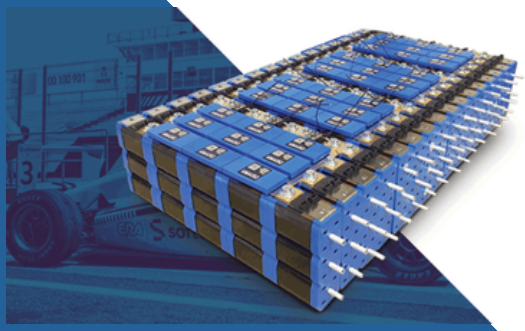
POWER BATTERY

WHITE PAPER



Engineering and Building FIA approved battery packs for race cars

IN THIS WHITE PAPER

Engineering and building battery packs for race cars is a profession in itself. Especially with FIA approved formula racing cars. Electric formula cars are often based on existing formula cars; they share the same chassis and monocoque. The weight and weight distribution of the car must then remain as close as possible to the original, so that the car's handling mimics that of an ICE race car as close as possible.

And that has implications for the development of the battery pack: it has to fit more or less in the same space as the former engine. Its weight must also be the same or less than that of the engine. That is quite a challenge.

CONTENT

The development of FIA approved battery packs is a complex process and depends on many factors. The most important one: How to comply with applicable regulations?

In this white paper, we take you through the entire process. We address the following questions:

1. What is the importance of concept design?
2. How far does detail engineering go?
3. How to keep the battery cool?
4. How do we ensure safe production?
5. What does testing involve
6. What does battery pack engineering mean for your application?

1. The importance of concept design

At first a concept design needs to be created. This is a puzzle to discover if the required amount of batteries can fit the given space, including BMS, electronics and housing.

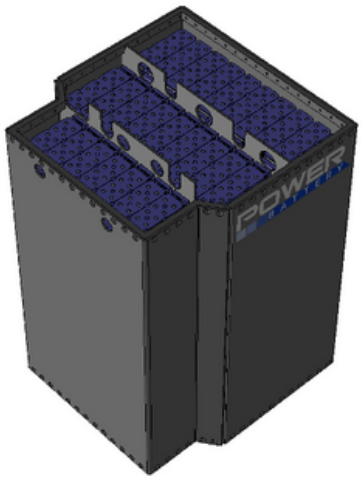
CONCEPT DESIGN

1.Space claim

We start with a space claim from the customer and try to fit the required amount of batteries or modules inside this space. Multiple layouts are created and discussed with the client.

2.Mock-up

When the layout is chosen and it fits the given spaceclaim, the concept is worked out to the point that a mock-up can be created. A concept layout of the battery pack can look like this:



Most of the times customers have a CAD-design of there application. With the electrification of used vehicles, the vehicles are scanned and imported into CAD-software. In the case of the electric formula car, it was a new car. So, the design and CAD-model of the car was already generated.

CONCEPT DESIGN

The CAD-model of the application is used to fit the concept design of the battery pack inside the application. If all looks well, the CAD-model of the application and the fitment of the battery pack need to be verified with the real world situation before detail engineering starts. A mock-up is used for this.

It is always important to make a mock-up before detail engineering of the battery pack starts. It is very painful if the battery pack is completely designed and produced and then it turns out it doesn't fit the application.

3.Adjustments

After the mock-up is fitted in the application, the concept design can be adjusted to the things we encounter during fitting.
When all is tested, the next phase of the project starts.

2. How far does detail engineering go?

The next phase, and the most time consuming phase of the project, is detail engineering of the battery pack. During this phase all requirements have to be taken into account.

DETAIL ENGINEERING

For battery packs additional requirements such as clearance and creepage are very important.

Clearance

This is the minimum required straight distance between live components and other components. The rule of thumb here is 1000V per 1 mm in perfect dry conditions. Moisture and condensation are not taken into account in this rule. At Power Battery we like to add an extra safety margin of clearance between the live parts and other components to make sure the voltage can never ‘jump’ to the housing and create an arc.

The rule of thumb: 1000V per 1 mm in perfect dry conditions.

Creepage

This is the minimum path between live parts and the other components. When a surface is polluted a current can ‘run’ on this surface. So even if insulating materials are used in the battery pack, the surface of this insulating material can still be a conductor if it is polluted.

DETAIL ENGINEERING

The best example is water droplets on top of the insulating material caused by condensation. If this water contains some pollution picked up at the surface, these droplets will conduct current. This can cause a voltage to ‘jump’ form the live parts to the other components.

We also include a safety margin in the design of the battery pack to increase the creepage distance.

On top of that, Goretex plugs are included to reduce the temperature and pressure difference between the inside of the battery pack and the outside environment. These plugs also filter the moisture from the air. This reduces the chance of condensation massively.

A safety margin in the design of the battery pack to increase the creepage distance is included.

3. How to keep the battery pack cool?

A critical factor in high performance applications such as racing is the cooling technology. What does this cooling technology involve?

BATTERY PACK COOLING

As a partner of ERA Championship, we put all our engineering skills to design and produce solid, safe and high power FIA approved battery packs for the fully-electric junior racing class.

A critical factor in high performance applications such as racing is the cooling technology. This enables you to continuously extract a lot of power from a battery pack without it overheating. With positive consequences for safety, and especially for the life span and reliability of the pack. What does this cooling technology involve?

Unique cooling technology

By optimally directing the cooling through the entire battery pack, the delta (temperature increase) of the cooling water is limited to half a degree Celsius.

To compare: the delta of a Tesla is 5 degrees Celsius. Power Battery's cooling system cools no less than 25 per cent of the cell surface and thus dissipates the generated heat very efficiently.

The temperature on the outside of the battery cells remains, even after a long period of high discharge, at around 55 degrees. Well within the suppliers' specifications.

4. How do we ensure safe production?

The modules for the battery pack are produced and tested to make sure every module complies with the strict requirements we have.

PRODUCTION

Testing

First, the modules for the battery pack are produced and tested to make sure every module complies with the strict requirements we have.

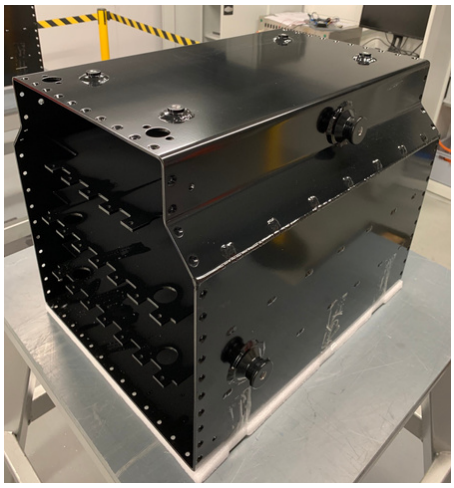
Cooling

After that, rows of modules are created and cooling is added. To increase the clearance and creepage distance, the rows of modules are surrounded with synthetic plates (see below).

2. Rows of modules with the synthetic plates on the side. The top will be covered.

Safety

During production of battery packs, safety is a major subject. At Power Battery we made specially insulated work tables for assembling battery packs.



3. insulating worktable with the housing of a battery pack.

The top plate consists of thick PVC plate. The worktable stands on insulation carpets that can withstand voltages up to 10.000V. Besides that, we only use insulated tools during production of the battery packs.

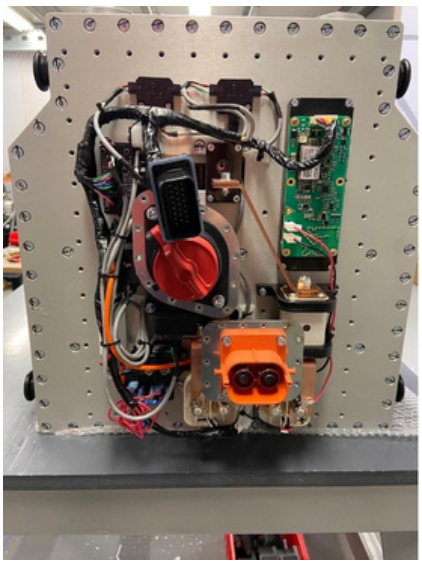
The packs are always designed in a way that all parts are lower than 50V up to the very last stage of the production of the battery pack. The rows of modules you see in the picture 2 have a maximum voltage of 43,2V. This is safe to handle without extra safety measures.

Integration

When the rows of modules are complete and tested, they can be fitted inside the casing of the battery pack.

After that, electronics are added, for example: contactors, fuse, pre-charge, insulation monitoring device, wiring loom, etc.

For this battery pack there was very little space for the electronics. Nonetheless we managed to fit it safe inside the junction box on top of the battery pack..



4. The electronics of a battery pack

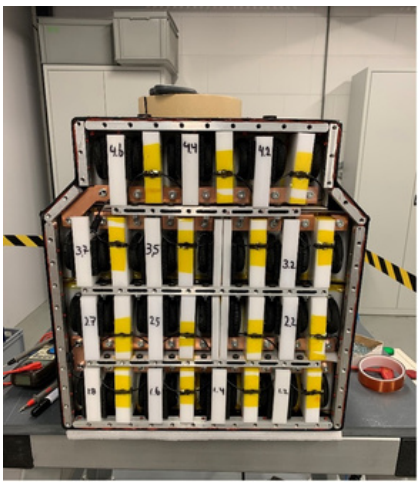
Connecting

When the electronics are tested and the function of the battery pack is verified, the last step of the process can begin; connecting the battery pack to its maximum voltage.

This step requires additional safety measures:

- Insulating gloves
- Face protecting mask
- The earlier mentioned insulation tools.

During connecting the rows of modules, an insulation monitoring device is always active to measure if any safety hazards are occurring. When a safety hazard occurs, a loud beeping sound is activated.



5. A fully connected battery pack with support blocks

5. How do we test?

When the battery pack is completely connected, several tests are conducted.

TESTING

Activate BMS

At first the BMS will be activated to see if it can connect to every battery module. When this is the case, an extra safety test is performed.

Insulation monitoring device

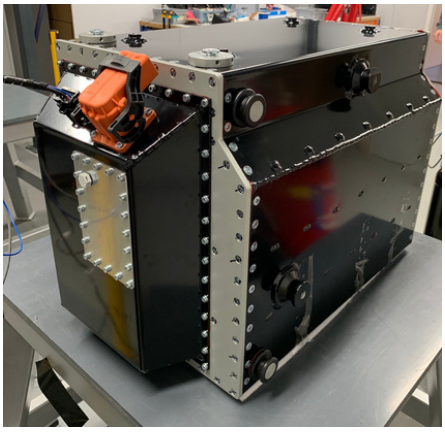
The insulation monitoring device of the battery pack is activated and the output signal is studied with an oscilloscope. The PWM signal from the output of the insulation monitoring device gives information about the measured resistance between the live components and the housing.
When the signal gives an ‘all ok’ PWM signal, the safety of the pack is verified.

Closing the pack

At last the pack is closed and is charged and discharged to verify the performance of the cooling system.

Shipping to customer

When the performance of the pack is verified, the battery pack can be shipped to the customer.



6. Conclusion

What does battery pack engineering mean for your application?

CONCLUSION

As you can see: developing a battery pack for e-racing applications is a careful process. It ensures that you get an optimal solution tailored to your specific situation.

Precisely by including all aspects of your application in the development at the front end, you will enjoy the benefit of a solid, sustainable and safe solution.

Do you have a question about the electrification of race cars or other applications?

Let us think along in a competitive solution. Get in touch here.

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*Find out the amount of modules you need with our **Battery Calculator** and get your free calculation sheet.*