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Thermal Propagation Testing of Electric Vehicles

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Current Research Test Program

Researching key parameters pertinent to thermal propagation within EVs while determining both boundary and optimal conditions for localized, rapid heating for single cell TR initiation.

In this meeting presentation:

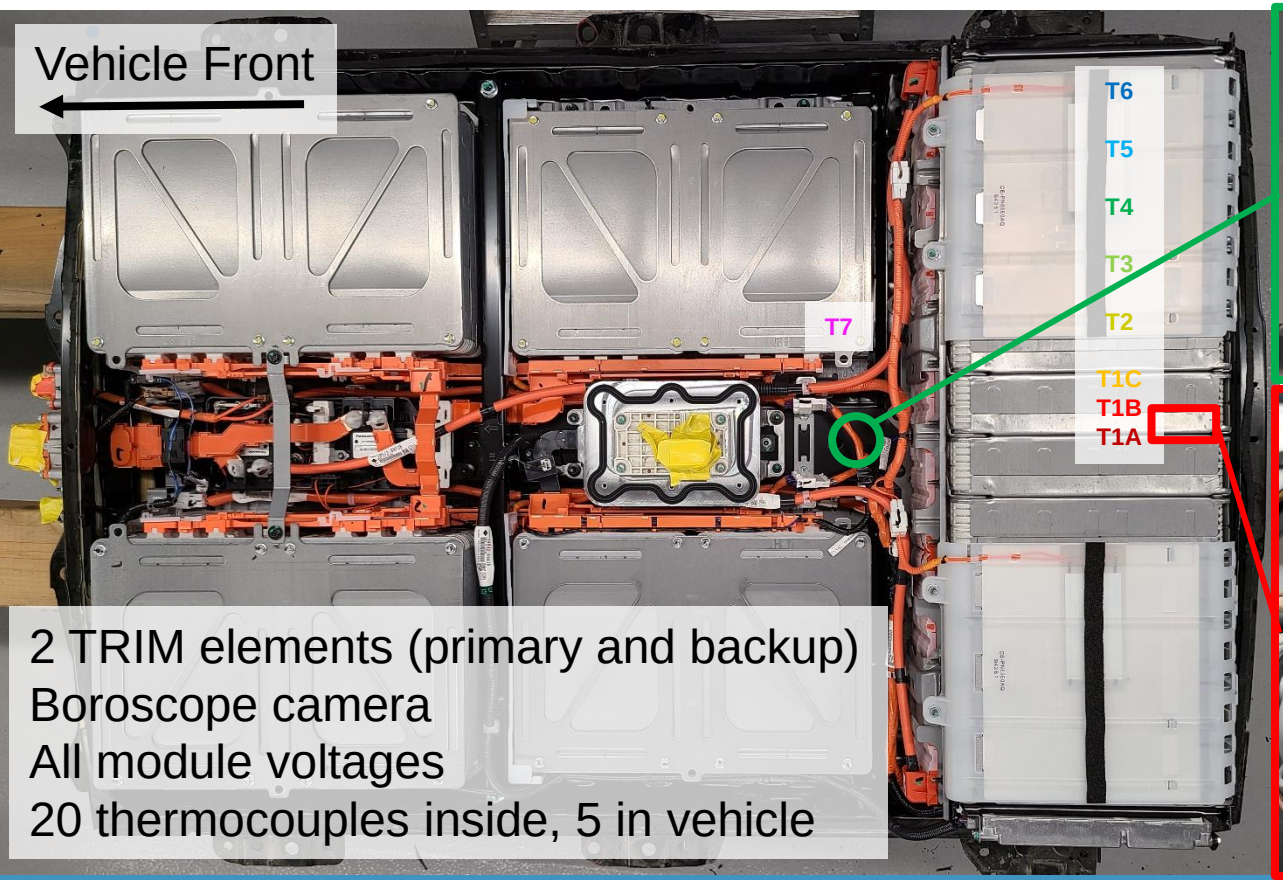
- Vehicle-level test results and observations from modern BEV (2019)

Vehicle level test objectives

1. Observe vehicle's response to the abusive event
   - Previous vehicle level test was conducted on a vehicle that predates warning in the event of thermal failure. New generation test vehicle (2019) should be equipped with more advanced warnings.
2. Observe the failure dynamics with a 2nd vehicle architecture
   - Higher capacity (40kWh) BEV with passive cooling thermal management
3. Validate and improve on test methodology from past experience

Pack instrumentation

- Extraction / disassembly / reseal / reinstallation following OEM service manual
- No vehicle error codes present after reinstallation



On-site test setup

Dash cam
Multigas meter
Smoke detector
CANbus reader

Test Conditions
100% SOC
Ambient 8℃
Pack 22℃
Wind 7m/s

Berm to collect leakage and potential fire water

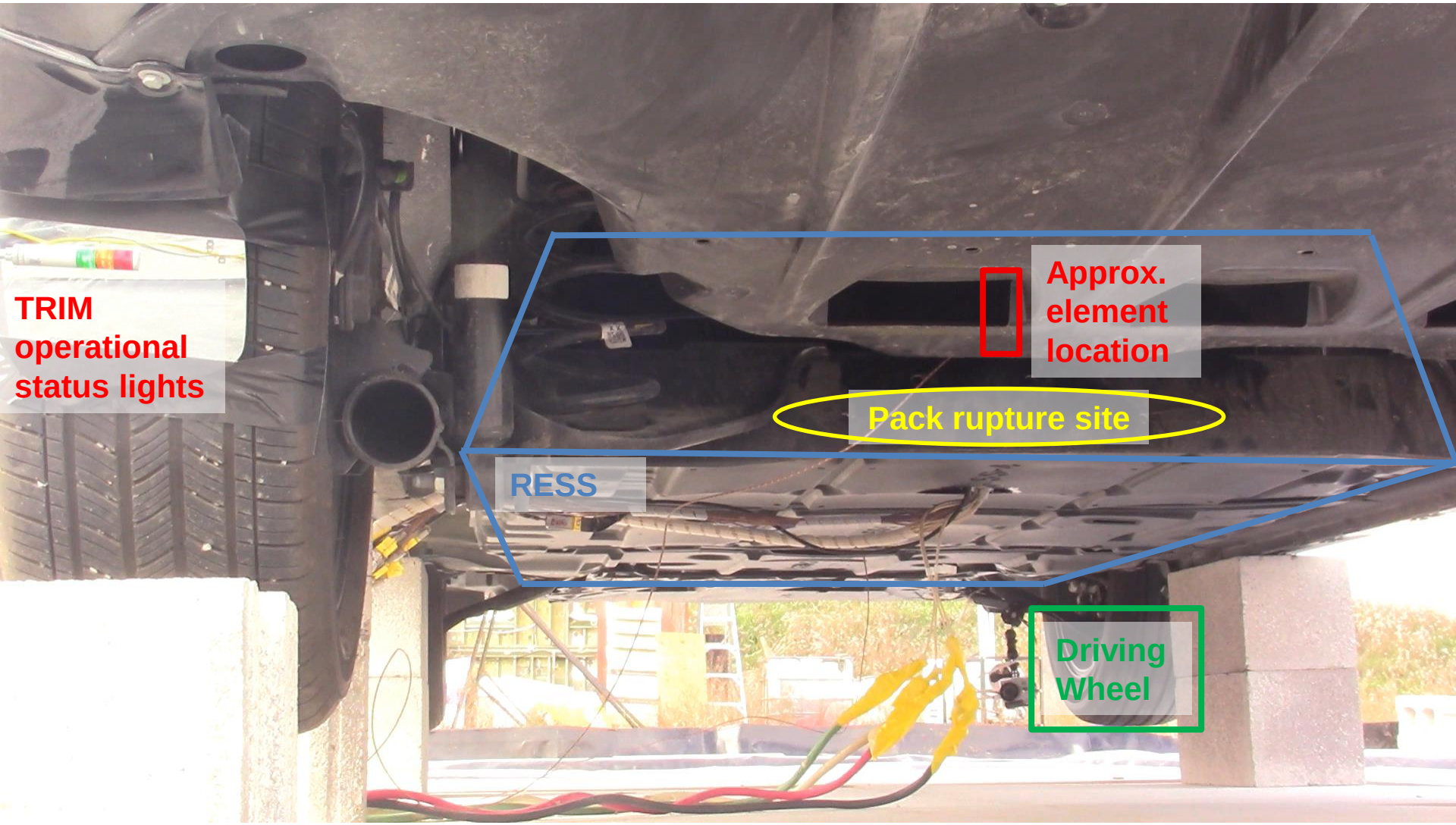
Vehicle blocks permit drive mode operation

Pretest
Vehicle shelter
Gas heater

4 cameras
IR video

Video viewpoint

Test video


TRIM operational status lights
Approx. element location
Pack rupture site
RESS
Driving Wheel

Event log

00:00 - Heating starts

00:11 - Initial TR occurs

00:12 - RESS enclosure ruptures at seal between top/bottom halves

00:15 - Heating stops

00:18 - Several visual dash warnings to stop were provided, vehicle propulsion was slowly reduced to stop.

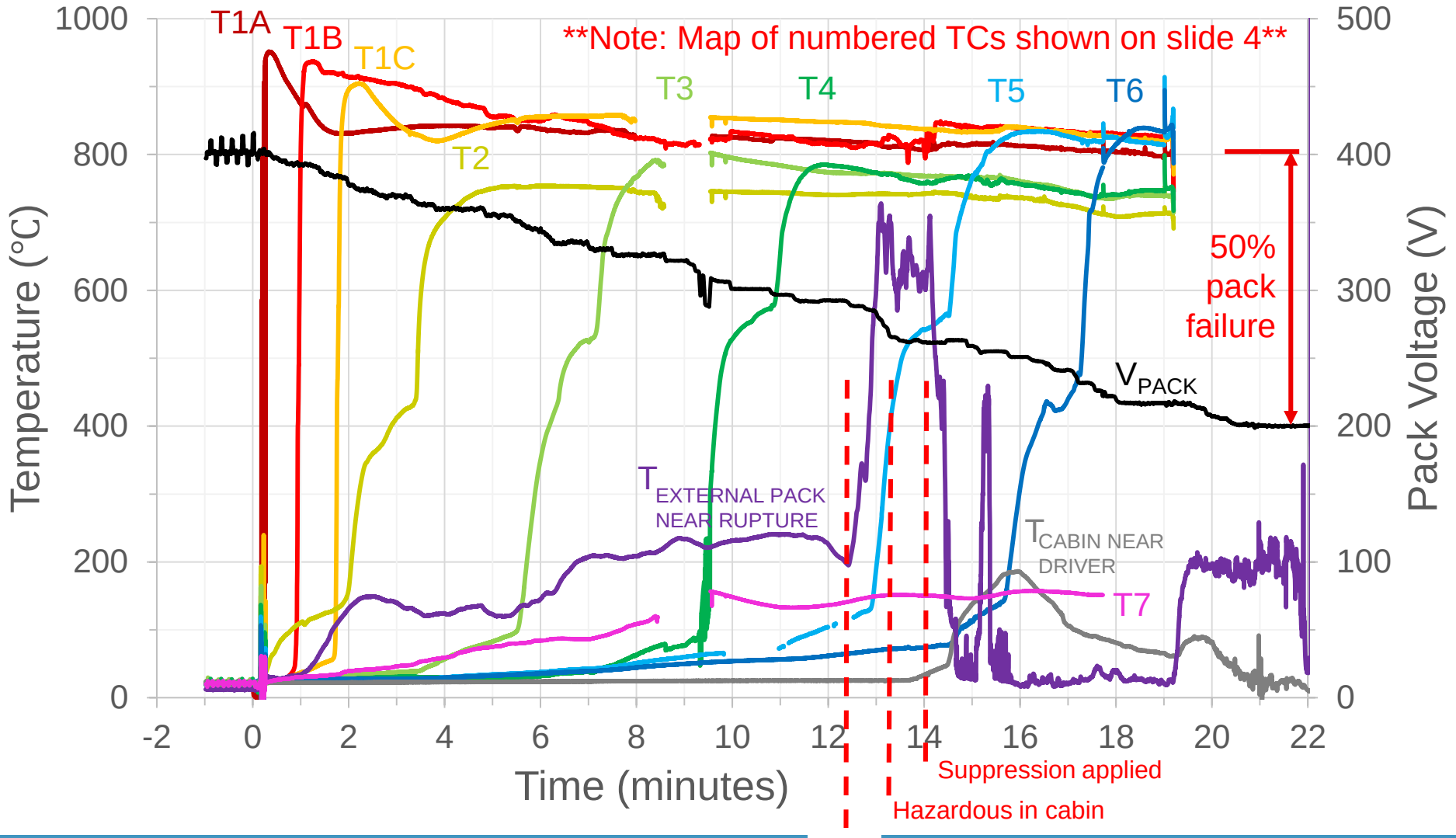
00:40 - Gas emissions intensify

12:20 - External fire begins from rupture site

13:20 - Hazardous environment is present within the cabin (based on multigas meter)

14:00 – External fire suppression applied (water)

Test results



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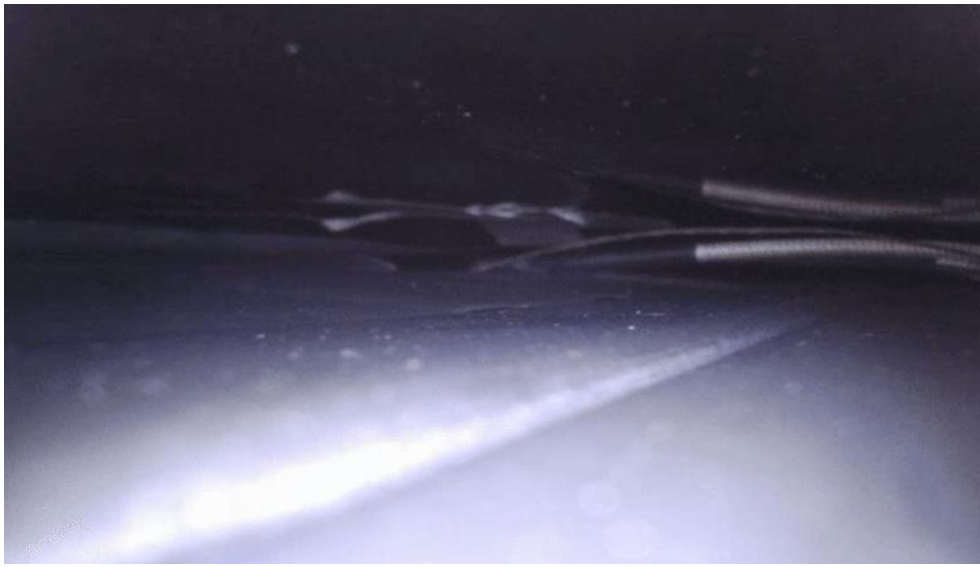
Observations and lessons learned

- Vehicle occupants had rapid warning of the initial failure. No hazardous environment present **within** the cabin until 13min after event under the given test conditions
  - All windows closed, air conditioning off, open air environment with moderate wind

- Large volumes of visible emissions occurred within 1 min after initial TR.
  - Vehicles parked inside an enclosed space (such as parking garage) could concentrate the hazard
  - May make vehicle occupant egress more difficult
  - There were no external warnings (horn, lights, etc.)

Lessons learned – testing methodology

- Tests can be performed without OEM support, however it is more challenging. OEM support facilitates part sourcing and troubleshooting.
- All thermocouples should be ungrounded to avoid interference during vehicle operation
- Heating a portable vehicle shelter is sufficient to maintain pack temperature in cold conditions
- Sensitive equipment should be kept >3m away; control station >10m and positioned upwind
- Fire water volume is substantial
- More information available on request



Borescope camera (internal to pack) provided an interesting view but failed quickly

Future topics

- Localized, rapid external heating is 1 of 3 considered for implementation into new ISO standard (ISO/TC 22/SC 37/WG 3)
- Addressing known challenges: Thick-walled prismatic cells are difficult to trigger with TRIM V4 elements. Rapid heating is a methodology, not an NRC element. Larger area elements are required and are in development.
- Another vehicle level test to demonstrate methodology on 3rd vehicle architecture.
- Comparison of the reactivity of cells as technology “improves” with each generation
- Gas analysis including FTIR
- Potential risks outside the vehicle? →

Electric car catches fire and explodes in Île-Bizard garage | CBC News
https://www.cbc.ca/news/canada/montreal/electric-car-catches-fire-and-explodes-in-%C3%AEle-bizard-garage-1.5227665

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Thank you for your kind attention!

Any Questions or Comments