



Thermal Runaway in Li-Ion Battery Packs

Prevention, Detection and Testing

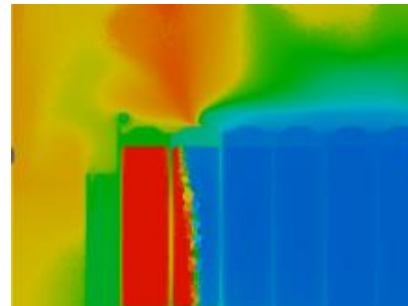
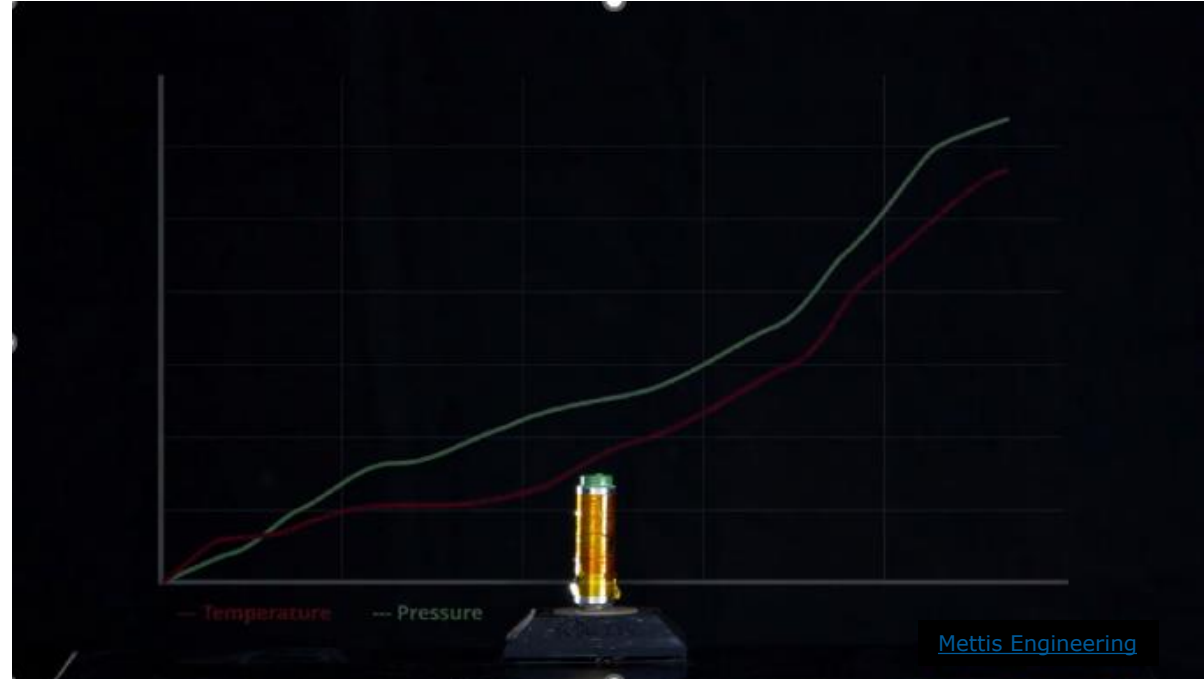
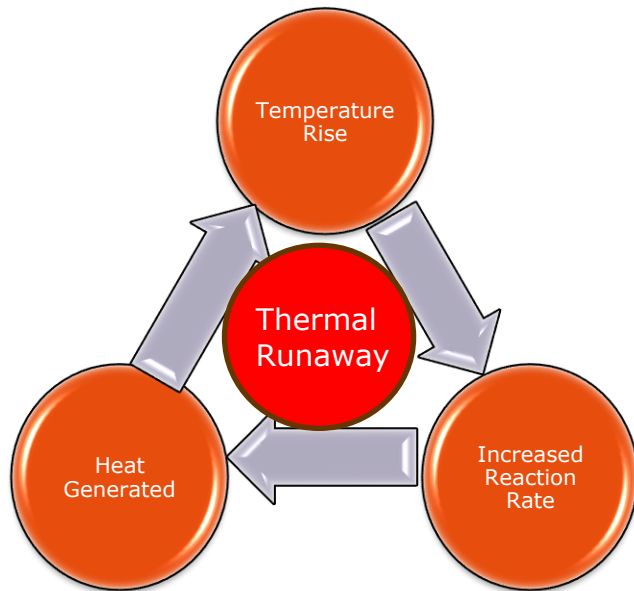
Corey Nicholls

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 - 5 How Do We Test for It

What Is Thermal Runaway?

- Uncontrollable
- Self-heating
- Increasing temperatures
- Cell venting
- Potential fire

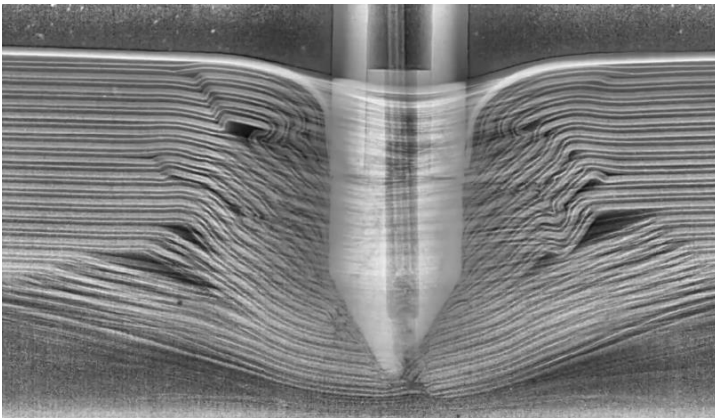


If left unchecked, **thermal propagation** occurs and the chain reaction continues to the neighbouring cell.

Thermal Runaway Initiation

Mechanical Abuse

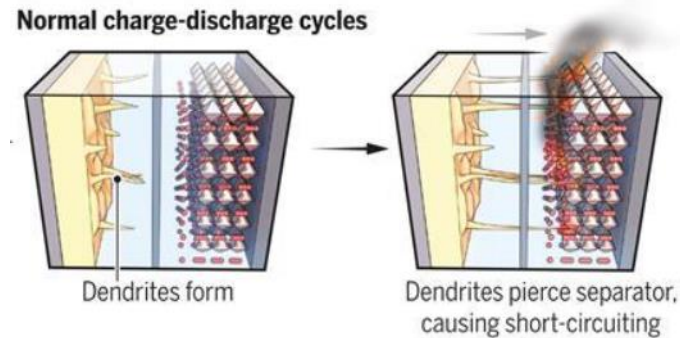
- Deformation
- Crush
- Penetration



[Nail penetration X-ray](#)

Electrical Abuse

- Over charge / discharge
- Internal or external short circuit
- Dendrite growth



[Dendrite growth](#)

Thermal Abuse

- Extreme temperature operation



Preventing Thermal Runaway

Mechanical

- Identify failure modes and abuse case early
- CAE – mechanical
- Manufacturing / Quality

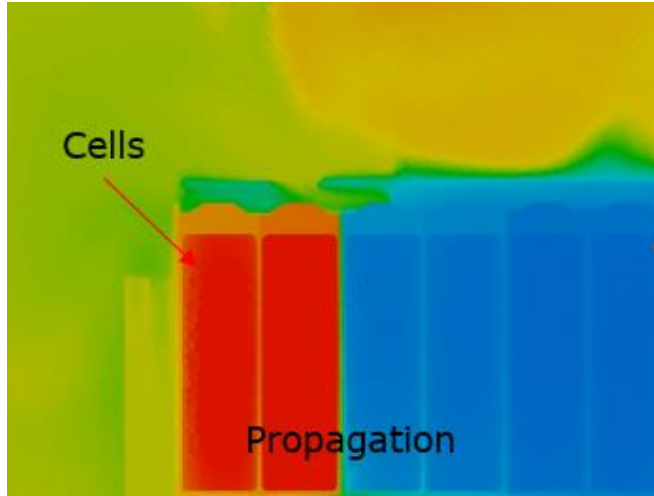
Electrical

- Cell testing and characterisation
- CAE – Electrochemical and electrothermal
- Creepage and clearance distances
- Fast charging optimisation

Thermal

- Thermal strategy
- Passive or Active cooling
- CAE – Electrothermal
- Requirements for no leaks and pack sealing



Thermal Propagation



>5min
...from detection
to propagation


- Current legal requirement (GB 38031-2020)

>15 to 30min



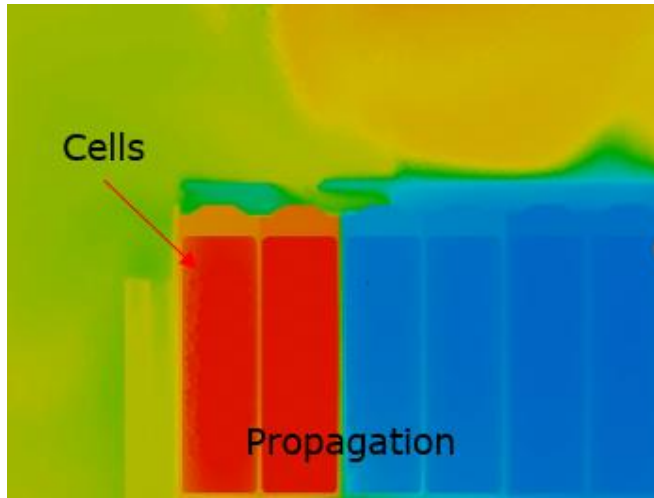
- Minimum customer requirement.

No Propagation



- Today's customer wish; future demand

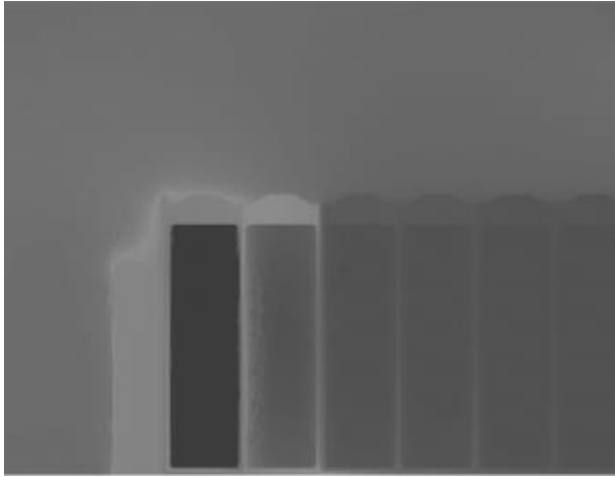
Target: Delayed Propagation or No Propagation?



Delayed Propagation:

- Delaying propagation beyond the legal requirement
- Possibility for safer passenger exits. Not guaranteed
- It will eventually propagate
- There is still a risk of fire & explosions

Target: Delayed Propagation or No Propagation?



No Propagation:

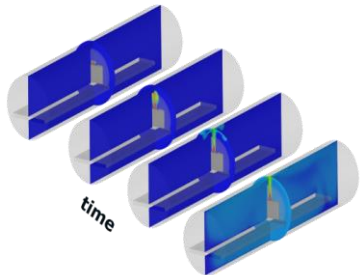
- No Flames out of the battery at any time and no time limit
- Ensures safety of occupants and general public
- This is our engineering target

No Propagation: Design

Correct Cell Chemistry/Package



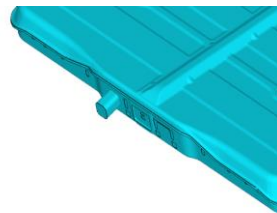
- Cell testing
- Cell selection
- Electrothermal & electrochemical modelling



No Gas Ignition



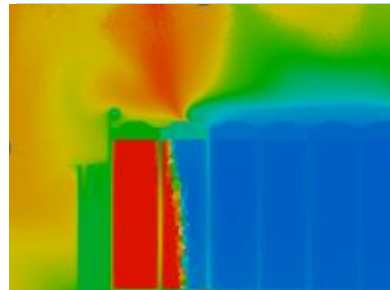
- Gas guidance
- Gas cool-down within venting path
- Heat path to environment.



No Cell2Cell Propagation



- Proper energy balance
- Insulating cells
- Material selection



Robust Design No Melting/Arcing



- Separation of HV system
- Creepage & clearance
- Material selection



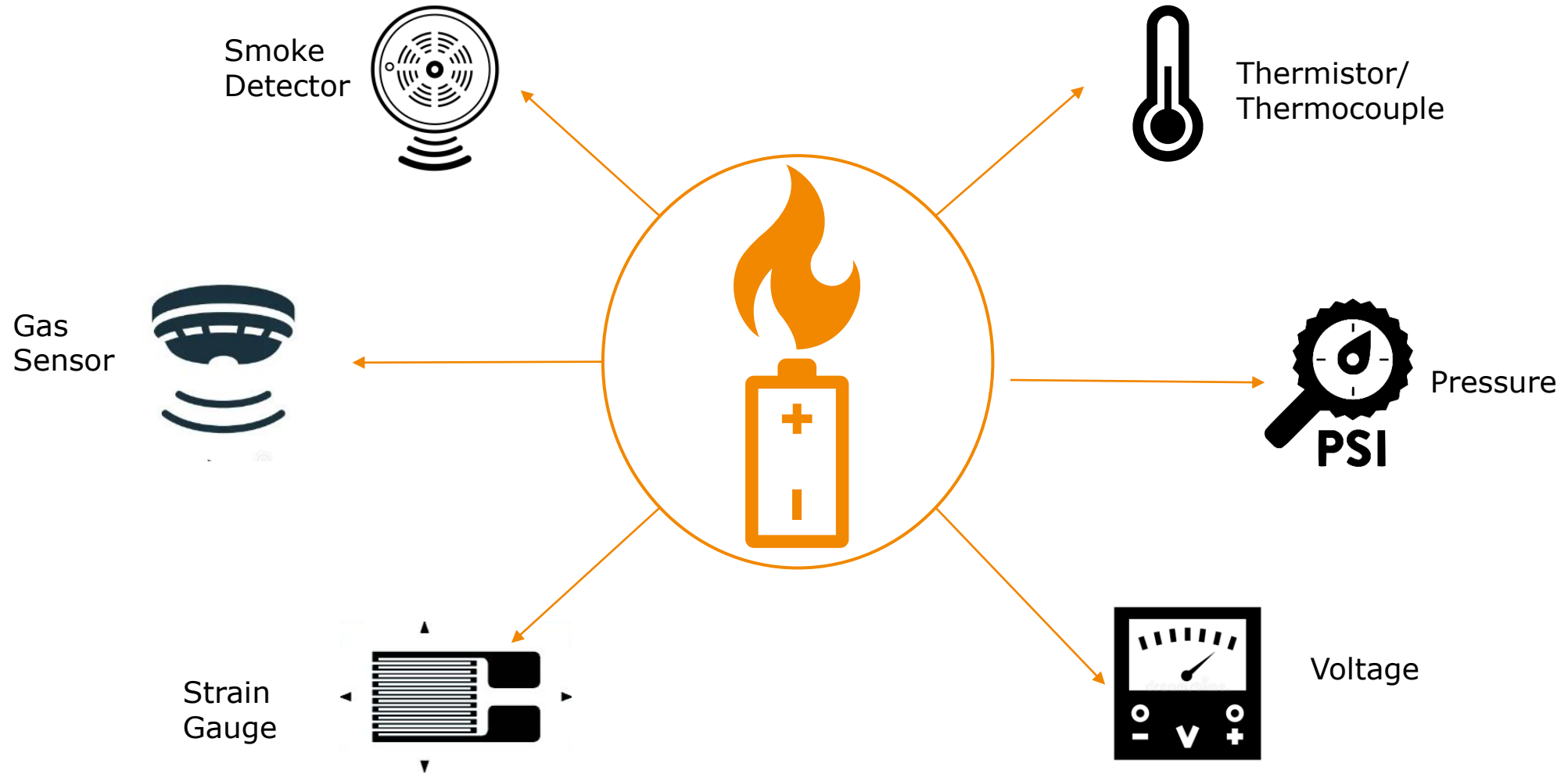
Robust Design Cover & Sealing



- Adequate venting
- Increased temperature & pressure
- Prevent ejection of a particles.



Detection of Thermal Runaway

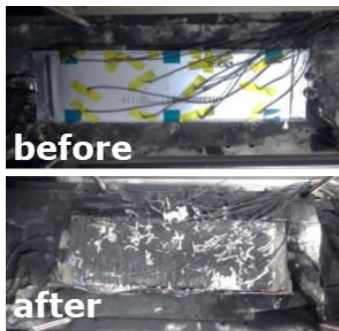


Testing

Cell Characterisation

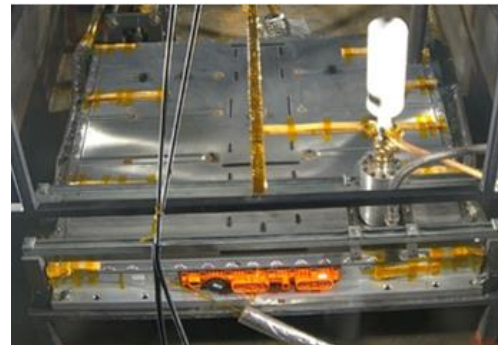
Standard test program:

- Multiple tests
- Thermal triggered event
- Nail penetration
- Overcharging
- Crush



Module & Pack Level Tests

- Pack thermal runaway (representative pack)
- Fire resistance test
- Thermal cycling
- Shock & Vibration tests
- Pack sealing test (IP rating)
- Pressure test



Conclusion

Correct Cell Chemistry/Package

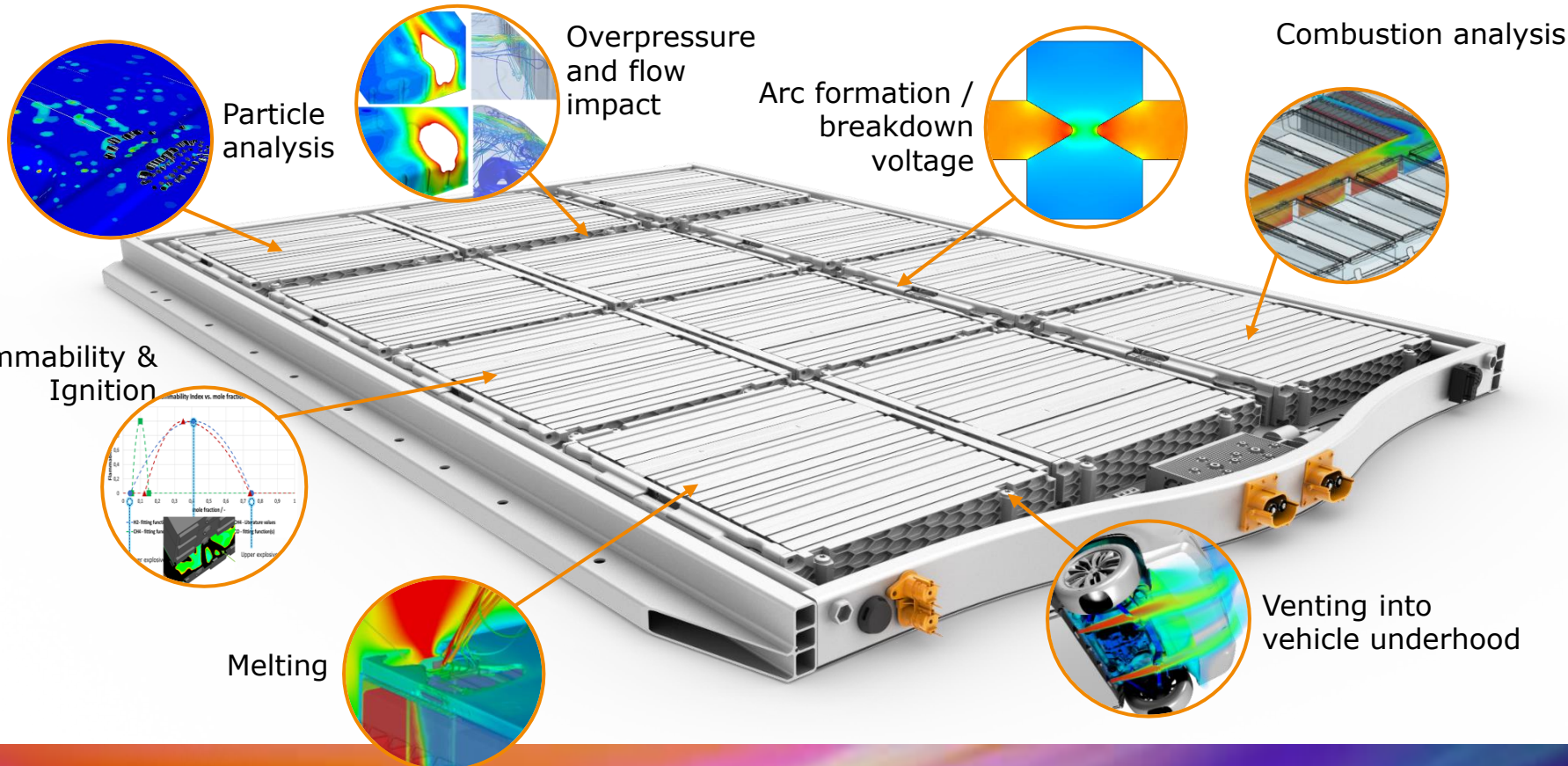
No Gas Ignition

No Cell2Cell Propagation

Robust Design No Melting/Arcing

Robust Design Cover & Sealing

Testing & Validation



- Combining simulation and test data along with good system and component design will ensure a robust battery pack
- AVL method applied in SOP developments, concept studies, & trouble shootings.

Thank you



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