

# Electrical cars – Results from full-scale experiments

Konrad Wilkens

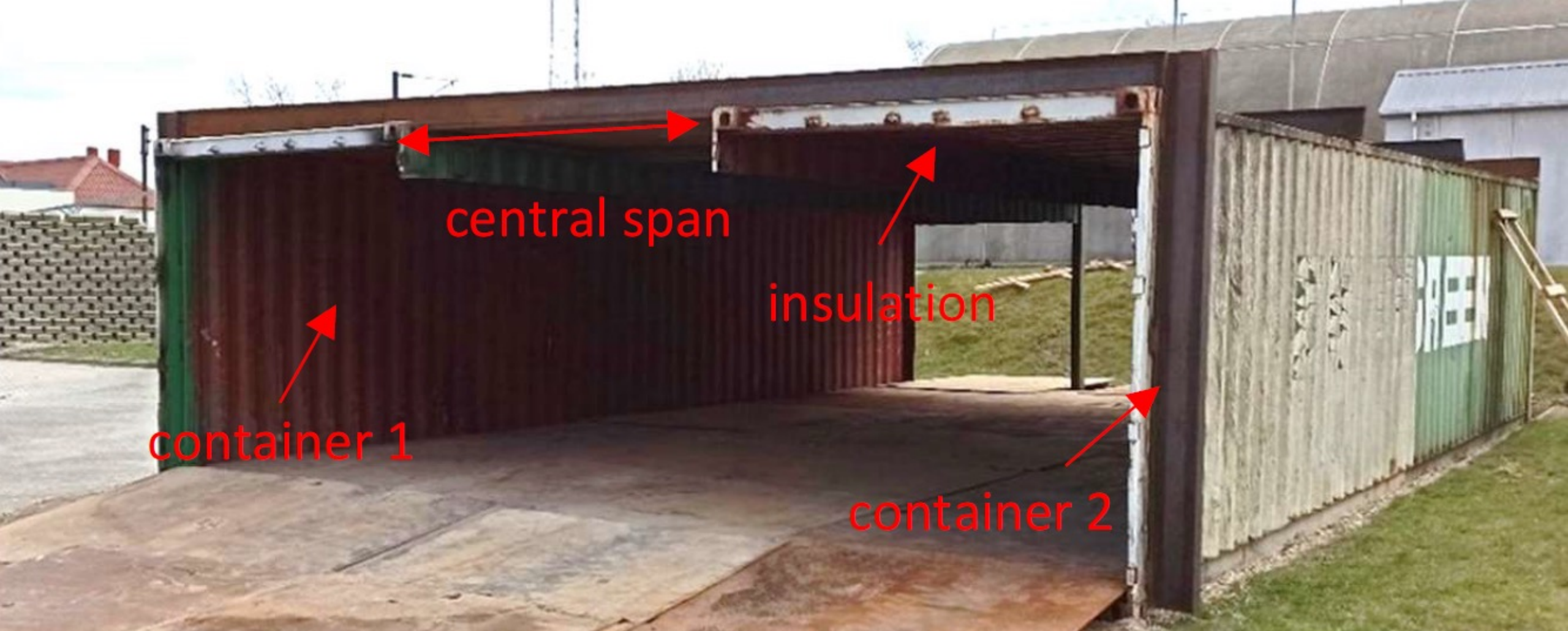


The image shows three vertical wooden panels, each constructed from horizontal slats of light-colored wood. They are positioned on a rooftop test site with a metal grid floor. In the background, there are buildings, trees, and a clear sky. The text "Wood or Cars?" is overlaid in the center of the panels.

# Wood or Cars?

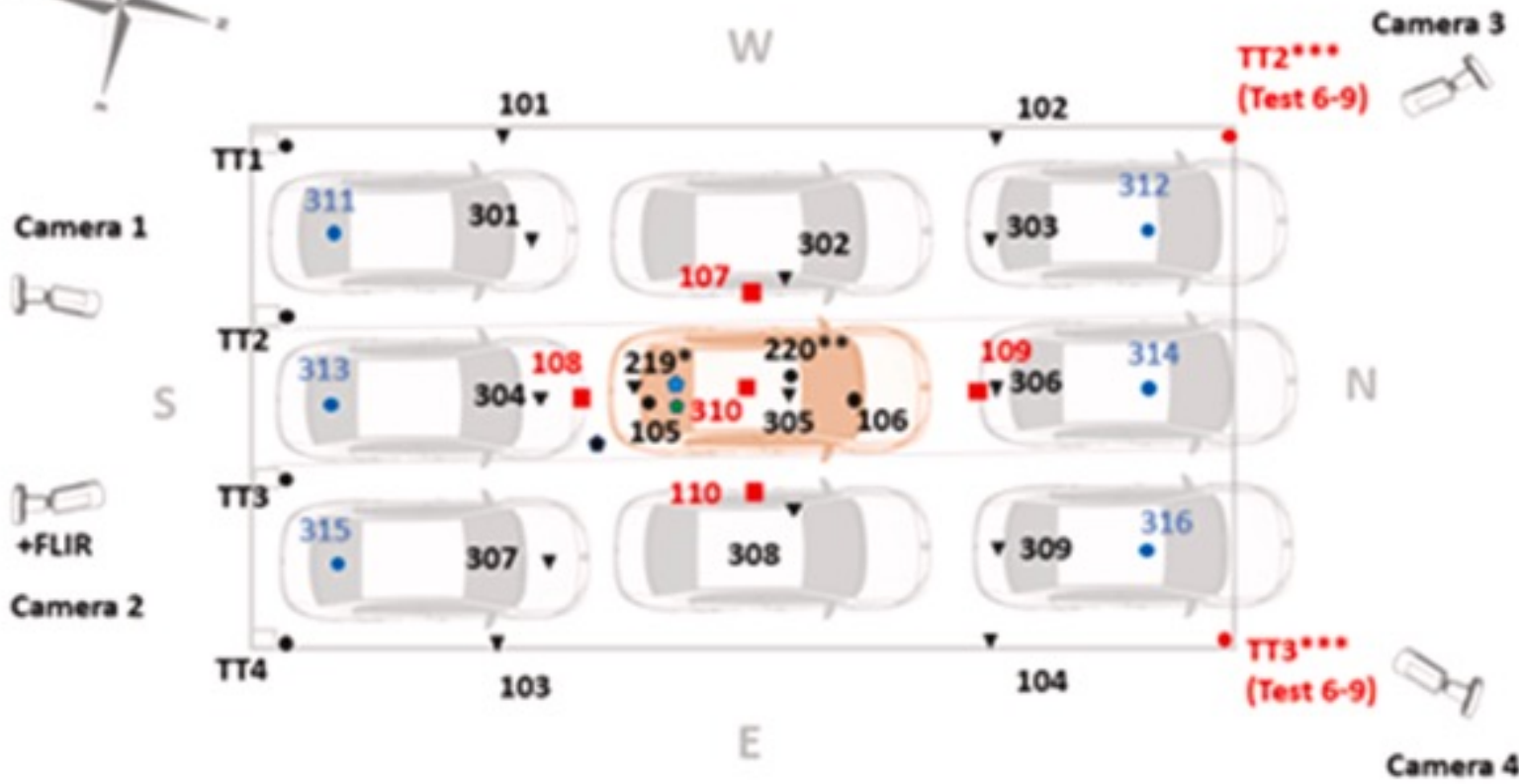


**DBI**   
BRAND OG SIKRING



# Test enclosure

Simulating a RORO car deck



- Thermocouple type K (bead)
  - ▼ Thermocouple type K (copper disc)
  - Plate thermometer
  - Optical smoke detector
  - DASPOS gas detector
  - Consilium aspiration air intake
  - HF electrochemical detector
- \*Location of TC219 differs depending on the battery pack location  
 \*\*TC 220 was placed on the roof of the container in Tests 6-9  
 \*\*\*TT2 and TT3 were moved in Tests 6-9



# Test Evolution

9 cars burned in total

Test #	Suppression method	Company
1	Fire blanket	Bridgehill
2	Extinguishing lance	MURER-Feuerschutz GmbH
3	Battery puncture device	Rosenbauer
4	Side and bottom water curtains + small portable curtain	JØNI EV Firefighter
5	Side car water curtains	DAFO (ALBERO)
6	Low pressure water mist system	VID Firekill
7	Water mist + lance	VID Firekill/ MURER
8	Fire blanket (DFDS crew) + water mist	Bridgehill
9	JØNI + Extinguishing lance	JØNI/DAFO (ALBERO), MURER

# Test 1 - Fire Blanket

Dimensions of 6x8 meters

Weight of about 26 kg



# Test 2 - Extinguishing lance

Weight ranging between 7-8 kg,  
Designed to be electrically insulated







# Test 3 – Puncture device

Weighs around 26 kg

Operates with a water flow rate of 30 liters per minute at a pressure of 7 bar.

Designed for battery packs situated under the car

# Test 4 & 5 – mobile water curtains

Two different designs tested:

Wall system

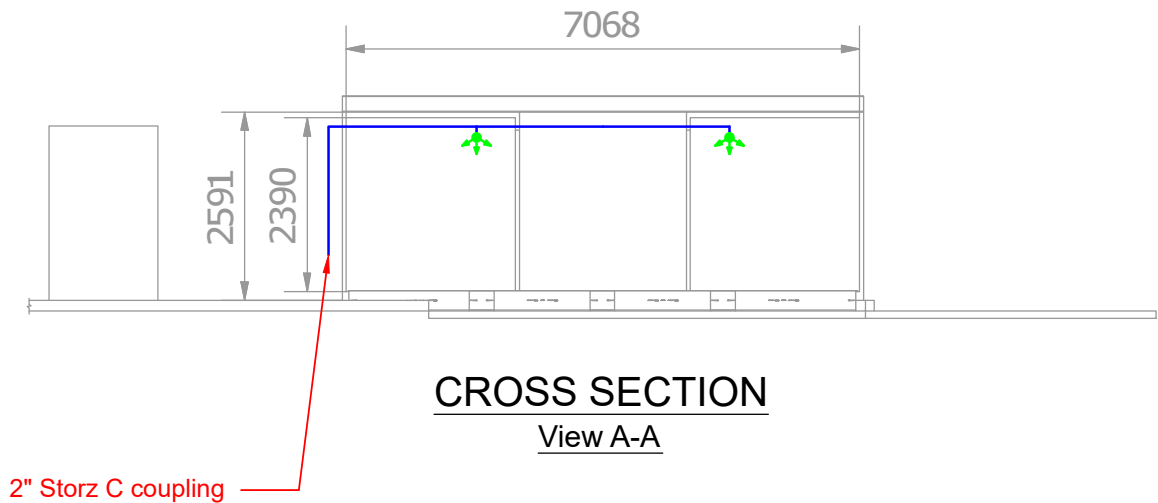
Floor system



# Test 6 – low pressure water mist

Operating at 8 barg

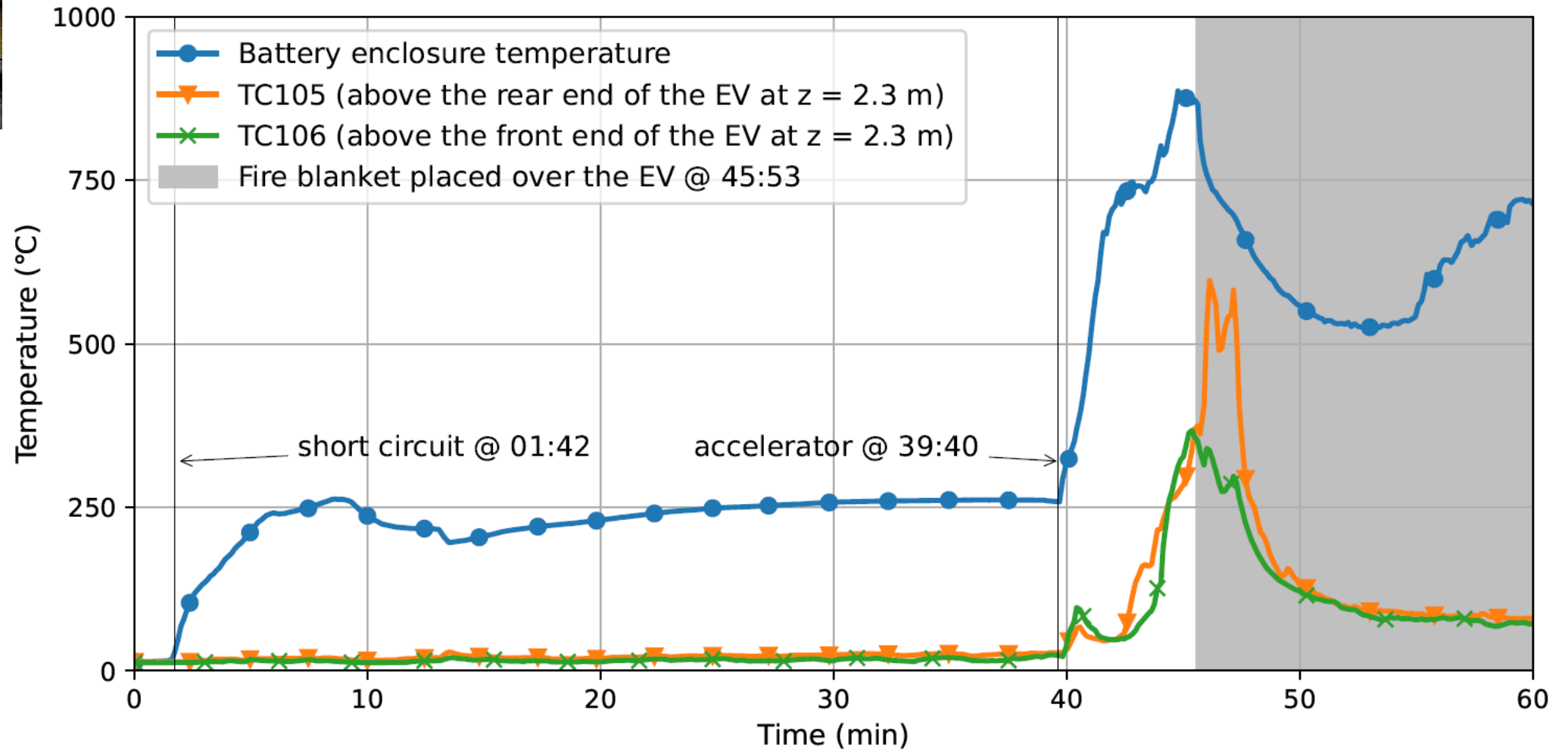
Flow rate of 400 l/min



# Some Results

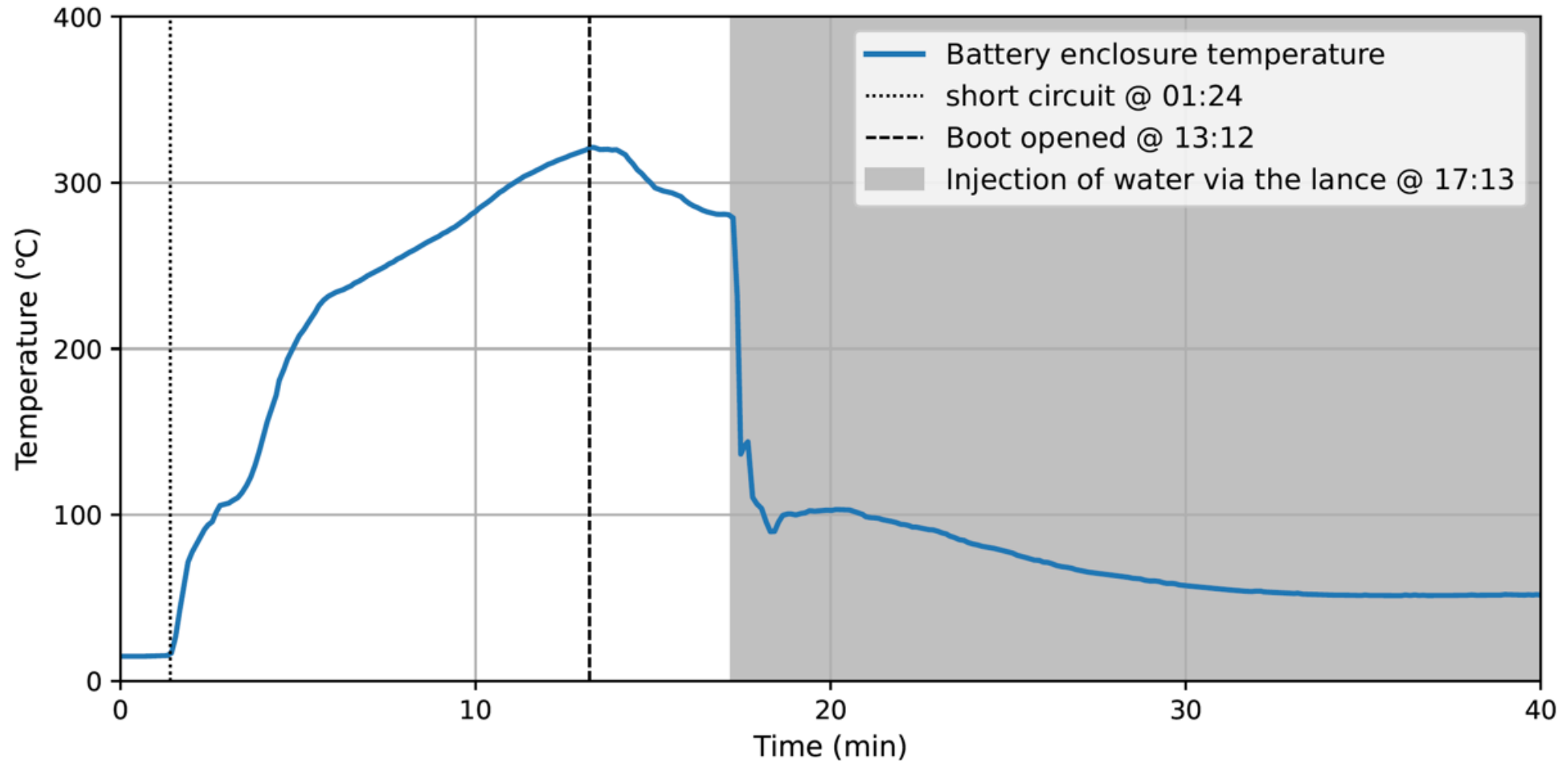


# Test 1 - Fire Blanket

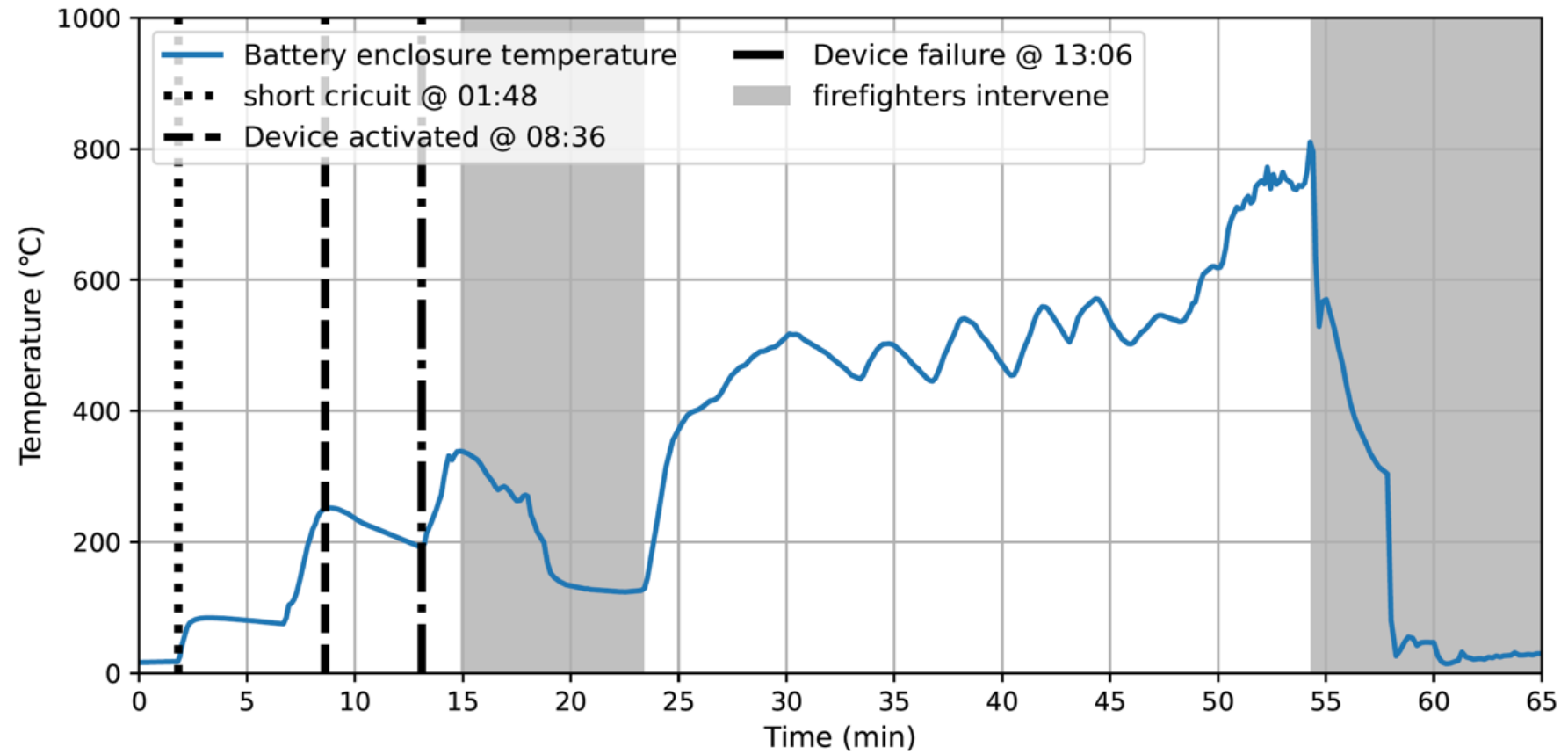
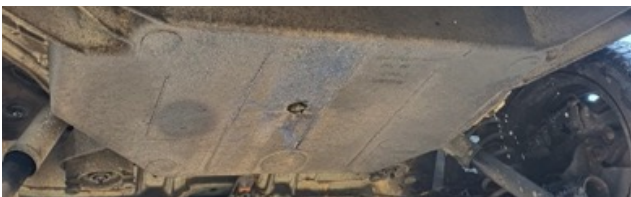




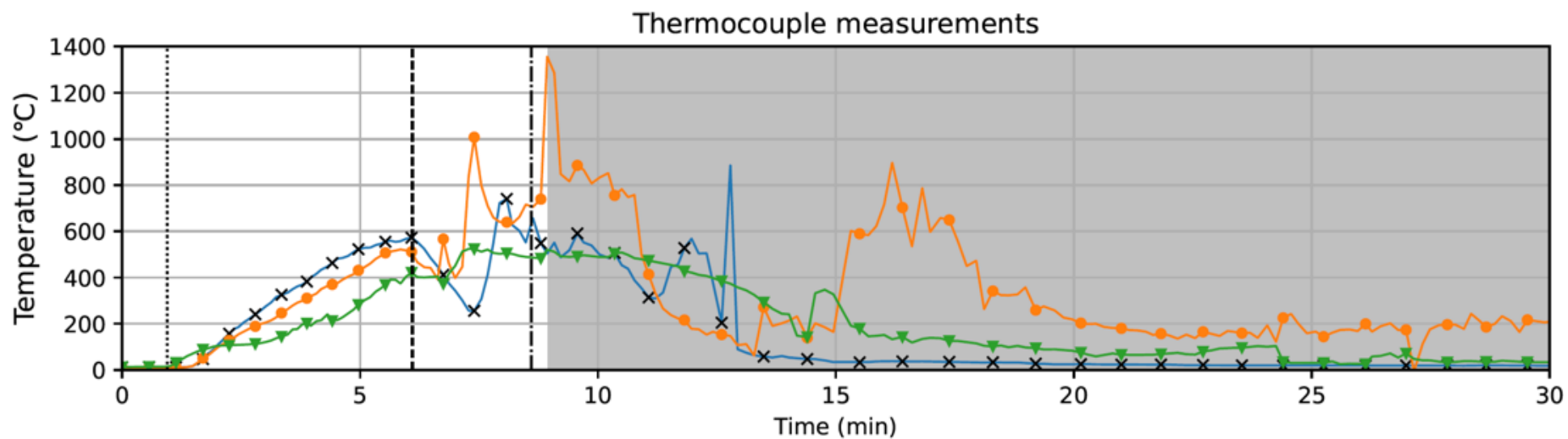
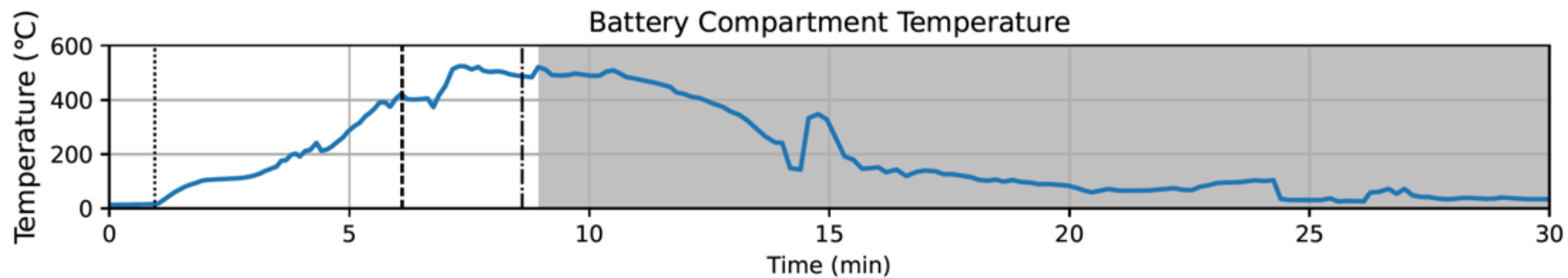
# Test 2 - Extinguishing lance



# Test 3 – Puncture device



# Test 4 & 5 – mobile water curtains



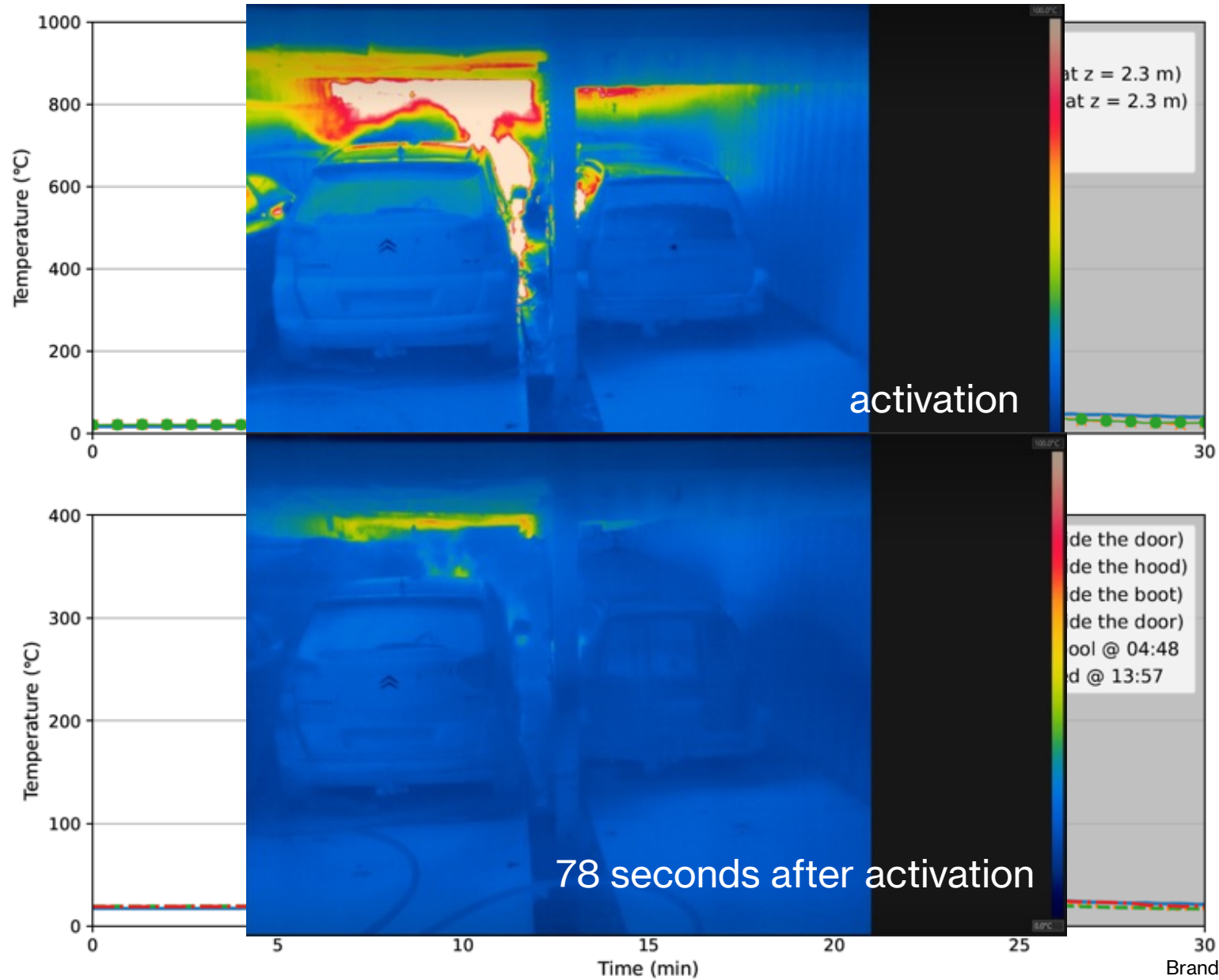
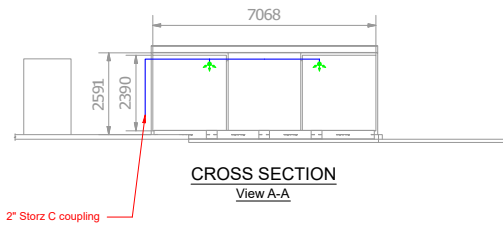
- Battery enclosure temperature
- TC107 (car 2 - outside the door)
- TC305 (EV - inside on the roof)
- TC110 (car 8 - outside the door)
- Water supplied on car 2 @ 08:45
- Short circuit @ 00:54
- Water supplied on car 8 @ 06:06
- Firefighters intervene @ 08:57



# Test 4 & 5 – mobile water curtains



# Test 6 - low pressure water mist

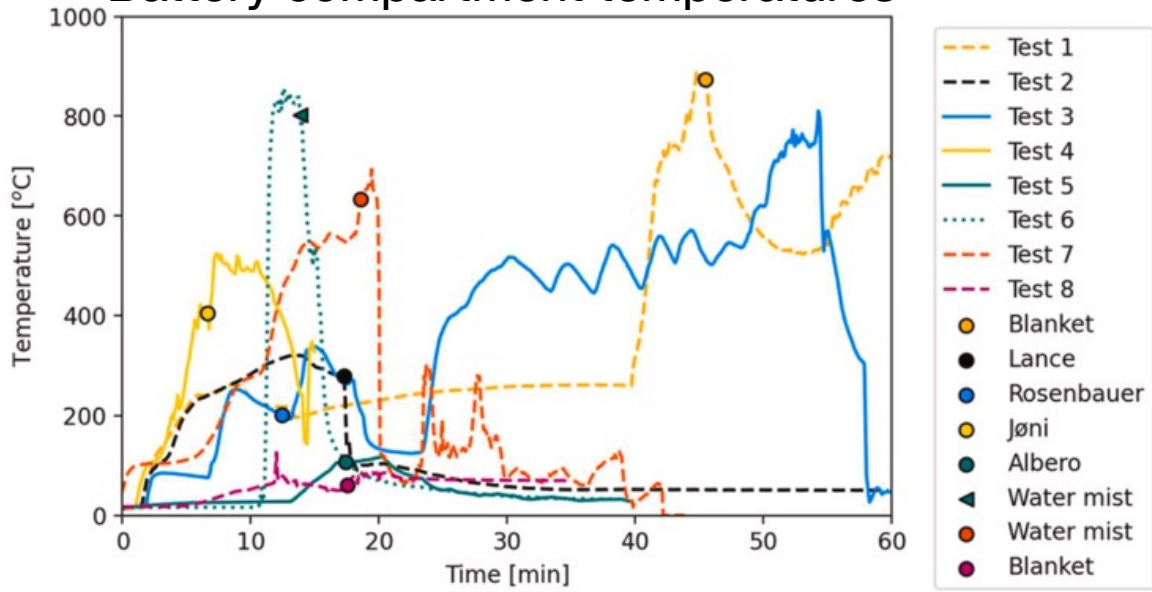


# Summary

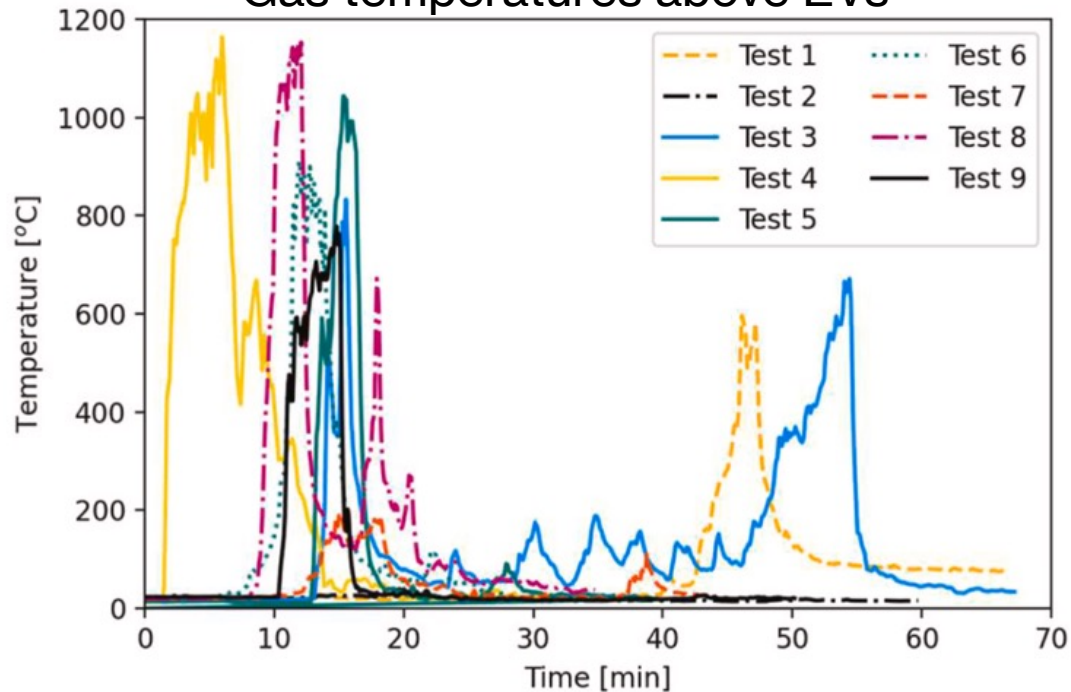
- Some methods seemed more effective than others, but..
  - Low sample size
  - High variation in tests
  - Water works – but how well is very dependent on when it is applied!
- No two tests behaved the same.
  - Used cars vs new cars
  - No such thing as a single "EV fire scenario" or "design fire"
- Impacts to structures need to be considered.



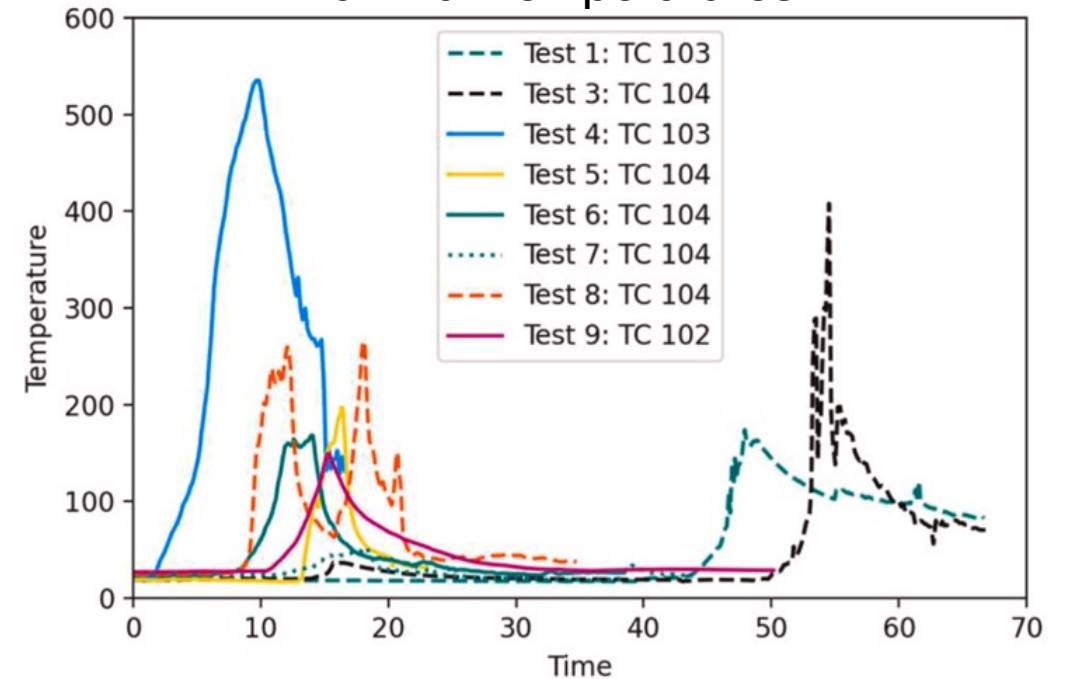
## Battery compartment temperatures



## Gas temperatures above EVs



## Max wall temperatures



Funk, E., Flecknoe-Brown, K. W., Wijesekere, T., Husted, B. P. & Andres, B. Fire extinguishment tests of electric vehicles in an open sided enclosure. *Fire Saf J* **141**, (2023).

# END.



## Fire extinguishment tests of electric vehicles in an open sided enclosure

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### ARTICLE INFO

**Keywords:**  
Electric vehicles  
Fire dynamics  
Thermal runaway  
Flame spread  
Large-scale test  
Car fire  
Transportation fire

### ABSTRACT

Electric vehicles may represent a new type of risk and require a change in fire protection and firefighting techniques in vehicle carriers and parking garages. This study presents an experimental assessment of firefighting techniques and fire dynamics of electric cars in an open-sided enclosure. The enclosure had dimensions of 12.2 m by 7.1 m, and openings of 7.1 m by 2.4 m on either end of the enclosure. A total of nine tests were performed, of which seven were conducted on the same type of car (Renault Fluence ZE). The other two electric cars tested were Tesla Model 3 and Nissan Leaf. The electric cars were surrounded by conventional internal combustion engine vehicles, and ignition was induced by short circuit of the battery. When this was not possible an external fuel load was used. The results of the tests show a significant variation in fire growth rates. Gas temperatures peaked at 1000 °C in some of the tests. The flame spread to neighboring cars occurred between 3 min and 46 min depending on the firefighting method used.

### 1. Introduction

The European Union (EU) has an ambitious plan to tackle current climate problems and environmental degradation, striving to become the first climate neutral continent [1]. As part of this plan, it is foreseen that the number of Electric Vehicles (EVs) will increase. The increase in EVs on EU roads is a major step towards achieving full climate neutrality by 2050. According to the EU, there will be at least 30 million zero-emission cars by 2030 [2]. However, while EVs have obvious benefits for decreasing CO<sub>2</sub> emissions, there are challenges to be resolved from the fire safety engineering perspective. The fire challenges are mostly related to the batteries and the complexity when tackling a

drivers both kilometres driven and downtime for re-charging breaks during the journey. That in turn introduces the new challenge of allowing passengers to recharge their vehicles while on-board. While some companies have chosen not to offer this option for safety reasons, and others only allow charging while waiting to board in port. The pressure from the market is considerable, and demand will likely increase to enable EV charging on board for as many vehicles as possible. However, with this comes an increased risk of fire on-board maritime transport, which adds additional demands for shipboard firefighting capabilities, in terms of training and materials. Since EV fires are already considered complicated to tackle on land, the requirements for successful fire containment and extinguishing at sea presents a pressing

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DAY 2  
TUESDAY 24 OCT

9:00	Registration Opens Conference Room 201 (2F)		
9:20-10:00	Naian Liu - "Wildland Surface Fire Spread: Behavior and Mechanism Transformation" Main Convention Hall (2F)		
20 min	Coffee/Tea Break		
10:20-12:00	Façade Fires Convention Hall 200 (2F)	Flammability and Toxicity B Conference Room 101 (1F)	Wildland and WUI Fires B Conference Room 102 (1F)
12:00-13:30	Lunch Poster Group A and Single Presentations - Multi Purpose Hall (1F)		
13:30-15:10	Fire Spread B Convention Hall 200 (2F)	Battery and EV Fires Conference Room 101 (1F)	Structures in Fire A Conference Room 102 (1F)
20 min	Coffee/Tea Break		
15:30-17:10	Flame Dynamics B Convention Hall 200 (2F)	Evacuation and Human Behaviour B Conference Room 101 (1F)	Automatic Fire Suppression B Conference Room 102 (1F)
17:20-18:50	IAFSS General Meeting and Award Ceremony Main Convention Hall (2F)		



Elena Funk

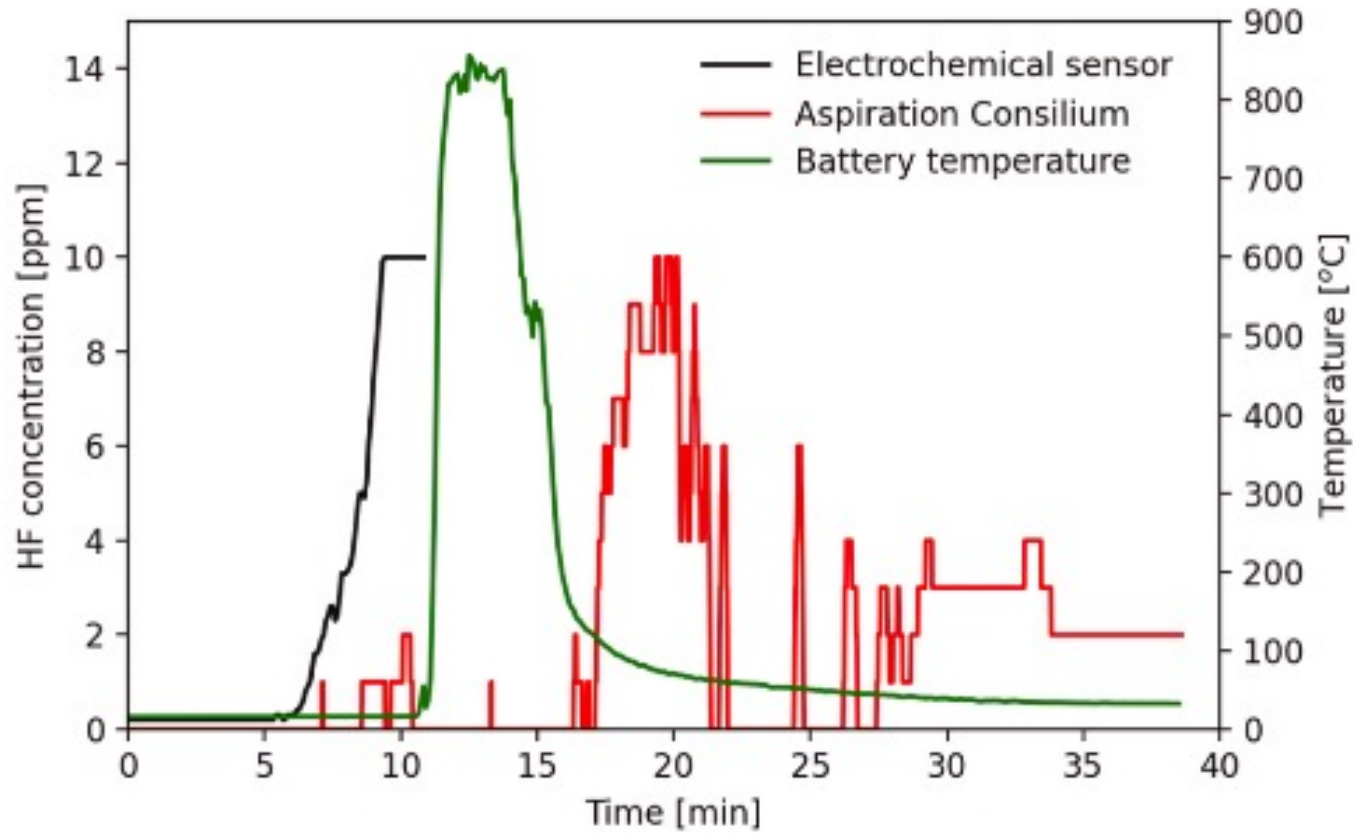


Fig. 14. Hydrogen fluoride concentration measurements in Test 6.

# Hydrogen Fluoride

**Table 1**  
Test matrix.

Test number	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7	Test 8	Test 9
<b>Car model</b>	Renault Fluence (2012)	Renault Fluence (2012)	Renault Fluence (2012)	Renault Fluence (2012)	Renault Fluence (2012)	Tesla 3 (2021)	Renault Fluence (2012)	Nissan Leaf (2013)	Renault Fluence (2012)
<b>Battery capacity (Extra) [kWh]</b>	22	22	22	22 (0.76)	22	55	22 (0.76)	24	22 (0.76)
<b>SOC</b>	100%	100%	100%	130%	100%	100%	100%	100%	100%
<b>SOC extra battery</b>				120%			120%		120%
<b>Battery</b>	NMC*-LMO*	NMC-LMO	NMC-LMO	NMC-LMO	NMC-LMO	LFP*	NMC-LMO	LMO-NCA*	NMC-LMO
<b>Short circuit</b>	yes	yes	yes	yes	yes	yes	yes	-	yes
<b>Accelerator used</b>	39:40	-	-	-	13:14	-	-	-	-
<b>Pool fire</b>	-	-	-	-	-	04:50	-	0:00yes	-
<b>Extinguishing method (time)</b>	Fire blanket (45:53)	Extinguishing lance (17:13)	Piercing device (08:36)	Water curtains Jøni (06:33)	Water curtains (Albero) (16:40)	Low pressure water mist (13:57)	Water mist /lance (18:33/38:43)	Fire blanket /lance (12:20/17:29)	Water curtain/lance (15:20/35:28)

\*NMC – Lithium Nickel Cobalt Manganese Oxide \*LMO - Lithium Manganese oxide \*NCA – Lithium Nickel Cobalt Aluminium Oxide \*LFP – Lithium Iron Phosphate