Drencher system tests

Comparing gasoline-fuelled and battery electric vehicles

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Background and objectives

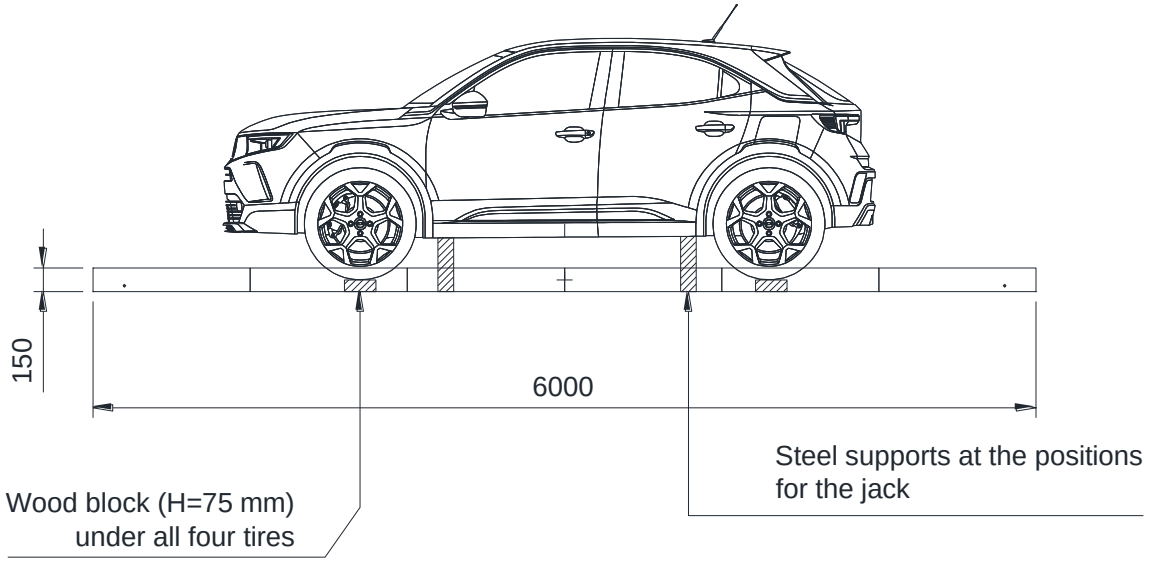
Background

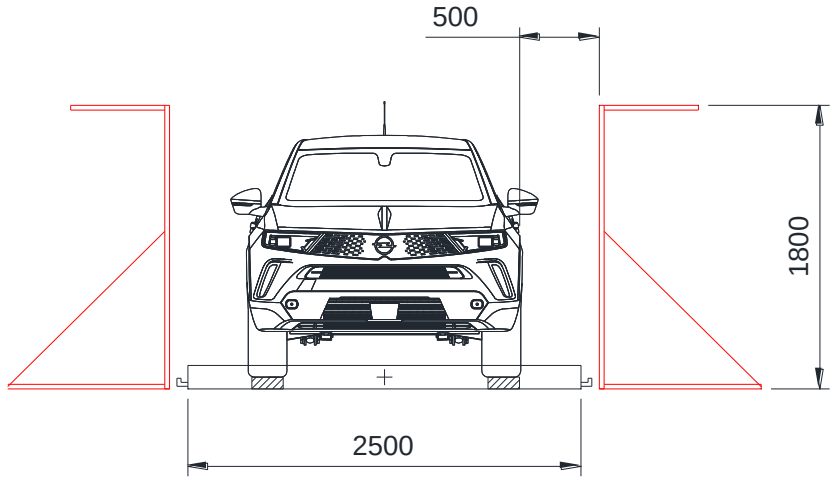
Concerns regarding the fire control performance of drencher systems in ro-ro cargo spaces with the introduction of Battery Electric Vehicles (BEV's).

Objectives

- A straightforward comparison of the fire control performance using two pairs of vehicles:
  - ICEV1 and BEV1: Similar sized vehicles of similar type.
  - ICEV2 and BEV2: Identical vehicles except for the powertrain.
- Drencher system designed according to MSC.1/Circ. 1430.

Fire test set-up






15 m² tray filled with water (with goose-neck devices to prevent overflow)

The water spray system

- Four pendent, open water spray nozzles.
- 5 m vertically above the water surface in the tray.
- K-factor: 80,6.
- Operating pressure: 1,3 bar.
- 3,05 m by 3,05 m spacing.
- Total discharge flow: 372 l/min.
- Density: 10 mm/min.

The vehicles

	ICEV1	BEV1	ICEV2	BEV2
Model year	2022	2022	2021	2021
Type of vehicle	Compact SUV	Compact SUV	Subcompact crossover SUV	Subcompact crossover SUV
Fuel tank (gasoline) or battery capacity	58 litre	82 kWh (total) 77 kWh (usable)	44 litre	50 kWh (total) 45 kWh (usable)
Amount (90%) of fuel and charge level used in the test	52,2 litre	69,3 kWh	39,6 litre	40,5 kWh

ICEV1 and BEV1 was similar except for the powertrain. The BEV was about 30 % heavier.
ICEV2 and BEV2 was basically identical except for the powertrain. The electric version is about 20 % heavier,

Fire ignition scenarios

ICEV's

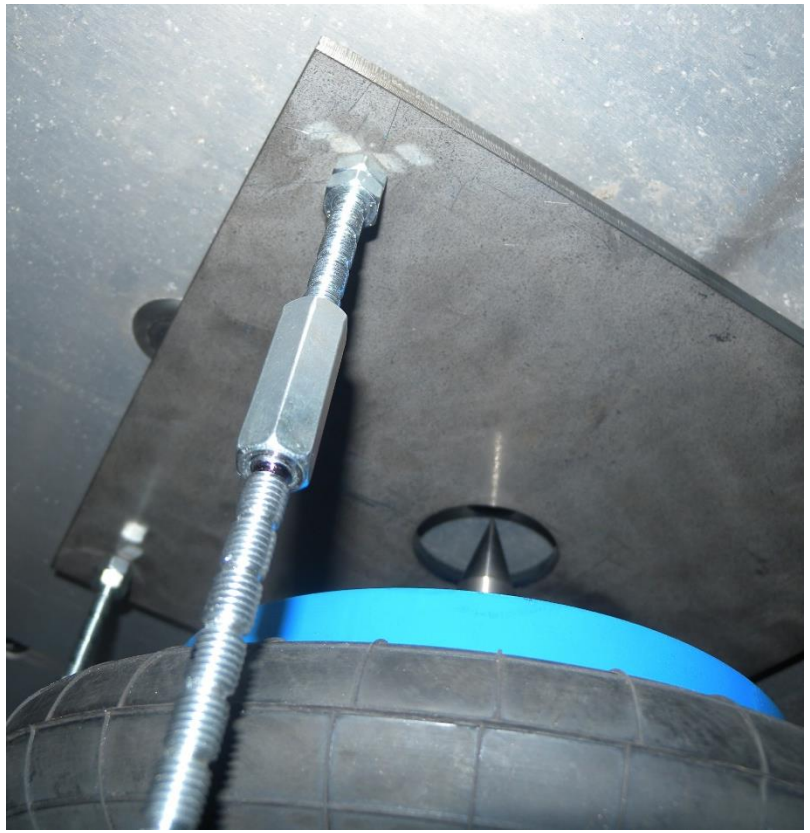
- Fuel tank (plastic) filled to 90 % capacity with gasoline.
- Pre-drilled 15 mm diameter hole with a rubber plug.
- Removal of the plug and ignition of the outflow of gasoline fuel.

BEV's

- State of charge: 90 %.
- Pre-drilled hole in the protection plate underneath the vehicle.
- Nail penetration from below in one of the battery modules.

ICEV fire ignition approach

BEV fire ignition approach



Fire test procedures

- Fire ignition.
- **Manual activation of the drencher system at a heat release rate of 1,5 MW.**
- **Discharge of water for 30 minutes.**
- End of discharge.
- Burn-out of the vehicle without any application of water. Approach used for two reasons:
  - Indication of fire control performance of the water spray system.
  - Facilitated scrapping of the vehicles after the test.

Measurements

- **The heat release rate.**
- **Surface temperatures at steel sheet screens simulating adjacent to the vehicle. Positioned 500 mm horizontally from the vehicle.**
- The gas temperature above the fire.
- The heat radiation with heat flux meters facing the sides of the vehicle. Positioned 500 mm horizontally from the vehicle.
- Surface temperature of Plate Thermometers positioned in front of and behind the vehicle.
- Water pressure and water flow rate.

ICEV1 and BEV1

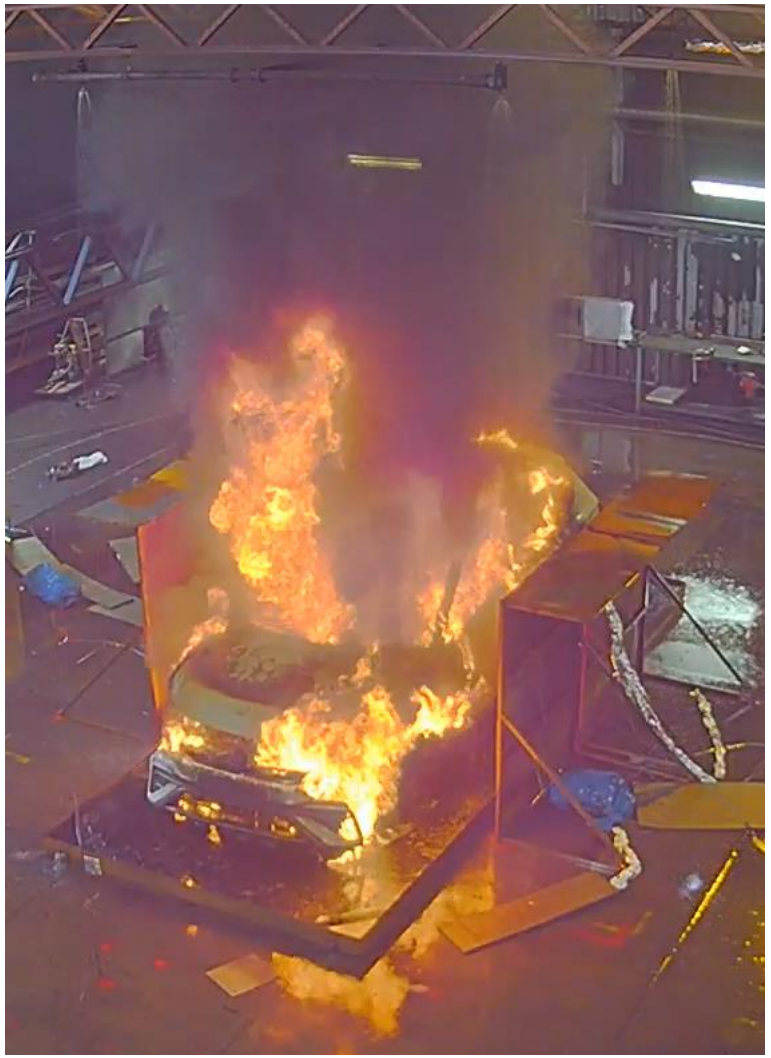
ICEV1: 01:12 (min:s) – start of application

ICEV1: ~03:00 (min:s) – the peak

ICEV1: ~06:00 (min:s) – fuel burn-out

ICEV1: ~ 31:12 (min:s) – end of application

ICEV1: ~ 40:00 (min:s) – post-application peak



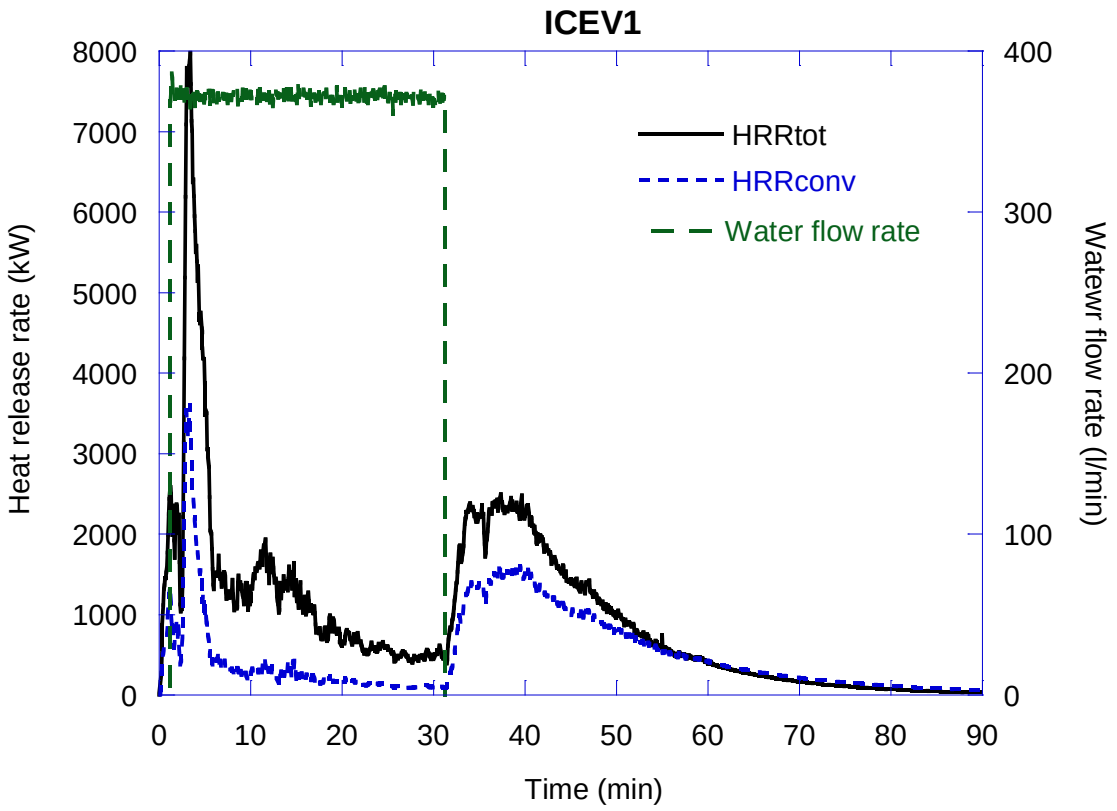
BEV1: 12:40 (min:s) – start of application

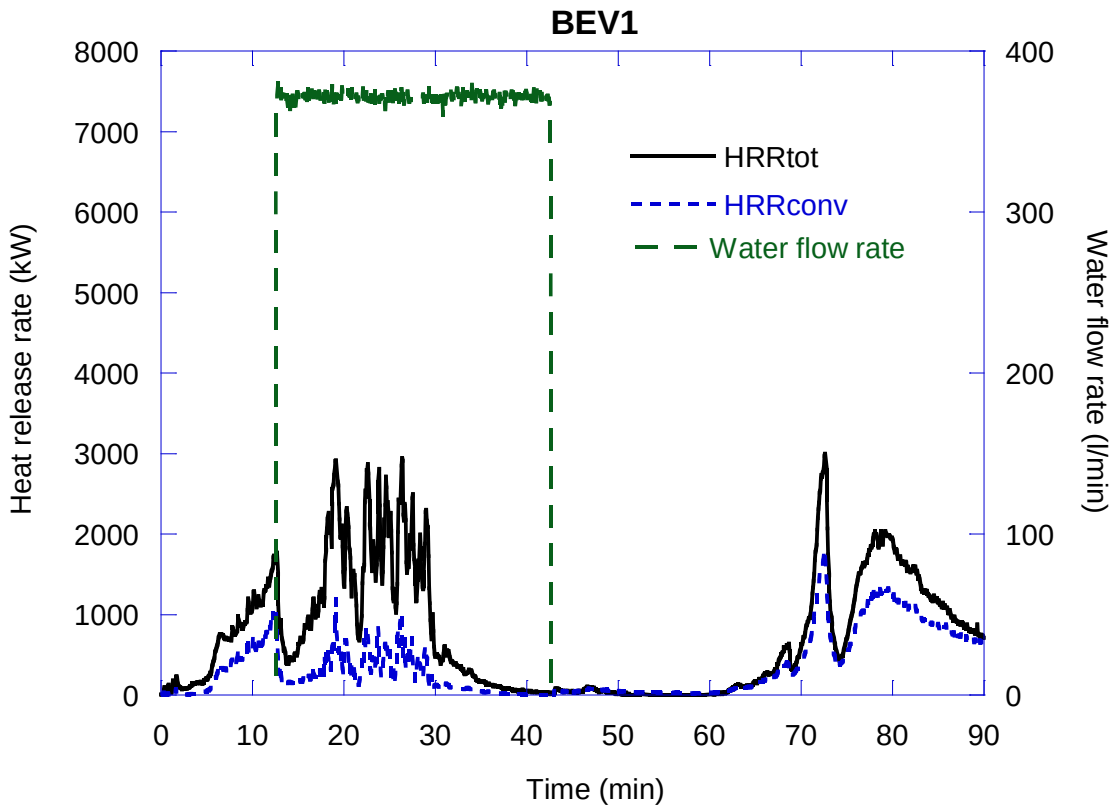
BEV1: ~20:00 (min:s) – peak

BEV1: ~42:40 (min:s) – end of appliction

BEV1: ~74:00 (min:s) – post-application peak

Heat release rates (0 – 90 min)





ICEV2 and BEV2

ICEV2: 00:58 (min:s) – start of application

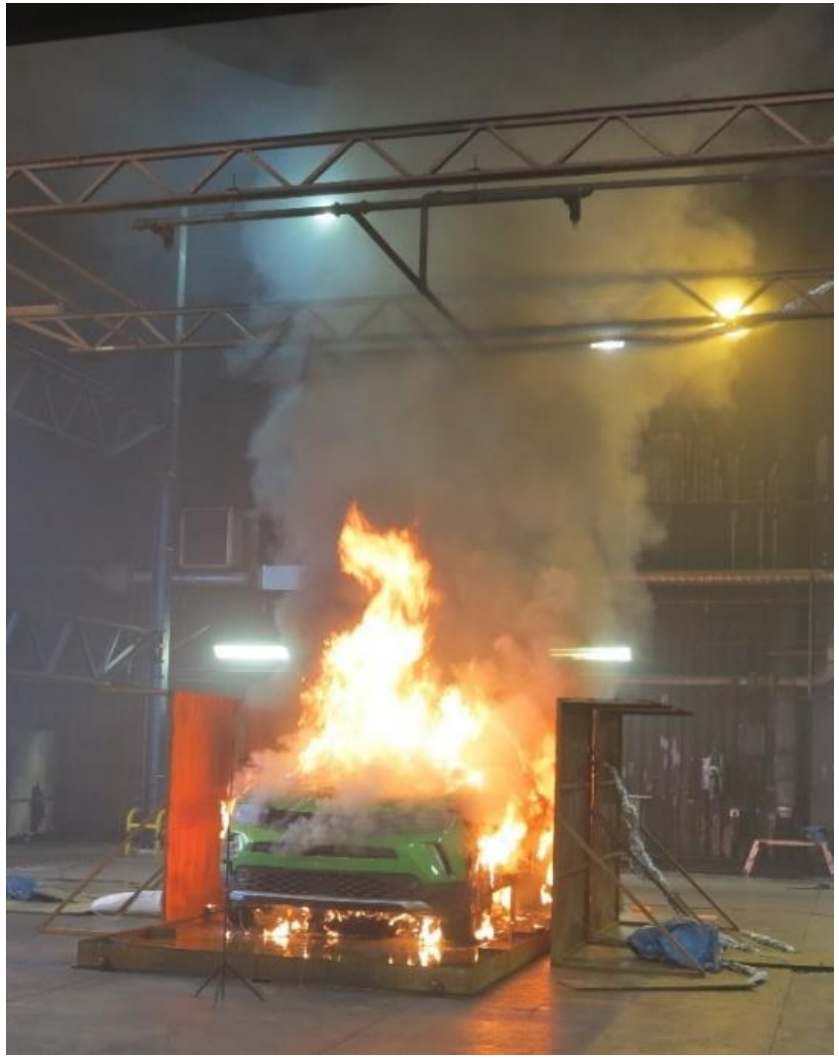
ICEV2: ~04:00 (min:s) – the peak

ICEV2: ~ 30:58 (min:s) – end of application

ICEV2: ~ 36:00 (min:s) – post-application peak

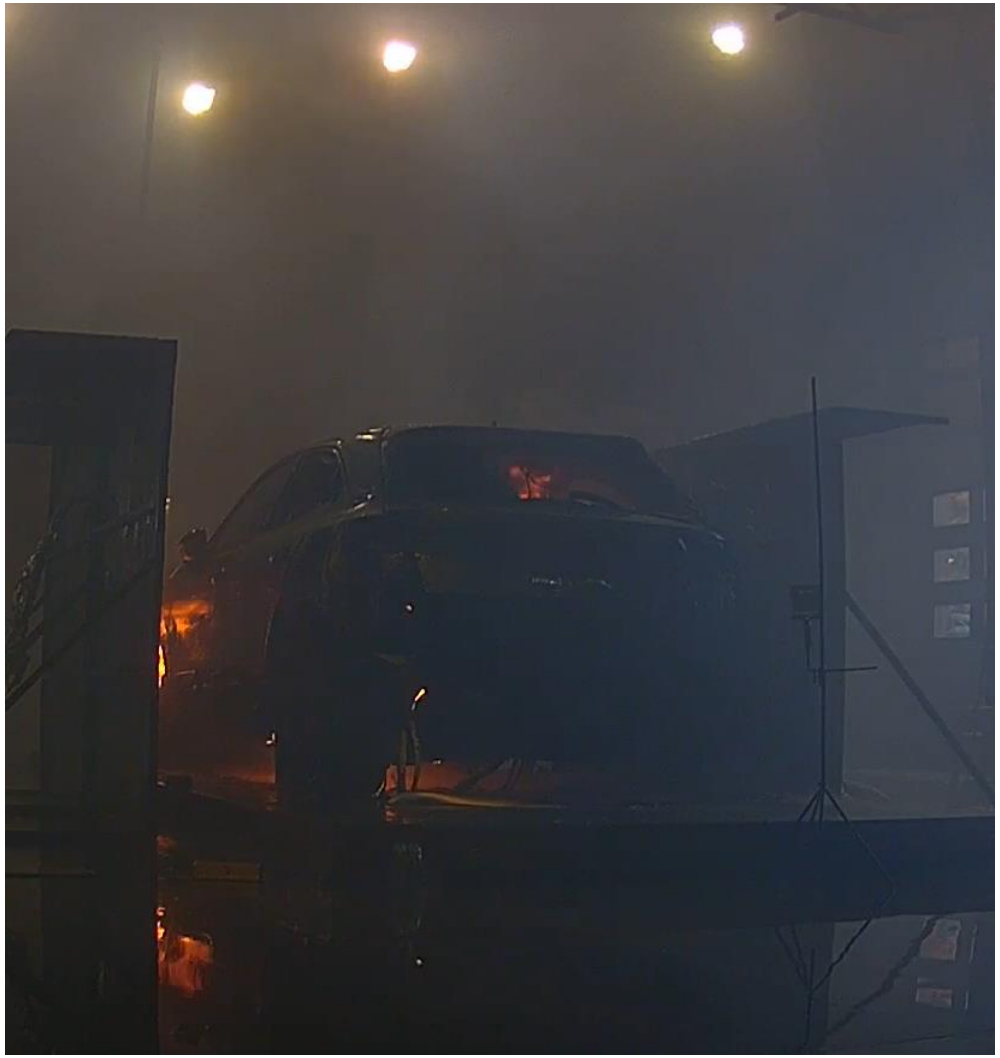
ICEV2: ~ 47:00 (min:s)

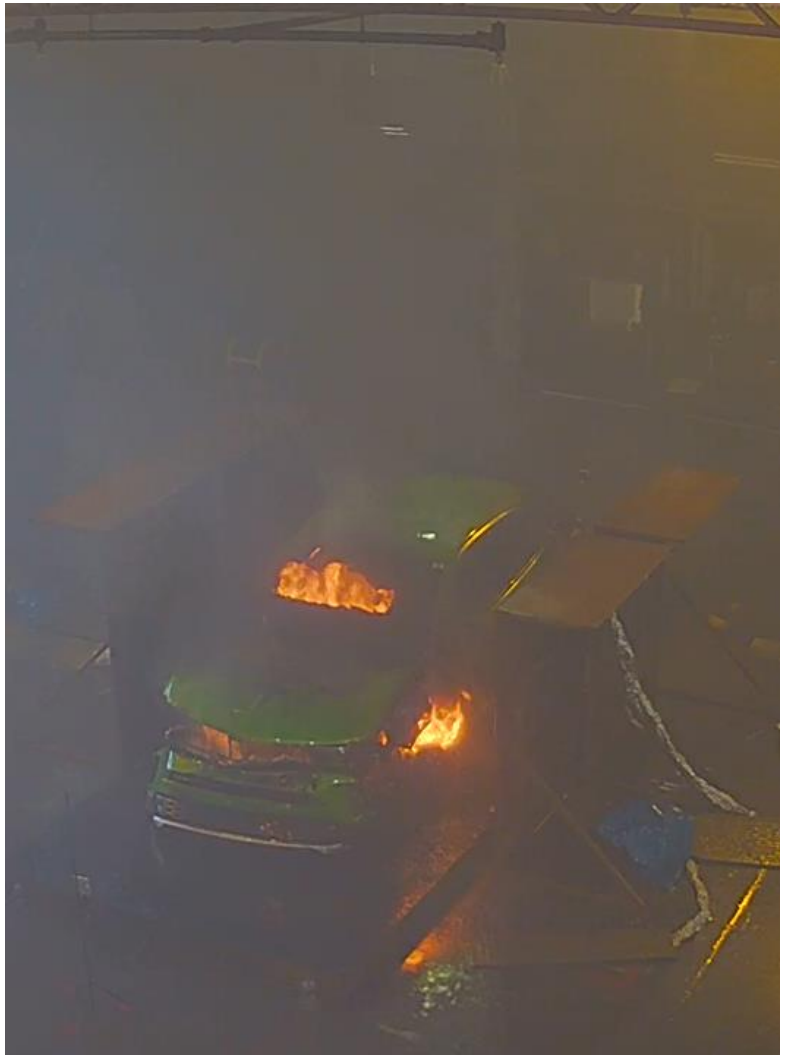
BEV2: 16:45 (min:s) – start of application



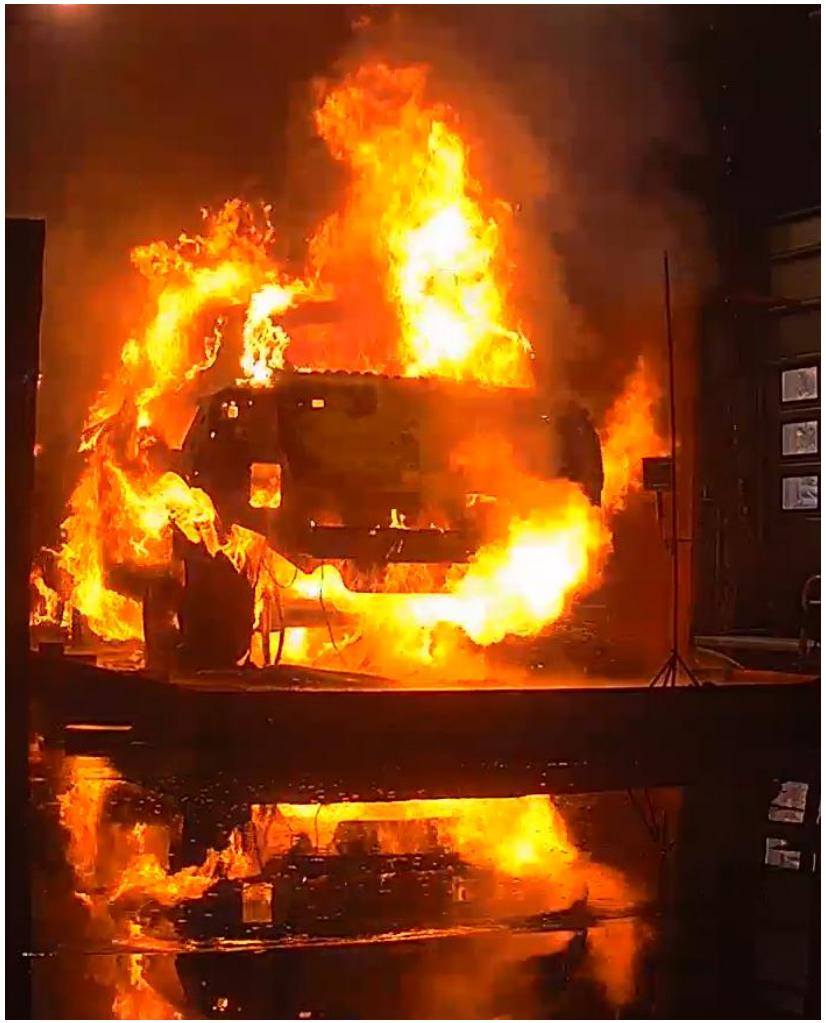
BEV2: ~ 24:40 (min:s) – peak

BEV2: ~ 46:45 (min:s) – end of application





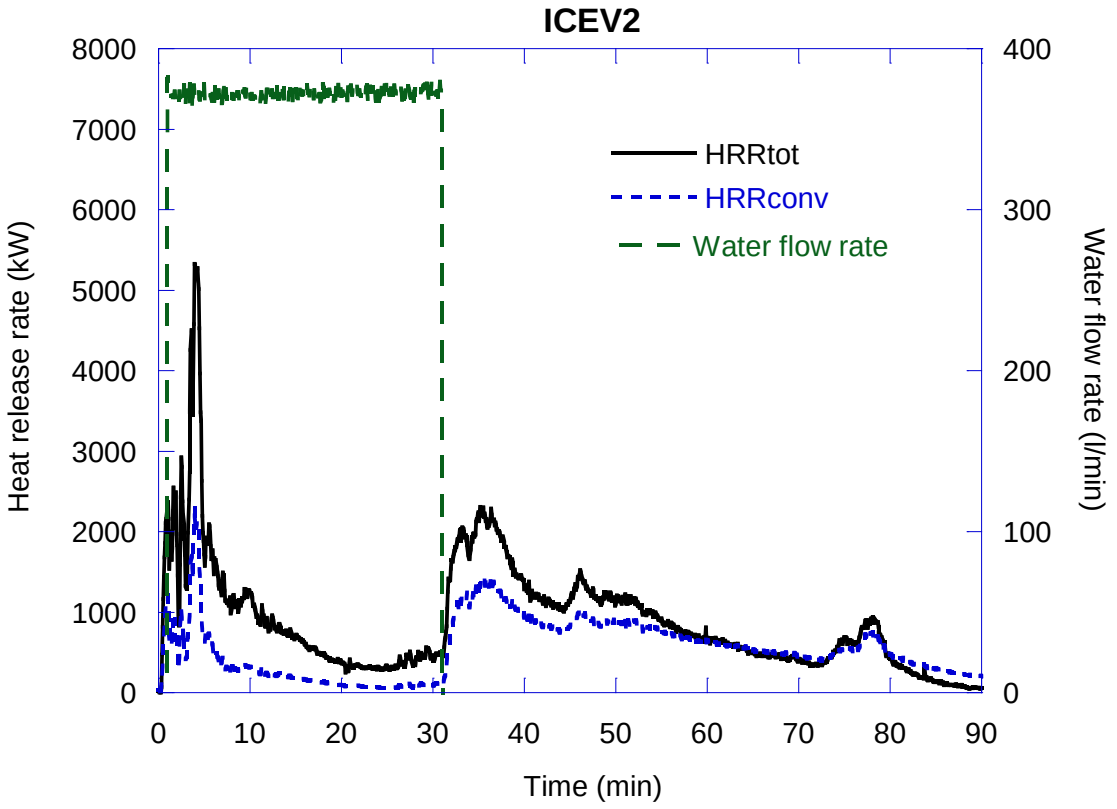
BEV2: 61:00 (min:s) – post-application peak

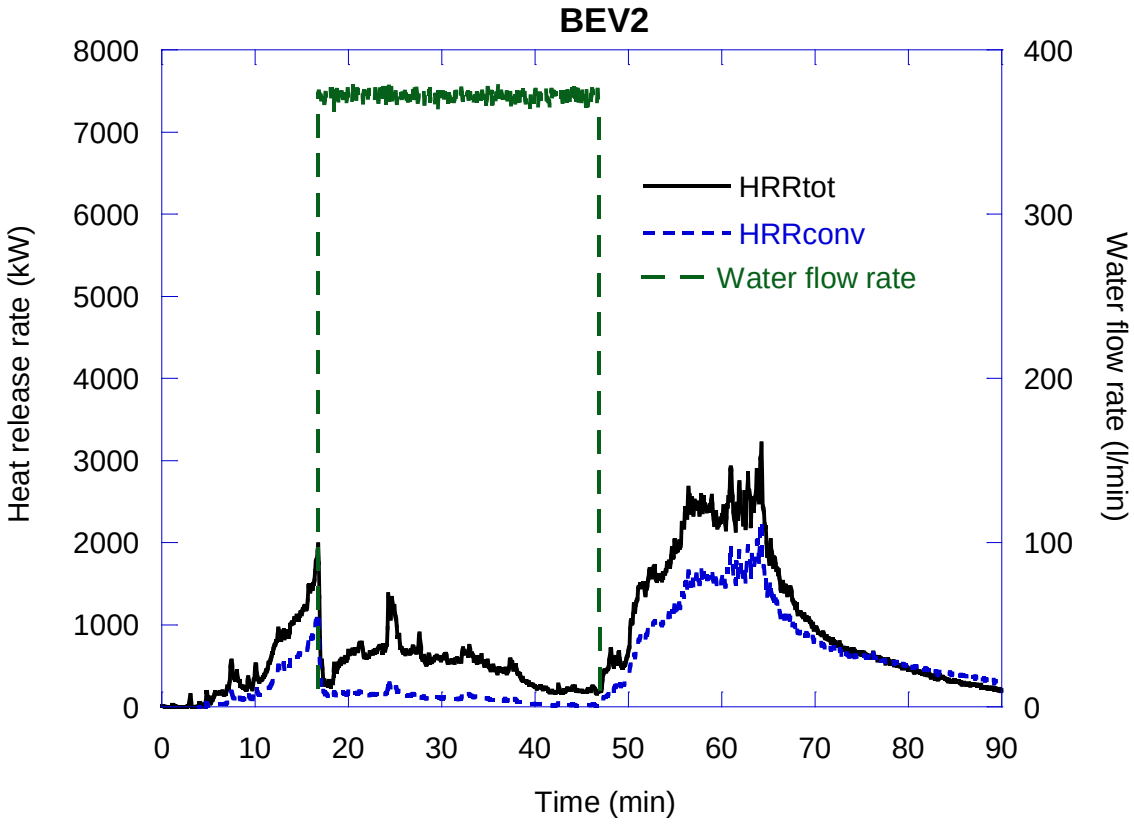


BEV2: 64:00 (min:s) – post-application peak

BEV2: 70:00 (min:s)

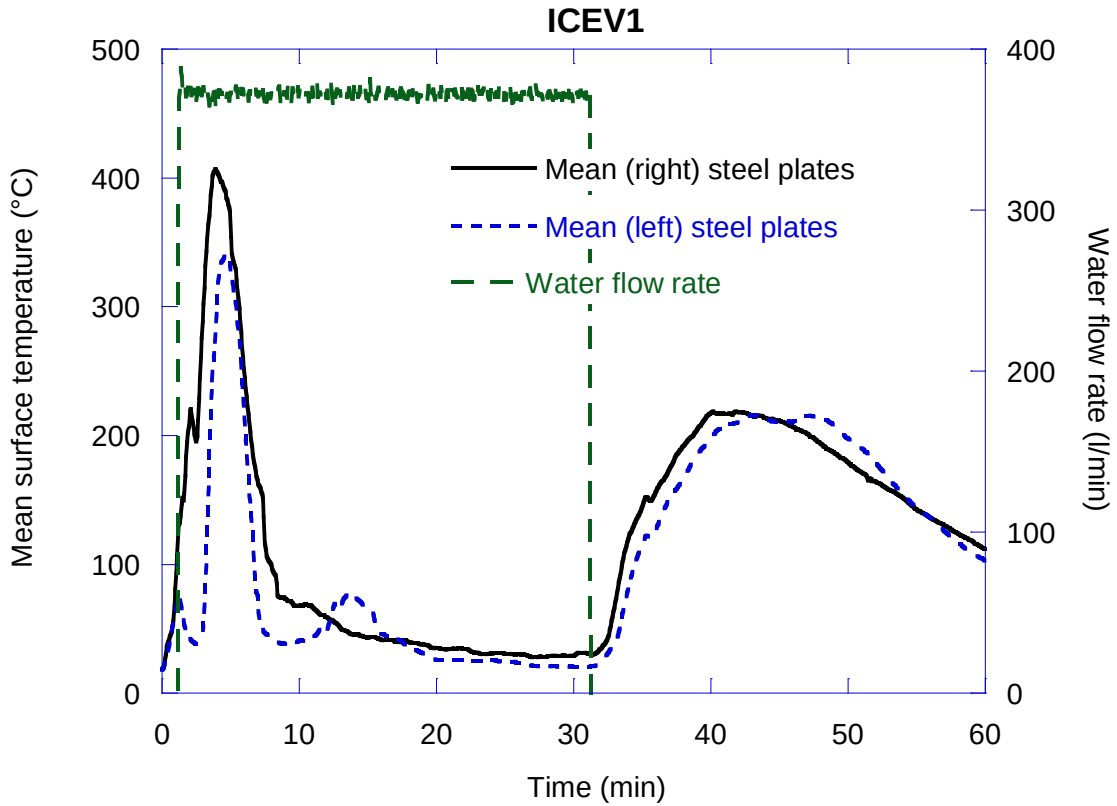
Heat release rates (0 – 90 min)

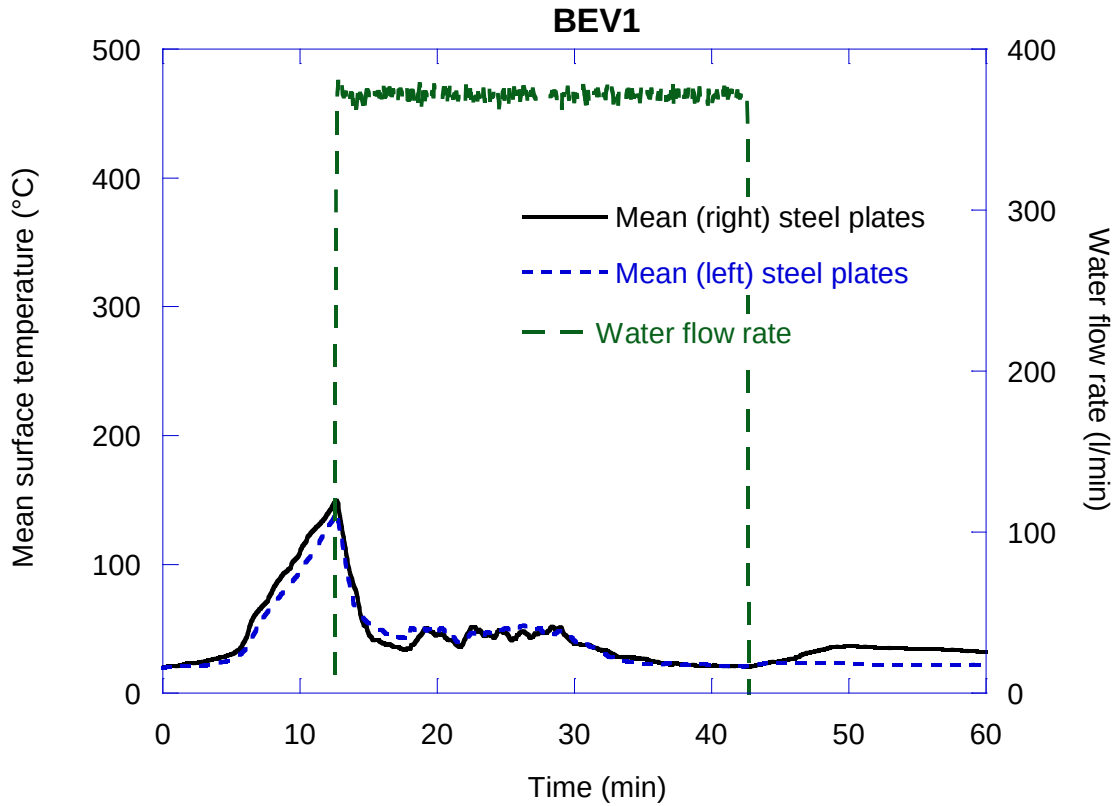




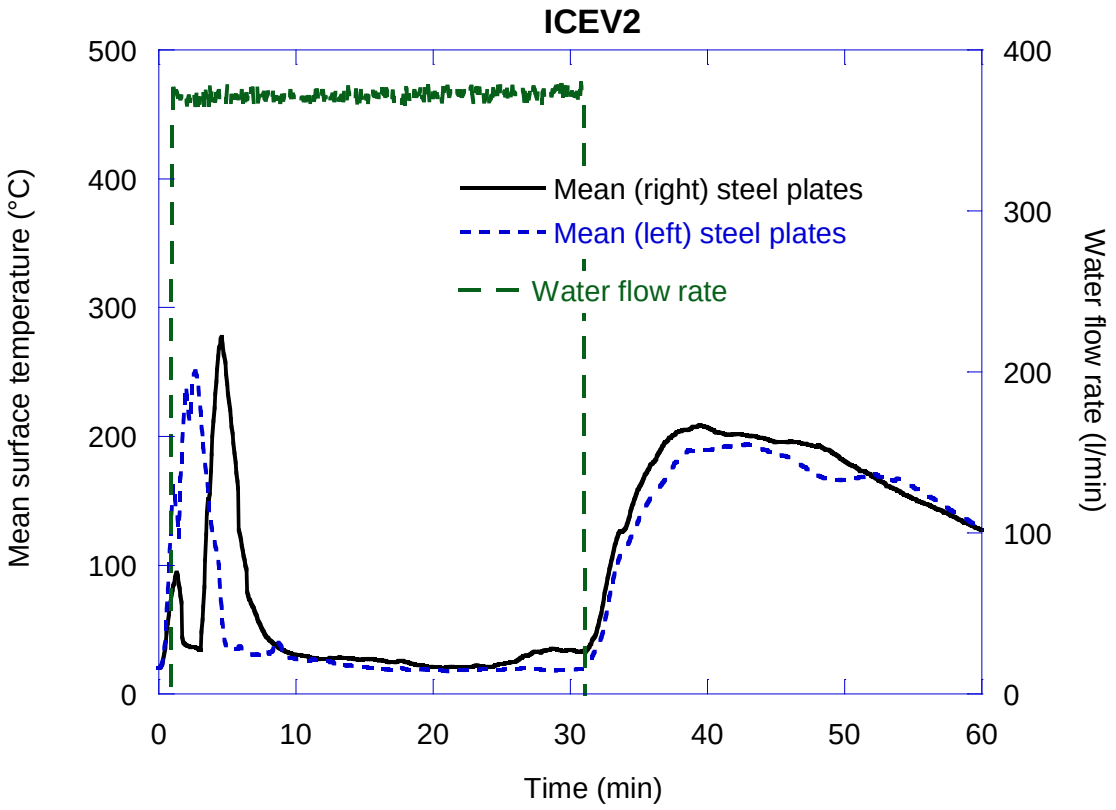
Drencher system performance

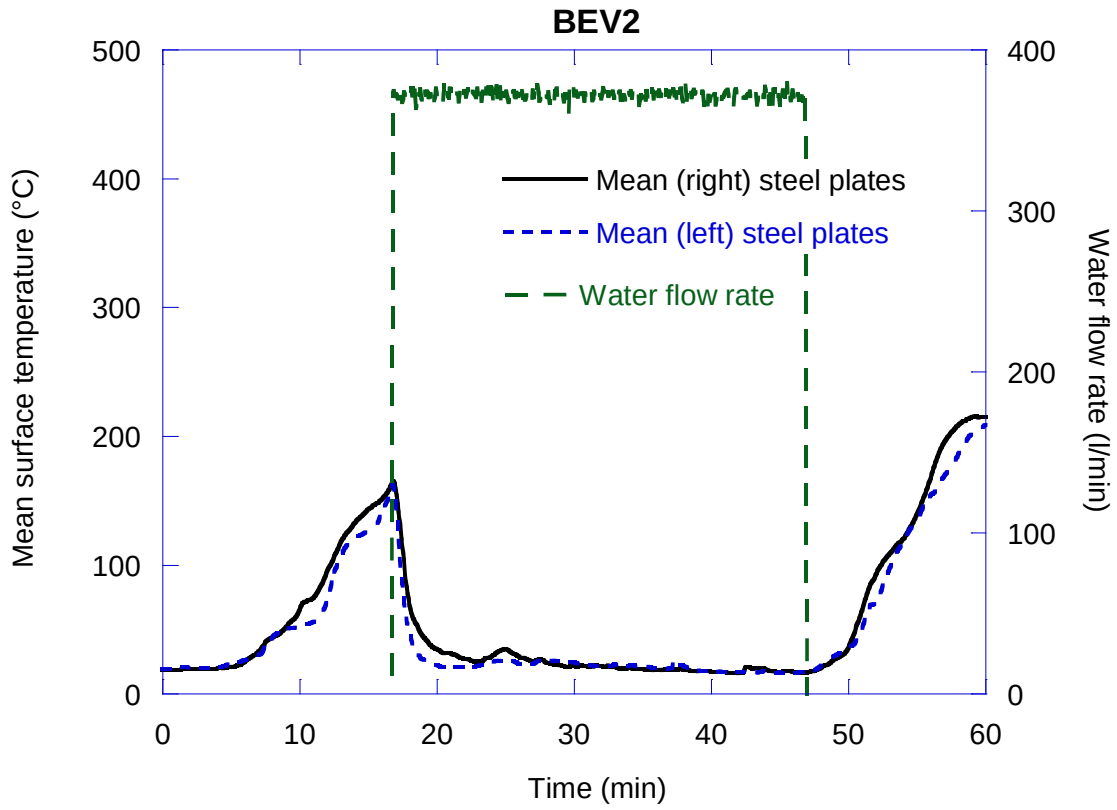
Surface temp. on steel sheet screens (0 – 60 min)





Surface temp. on steel sheet screens (0 – 60 min)





Conclusions (1)

The fire scenarios

- Faster initial fire growth rate and higher overall peak heat release rate for the ICEV's.
- Higher peak heat release rate for BEV's – during water application. This is partly associated with fire progress in the battery pack.
- Fire re-growth immediately after the termination of the water application, except for BEV1.
- Battery pack burnt out during the time of water application (BEV1) or during and after water application (BEV2).
- During the post-application stage, the unburnt exterior combustibles (as front and rear parts and paint) and the interior were completely consumed.
- Significant post-application heat release rate peaks observed in all tests.

Conclusions (2)

The performance of the drencher system

- Clear reduction of:
  - The surface temperature of the steel sheet screens.
  - The gas temperature above the vehicle (data not shown here).
  - The heat radiation (data not shown here).
- The fire re-growth after the termination of the water application is an evidence that the application of water do control the fire.
- Battery electric vehicles does not seem more challenging for the drencher system design in MSC.1/Circ. 1430 than gasoline-fueled vehicles. At least not the way battery electric vehicles are constructed today.

Acknowledgement and disclaimer

- The vehicle manufacturers that sponsored the tests with vehicles are gratefully acknowledged.

- Johnson Controls that provided the water spray nozzles are gratefully acknowledged.

- The information in this presentation reflects only the author's view and the Agency is not responsible for any use that may be made of the information it contains.

- A report (D10.4) including the tests is available at www.lashfire.eu.

LASH FIRE

Legislative Safety Assessment for Safety Hazards of Fire and Innovations in Ro-Ro Ship Environment

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