Ticket #920

Ticket Status:	Closed	**Name:**	Philip Piper
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Create Date:	05/16/2015 9:12 am	**Phone:**	(713) 501-2744
Field of Study:	Electrical Engineering		

Subject: **Yale**
05/16/2015 9:12 am Philip Piper

Hi Formula Hybrid Support, its Bulldogs Racing from Yale University again.

We have a question about EV3.8.5 which requires a repeating frame to hold pouch cells in position. We are trying to avoid any plastic repeating frame that attaches to the expansion limiter threaded rods because we have found that it would interfere with our aluminum heat sink cooling method, and because it would be difficult to manufacture.

We decided to calculate how much acceleration it would take to exceed the force of static friction due to the pressure of the expansion limiter. Since we are using A123 Amp20 cells, we are trying to follow A123's battery pack design guidelines which are attached to this ticket. Page 32 suggests that about 14 psi is optimal to extend cell life. Running the numbers for the acceleration needed to break the static friction of this pressure (assuming 22 cells in a stack and a coefficient of static friction of 0.4) shows that over 10g's would be required for the cells to start slipping. Note that 0.4 was chosen as the coefficient of static friction of a Kapton tape to cell interface as we determined that that would be the slipperiest interface.

Additionally the aluminum heat fins protect the sides and bottoms of the cells and the expansion limiter, shown in the "Pouch Cell Stack.pdf" attached image, also limits cell movement due to how close the threaded rods are to the aluminum heat fins. Lastly the "Two Cell Module.pdf" photograph shows the modular design of the stack, where the darker surface on the cell is 1 mil kapton tape with a dieletric breakdown of 7000 V.

In this design the sides of the cells would also be insulated with kapton tape in order to prevent a short with the aluminum fins. We are also experimenting with connecting the aluminum fins to low voltage ground through a 100K resistor such that the GFD could catch any cell impingement (this idea was suggested to us when we visited competition this year).

So having said all of that, our question comes down to are the aluminum heat fins, expansion limiter threaded rods, and 14 psi of pressure sufficient to pass EV3.8.5 in terms of holding the cells in position?

Thanks for your time and we look forward to seeing the new rules!
Item 2 A123_AMP20_battery_Design_guide.pdf*(1.9 mb)* Two Cell Module.pdf*(105.6 kb)* Pouch Cell Stack.pdf*(412.1 kb)*

07/24/2015 8:06 am

Philip,

We apologize for the excessive delay in responding to your query. Most of us were pretty busy with the 2016 rules, and this fell through the cracks.

We will look through this shortly.

In the meantime, your two solidworks illustrations are a bit difficult to follow. For example, we can't make out which are the 'heat fins'. Perhaps overlay some arrows and text?

Also, please look over the new rules to see if anything has changed that might help clarify these issues.

Thanks,

-fh

07/28/2015 12:07 pm

Yale Team - we are just getting active again for the 2016 season; apologies for our lack of response.
The official 2016 rules are now posted on the web site at:
http://www.formula-hybrid.org/wp-content/uploads/2016-Formula-Hybrid-Rules-Rev-0.pdf

There are no major changes to the pouch section EV3.9, just the addition of a note.

Resistive grounding of metallic battery parts such as repeating frames is now mandatory per EV3.9.5:
A repeating frame or similar component, if conductive, must be resistively grounded such that an insulation failure will trip the IMD. The grounding resistance should be less than 250 ohms per volt (based on nominal system voltage) and be rated for the power it would dissipate at full system voltage.

Regarding the friction question, I will put it to the battery experts on the rules committee and promise a response early this coming week -
Rob Wills
FHelecRules

07/28/2015 9:44 pm Philip Piper

I have attached a labeled image of the two cell module. Let me know if you need anything else to resolve this ticket.

I plan to have the first major revision of the battery pack completed by mid August. I can either submit separate issue tickets, or a major design review ticket when that time comes. Which would you prefer? I figure that its worth resolving issues now, especially with the battery system, rather than at competition.

Thanks, as always, for taking time out of your busy schedules for us!

Phil
Two Cell Module.pdf*(61.7 kb)*

08/04/2015 3:45 pm

Philip - our battery expert said:
"The nissan leaf uses a sardine can design like this. Inside the can they have a repeating frame that actually pins the top and bottom of each cell in place. I think they can find a way to make a repeating frame for their battery - it does not have to interfere with the can or attach to the expansion limiter rods."

We also have a concern that unconstrained cell edges might be more open to shorts to the outer can. I would like to see at least Kapton on the inside face.

Please work on this and see if you can come up with something compliant!

Thanks

FHelecRules

http://nissan-leaf.net/wp-content/uploads/2010/11/LEAFbatt.jpg
http://i913.photobucket.com/albums/ac335/sunworksco/image-618.jpg

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08/05/2015 12:14 am Philip Piper

Alright I return with updates! Good idea with insulating the cell edges. I have wrapped the Kapton tape around the sides of the cells as can be seen in "Two Cell Module Insulation.pdf". Additionally I extended the edges of the cell load spreader (black).

As to the repeating frame, I have been working on the stack structure that includes a plastic cover for housing the tabs. However to get to the repeating frame I think it would be useful to go through a few other design decisions.

Tabs will be connected via two 0.1in thick aluminum load spreaders that have 4-40 grade 8 socket head bolts and Nyloc nuts on either side. The tabs are folded together and the bolts are preloaded to about 60%-70% (still working on the torque calculations to make sure the 0.1in aluminum isn't plastically deformed at the edges). Look at "Tab Connections.pdf" for reference.

As a side note we chose to bolt rather than weld because we can imagine a world where stress testing the car leads to a few cells going bad, and it is much easier to replace bolted cells than welded ones.

The aluminum load spreaders sit inside the plastic cover with the Nyloc nuts sitting in a recessed groove for easy assembly. Tabs pass through thin slits in the plastic cover and then fold into their respective connections. A second top plastic cover sits over the bottom one to prevent tabs from vibrating independently of the stack structure. See "Bottom Plastic Cover.pdf" for a look at the tab connections sitting in the cover. "Transparent Bottom Plastic Cover.pdf" may be of better for understanding the cover's use. Additionally I have attached "Stack Big Picture.pdf" for a look at the stack with both plastic covers on.

Now on to addressing the repeating frame. I think that the plastic cover fulfills the role of a repeating frame on the top of the cells. It is very similar in function to the second Nissan Leaf cell stack picture that you linked, only its a little bigger because the tabs are bolted together rather than laser/ultrasonic/resistance welded!

As for the repeating structure on the bottom, I think you will easily be able to see our problem when you look at "Our Problem.pdf". The aluminum heat spreaders would impede any repeating frame on the bottom of the cells due to its bottom protective bend. Of course this bend can be removed, but I don't entirely see the purpose of removing it and replacing it with some complicated, difficult to manufacture plastic repeating frame on the bottom. The top plastic cover that houses the tabs is already going to either cost a decent chunk of change to 3D print on an Objet, or a decent chunk of time to machine out of polypropylene. Multiply that by 8 because we will have a top and bottom plastic cover for 4 cell stacks, and things are already getting a little out of hand.

One solution I propose for the bottom repeating frame problem is to connect the bottom of the stack together with conductive tape. This serves two purposes:

1. Act as a repeating frame at the two cell module level to connect the modules together and to the end plates.
2. Electrically connect all of the aluminum heat spreaders to the aluminum end plates so that a single resistor can be grounded to the chassis fulfilling the note at the end of EV3.9.5.

See "Tape.pdf" for an example of what I am suggesting. This tape job can also be applied to the sides of the stack to prevent cell movement in the lateral direction with respect to the end plates (where longitudinal is down the axis of the stack).

Sorry for the staggering wall of text! I tried to be as thorough as possible in an attempt to make your job a little easier. Tell me what you think about the top and bottom repeating frame ideas. Additionally if anything else with the tab or stack design sticks out as non-rule compliant or bad engineering practice then let me know.

Thanks for all of the time you put into helping us!

Phil
Bottom Plastic Cover.pdf*(305 kb)* Module Insulation.pdf*(120.4 kb)* Our Problem.pdf*(134.4 kb)* Stack Big Picture.pdf*(120.3 kb)* Tab Connections.pdf*(136.6 kb)* Tape.pdf*(107 kb)* Transparent Bottom Plastic Cover.pdf*(424.4 kb)* Two Cell Module Insulation.pdf*(114.1 kb)* Two Cell Module.pdf*(61.7 kb)*

08/05/2015 10:58 am

Phillip - we are reviewing your latest proposal.
Regarding cell edges, it might be better to apply kapton to the metal shell rather than the cell edges in order to minimize cell handling - applying the tape could result in reduced cell reliability.

08/05/2015 9:41 pm Philip Piper

Awesome suggestion! That should make assembly much easier, and safer.
Even Stack.pdf*(93.8 kb)*

08/07/2015 3:04 pm

Here is the response from the experts..
As to the repeating frame, I have been working on the stack structure that includes a plastic cover for housing the tabs. However to get to the repeating frame I think it would be useful to go through a few other design decisions.

As a side note we chose to bolt rather than weld because we can imagine a world where stress testing the car leads to a few cells going bad, and it is much easier to replace bolted cells than welded ones.

The choice to bolt a cell should not be based on the ability to replace a cell. Replacing a cell will result in miss-matched cells within a battery pack and will reduce the performance of the battery. Depending on the design and configuration of your AMS replacing a single cell could also introduce risk of over charging a single cell or reversing a single cell which are both known safety issues. Single cell replacement would never be a type of repair performed on any professionally designed battery pack. The choice to bolt a cell vs welding a cell is based mainly on cost tradeoffs relating to tooling, volume, and development/validation costs.

Now on to addressing the repeating frame. I think that the plastic cover fulfills the role of a repeating frame on the top of the cells. It is very similar in function to the second Nissan Leaf cell stack picture that you linked, only its a little bigger because the tabs are bolted together rather than laser/ultrasonic/resistance welded!

Because the tabs pass through thin slits in the bottom plastic cover the top of the cells are fixed in position - in only one axis. The cells can still be clamped at different positions up and down as well as out of angle (where one tab may protrude more than another through the bottom cover). Both of these axis of freedom must be constrained in order to meet the requirements of a repeating frame. Some minimum clearance distance must be maintained between the edge of the cell and the aluminum heat spreader. The Leaf battery accomplishes this with a custom manufactured cell that has pinning holes on the bottom side of the cell.

As for the repeating structure on the bottom, I think you will easily be able to see our problem when you look at "Our Problem.pdf". The aluminum heat spreaders would impede any repeating frame on the bottom of the cells due to its bottom protective bend. Of course this bend can be removed, but I don't entirely see the purpose of removing it and replacing it with some complicated, difficult to manufacture plastic repeating frame on the bottom. The top plastic cover that houses the tabs is already going to either cost a decent chunk of change to 3D print on an Objet, or a decent chunk of time to machine out of polypropylene. Multiply that by 8 because we will have a top and bottom plastic cover for 4 cell stacks, and things are already getting a little out of hand.

Please send a photo of the aluminum heat spreader part without any cells in place - I'm not entirely certain how the part is made or its complete 3d shape. In regards to cost - consider designs that when made in mass quantities could be made very inexpensively (ie injection molding), this will reflect well in a business presentation. In terms of meeting your racing budget going with pouch cells is not an economical choice since you have to build custom retaining hardware for the cells. These rules were put in place to ensure equivalent safety of packs built with pouch cells when compared with battery packs built with cylindrical or prismatic cells (or COTS batteries built with pouch cells).

One solution I propose for the bottom repeating frame problem is to connect the bottom of the stack together with conductive tape. This serves two purposes:

1. Act as a repeating frame at the two cell module level to connect the modules together and to the end plates.

This tape does not address the two unconstrained axis of freedom identified previously.

2. Electrically connect all of the aluminum heat spreaders to the aluminum end plates so that a single resistor can be

grounded to the chassis fulfilling the note at the end of EV3.9.5.

Ensure that the type of conductive tape you select has relatively low resistance (some tapes use graphite or nickel and that the adhesive on the tape is also conductive - many conductive tapes do not have conductive adhesive.

08/08/2015 12:41 pm Philip Piper

Bolting vs. Welding:

I understand your concern about us making the design decision to bolt vs. weld. To be fair we did consider our cost, manufacturing capabilities, and maintenance needs. I wasn't explicit enough in my explanation from the last post.

Let me assure you that we are well aware of your concerns about single cell replacement. However we only have the resources to construct one pack and retain a reserve of twenty or so cells. Having said that, we thoroughly check the capacity and internal resistance of every cell using a programmable DC load such that we can match cells for a well balanced pack.

Repeating Frame (EV3.8.5):

I am confused as to the purpose of the repeating frame rule. From your explanation, it sounds like the rule is meant as a design for manufacturing specification rather than a cell stack performance metric. Can you clarify whether the repeating frame is meant to satisfy only 1, or both 1 and 2?

1. Align the cells in all axes so that they can be properly clamped together during stack assembly
2. Prevent cells from moving relative to each other during operation of the car

I ask this because our original plan for 2, which is taken directly from the A123 cell stack design, was to constrain the cells from moving after assembly through the pressure exerted by the expansion limiter. This pressure would nominally be 12psi, which is enough to clamp the cells together for over 40g accelerations. Obviously we have some work to do on 1, but I want to be sure of the purpose of this rule before continuing with the design.

Heat Spreaders:

The heat spreader is 0.020" aluminum sheet. It can be stamped and formed via a die for manufacturing at quantity, or manually bent in only three places for one offs. See "Heat Sink Full.pdf" for a view of the heat spreader and "Even Stack Heat Sinks.pdf" for a look at the battery stack with most of the cells and surrounding materials removed such that only the heat spreaders are left behind.

Pouch vs. Cylindrical/Prismatic

We chose lithium iron phosphate pouch cells for a variety of reasons. First and foremost we are concerned about the safety of the pack we intend to design and fabricate. In this regard lithium iron cells are clearly the way to go due to their thermal stability, puncture resistance, and non-hazardous cathode material when compared to lithium ion cells. After researching lithium iron cells about 6 months ago, it was abundantly clear that one manufacturer stood out from the rest. A123 cells have better energy density, power density, cost per power, cost per energy, and diversity in form factor than any other lithium iron cell on the market. With that we were narrowed down to three different cells: the Amp20 pouch cell, AHR31123 cylindrical cell, and ANR26650 cylindrical cell.

Our two Emrax 207 motors operate with a flat torque curve up to about 300V, and require 300A at peak torque. Therefore we designed a battery pack that could deliver 600A at 300V with an energy capacity that meets the 5.4kWh limit. This pack could either take the form of 85 Amp20 cells, 430 AHR31123 cells, or 860 ANR26650 cells. The Amp20 pouch cells have better energy density, power density, manufacturability, and cost than the other two options. Therefore we decided to take the time to design and fabricate custom retaining hardware in order to gain substantial benefits in most other regards.

Tape for note at end of EV3.9.5:

We will be sure that the tape has a conductive adhesive. Thanks for the heads up.

Best,

Phil
Heat Sink Full.pdf*(62.3 kb)* Even Stack Heat Sinks.pdf*(137.2 kb)*

08/13/2015 3:30 pm

The repeating frame is a modular way of aligning pouch cells with each other inside a battery. Correctly positioning the cell, filler material, heat spreader, and electrical insulation material such that when fully assembled the battery pack will not impinge on the cell separator material or unevenly distribute compressive force over the surface of the cell. The repeating frame can not alter or risk altering the natural shape of the cell as provided from the cell manufacturer. The compressive force provided by the expansion limiter and filler material is to improve the capacity and lifetime of the lithium ion cells. Cells expand and contract volumetrically when cycled (hence the filler material), on top of this cyclic volumetric change with SOC there is a lifetime expansion of the cell that occurs over many hundreds of cycles. Compression of the cells also helps increase the cells tolerance to abuse and produces a less severe cell failure than if left unconstrained. Compression of the battery is the main force holding the cells in place once the battery is fully assembled, however vibration, impact, and volumetric changes in the cells may utilize the repeating frame to keep the cells from moving out of alignment of the stack. So both point 1 and 2 are correct. Be aware that vibration and impact analysis are complex and different from standard FEA methods because it's more about the resonate frequencies of the structure then the peak or average acceleration.

Thank you for the images of the heat spreader.

In your next response please address how you have resolved the cell alignment issues currently deficient in your design.

08/19/2015 1:37 pm Philip Piper

Thanks for the feedback! It sounds like I'm more or less on the same page now.

Repeating Frame

There are two major parts to the repeating frame, one on the top and one on the bottom of the cells. The top part of the repeating frame is integrated into the plastic tab cover used to fix and insulate the bolted connections. See "Top Repeating Frame.pdf" for a view of only the cover. "Top Repeating Frame With Cells.pdf" shows this part in use. This part will be 3D printed out of high temperature thermoplastic to accommodate our low volume needs. I'm in the process of revising it such that it can be injection molded. This part fixes cells such that they can't be offset from the stack to the sides or up/down during assembly. Additionally the top part of the cell which fits into the grooves is flexible enough to allow for cell expansion and contraction during use. See "Cell Top.pdf" for a view of the part of the cell that fits in the grooves.

I looked into aligning the cells using holes, but there's no feasible way to put holes in the A123 cells. They are hermetically sealed and will quickly deteriorate if punctured (according to A123). Additionally there is a cell vent in one of the corners that is left uncovered by the tab cover such that an overpressure event would vent as designed by A123.

The bottom of each heat spreader was removed such that a bottom repeating frame part could be manufactured to bolt on to both stack end plates. See "Bottom Repeating Frame.pdf" for a view of the part and "Bottom Repeating Frame With Cells.pdf" for a view of the part in use. It will be CNC'ed out of 6061 aluminum, however it can also be extruded or cast for higher volumes. Its purpose is to provide impact resistance to the bottom of the cell stack. Note that the bottom portion of the cell that fits into the grooves is flexible enough to allow for cell expansion and contraction. See "Cell Bottom.pdf" for a view of the part of the cell that fits in the grooves. Additionally the bottom of the cells will be insulated with Kapton tape to prevent shorts through the aluminum bottom repeating frame.

A summary of the plan for assembly is as follows:

1. Bolt the plastic tab cover to one end plate
2. Run aluminum threaded rods through the end plate and secure nuts on one end
3. Push first cell tabs through the tab cover openings and align using the repeating frame
4. Place heat spreader using the bottom of the plastic tab cover and sides of the cell from part (2) to align
5. Push next cell tabs through the next tab opening
6. Bolt appropriate cell tabs together
7. Place foam insulation

8. Repeat steps 3 to 5 until 22 cells are stacked
9. Fit second end plate over threaded rods
10. Tighten nuts on the threaded rods until the second end plate is flush with the plastic tab cover
11. Bolt plastic tab cover to second end plate
12. Bolt bottom aluminum repeating frame to both end plates

Obviously we will construct a much more detailed work packet for stack assembly before beginning. Additionally I am currently looking into vibration analysis in Solidworks, and will look for ways to perform impact analysis. Any suggestions are welcome.

Let me know what you think about the repeating frame ideas, and thanks again for the oversight!

Phil
Bottom Repeating Frame With Cells.pdf*(154.3 kb)* Bottom Repeating Frame.pdf*(127.5 kb)* Cell Bottom.pdf*(41.9 kb)* Cell Top.pdf*(63.2 kb)* Top Repeating Frame With Cells.pdf*(85.5 kb)* Top Repeating Frame.pdf*(87.8 kb)*

08/19/2015 8:22 pm

Hi Phil,

The top and bottom 'flexible' portions of the cell are were the cell separator is most fragile. Internal short circuits are most likely to occur at these locations when this part of the cell is deformed. The repeating frame design you've produced does not protect this part of the cell. In fact it seems that it makes these parts of the cell more vulnerable than your previous design.

Also the Amp20 cell model you have seems odd - I do not remember there being a rectangular fold over crimp edge on the sides. Please check your model of the cell to ensure accuracy.

If you need a design suggestion, I would recommend sticking with your original battery design but install rectangular picture frame type foam, rubber, or elastomer parts in between each cell. Make the inner dimension of the picture frame slightly larger than the main body of the cell. Make the outer dimensions of the picture frame larger than the maximum LxWxH of the cell. The picture frame should keep the main body of the cell aligned in all directions while protecting and preserving the shape of the cell edges.

If you have questions you can call my mobile number 802-735-5345

~Chris

08/21/2015 1:35 pm Philip Piper

Hi Chris,

Sorry for the impromptu call. I'm busy from 2:45 to 7pm today so Monday is probably best (unless you're OK with talking outside of the work week).

As for the design, I get your point about flexing the top and bottom portions of the cell. I think a picture frame style repeating frame is definitely doable, although I'm still working on how it attaches to the rest of the stack. Previously you suggested that it doesn't have to be connected to the expansion limiting rods that are put in tension to compress the cells. If that is the case then perhaps the best way to attach the frames would be to attach them to the top tab cover either on sliding rails, or through another rod. In this manner the cell will be aligned such that it can't move left/right/up/down during assembly, but it can still expand/contract freely. I'll try to get a few ideas drawn up tonight to send to you.

What do you think about making the repeating frame out of plastic? If it is designed in a manner that is fixed within the stack, and not prone to puncturing the cells, then it may be easier to manufacture than a foam, rubber, or elastomer part. We would still of course use the Poron fillers to allow for expansion/contraction.

Best,

Phil

08/22/2015 9:40 am

Hi Phil,

Please read through A123's AMP20 pack guide in completeness. This guide is very thorough and covers many of the design rules that are part of the FH rule set. This will give you some better background and will improve your design making decision process.

https://www.buya123products.com/uploads/vipcase/b24d4f5b63934c59d43e93b3bb4db60a.pdf

I specifically did not mention plastic as a picture frame material for the very reason you mention. Just remember the purpose of the picture frame is to protect the cell - not threaten it.

~Chris

08/22/2015 10:50 am

I did not read your comment carefully enough:

What do you think about making the repeating frame out of plastic? If it is designed in a manner that is fixed within the stack, and not prone to puncturing the cells, then it may be easier to manufacture than a foam, rubber, or elastomer part. We would still of course use the Poron fillers to allow for expansion/contraction.

You could use plastic if there were no chance that the picture frame would puncture or chafe on the cell pouch. This will require shaping and deburring the plastic very carefully.

~Chris

08/29/2015 3:34 pm

Philip - please also note that a plastic frame must meet flamability requirements - at least UL94-V0

08/29/2015 10:43 pm Philip Piper

Chris,

Thanks again for the advice yesterday. Below is another attempt at the repeating frame.

"Repeating Frame.pdf" shows the frame part that fits between the cell body and the aluminum heat spreaders. On the left, right, and bottom the frame touches the heat spreaders (pictured in "Two Cell Module.pdf"). On the top the frame touches the plastic tab cover (pictured in "Even Stack.pdf"). The frame inner dimensions are tailored to fit snugly against the cell body.

There are a few different thicknesses (1/16", 1/8", 1/4") of repeating frames such that the cells are supported on both sides (front and back) of the body. See "Two Cell Module.pdf" for a top isometric view of the repeating frames around the cell. Note that the 1/16" thick foam is on the outside faces of the two cell module, while the 1/4" foam sits between the two cells of the module. The 1/8" may be used for stack end modules, or two 1/16" frames will be stacked to reduce part count (not pictured). Also note that the crimp on the edge of the cell has been reduced in size according to measurements from a few test cells we had lying around (finally back at school, and in the garage!).

We plan on using Poron polyurethane foam or weather-resistant neoprene/EPDM/SBR foam. Both foams have similar temperature ranges, firmness properties, and are closed cell. However the 1/16" Poron foam is only rated for UL94HBF while the neoprene foam is rated for UL94HF1, so we will likely go with the neoprene foam. UL94HF1 is considered superior to UL94-V0 right? Just confirming from ticket #930.

Additionally "Even Stack.pdf" shows that we have completely enclosed the cells on the sides and bottom in the aluminum

heat spreaders for better impact resistance. We still plan on using conductive tape to connect all of the spreaders to LV ground through a high resistance, although that is not pictured.

Best,

Phil
Even Stack.pdf*(143.7 kb)* Repeating Frame.pdf*(31.7 kb)* Two Cell Module.pdf*(101.7 kb)*

09/01/2015 4:12 pm

Hi Phil,

How do you have the heat spreaders pinned in place and aligned with each other?

Also HF1 is not comparable to V0 the test procedures are different because one is for foam and the other is for solid materials. However HF1 is much better than HBF - if given the choice between the two with all other factors equal, go for the higher flame resistance.

~Chris

09/05/2015 7:15 pm Philip Piper

Hey Chris,

After some deliberation we decided to pin the heat spreaders and repeating frames together using the expansion limiters. This fixes the heat spreaders relative to each other, and relative to the end plates. See "Two Cell Module.pdf" for a view of the holes at the module level. Additionally "Two Cell Module Transparent.pdf" shows how the holes are isolated from the cells. "Repeating Frame.pdf" shows a single repeating frame with holes in it. "Heat Spreader.pdf" shows a heat spreader with holes in it. "Stack.pdf" shows the stack with expansion limiters integrated inside of the heat spreaders.

Thanks for the clarification on UL94. We will go for HF1 where possible.

Best,

Phil
Heat Spreader.pdf*(36.1 kb)* Repeating Frame.pdf*(37.2 kb)* Stack.pdf*(93.6 kb)* Two Cell Module Transparent.pdf*(47.9 kb)* Two Cell Module.pdf*(41 kb)*

09/09/2015 7:33 pm

Thanks Phil - I'm closing this thread unless you have further questions
Rob Wills

Please Wait!

Please wait... it will take a second!