UK BATTERY INDUSTRIALISATION CENTRE

The UK's battery manufacturing development facility

Providing scale-up, laboratory expertise, and helping develop skills to support the sector.

We link research and development to mass-manufacture.

Department for Business & Trade

UKRI Innovate UK

Two scales of electrode production

Flexible Pilot Line (FPL)

Product development and validation line from electrode to multi-format cell assembly

- Cost effective for smaller runs
- Multi-solvent compatible
- Coating and drying

Industrial Scale-up Line (ISL)

Giga-scale line from electrode to cylindrical and pouch cell assembly

- Reduces risk for high volume
- Mixing
- Coating and drying
- Cell assembly

UK BATTERY INDUSTRIALISATION CENTRE

Enabling the manufacture of next generation cell formats through design and process consideration

Aishwarya Chougule, CAD Engineer

The outline

- Market analysis – A customer survey was carried out to strategically select the next preferred cell format for UKBIC
- Cell chemistry agnostic architecture was proposed for FPL's equipment commissioning
- Purpose was to strengthen UKBIC's knowhow for specifying equipment for next generation cells
- Tabless 21700 extending up to tabless 4695 were the two down selected cell designs
- A smaller pouch format of 220*115 was also chosen as a baseline for prismatic cells
- 'Electroder' – as the design partner, assisted in the cell architecture selection and supplier finalisation process

Product concept design

Product concept design

- IP Landscape
- Benchmarking cells

Process design

- Variation trees
- Down select components
- Explore suppliers

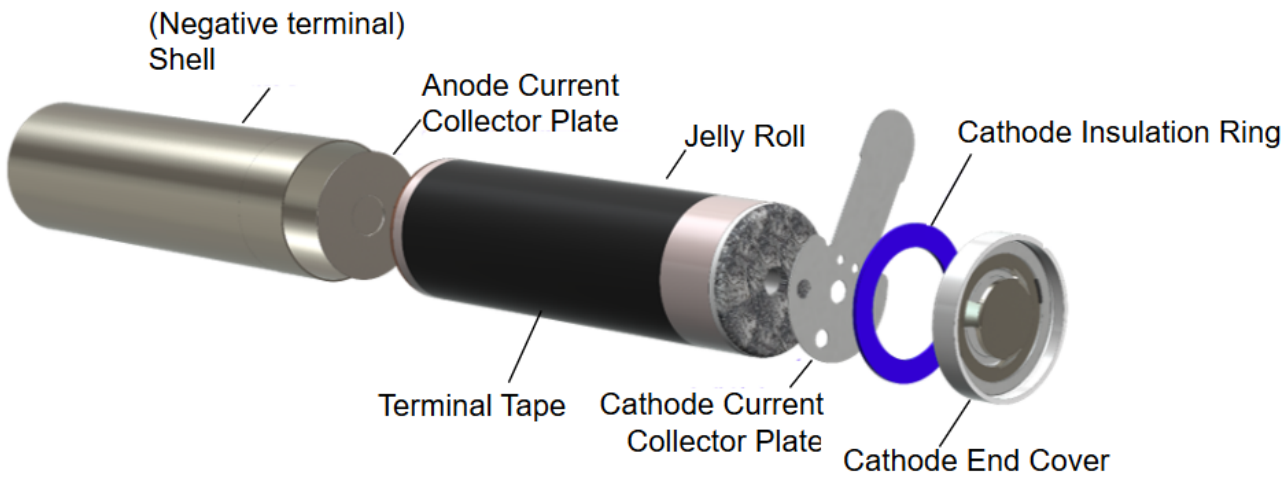
Product detail design

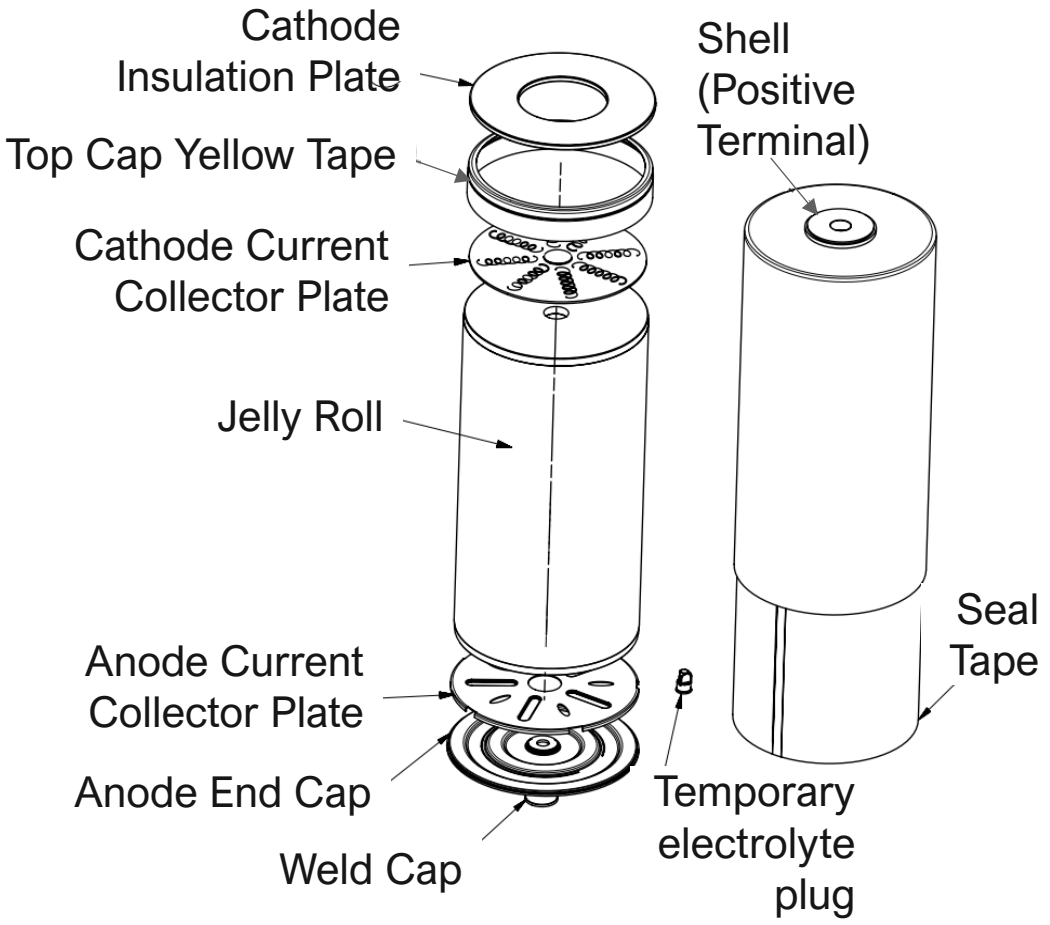
- Analysis trade offs
- Safety design considerations

Design freeze

- Creating final BOM
- CAD for FAT trial

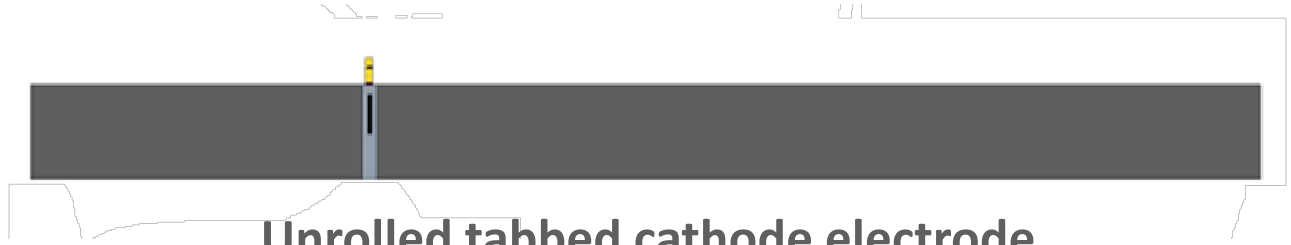
Tabless cell representation – 21700 and 4695





Difference between tabbed and tabless cell architecture

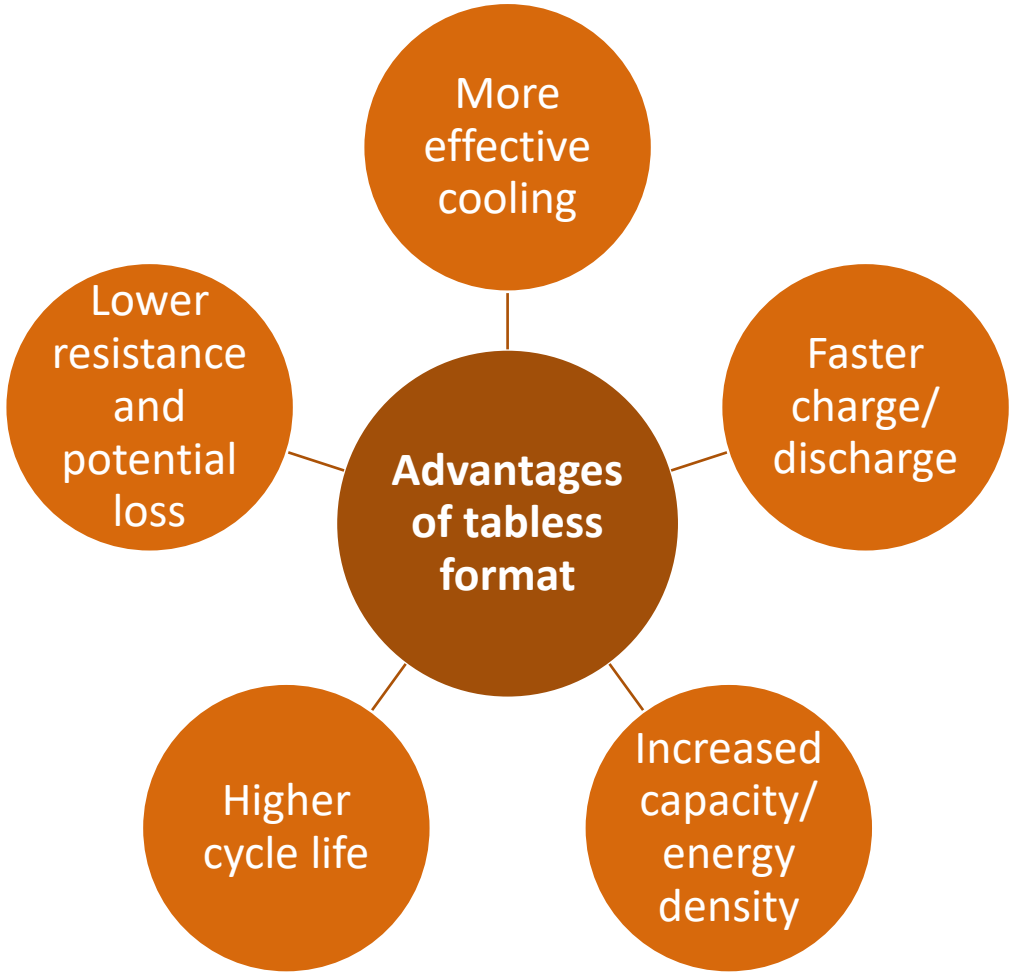
- Robust design due to increased current and heat flow paths
- Reduced ovality in coil pack
- Introduction of current collector plates for transferring current from the tabless regions to can and cap



Unrolled tabbed cathode electrode

Unrolled tabless cathode electrode

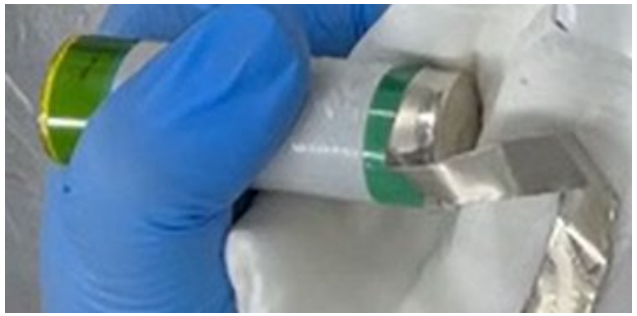
Tabless cell advantages



Model Name	DCIR at 50% SOC (mΩ)
Standard 21700- 1 anode tabs and 1 cathode tab	31
21700- 2 anode tabs and 1 cathode tab	26
21700- 3 anode tabs and 2 cathode tabs	18.5
Molicel INR-21700-P50B	12.5
BAK 21700P (N21700CGP)	12
Tesla 4680	7

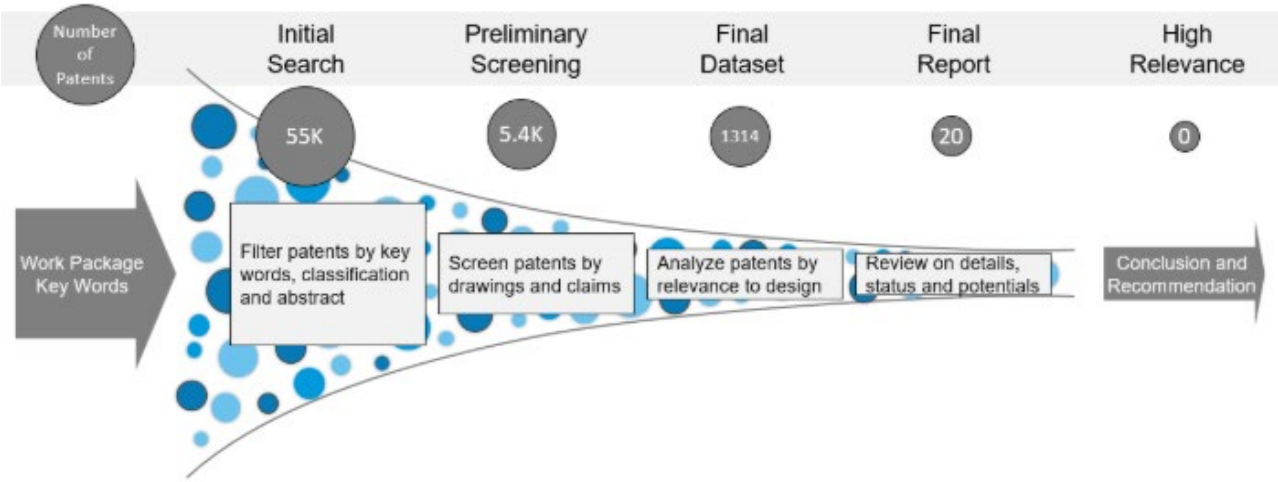
Product concept design

- Benchmarking 11 cells (5 tabless cylindrical, 5 prismatic, 1 blade)
- Helped understand the design, structure, material of components of cell types
- Provided a visual comparison between the cell types
- Aided in decision making of down selecting the 21700 and 4695
- What did we learn from teardown, couple of instances- larger cell formats used ceramic edge coating, some prismatic were wound/folded, hard connection, soft ones



Product concept design

- A Freedom-to-Operate analysis (FTO) was conducted for the tabless cell designs in search of existing patents
- Patent search assessment was divided into:
  - Tabless or all tabs structure
  - Electrode architecture
  - Component structure
  - Manufacturing processes
- **Conclusion:** there is a low risk of the two 21700 and 4695 cylindrical all-tab mechanical designs in term of intellectual property rights



Product variation tree

- Helped to choose the most suitable component in terms of collector plates, insulation tapes, can sleeve, can type and structure, caps, etc. to make the bespoke tabless cell
- Soft connection provides more vibration resistance (like our existing MK2 cell)
- Hard connection provides more mechanical strength for larger cell formats and better cell internal volume utilisation

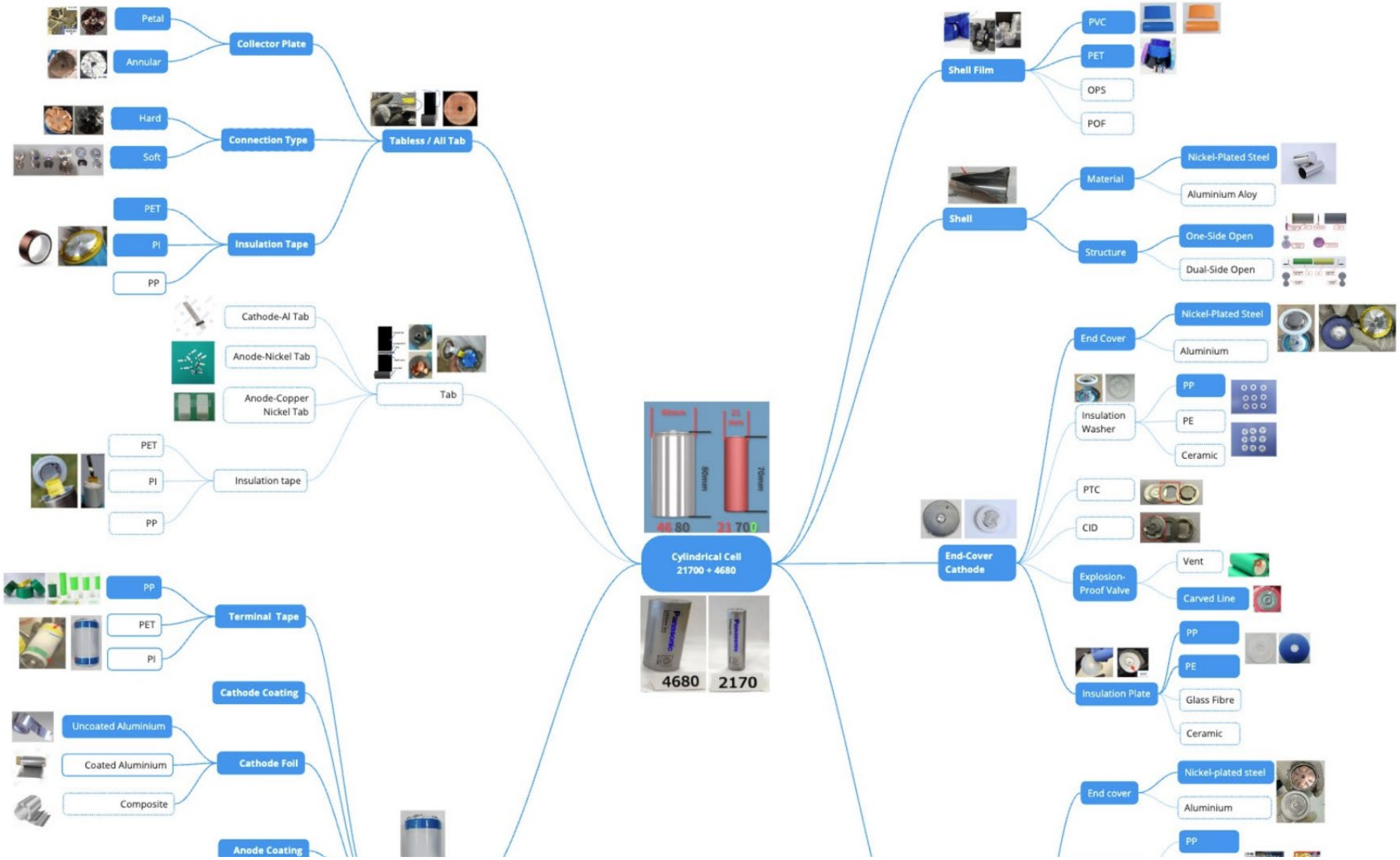
Welded to the cap

Welded to the coil pack

Soft connections

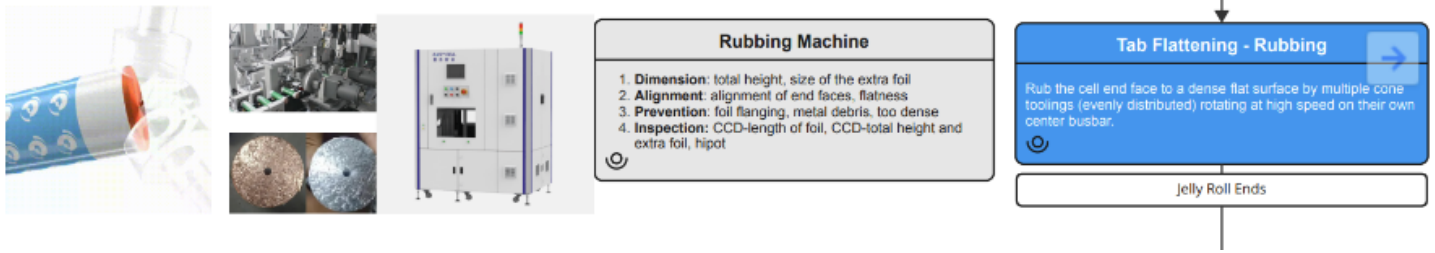
Hard connections-welded to coil pack

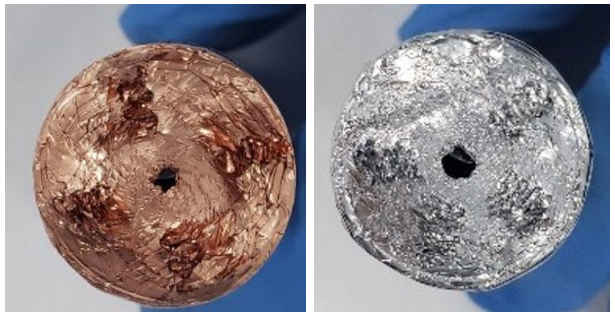
Product variation tree example



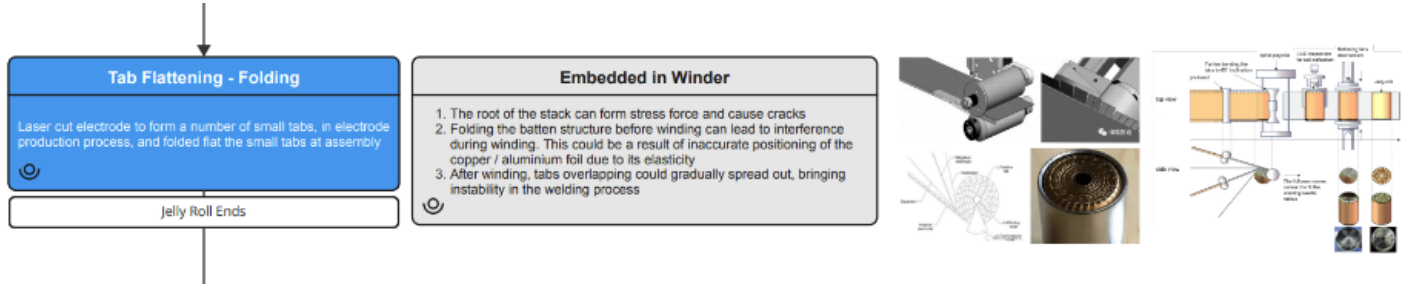
Process variation tree

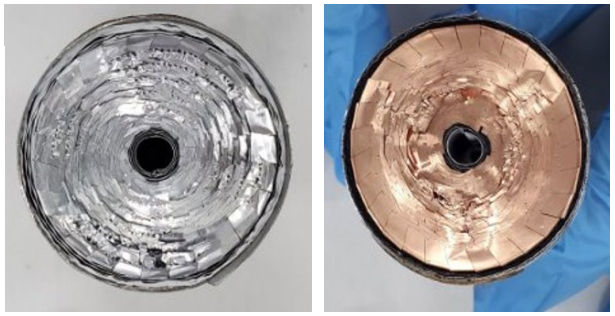
- A process variation tree lists down the options available to chose from, at each cell assembly step
- Helped to make the right choice for FPL cell design based on the MOQ, time for assembly step, equipment and product suitability etc





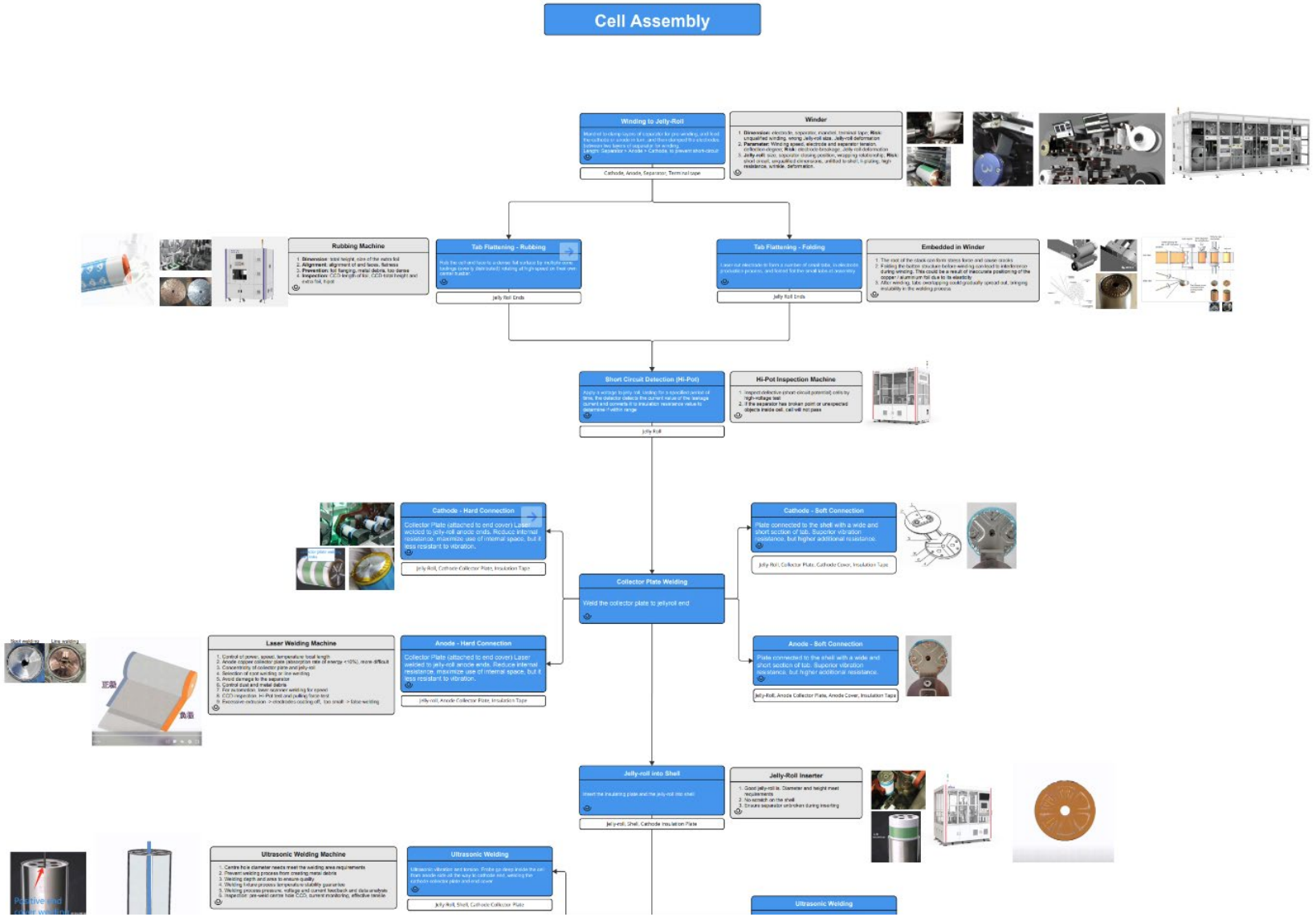
'Rubbed' profile of tabs





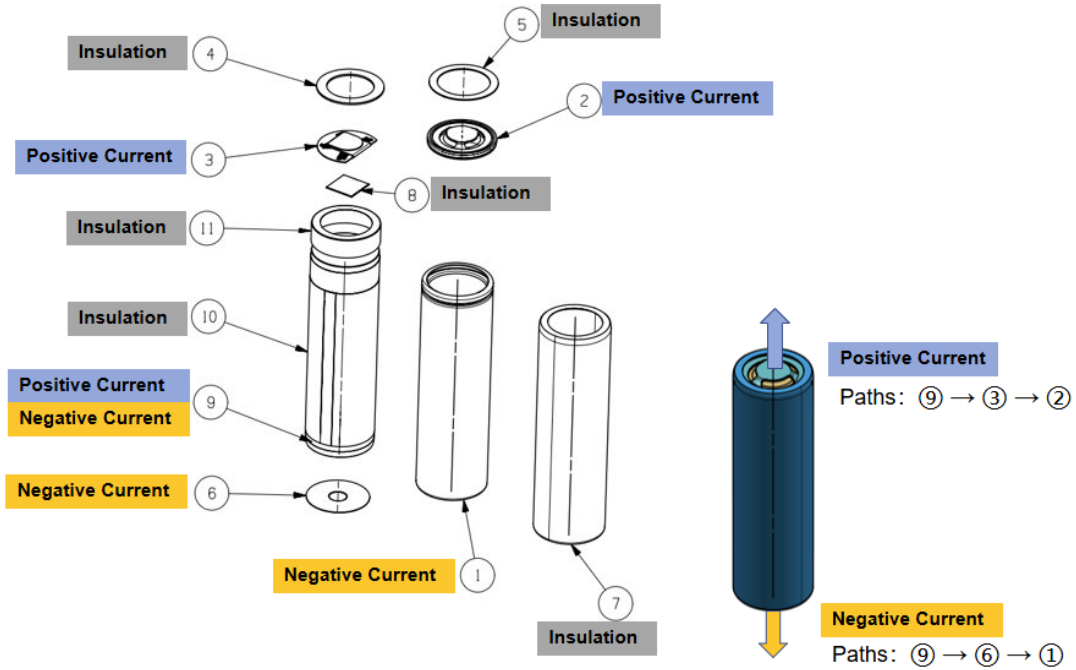
'Folded' profile of tabs

Process variation tree example

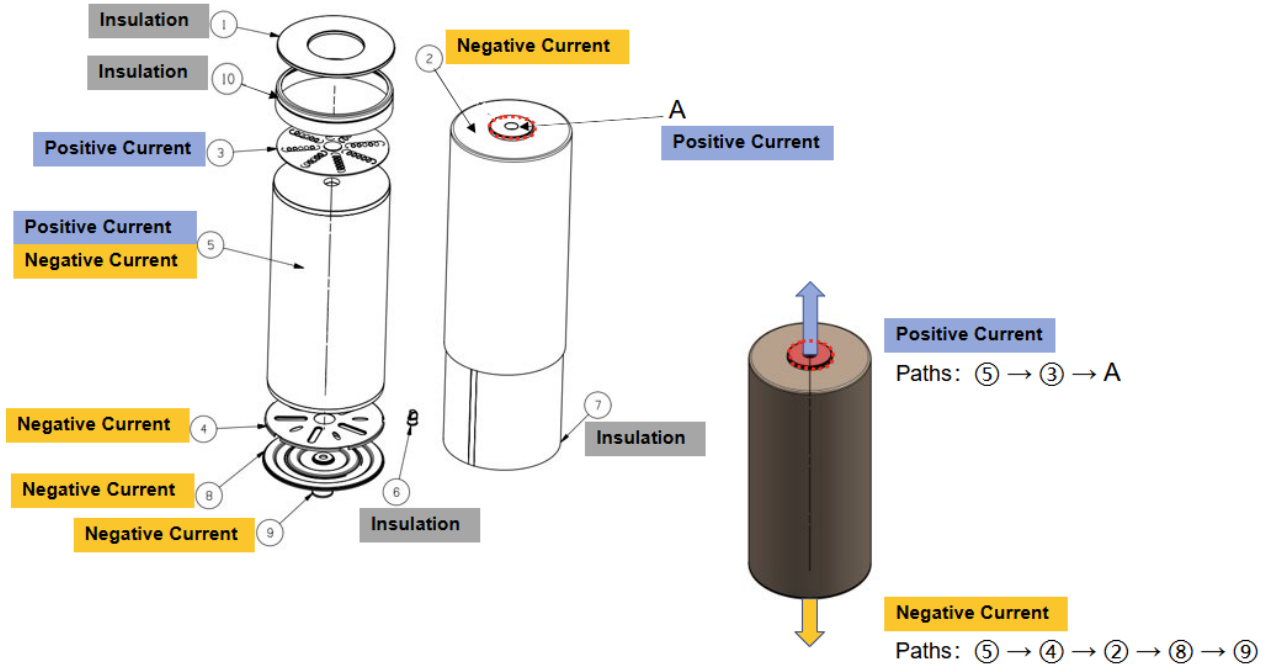


Current paths of 21700, 4695

Current flow path for 21700



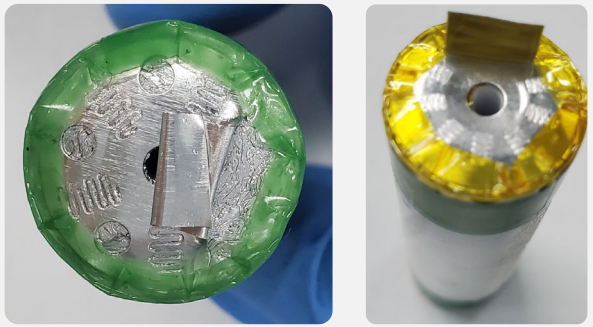
Current flow path for 4695



Safety design features- short-circuit prevention

Insulation Tape – 21700 and 4695

Helps in insulating the coil pack at edges and avoid the coil pack touching the can

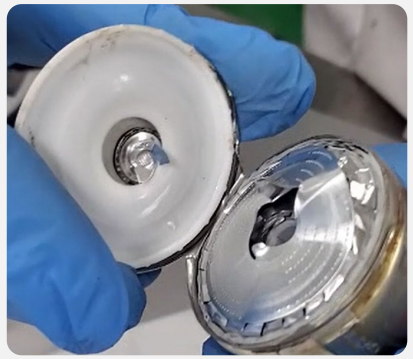


Insulation Ring (Cathode) – 21700

Separates the positive coil pack side from negative can

Insulation Plate (Cathode) – 4695

Covers and insulates more coil pack area to provide stability



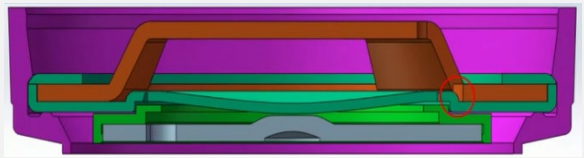
Ceramic edge coating (Cathode) – Optional

Prevents the wider anode touching cathode in tabless design

Safety design features – pressure relief

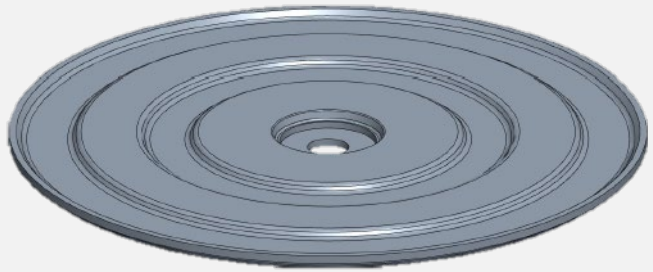
CID in Cap – 21700

- The CID is normally under pressure and is designed to fail beyond threshold pressure
- Acts in 2 stages:
  1. Interrupts the current flow by breaking the negative-positive contact
  2. When it reaches the threshold, it pops and pressure is relieved



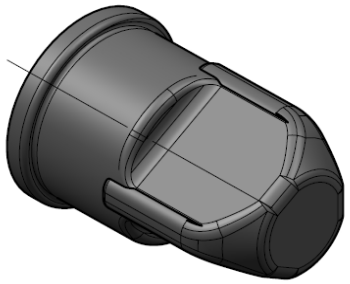
Relief grooves – 4695

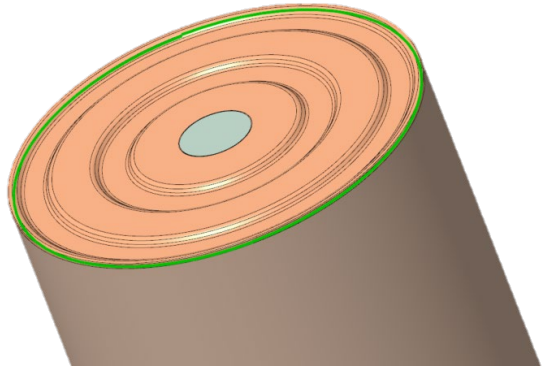
- The relief grooves are designed to directly release the pressure in case of overriding threshold pressure incident
- It is a fail-safe design to release pressure from the break point area which is the end cap



Design trade-off

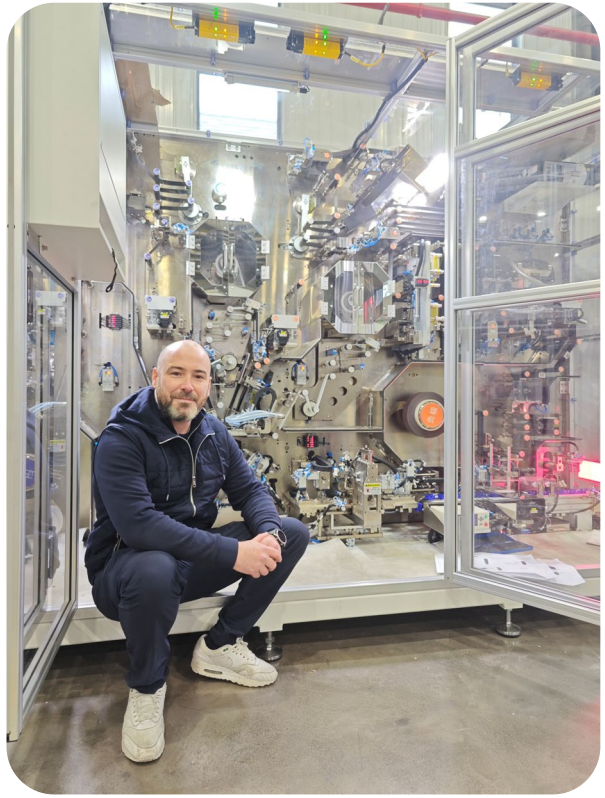
Sr. No.	Design for manufacture item	Description of Paths	New 21700 tabless Design	New 4695 tabless Design
1.	Tab Flattening	Rubbing or Cut-and-Fold	Rubbing	Rubbing
2.	Cell Can Type	One or two side open	One-Side Open	One-Side Open
3.	Current Collector Plate	Soft (Indirect) or Hard (Direct) to Cap Connection	Cathode (Soft) Anode (Hard)	Hard Connection
4.	Ceramic Coating	Ceramic on electrode edge to prevent short-circuit	Independent Electrode Line Improvement	
5.	Can Sealing	Laser or crimping sealing	Crimping	Laser
6.	Explosion Prevention	(Current Interrupt Disc) CID or Relief grooves (designed break point)	CID	Relief grooves
7.	Electrolyte Injection	Injecting electrolyte into can	Open Cap Injection	Injection Hole



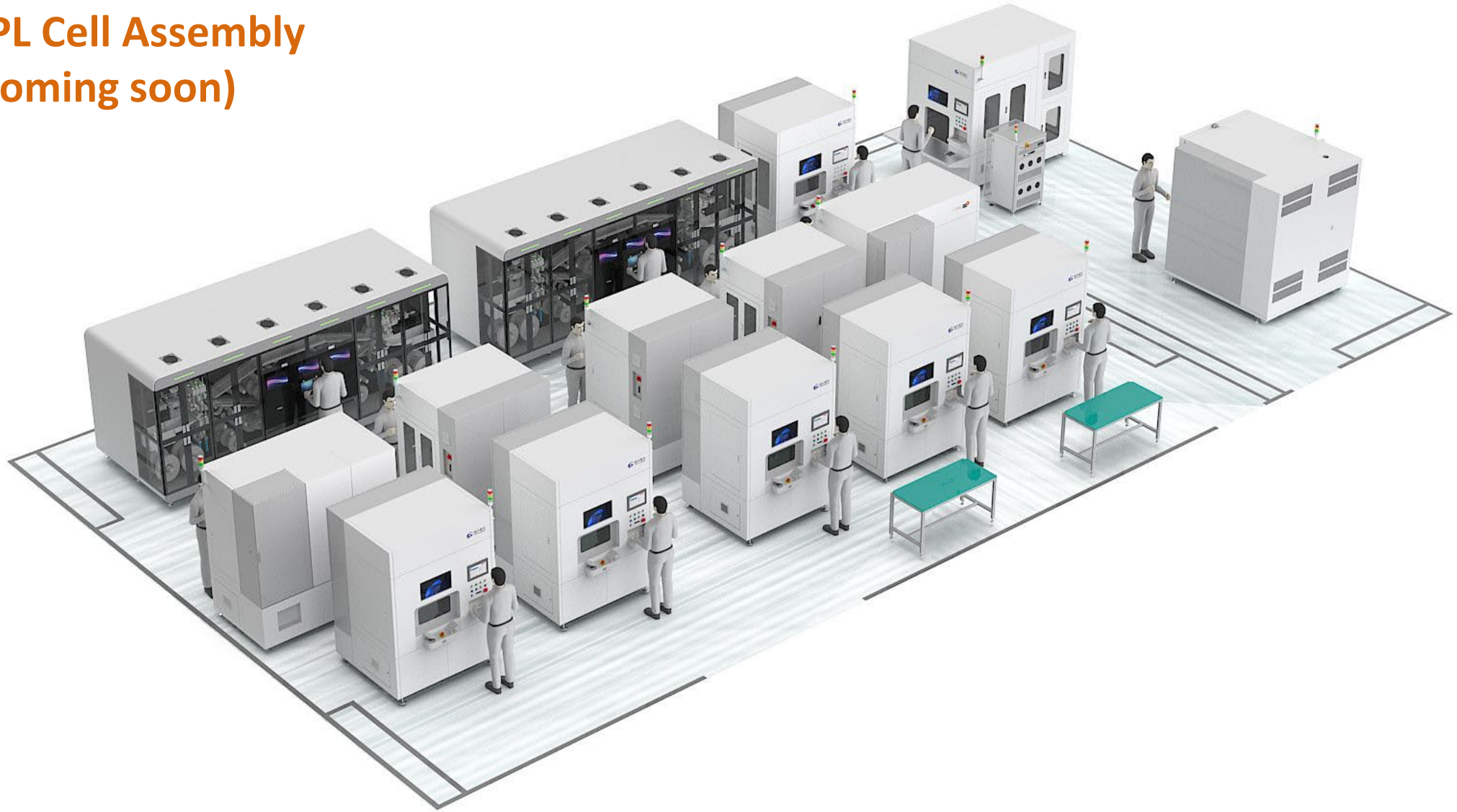


Next steps

- Design freeze for 21700 and 4695 has been completed – subject to change for electrodes
- Electrochemical parameters like cell voltage, capacity, cell discharge will be established after FAT, SAT trials respectively
- Few design changes such as welding pattern refinement, coil pack tolerance re-evaluation were proposed after FAT



FPL Cell Assembly (coming soon)

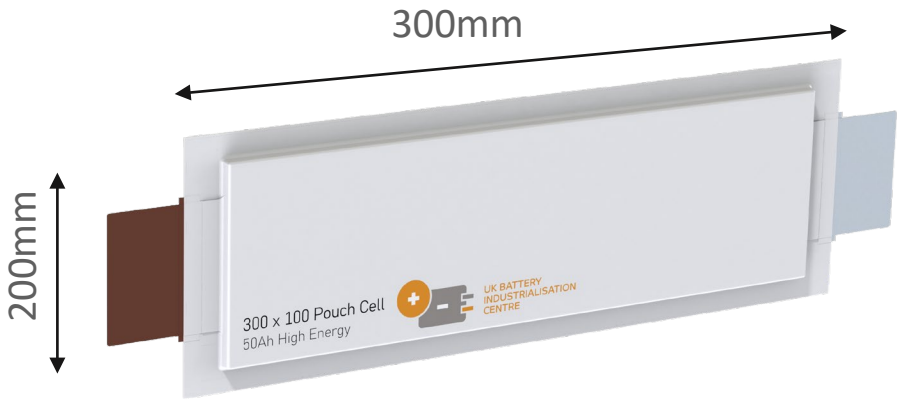


UKBIC cell formats

ISL capability

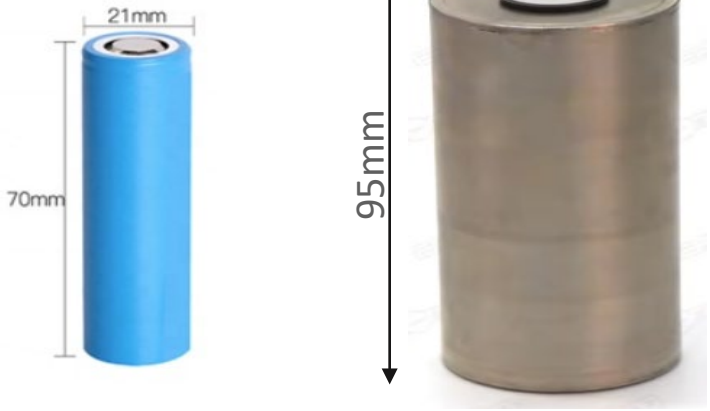
21700

Tabbed cylindrical cell

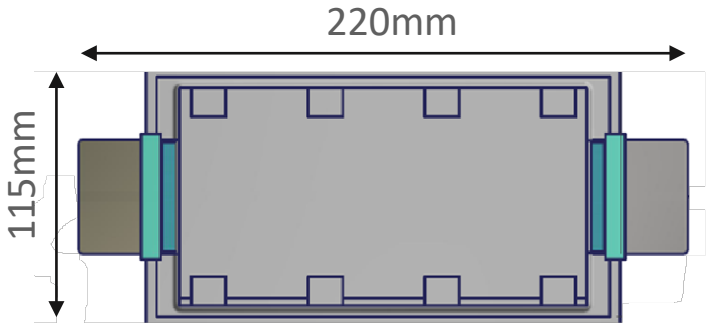


Pouch cell

FPL capability



Tabless cylindrical cells



Pouch cell

Question and answer panel:

Use the Q&A function rather than the chat function

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Thank you

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