Fusible Link Design Report Guide & Template

Introduction:

Fusible links are generally used to meet EV2.6.3, which requires that parallel cells be appropriately fused. Referencing Figure 1, the fusible links provide the fuse protection offered by the "*i*" fuses.

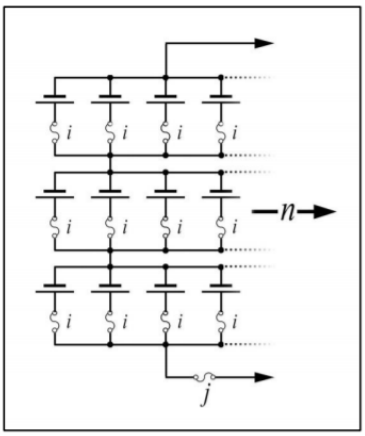


Figure 1

Formula Hybrid allows (and encourages) students to design and construct their own packs using fusible links, but it requires conformance with this document as well as documented testing of the design.

Overview:

In this document we will be looking at the following aspects of your fusible link design.

1. Ability to stay cool at continuous current rating
2. Ability to blow above a specified current
3. Behavior during failure

While calculations and simulations may help inform your design, Formula Hybrid requires that you physically test your design to prove its effectiveness. The required tests for each of these aspects are described in detail in the remainder of this document. For each test, students should create one or more videos at a resolution of 720p or higher, along with a description of the test and a summary of the test results. The text should be consolidated into a single document with hyperlinks to the videos. This document should be submitted to the ticket system for approval as early as possible.

Warning: These tests may require large currents and high voltages and destructive testing can be dangerous. Please look for expert guidance and take all relevant safety precautions to ensure your tests are executed safely. Always use proper laboratory equipment to supply the required power, DO NOT use your accumulator or spare battery cells to test your fusible links in situ.

Performance at Rated Current

Your fusible links must be able to carry the packs rated current for 10 minutes without excessive temperature rise that could endanger your accumulator, insulation, wiring, etc. The continuous current rating is defined as the main pack fuse continuous current rating divided by the number of parallel cells. For example, In Figure 1, this would be the continuous current rating of fuse "*j*" divided by 4.

The temperature of the link should be no more than 50C above an ambient temperature of between 20C and 35C. Note: A 50C rise may be excessive if BMS temperature monitoring is located close to links, or if a cell-level distributed BMS is used. In those cases, experiments or calculations may be result in a requirement for a lower temperature rise for reliable operation

Cell temperature should be recorded by thermocouple or by thermal imaging. IR thermometers are not recommended because it is difficult to determine in a video clip if they are being aimed correctly.

During testing, the fusible link should be in oriented as it would be when installed – horizontally, vertically, etc.

To test this performance, you must attach your fusible links to a current limited power supply set to at least your cells expected continuous current and film the process.

For example, attach a thermocouple to the fuse neck at the rated current. Rather than using actual cell terminations, a copper conductor or block of similar size and thermal sinking capability as a cell should be used to prevent possible cascading failures during test.

Fusible Link Design

FUSIBLE LINKS MUST HAVE A DESIGNATED NECK AREA AT NO MORE THAN 50% OF THE AREA OF CONTACT WITH THE CELL.

Required Documentation:

1/ A brief overview of your design and design methodology, including any calculations and a summary of any simulations.

2/ Explain compliance with the requirements of EV2.6.

3/ Test Reports demonstrating the ability to:

(i) Carry full DC rated current for at least 10 minutes with less than 50° C temperature rise (or less if the pack/BMS design requires).
(ii) Trip at 300% of rated current.
(iii) Interrupt current equal to the maximum short circuit current expected without producing heat, sparks, or flames that might damage nearby cells. For example, in FH rules Figure 29, this requirement is met if $j \leq n \cdot i$ 3 , where i is the cell fuse or link rating, n is the number of cells in parallel and j is the master series fuse rating.

Following is a suggested template for your submission to the FH ticket system.

FUSIBLE LINK DESIGN REPORT

Team: *Team Name*

Responsible Team Member(s): *Team Member Name*

Accumulator Information

Main Pack Fuse Continuous Rating: _____

Number of Cells in Parallel: _____

Maximum Continuous Current per Cell: _____

Maximum Cell Voltage: _____

Cell Size: _____(18650, 26650, etc)

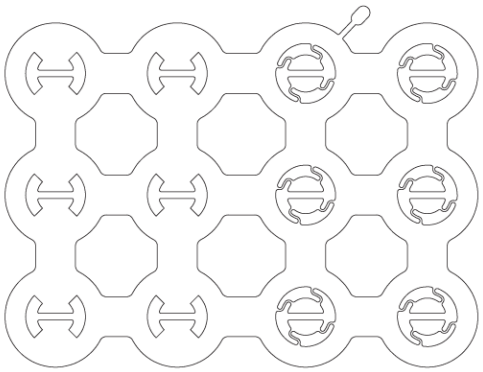
Design Description

(Insert Design Description Here)

Required Information:

- Intended Continuous Rating: _____
- Intended Trip Current: _____
- Photo or rendering of link and pack assembly
- Dimensions of link and fusable area

Orientation of Fusible Links in Vehicle: ___(horizontal, vertical, angled)___.



Normal View of Fusible Link Sheet or Installation

Please Ensure the Following:

- You follow proper lab safety procedures (safety glasses, fire extinguisher handy, etc.)
- Your current and temperature readings are visible in videos
- You test the fusible links in a way that is representative of highest likely continuous temperature

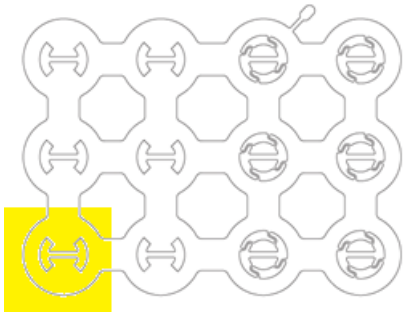
- You do not excessively heat-sink your fusible links. Wiring or other connections to the links should be representative of the surface area and thermal sinking ability of the battery terminal or tab.

Continuous Current Testing

(Insert Test Summary Here)

Required Information:

- Which links did you choose to simulate in testing (highlight on normal view), why?



Highlighted Normal View of Links

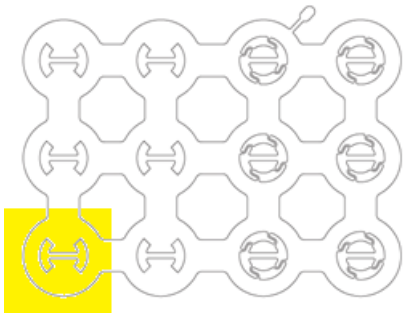
- Minimum Required Current: _____
- Current During Test: _____
- Orientation of Fusible Links During Test: _____
- Number of Tests Completed: _____
- Ambient Temperature: _____
- Maximum Temperature Rise at 10m in Any Test: _____
- Links to video of (at minimum) the tests with the largest and smallest temperature rise

Fusing Current Testing

(Insert Test Summary Here)

Required Information:

- Which links did you choose to simulate in testing (highlight on normal view), why?



Highlighted Normal View of Links

- Minimum Required Current: _____
- Current During Test: _____
- Orientation of Fusible Links During Test: _____

- Number of Tests Completed: _____
- Ambient Temperature: _____
- Links to video of (at minimum) the tests with the largest and smallest temperature rise