



# JRC's thermal runaway propagation test campaign at pack and vehicle level

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# JRC experimental TP activity

## Cell & material

Comparison of initiation techniques

- Trigger energy/energy release

## Short stack

Analyse influential factors on the outcome

- Temperature, SOC...
- Cell orientation
- Cell separation

## Module

Evaluate repeatability, reproducibility

- Check proposed test descriptions (also with testing bodies)
- Round robin tests
- Define pass/fail criteria

## Pack, Vehicle

Verification and finalization of method

- Round robin tests
- Practical aspects
- Define robust evaluation methods (e.g. gas analysis)

Narrow down init. methods  
+ ARC, DSC

Refine test description

Select equivalent test(s)

# Experimental set-up



## Ambient conditions:

T: 20-27°C

Wind: mostly wind-still conditions  
wind breakers

Pool to contain water used for fire  
extinguishing

Fire fighters in stand-by

Applus<sup>+</sup>  
IDIADA

Test performed at Applus IDIADA  
in Tarragona, Spain

# DUTs



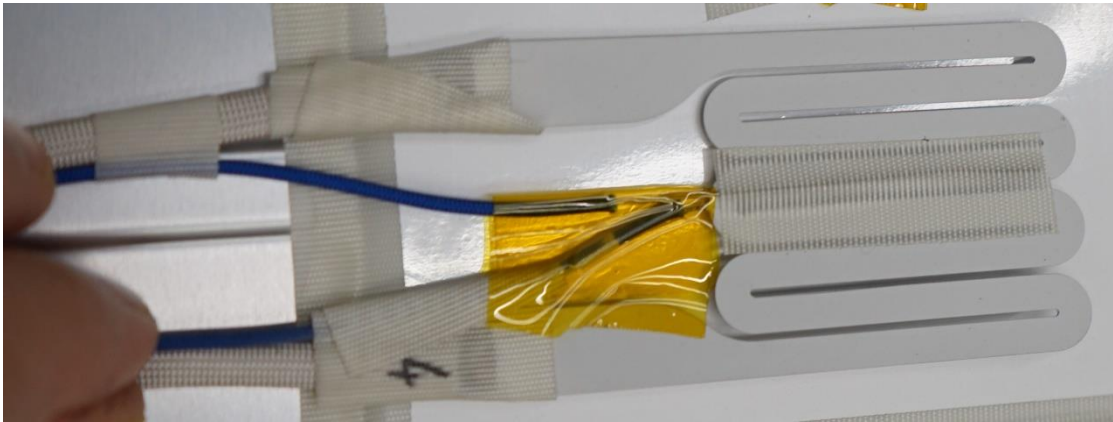
- Two factory-new Li-ion battery packs
- Extracted from contemporary commercially-available electric vehicles
- 52 kWh, 12 modules, 192 cells (96S 2P)
- Pouch cells
- NMC 622 / graphite chemistry

# DUTs



- Factory-new contemporary commercially-available electric vehicle
- Li-ion battery pack
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# Triggering method



- Localised rapid external heating
- V5 elements developed by NRC Canada
- Active heating area: 39 mm x 55 mm (21.5 cm<sup>2</sup>)
- Thickness of the element: 0.7 mm
- Thickness of connections: 0.7 mm

Canada  
NRC-CMRC



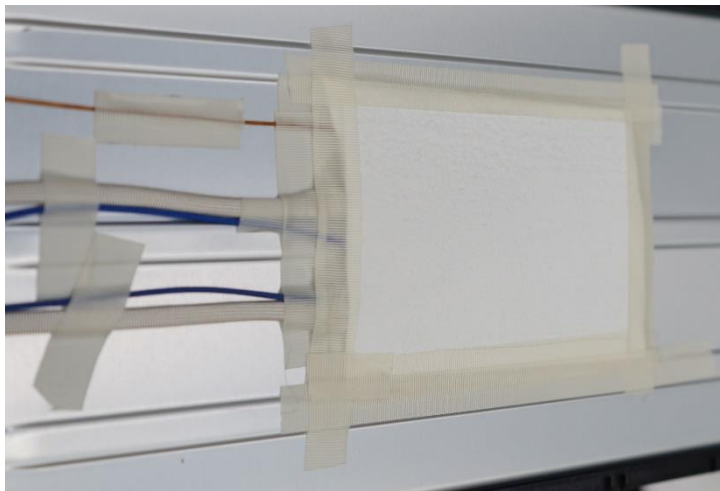
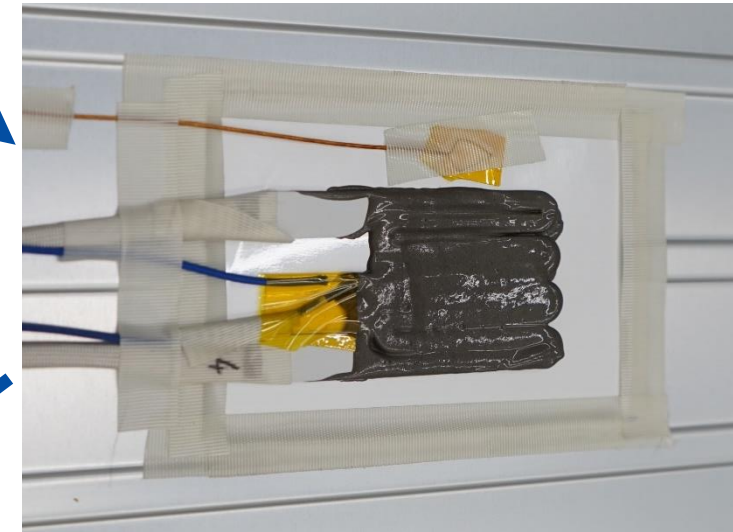
Transport  
Canada

Transports  
Canada

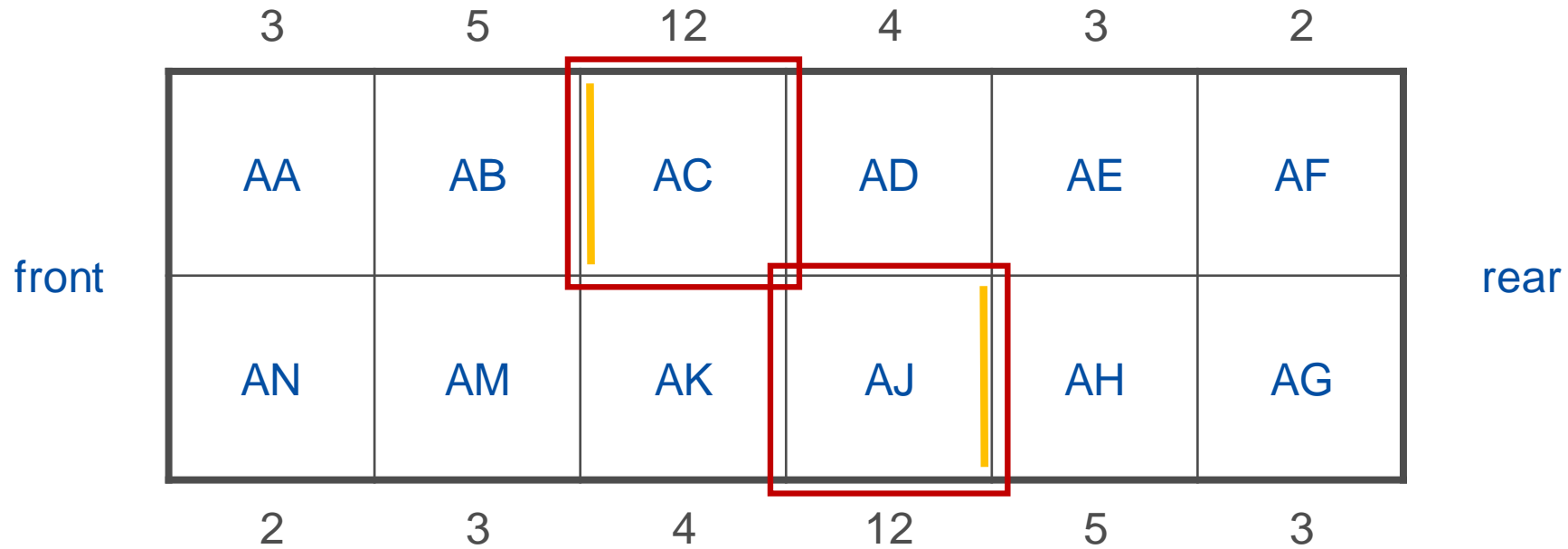
*“Apparatus and Method for initiating Thermal Runaway in a Battery” with application date of January 18, 2018.  
PCT/CA2018/050055*



# Instrumentation – TRIM installation



# Instrumentation – thermocouples in the pack



Initiating and back-up initiating modules

12

Number of thermocouples installed in a module



TRIM heater position



# Instrumentation – other sensors

- Initiating and back-up module cell voltages
- Module temperatures and voltages
- Temperatures on the exterior of the packs
- Temperatures inside the passenger cabin of a vehicle
- Pressure sensors in the packs
- Video and IR footage
- Smoke and hazardous gas detectors in the passenger cabin
- Gas analysis:
  - Online FTIR
  - Offline (canisters + GC)
  - Washing bottles (HF)
  - Open path FTIR



# First results – time sequence of the events

	<b>Pack #1</b>	<b>Vehicle</b>	<b>Pack #2</b>
Start of data logging	11:38:01	14:43:43	10:54:31
Start TRIM	11:41:01	14:49:01	10:58:00
Stop TRIM	11:41:34	14:49:25	10:58:27
Smoke external to the DUT	11:41:24	14:49:23	10:58:21
Open visible flames	11:47:33	14:57:55	11:03:03
Time to smoke	23 s	22 s	21 s
Time to flames	6 min 32 s	8 min 54 s	5 min 03 s

# First results – time sequence of the events

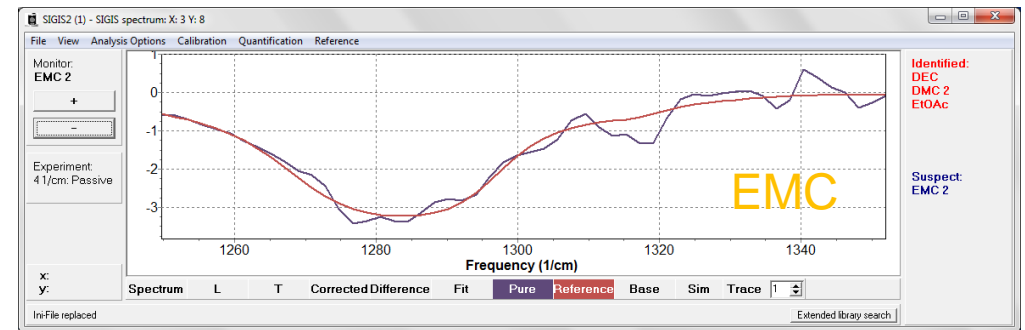
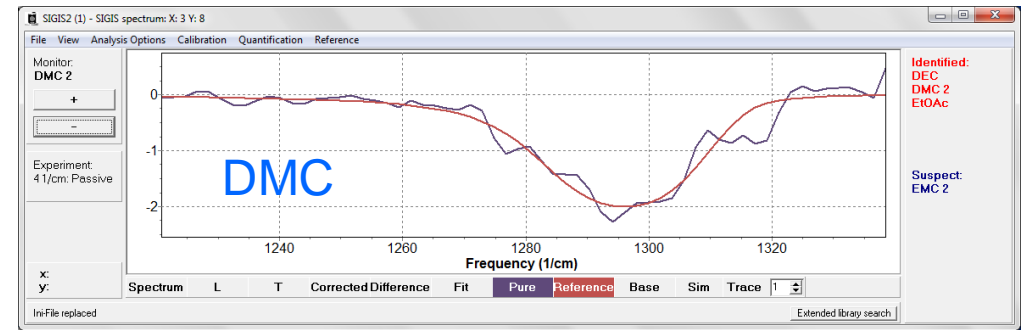
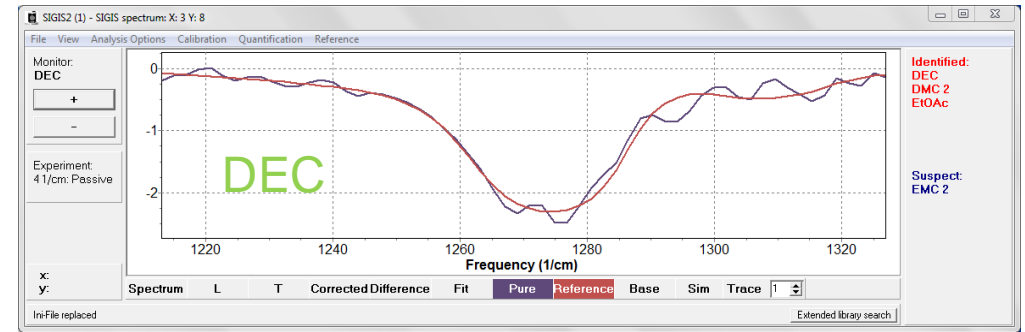
	Vehicle
Start of data logging	14:43:43
Start TRIM	14:49:01
Stop TRIM	14:49:25
Smoke external to the vehicle	14:49:23
First warning on a dashboard	14:49:47
Smoke in the cabin	14:53:10
Dashboard off	14:53:18
Open visible flames	14:57:55
Time to smoke external to the vehicle	22 s
Time to smoke in the cabin	4 min 09 s
Time to flames	8 min 54 s

# First results – gas detection with open path FTIR

Pack #1 – 52 s after smoke external to the pack is observed



DEC EMC Ethyl Acetate DMC  
DEC, Ethyl Acetate and DMC overlap in the light green area.



# Summary

First JRC experimental results suggest that:

- Thermal runaway propagation tests at pack and vehicle levels are feasible
- Events - time to smoke external to the DUT - are fairly repeatable and do not seem to strongly depend on whether the DUT is a pack or a vehicle
- Time to open flames is somewhat longer at vehicle level

Data processing will continue to evaluate:

- Robustness of the thermal runaway criteria at pack and vehicle level
- Composition of the vent gases



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# Thank you



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