



The importance of Fire Safety Testing for polymeric materials used in end-product applications – showcased on examples for the Electrical & Electronics and E-mobility industries

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safety of electrical and electronic products and material recognition



UL Solutions safety science and hazard-based safety engineering



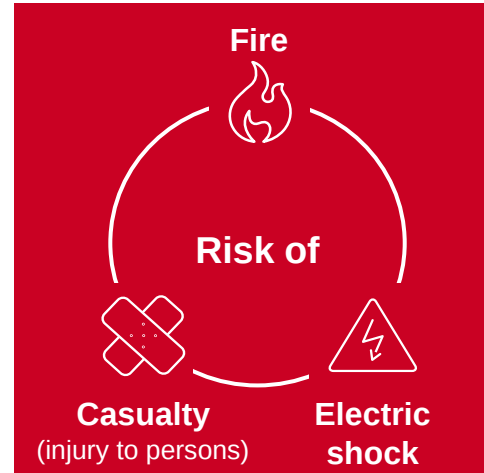
Working for a safer world

Plastic material uses

- Enclosures
- Internal parts

Associated safety concerns

- Flammability
- Resistance to ignition
- Electrical insulation
- Use temperature
- Mechanical integrity



UL Solutions product fire hazard assessment

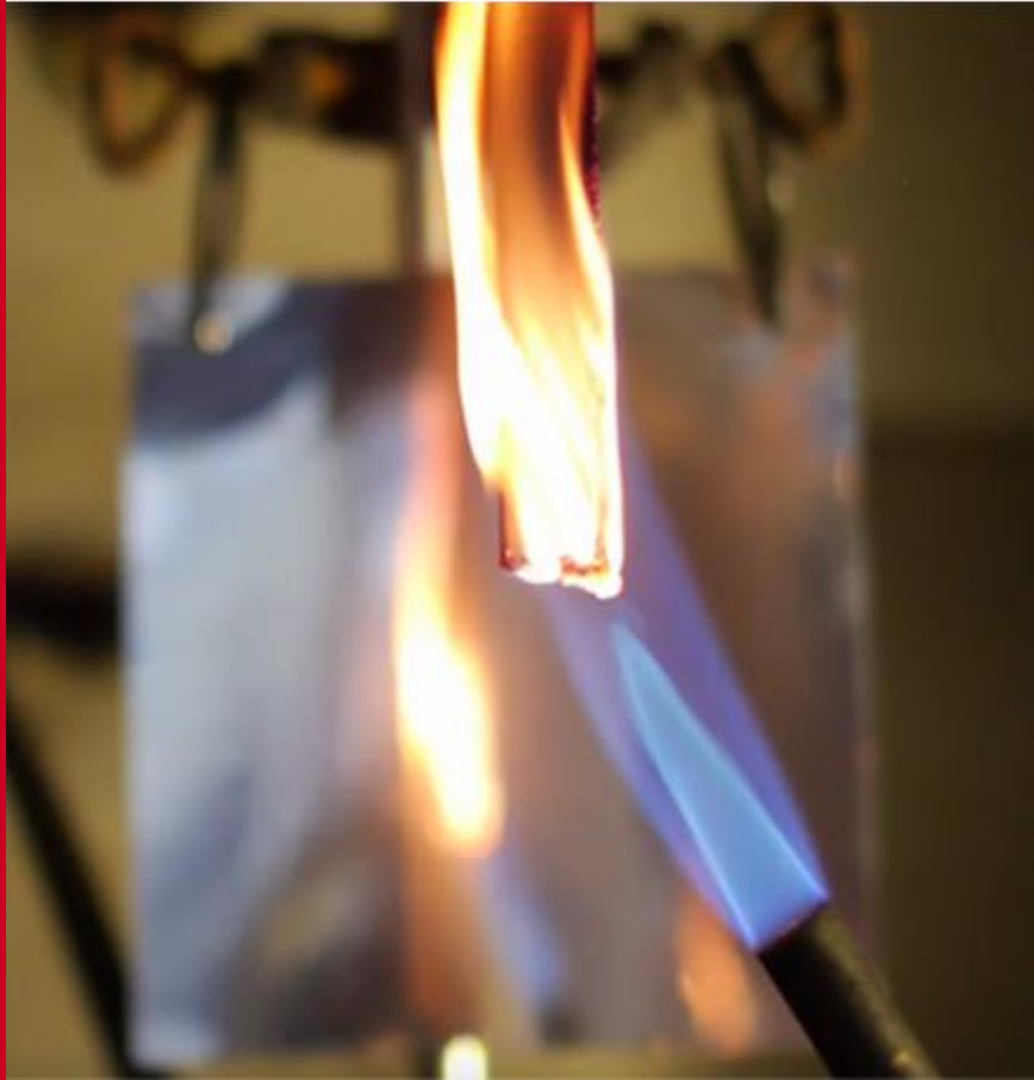
Fire enclosure

Intended to minimize the spread of fire or flames from within a piece of equipment

Risk of fire

A risk of fire is considered to exist at any two points in a circuit where:

- The open-circuit voltage is more than 42.4 V peak and the energy available to the circuit under any condition of load, including short circuit, results in a current of 8 A or more after one minute of operation
- A power of more than 15 watts can be delivered into an external resistor connected between the two points



UL Solutions product fire hazard assessment

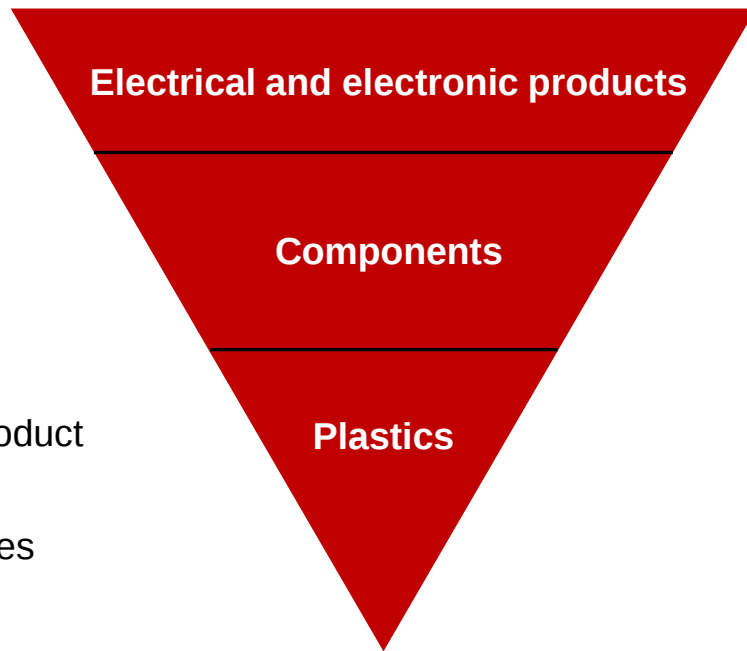
- Risk of fire needs to be assessed for each product design
- The assessment evaluation for the risk of fire can include:
 - Testing evaluation at the product level
 - End-product testing
 - Testing evaluation at the component level
 - Materials/component testing

Preselection testing



UL Component Recognition (certification)

- Upstream evaluation of materials
 - Plastics and components
 - Power supplies, connectors, materials, etc.
- Mandate the minimum performance requirements in downstream products
 - End-product standards
 - Household appliances, television standards
- Eliminate duplicative evaluation downstream
- Identify and communicate recognized properties — UL Product iQ® database (certification directory)
- Preselect materials with appropriate performance properties



UL 94 — safety Standard for flammability

Flammability classifications

- HB
- V-0, V-1, V-2
- 5VA, 5VB
- VTM-0, VTM-1, VTM-2
- HF-1, HF-2, HBF

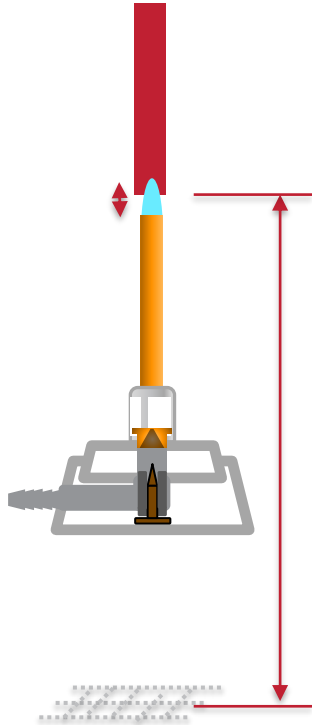


Standardized test flames

- 20-mm test flame,
50-watt nominal test flame
- 125-mm test flame,
500-watt nominal test flame

UL 94 — safety Standard for flammability

Vertical burning test (V-0, V-1, V-2)

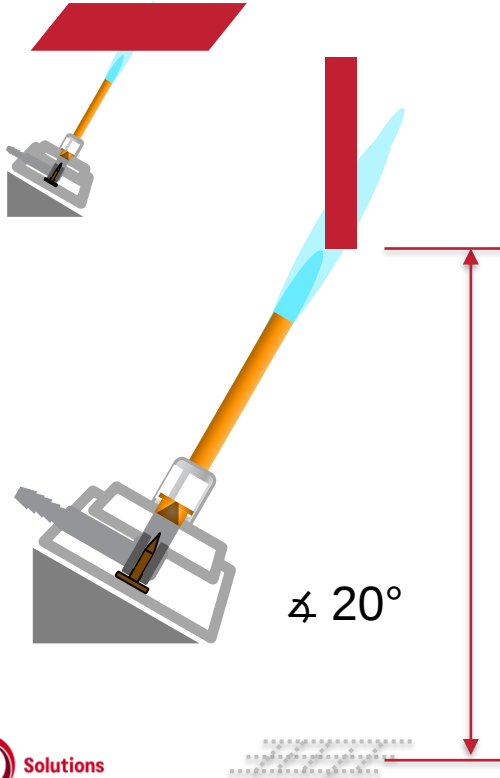


Criteria conditions	V-0	V-1	V-2
Afterflame time for each individual specimen t_1 and t_2	≤ 10 s	≤ 30 s	≤ 30 s
Total afterflame time for any condition set (t_1 plus t_2 for the five specimens)	≤ 50 s	≤ 250 s	≤ 250 s
Afterflame plus afterglow time for each individual specimen after the second flame application ($t_2 + t_3$)	≤ 30 s	≤ 60 s	≤ 60 s
Afterflame or afterglow of any specimen up to the holding clamp?	No	No	No
Cotton indicator ignited by flaming particles or drops?	No	No	Yes

If only one specimen from a set of five specimens does not comply with the requirements, another set of five specimens is to be tested.

UL 94 — safety Standard for flammability

Vertical burning test (5VA, 5VB)



Criteria conditions	5VA	5VB
Afterflame time plus afterglow time after the fifth flame application ($t_1 + t_2$) for each individual bar specimen	≤ 60 s	≤ 60 s
Cotton pad indicator ignited by flaming particles or drops from any bar test specimen?	No	No
Classified as V-0 or V-1?	Yes	Yes
Either: • Burn-through occurs with any of the individual plate test specimens • No plate test specimens have been tested	No	Yes

If only one specimen from a set of five specimens does not comply with the requirements, another set of five specimens is to be tested.

Principles of UL 746C

Function of product type and usage

Portable equipment

Other equipment

Attended

Unattended



Household or commercial



The hazard-based safety engineering principles of UL 746C, the Standard for Polymeric Materials for Use in Electrical Equipment Evaluations, and the concept of identifying minimum safety performance criteria for materials is referenced in more than 385 UL product Standards.

Materials used in electric vehicle applications and some new testing procedures

Material innovations in EV battery enclosures, including UL Solutions' battery enclosure material screening (BEMS)



Innovating safely

Hazard-based safety engineering and a thermal runaway event that is quite dynamic

Thermal runaway is caused by an internal chain reaction within the battery cell and is hard to stop once it starts.



- **Temperature**

Heat is generated and flammable gasses that burn at very high temperatures are released, causing propagation from one cell to the others.



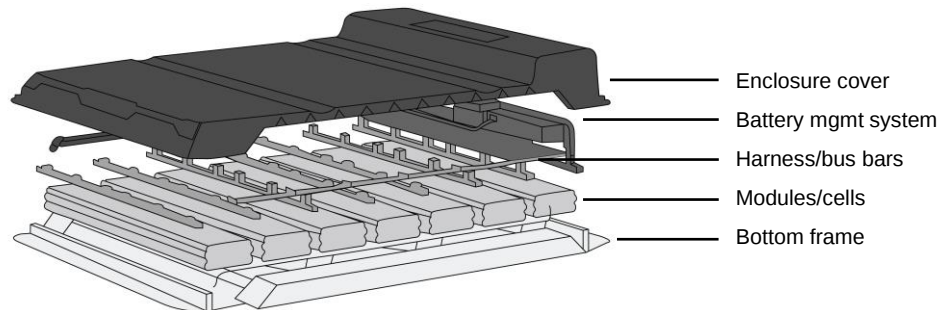
- **Pressure**

Created by outgassing cells, controlled by enclosure venting design



- **Mechanical impact**

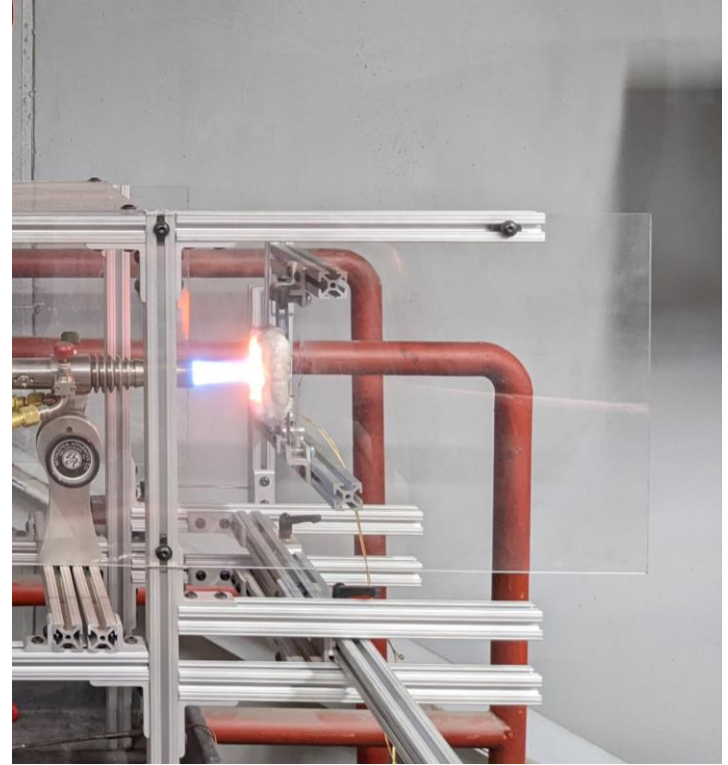
Abrasion from particles inside the battery propelled by outgassing



Torch and grit (TaG) test

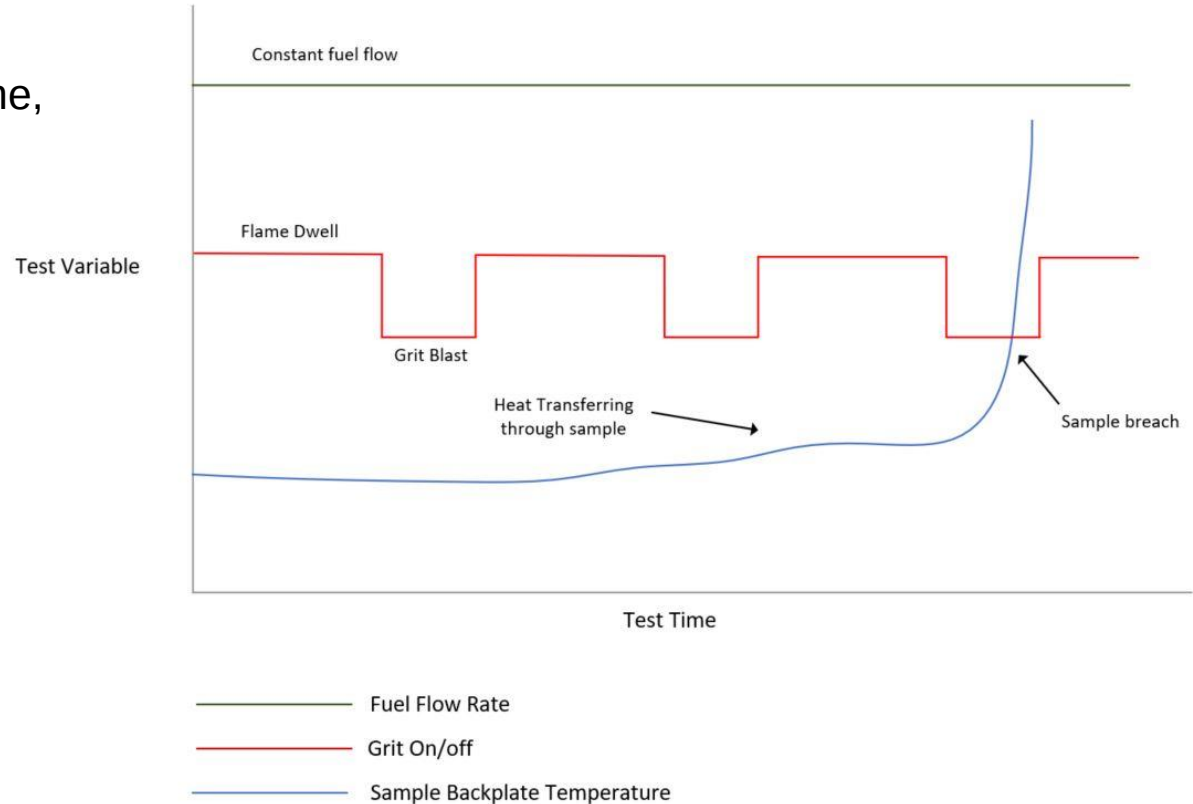
Objective: Develop a material screening test that includes the dynamic stresses found in an actual automotive battery thermal runaway event.

- High temperature
- Abrasion due to battery particles propelled while cells break down and outgas
- Supplement to UL 2596 thermal runaway test without pressure component, but quicker to run.

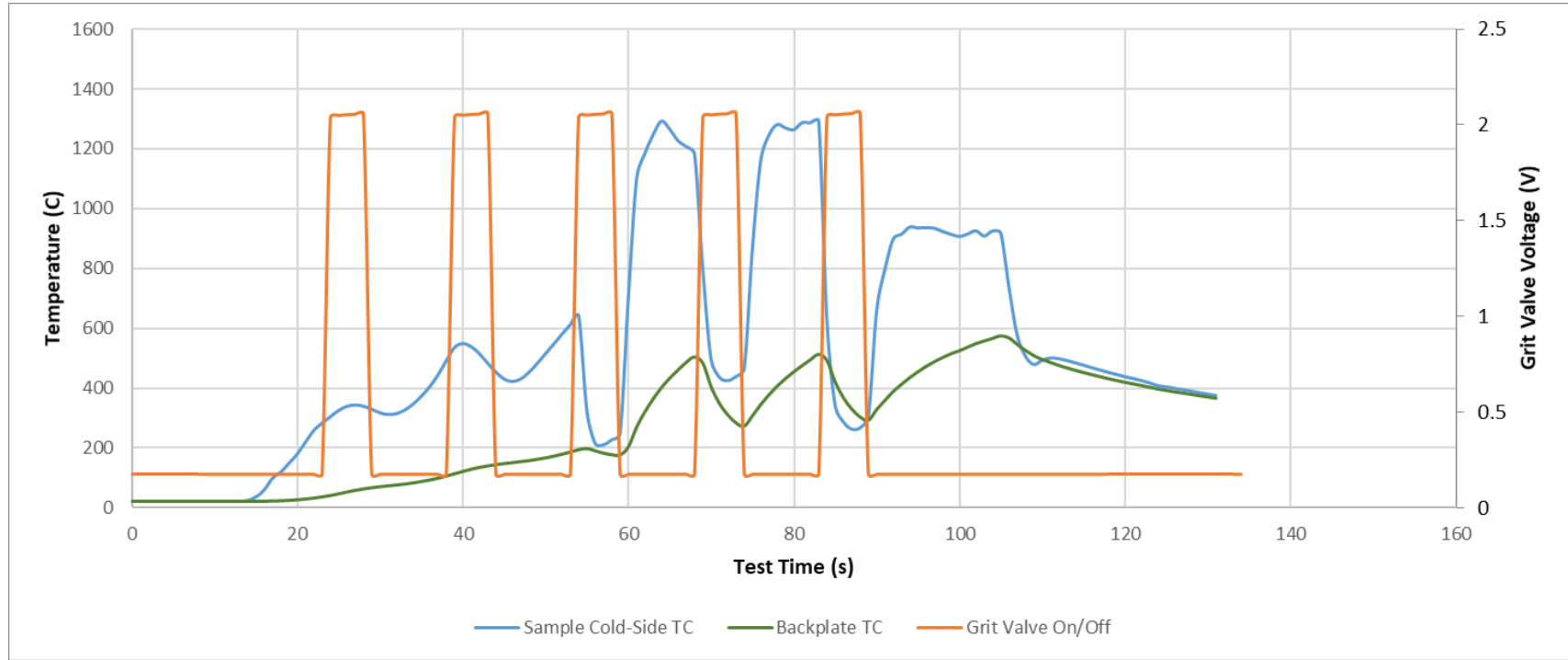


Torch and grit (TaG) test sequence

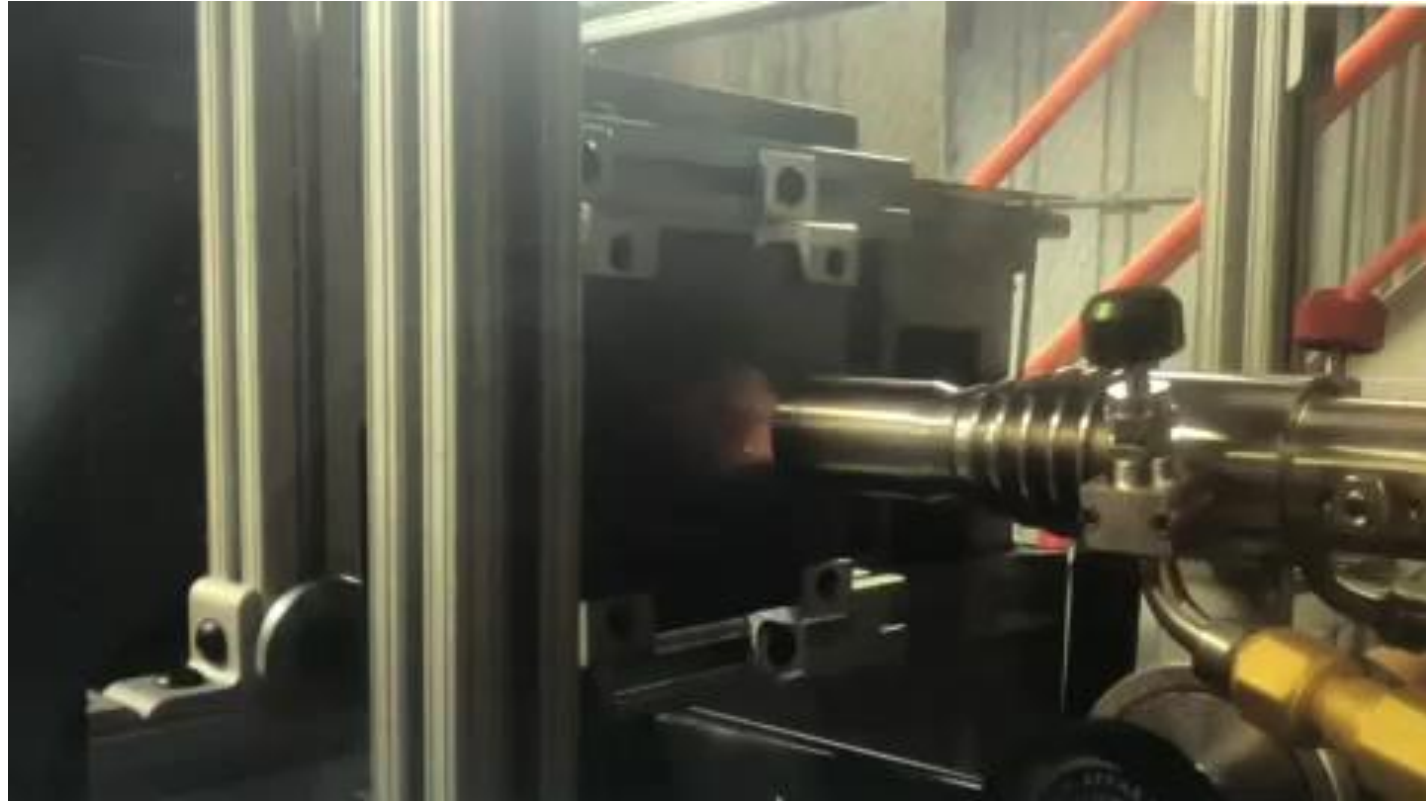
- 15 seconds, 1,200°C flame, followed by 5 seconds of flame and grit blast
- Cycle repeated until sample breaches



Torch and grit (TaG) test



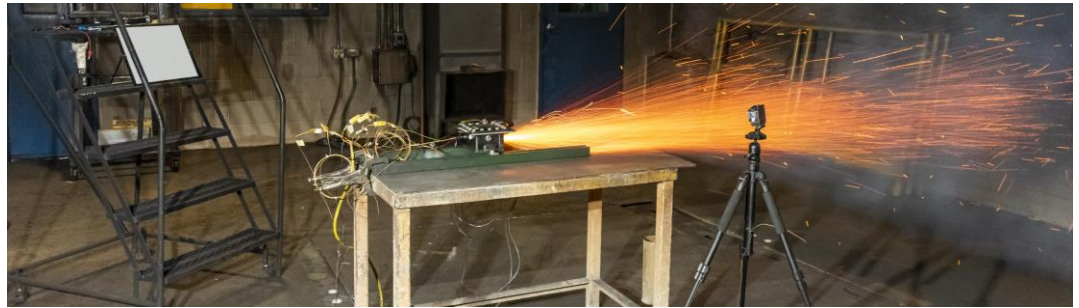
Torch and grit (TaG) test



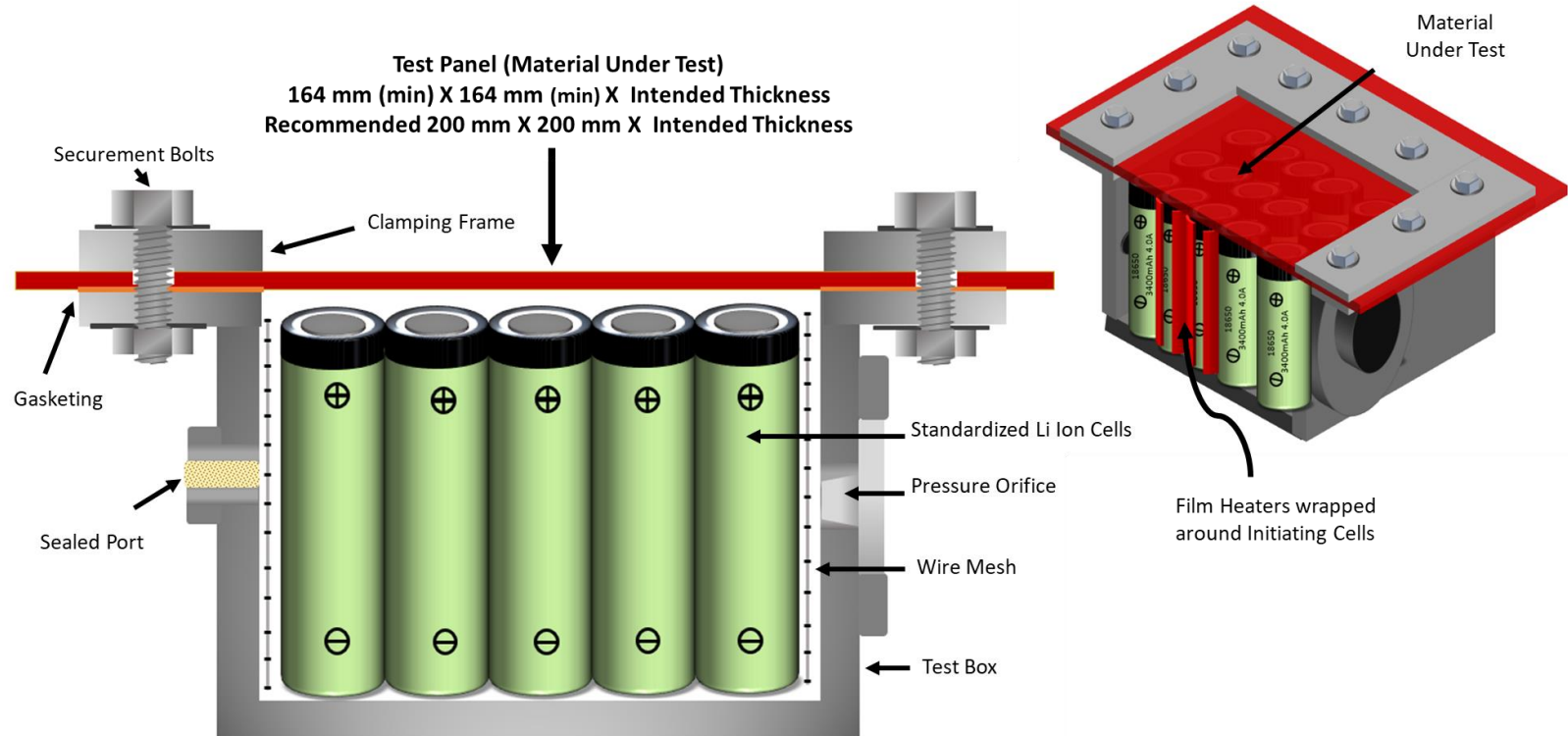
The next step in battery enclosure material screening (BEMS)

Battery enclosure thermal runaway (BETR) evaluation

- Our first test in **UL 2596, Standard for Test Method for Thermal and Mechanical Performance of Battery Enclosure Materials**
- A rigorous test to evaluate material performance in a simulated thermal runaway event

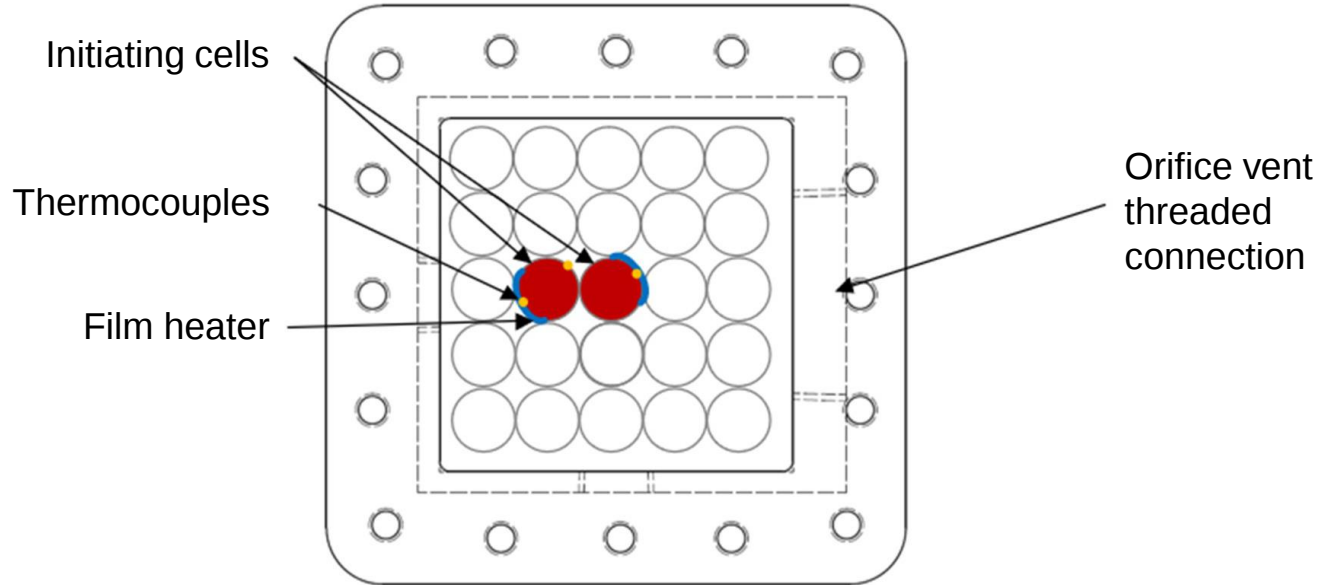


UL 2596, Standard for Test Method for Thermal and Mechanical Performance of Battery Enclosure Materials



BETR test enclosure setup

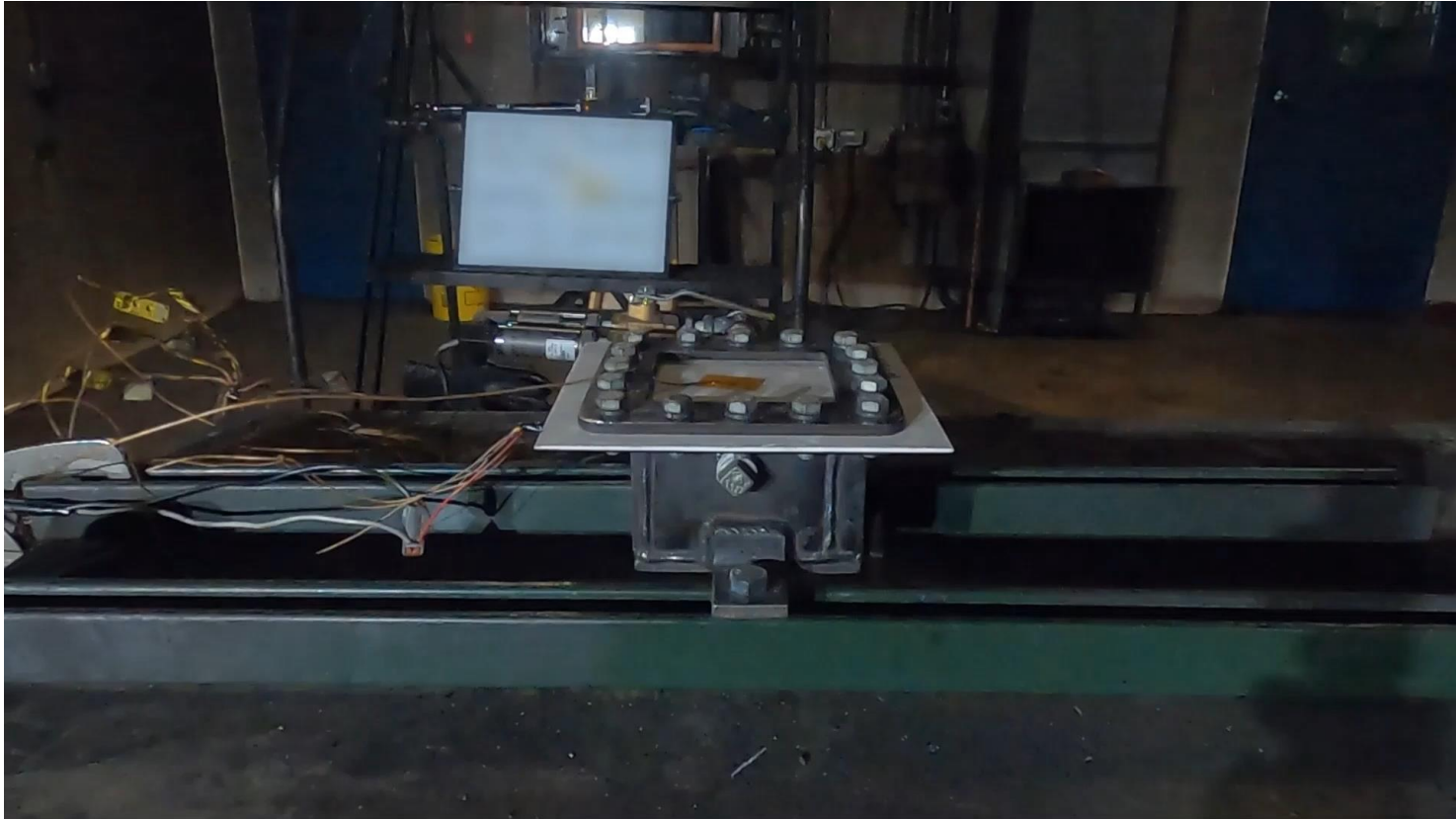
Inside the box



25 18650 cylindrical Li-ion cells

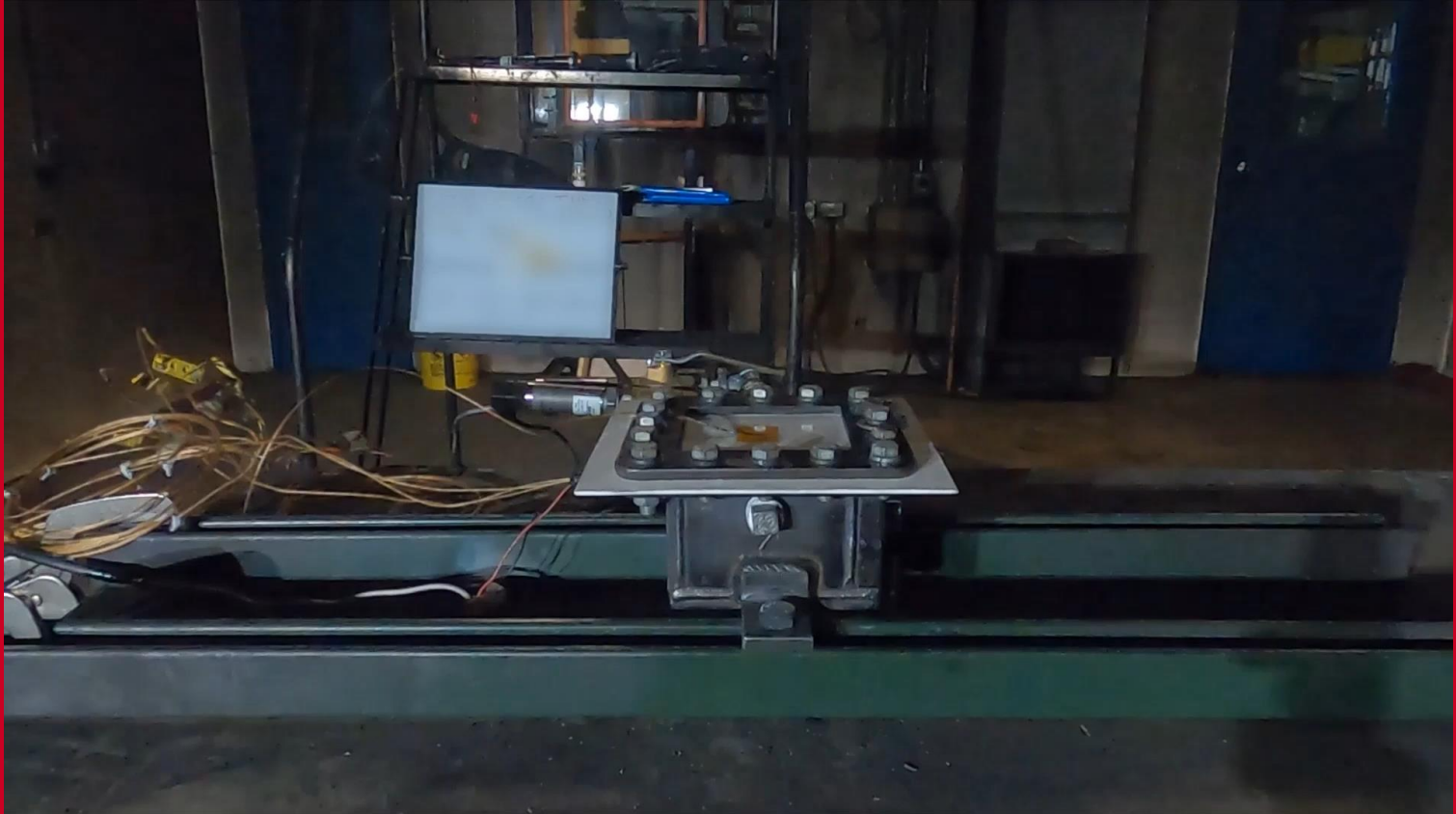
BETR test

No rupture



BETR test

With rupture



Value to OEMS and materials producers

- This test focuses specifically on enclosure material performance in a thermal runaway event, replicating a real-world scenario.
- Enables testing of material plaques vs. entire battery assembly, thereby reducing cost and development time
- Provides material producers a research and development option to screen multiple formulas and constructions, allowing them to bring only the best candidates to their customers (OEMs or Tier 1)
- Offers OEMs the ability to compare the performance of multiple vendor materials to select the best suitable candidates
- UL 2596 can be referenced in OEM material selection specifications.
- Third-party performance testing from a globally trusted and impartial company



Thank you

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