior to the start of *Batterypalooza*, those that wanted to build batteries needed to order a long list of items. But what exactly did we need to order? I know that Dave, Jimby and myself had no idea what we needed. Thankfully, Fred came to the rescue and put together an extensive list of supplies to order and where to order them from. The majority of the supplies came from Amazon, with the exception of the individual *Molicel* 3000 mAh battery cells that we wanted to use.

Finally it was decided that *Batterypalooza* would take place on Tuesday, December 3 at Howard's place. We weren't sure how long it would last, perhaps a day or two, maybe 3 days at most. Nor did we really know how many would actually show up. Well… For me and Jimby, *Batterypalooza* ended up lasting *6 days!*

Getting to *Batterypalooza*:

Now the only issue was getting to Olympia, Washington! Everyone was scattered all over the west coast: Canada, Washington, Oregon or California. For those of us living in California, we had the option of driving 740 miles for 13 hours or flying commercially with a boatload of battery cells, wire, connectors, soldering equipment, shrink-wrap, tools, etc. Enough for a small army and perhaps a problem when going through airport

security! Jimby and I decided that we didn't want to put ourselves in the position of submitting to a full body cavity search and/or checking out the living conditions at the nearest jail. We opted to drive together instead.

But you may be asking yourself, "Why did we have all this stuff for <u>*three*</u> people, when only two of us were driving together?" Read on…

Not everyone could remain for the entire duration. Some, like Fred and Randy, would be there just for a day to help out and share their knowledge. Jimby and I would remain for the entire time.

Dave Fitzgerald and Chris Cox had an *interesting* way of getting to Howard's place. Dave purchased Chris' beautiful full-size airplane, an RV-7 named *"Rosie"*. Dave flew up to Canada to meet Chris and to take possession of the plane. Both Chris and Dave planned to fly *Rosie* down to Olympia for *Batterypalooza*. After *Batterypalooza*, the two would fly down to the plane's new home in Napa, California. Chris would later take a commercial flight back home to Canada.


The RV-7 "Rosie" in Canada (left) and the New Owner with the "Rosie" in Napa

So, Jimby ordered all the needed supplies to make battery packs for Dave and himself while I ordered mine separately. That's how we ended up with stuff for 3 people.

Sadly, the weather decided not to cooperate on the day that Chris and Dave were to depart from Canada. Heavy fog both in Canada and Olympia prevented them from flying. They waited several hours for the fog to lift and while it did in Canada, Olympia remained socked in. Landing an airplane is always a good idea, so at the last minute, they decided to skip *Batterypalooza* and eventually made their way down to Napa where the weather conditions were more favorable. Too bad, they missed out on a fantastic time!

So it was Howard, Fred, Randy, Jimby and myself showing up for *Batterypalooza*. Fred and Randy came in just for a day, but they each came on different days.

> <u>*Side Note:*</u> *Thanks to Howard for giving Jimby and me a place to stay for the entire duration. A special "Thank You" must go to Mary Lou, Howard's wife, for her outstanding hospitality and putting up with us! We enjoyed our*

stay tremendously, although I'd bet Mary Lou thought that we would never go home!

Making Batteries at Batterypalooza:

Back in November, Fred Underwood, our now resident "Expert", emailed an extensive list of items required in order to build Li-Ion batteries.

You will need to decide which method you are going to use to assemble your battery packs, (1) soldering using tinned copper straps to attach to the battery terminals or (2) spot welding, using pure nickel strips to attach to the battery terminals.

Howard was able to borrow Randy Ling's spot welder, although I planned to try soldering mine instead.

After soldering two battery packs together, I soon discovered that the spot welder was a much easier and quicker method. With the soldering method, you must be extremely careful not to put too much heat and for too long a period of time when soldering tabs and/or leads to the cells. Too much heat can damage the cells.

Though I've now built batteries using both methods, *I prefer and highly recommend spot welding.*

Some of the Tools and Equipment Needed:

Just Some of the Materials and Tools Needed to Make Li-Ion Batteries

I ended up purchasing my own 11,000 mAh Portable Spot Welder Kit from Amazon made specifically for making battery packs for around $70.00.

Portable Spot Welder Kit from Amazon

Another important piece of equipment is an inexpensive Multimeter. I happened to have one that I got for free from Harbor Freight on some promotional sale event. They can be purchased for around $5.00.

Even with the spot welding method, there is still some soldering that is required, such as the main leads and balance lead connections to the nickel tabs. For this, a simple 80 Watt Soldering Iron Kit will work. This can be purchased from Amazon for around $10.00.

Multimeter from Harbor Freight (left) and Soldering Iron Kit from Amazon (right)

Li-Ion Batteries Used:

Up until now, the popular individual Li-Ion cell was the *Molicel* INR-18650-P28A 2800 mAh cell. This was the cell that Dane used to make my first set of Li-Ion batteries. These cells were plentiful and relatively inexpensive. However, the *Molicel* INR-18650-

P30B 3000 mAh battery are now available at a reasonable price. Surprisingly, the 3000 mAh battery is 1 gram lighter than the 2800 mAh battery. However, what I'm hoping for is that the extra battery capacity will help with my cold weather limitations.

Preparing the Li-Ion Cells:

Before getting started, I suggest watching two YouTube videos produced by Dane Martin. The videos are entitled, "Li-Ion Safety and General Building Practices" and the other is "DIY Li-Ion Packs! How to Solder Mains and Balance Leads". This gives a general overview on assembling Li-Ion battery packs.

Using a Multimeter, before assembly, check all the voltages of each individual Li-Ion cell that will be used in your battery pack. Make sure that the voltages of each cell are about the same (about 3.5v) and that there are no cells that are DOA, overcharged or undercharged.

With a paper towel or cloth and some alcohol, clean the terminal ends of each cell. Next, install the insulation rings on the positive end of each cell. This is important because you want to protect the positive terminal from coming in contact with any other part of the battery.

I made what I call a "traditional" 6-cell battery pack, which is a 3 x 2 lengthwise configuration, forming a long and skinny triangle shaped pack. You will need to make a set of 3 banks for each battery pack.

Adding Insulation Rings to Positive End of Batteries

Did you notice the orange Battery Welding Clamp in the pictures above? These work great at keeping the batteries from rolling all over the place and for spot welding (or soldering) the nickel strips in place.

I wrap the negative end of the battery with Kapton® tape. What is Kapton® tape?

According to Wikipedia: *"Kapton is a polyimide film used in flexible printed circuits (flexible electronics) and space blankets, which are used on spacecraft, satellites, and various space instruments. Invented by the DuPont Corporation in the 1960s, Kapton*

remains stable across a wide range of temperatures, from 4 to 673 K (−269 to +400 °C). Kapton is used in electronics manufacturing, space applications, with x-ray equipment, and in 3D printing applications. Its favorable thermal properties and outgassing characteristics result in its regular use in cryogenic applications and in situations where high vacuum environments are experienced".

Kapton Tape (Polyimide Film)

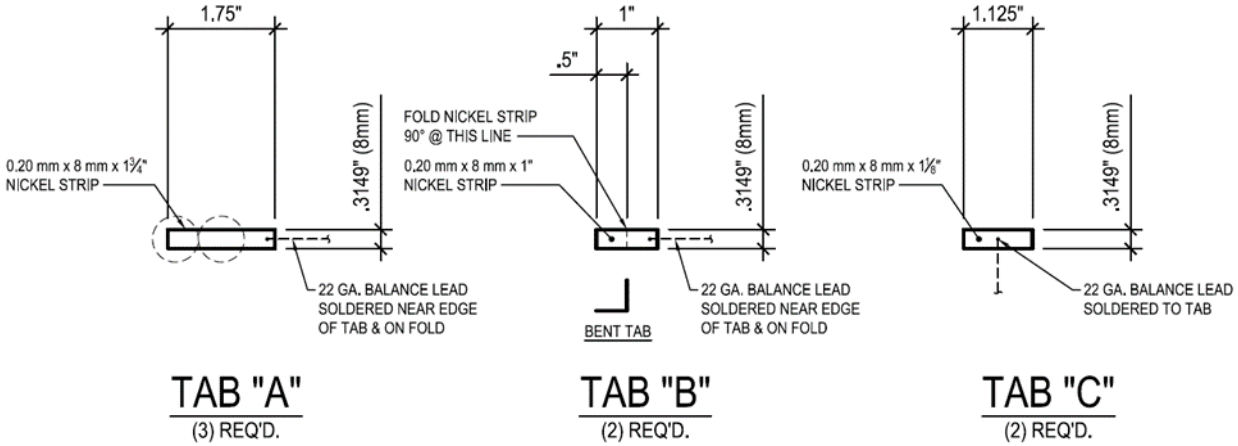
Boy, that's a mouthful. Simply put, it's a high temperature and extremely durable electrical tape that works great for our purpose.

Allow the tape to overhang the end of the cell by about 1/32", fold or roll over the tape on to the end of the cell. I tried using heat shrink tubing for this, but I've had trouble with the heat shrink sometimes sliding off the end of the battery. I prefer using the Kapton® tape as it doesn't slip off and is exceptionally durable. You can even solder on it and it won't melt!

Spot Welding the Nickel Strips:

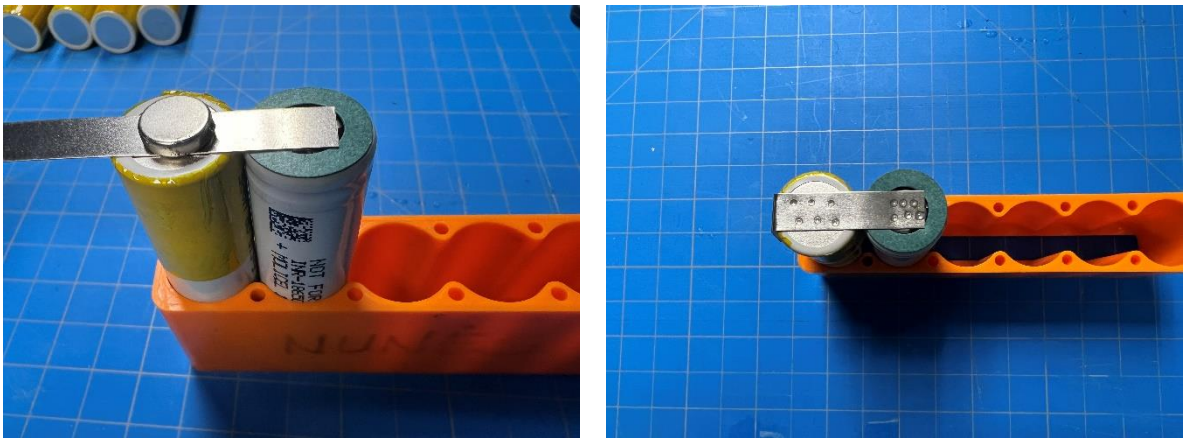
Cut the 8 mm wide nickel strips to length as shown below. Bend only the (2) 1" long nickel tabs at 90° (TAB "B") as shown above.

Next, take two batteries, and place them in the Battery Welding Clamp. Spot weld a 0.20 mm x 8 mm x 1.75" long nickel strip (TAB "A") to the positive terminal and then spot weld to the negative terminal.



Fred showed us a neat little trick for holding the nickel strip in place when either soldering or spot welding. Place a small magnet on the negative terminal to hold the nickel strip in place while spot welding to the positive terminal. Remove the magnet and spot well to the negative terminal.

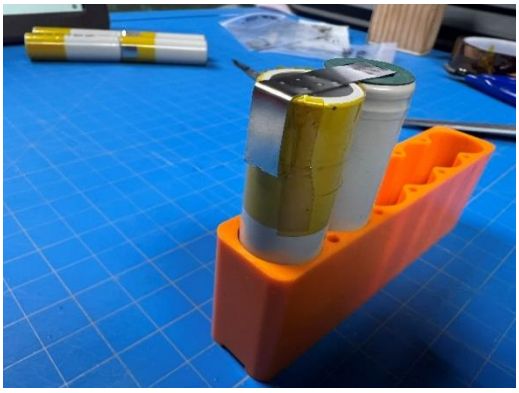
In the pictures below, the individual cells are held in place with the use of the orange 18650 Battery Welding Clamp. Notice the Isolation Ring on the positive terminal and the Kapton® tape on the end of the negative terminal.



Preparing to Spot Weld TAB "A" to Batteries (left) Spot Welded Tab (right)

Once the two cells are spot welded together, bend the end of the tab down, where you will later solder the balance lead. Notice that the tab is bent down on the negative terminal, over the Kapton® tape.

Next, it's a matter of carefully bending the two cells into a straight bank. Carefully bend TAB "A" by holding on to each cell and straightening the two cells and pushing them together. Once straightened, use a strip of Kapton® tape around the joint to hold them in the straight position. Make sure to leave the end of the TAB "A" exposed to allow for the soldering of the balance lead later in the process.



Bending the Tab "A" down from the Negative Terminal (left). Bending the two cell straight (right)

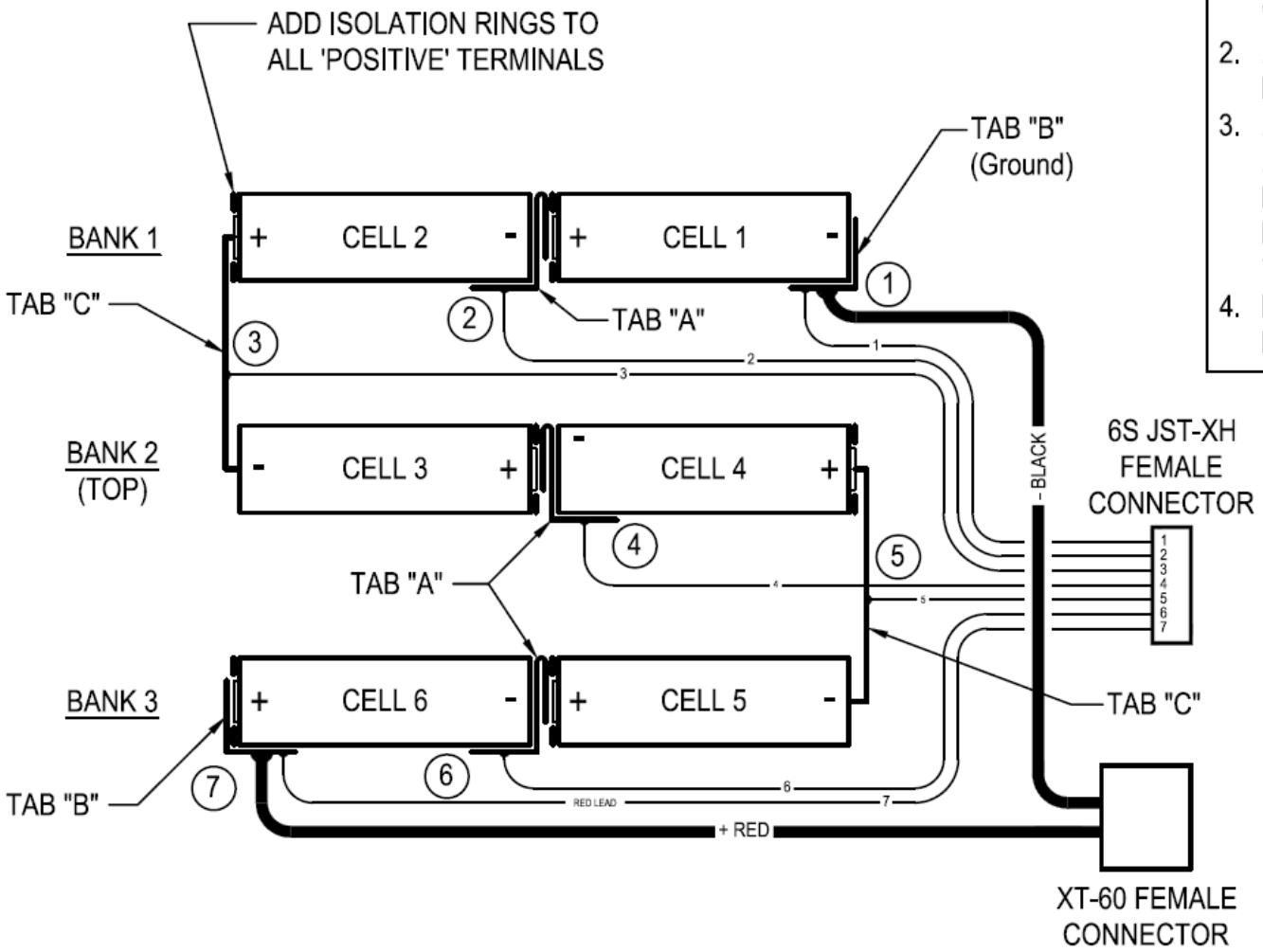
Two cells bent straight and wrapped with Kapton® tape
(Notice the end of TAB "A" is exposed)

Assembling the Battery Pack:

The banks of cells should be ready to assemble into a triangle shaped battery pack. Pay close attention to the polarity direction of each bank, as Bank 2 is different from Bank 1 and Bank 3. Note this in the wiring diagram below.

I found it helpful, using a Sharpie, to write the "node" number near the end of each cell to keep the polarity in the correct orientation. For Bank 1, start with the negative end of the bank and mark this as "1". The middle connection between Cell 1 and Cell 2, mark as "2". Note that TAB "A" should be bent towards the negative side of Cell 2. Then mark the end of Cell 2 as "3". Continue this on to the other two cell banks using the appropriate numbers for Cell 3, Cell 4, Cell 5 and Cell 6. This will be very helpful in identifying the location for the balance lead connection. Again, follow the Wiring Schematic.

<u>NOTE:</u> Please keep in mind that each Cell and each Bank are "live". In other words, be careful not to inadvertently touch the negative and positive ends of the Cell or Bank with tools or loose wires laying around. You'll be surprised by the nice loud "spark" that will get your attention!



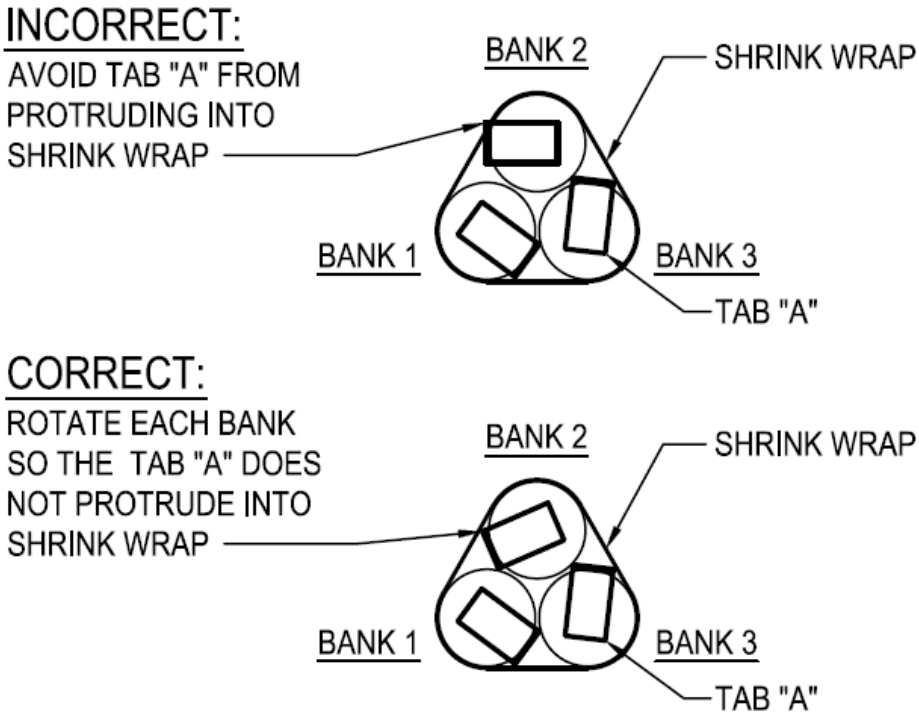
NOTES:

1. ADD ISOLATION RINGS ON ALL 'POSITIVE' TERMINALS.
2. ALL TABS ARE SPOT WELDED TO BATTERY TERMINALS.
3. ALL LEADS & BALANCE WIRES ARE SOLDERED TO TABS. NO LEADS/WIRES SOLDERED DIRECTLY TO BATTERIES TERMINALS.
4. ISOLATE POSITIVE END (CELL 6) BETWEEN TAB & BATTERY CASE.

VOLTAGE NODE POINTS	
NODE	VOLTAGE
1	GROUND
2	±3.5 VOLTS
3	±7.0 VOLTS
4	±10.5 VOLTS
5	±14.0 VOLTS
6	±17.5 VOLTS
7	±21.0 VOLTS

Wiring Schematic

Assemble the three banks together forming a triangular battery pack. Rotate each bank so that TAB “A” is oriented according to the illustration, *“Rotate Banks with TAB “A”* shown below. This is to avoid having the edge of the tabs protrude into and possibly through the shrink wrap.



Rotate Banks with TAB “A”

Getting the tabs in the proper orientation can be a little frustrating. It’s sort of like herding cats! The banks have a tendency to roll, shift and move around. It seems like you get one tab in place and the other two will move. A nice trick that helps is to take a rubber band and wrap it around one end of the 3 banks. Rotate each bank so that the tab won’t protrude into the final shrink wrap. Also make sure the ends of each of the battery banks are evenly aligned.

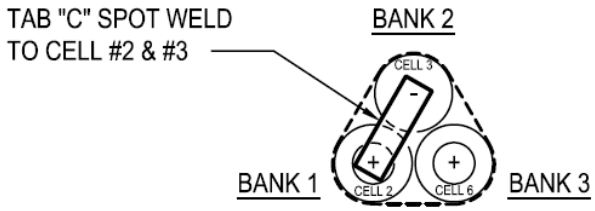
Use a Rubber Band to Temporarily Banks Hold Banks Together

Once all 3 banks are in the proper orientation, take a strip of electric tape and wrap the tape around the middle of each group of cells on the opposite end to hold the pack together, remove the rubber band and add another strip of electrical tape to replace the rubber band, thus forming the triangular shaped battery pack.

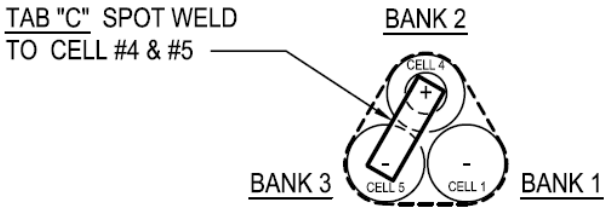
Adding Electrical Tape to Hold the Banks Together

Battery Pack Held Together with Electrical Tape

Now it's time to spot weld TAB "C" to each end of the battery pack. One TAB "C" from Cell 2 to Cell 3 (Left End View). Another TAB "C" from Cell 4 to Cell 5 (Right End View).



Left End Views



Right End View

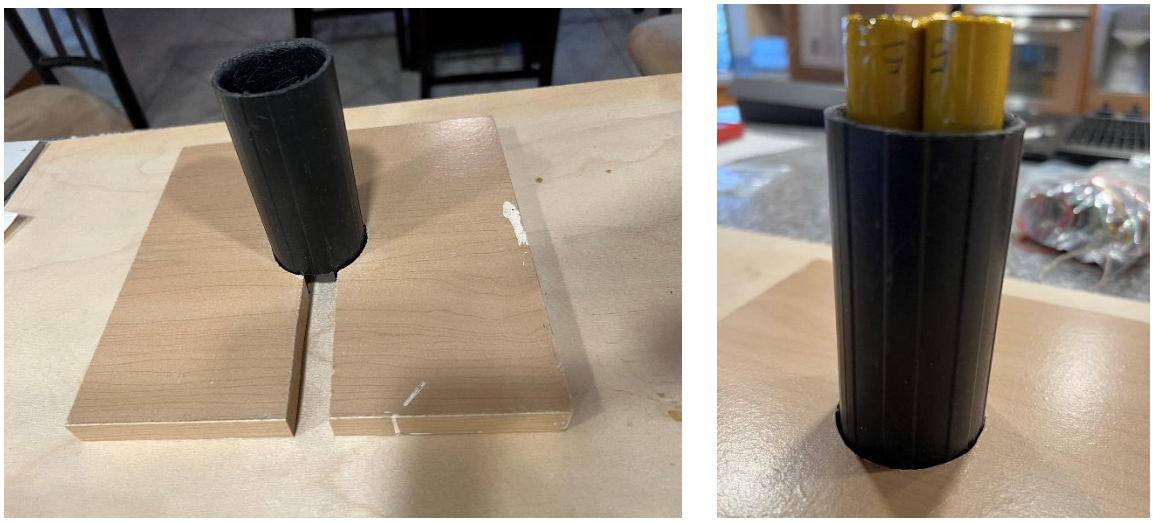
Spot welding the tabs on the end of the battery pack can be a little awkward. I made a simple device to hold the battery pack in the vertical position for spot welding. It's made

from a 5” long piece of 2” Schedule 40 PVC pipe (the white stuff) or equivalent. Note that the pipes shown are cut from my wife’s vacuum cleaner (strongly not recommended!).

Make sure that the inside diameter of the pipe is large enough to house the triangle shaped battery pack. A piece of ¾” x 8” square wood was used for the base. (See picture and drawing below)

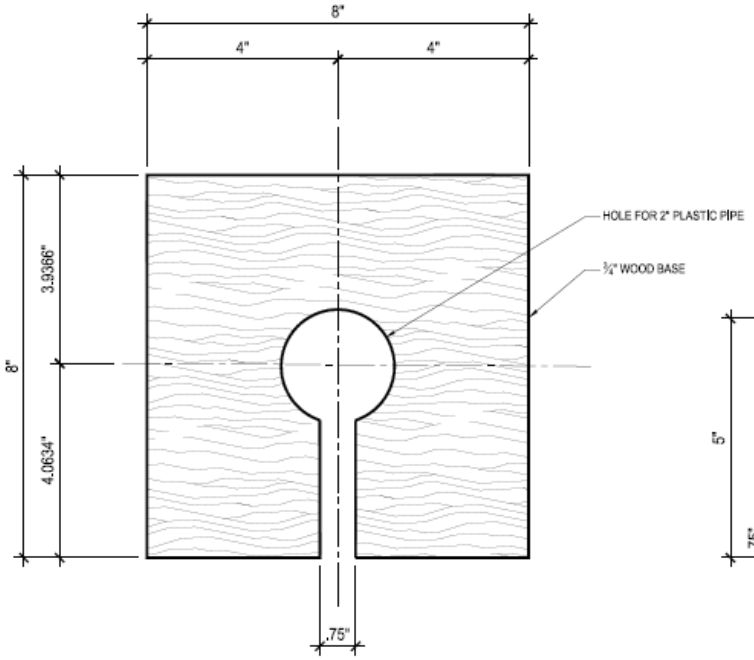
Cut a hole in the wood base to hold the pipe. Notch the wood base and the end of the plastic pipe for the battery leads and/or balance wire to exit if needed.

If the battery wobbles in the holder, place something (wood, foam rubber) in between the battery pack and the interior walls of the pipe to keep the battery pack in place while spot welding.



Spotting Welding Device Used for End Tabs

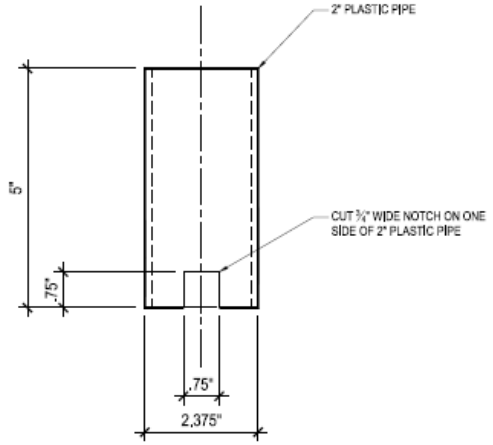
Spot Welding Device in Use



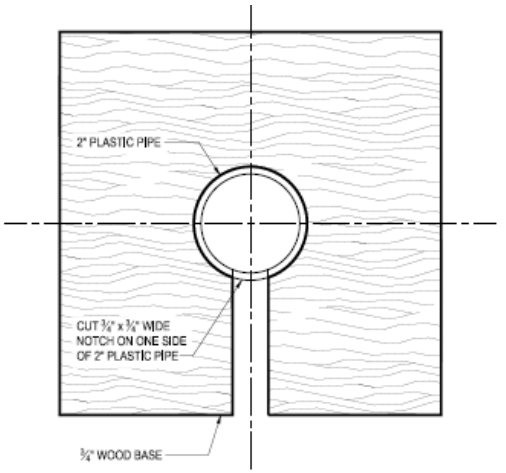
WOOD BASE

NOTE:

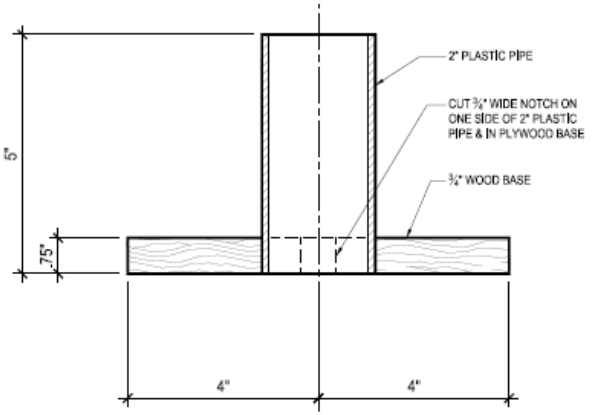
1. MAKE SURE THE INSIDE DIAMETER OF THE PLASTIC PIPE IS LARGE ENOUGH TO SLIDE IN THE TRIANGLE SHAPED BATTERY PACK.
2. THE NOTCH IN THE WOOD BASE AND THE PLASTIC PIPE IS TO THE ALLOW WIRES TO BE MOVED OUT OF THE WAY.



PLASTIC PIPE RISER



PLAN VIEW

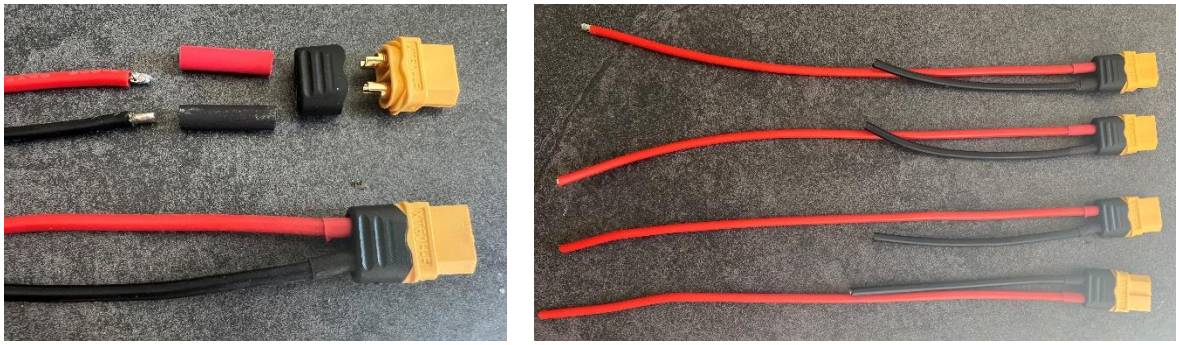


SECTION

Vertical Battery Pack Holder

Making Main Leads:

The main leads are made from 14 gauge wire. Red is used for the positive lead and Black for the negative lead. I found it easier to solder the leads to the XT-60 connector first before soldering the leads to the tabs. I prefer not to solder any of the battery lead directly to the terminal end of the cell. Too much heat applied to the battery terminal can damage the cell.



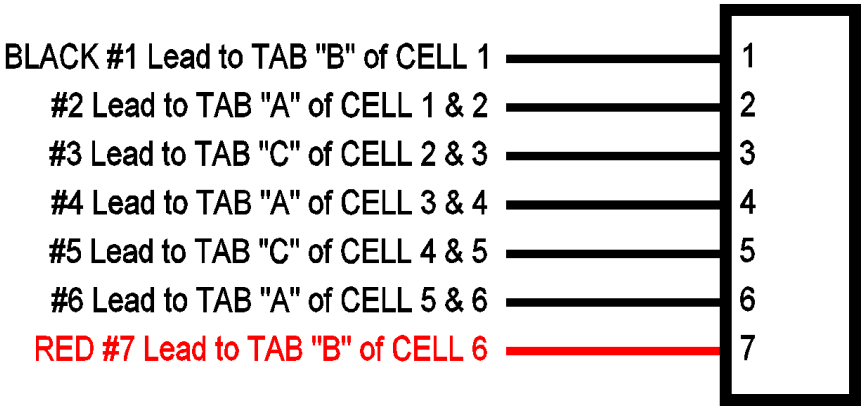
Assembling the Main Leads

Once the main leads are assembled, trim the Black negative lead to the desired length and solder to TAB “B” for CELL 1. When cool, spot weld the tab to the negative terminal on CELL 1.

Snake the Red battery lead under the tape and trim to length. Solder the lead to TAB “B” for CELL 6. When cool, spot weld the tab to the positive terminal on CELL 6.

Balance Leads:

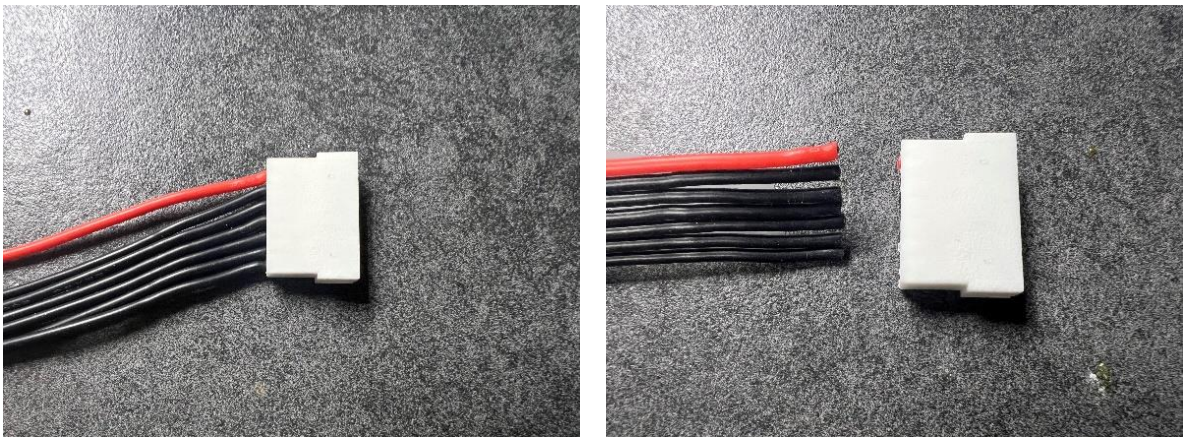
Now comes the fun part, threading and soldering the balance leads to each of the tabs! Notice the numbering in the picture below of the 6S JST-XH Balance Plug Extension Lead and to which tab it will be soldered to. This step is important when connecting the balance leads. *DO NOT get them out of order!*



6S JST-XH Balance Plug Extension Lead Numbering and Tab Connection

The balance leads are made from 200mm long 6S JST-XH Balance Plug Extension Leads. In order to use these extensions, cut off the “male” end flush with the connector

6S JST-XH Balance Plug Extension Lead



Cut Off the Male Connector of the 6S JST-XH Balance Plug Extension Lead

Start with the #3 lead. This is usually the longest lead. Strip off 1/8” of insulation at the end of the wire. With a soldering iron, tin the ends of each wire and build up a small “blob” of solder on each end. This will help when soldering the wire to the tab.

Solder the lead to TAB “C” between CELL 2 and CELL 3. Make sure to slide the wire underneath the electrical tape to avoid having the wire show when the final shrink wrap is placed over the entire battery pack. Please don’t ask me how I know.

It doesn’t take a lot of heat from the solder iron to attach the lead to the tab. This should be done rather quickly, less than a second to attach the lead and prevent transferring the heat from the tab to the cell terminal.

Solder the next longest balance lead wire. This should be the RED lead #7 to TAB “B” on CELL 6. Repeat this process to the next longest lead until all the balance leads are attached. Trim each balance lead as needed. Make sure to keep the numbered leads in the proper location and order.

Testing Voltage Everywhere:

Now it’s time to test the voltage at each of the Node Points. The example below is if each battery cells measured 3.5 volts. Yours may be vary.

VOLTAGE NODE POINTS	
NODE	VOLTAGE
①	GROUND
②	±3.5 VOLTS
③	±7.0 VOLTS
④	±10.5 VOLTS
⑤	±14.0 VOLTS
⑥	±17.5 VOLTS
⑦	±21.0 VOLTS

Voltage Node Points

Also test the “6S JST-XH Female Connector”. The number 1 pin is the ground. Move the positive lead from the volt meter to each pin from 2 through 7. If the voltage does not match the node points as shown above, you have attached a balance lead to the wrong connector/tab.

Do not ignore this! The voltages at the female connector are extremely important when charging your batteries.

Covering End of Pack:

The ends of the battery pack must be protected. This is done with self-adhesive battery pack insulator gasket, also known as fish tape. I was able to have Jim Aron, who happens to have a Cricut® cutting machine, cut the fish tape to match the ends of the battery pack. If you don’t have a cutting machine, you can trace the end of the battery pack on to the fish tape and cut them out with scissors. Make sure to put the fish tape on both ends of the battery pack.

Fish Tape on End of Battery Pack

Shrink Wrap the Pack:

Now it's time to wrap the battery pack with a large heat shrink tube. Make sure to cut the heat shrink tubing longer than needed. The large heat shrink tubing shrinks more than you think. If not careful you can come up short on the length because of the shrinkage. The heat shrink tubing should overlap the end of the pack to help hold down the fish tape on the each end of the pack.

Finished Battery Pack

Cycling the Battery Pack:

When I purchased my Li-Ion batteries from Dane Martin, he suggested that I "cycle" the battery packs 2 or 3 times using my charger before putting them into service. Cycling is charging the packs up to a full charge and then discharging them back to a storage level.

Dane recommended that the first time you use a new battery *in a plane*, restrict your flight time to 2 or 3 minutes. Once this is done, they are supposedly ready for full flights when they are fully charged again.

On my last batch of battery packs, I cycled them 3 times using my charger. I DID NOT do the recommended 2 or 3 minute flights. Instead I did full flights with no apparent issues. In talking with several other, they have done the same thing as well.

I also decided to use a “test dummy” plane, my *Circulas 46 IIe Profile.* I use this plane to test all new batteries before putting them into fulltime service and into my #1 ship. It’s nice to have a test plane!

“Test Dummy” – Circulas 46 IIe

Another thing I learned about using Li-Ion batteries, is my dealings with my battery checker. I have an inexpensive unit that works great for checking the voltage and the remaining battery capacity percentage of Li-Po batteries. Though this unit has a setting for Li-Ion batteries, when checking the remaining battery capacity, it does not seem to report the remaining capacity accurately. My checker indicated that I had 4-6% remaining battery capacity, which is very low. However, when charging the batteries back up to full strength, I found that that my charger put back only 2200 mAh into the pack. When you do the math, this calculates the remaining battery capacity at roughly 26%, not 4-6%. So beware when using a battery checker with Li-Ion batteries.

Also, a popular trend when it comes to charging Li-Ion batteries is to slightly “overcharge” them at 4.23v per cell, instead of the standard 4.20 volts. When speaking with Will DeMauro, he stated, *“Most chargers short charge the battery on default setting at 4.17v-4.19v”*. So charging to 4.23v you are only charging them to 4.18v-4.20v. So far this hasn’t resulted in any issues that we know of.

Conclusion:

There you have it. It really isn’t that difficult to make up Li-Ion battery packs. Time consuming? Yes! It takes some practice. Just take it slow and easy. Check and double-check your work. I’ve only shown how to build a traditional 6-cell pack, but you can make 3, 4, 5, and 6-cell packs in any configuration you would like or need. Look at the

picture at the end of this article. It is a picture of Jim Aron making a unique 5-cell “brick-type” battery pack. Have at it!

Included in this article is a list of all the materials and some of the tools needed to assemble battery packs. I also included the current prices (as of March 1, 2025) and a link to the vendors. Prices and availability can and will change. Some of the items are a “one time purchase”. Other items will allow you to make many more packs in the future.

I’ve also included a list of *“Important Safety Warnings”*. Please read these very carefully.

A thing about the cost of making Li-Ion batteries is that if you are starting out from scratch, the cost of the materials and tools required are front loaded and amortized over the life of your battery building career. The cost of every subsequent pack will get lower. In the end, these packs will be significantly cheaper than Li-Po’s. The most expensive part, of course, are the Li-Ion cells. The cost, configuration and availability of these cells is constantly changing; sometimes for the better and sometimes for the worse. Welcome to the wild west of Li-ion battery fabrication!

DISCLAIMER:
What I’ve shown in this article is just the way that I’ve built “my” batteries. There are 12 or more ways to skin a cat. Others may do things differently. Some may agree or disagree with some of the things I’ve done and shown. My methods keep evolving and changing with each set of batteries I build. This article was written as a starting point for those who would like to make their own Li-Ion batteries. There are risk involved when dealing with lithium batteries. Please be aware of those risk.

Although I probably have you bored to death and totally confused, I hope I’ve taken some of the concerns and fears away when it comes to making Li-Ion battery packs.

At least now I don’t have to wait for Thunder Power to have a sale on their batteries. Now I can just make my own!

Enjoy,

Dennis S. Nunes

Lithium Ion Battery Components, Supplies & Tools

Qty.	Description	Supplier	Each	Subtotal	Shipping	9% Sales Tax	Total
50	Molicel INR-18650-P30B, 3.6 Volt 3000mAh Lithium-Ion Cell	StorTronics	$5.96	$298.00	$23.34	$26.82	$348.16
1	(10) 6S JST-XH Balance Plug Extension Lead (8"/200mm)	Amazon	$5.37	$5.37	$1.99	$0.48	$7.84
1	0.2mm x 8mm x 5m Pure Nickel Strip for 18650 Battery Soldering Tabs **(FOR SPOT WELDING)**	Temu	$3.75	$3.75	$0.00	$0.34	$4.09
1	(500) 18650 Lithium Battery Insulator Ring	Amazon	$9.95	$4.38	$0.00	$0.39	$4.41
1	16.4ft/Roll 100mm(3.93in) Width Self Adhesive Battery Pack Insulator Gasket - (aka Fish Tape)	Amazon	$15.35	$15.35	$0.00	$1.38	$16.73
1	Bryne 14 Gauge Ultra Flexible Silicone Wire 50 Ft (25 Ft Red and 25 Ft Black), 400 Strands 0.08mm of Tinned Copper	Amazon	$19.98	$19.98	$0.00	$1.80	$21.78
1	MCIGICM 10 Pair XT60H (XT60 Upgrade) Male/Female Connector Plugs	Amazon	$7.99	$7.99	$0.00	$0.72	$8.71
1	(2) Rolls 1 in. x 36 yds, Polyimide Film Adhesive Tape High Temperature	Amazon	$14.39	$14.39	$0.00	$1.30	$15.69
1	MECCANIXITY Battery Wrap PVC Heat Shrink Tubing 44mm Dia 70mm Flat 4m Black Insulation for Battery Pack	Amazon	$14.49	$14.49	$0.00	$1.30	$15.79
1	Chanzon 3/16" (4.8mm) x 8 foot, Heat Shrink Tubing - Marine Grade Waterproof Adhesive Lined	Amazon	$5.99	$5.99	$0.00	$0.54	$6.53
1	(2) 18650 Battery Spot Welding Clamp (6-Sections)	Amazon	$10.29	$10.29	$0.00	$0.93	$11.22
1	Seesii 11000 mAh Battery Spot Welder with LCD Screen Upgraded Enhanced 80 Gears Adjustable Portable Mini Spot Welder	Amazon	$67.65	$67.65	$0.00	$6.09	$73.74
1	Soldering Iron Kit, 80W 110V LCD Digital Soldering Welding Iron Kit with Ceramic Heater, Portable Soldering Kit	Amazon	$9.96	$9.96	$0.00	$0.90	$10.86
1	AUSTOR 63-37 Tin Lead Rosin Core Solder Wire for Electrical Soldering (1.5mm, 100g)	Amazon	$9.99	$9.99	$0.00	$0.90	$10.89
1	SRA Solder 135 Rosin Paste Soldering Flux For Electronics	Amazon	$8.49	$8.49	$0.00	$0.76	$9.25
1	Hakko-CHP-170 Flush Cut Soft Wire Cutter	Amazon	$5.47	$5.47	$0.00	$0.49	$5.96
1	7-Function Digital Multimeter	Harbor Freight	$6.99	$6.99	$0.00	$0.63	$7.62
						Total:	**$565.68**

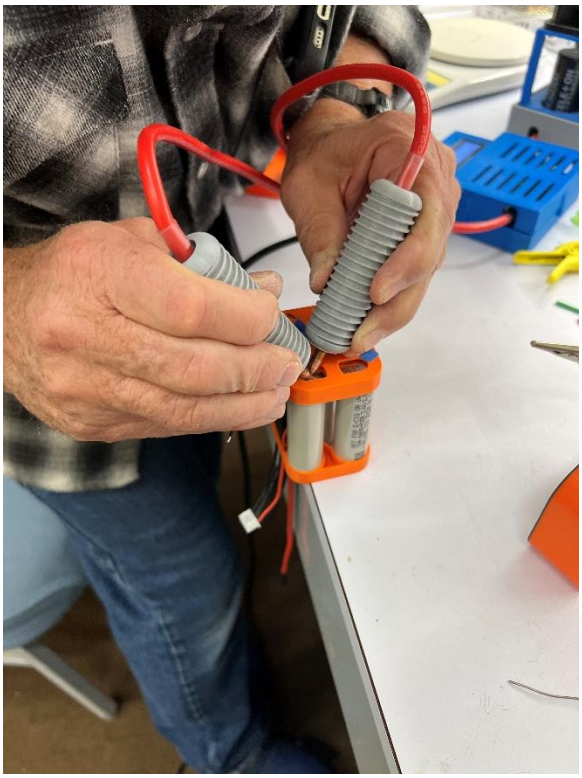
Important Safety Warnings

Improper handling or misuse of this lithium-ion battery can result in **FIRE, EXPLOSION**, or **THERMAL RUNAWAY**, causing personal injury, property damage, or death. Users must read and follow all safety guidelines before purchase and use.

- **Critical Warning:** Never carry loose batteries in your pocket, purse, or bag. Loose batteries can come into contact with metal objects like keys or coins, causing a short circuit, which may result in severe burns, fire, or explosion. Always store or transport batteries in a protective case.
- **Thermal Runaway:** A chain reaction where heat from a failing battery causes further overheating, potentially leading to fire or explosion.
  - **Causes:** Overcharging, short circuits, physical damage, or exposure to high temperatures.
  - **Prevention:** Use a smart charger, avoid damage, and store batteries in a cool, dry place.
- **Storage & Transport:** Always store batteries in protective cases to prevent accidental contact with metal objects. Never store loose batteries in pockets, purses, bags, or near conductive materials.
- **Inspection:** Do not use if the **PVC wrapper**, **terminal insulator**, or **casing** is damaged, dented, leaking, or bulging. Continued use could result in failure, fire, or explosion.
- **Charging:** Use a **smart charger** specifically designed for lithium-ion batteries and ensure the charger's voltage matches the battery's specifications. Never overcharge, over-discharge, or leave unattended while charging.
- **Prohibited Activities:**
  - Do not expose the battery to extreme heat, fire, or liquids.
  - Do not short circuit, puncture, crush, or modify the battery.
  - Do not charge or discharge beyond the manufacturer’s voltage range.
  - Do not dispose of in regular trash—always recycle at approved facilities.
- **Emergency Response:** If the battery overheats, emits smoke, or swells, move it to a non-flammable surface (e.g., sand or concrete) and stop use immediately. In case of fire, use a **Class D fire extinguisher** or sand. Do not use water.

Miscellaneous Stuff:

At Batterypalooza, Jimby and Howard experimented making “brick-type” battery packs, both 5 and 6-cell. Their theory was that the possible cooling issues associated with these packs could be avoided by 3D printing end caps that would create better spacing, allowing air to circulate around the individual cells and also to eliminate the need for shrink wrap which traps heat. Also, the shorter brick configuration allows for more control over the CG. We are waiting for Jimby to test the theory when he next flies Wile E's Curse.



Jimby spot welding a 5-cell Brick-Type Battery Pack
(Notice the Orange End Caps)