

Smoke, Sparks, Flames or Explosions?

An Experimental Study into how Lithium-ion Cell Failure Varies in Open Field

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Bespoke research and consultancy - using our scientific expertise and regulatory insight to address health and safety risks

Test Facilities



Abuse Tests

Over-temperature

- External heating
- External flame
- Accelerating rate calorimetry (ARC)



Electrical

- Over-charge
- External short circuit

Mechanical

- Nail penetration



Analytical Techniques

Video Imaging

- High Speed
- Thermal (IR)

Cell Temperature

Cell Voltage

Gas analysis

- Compositions
- Volumes
- Real-time



Analytical Techniques

Video Imaging

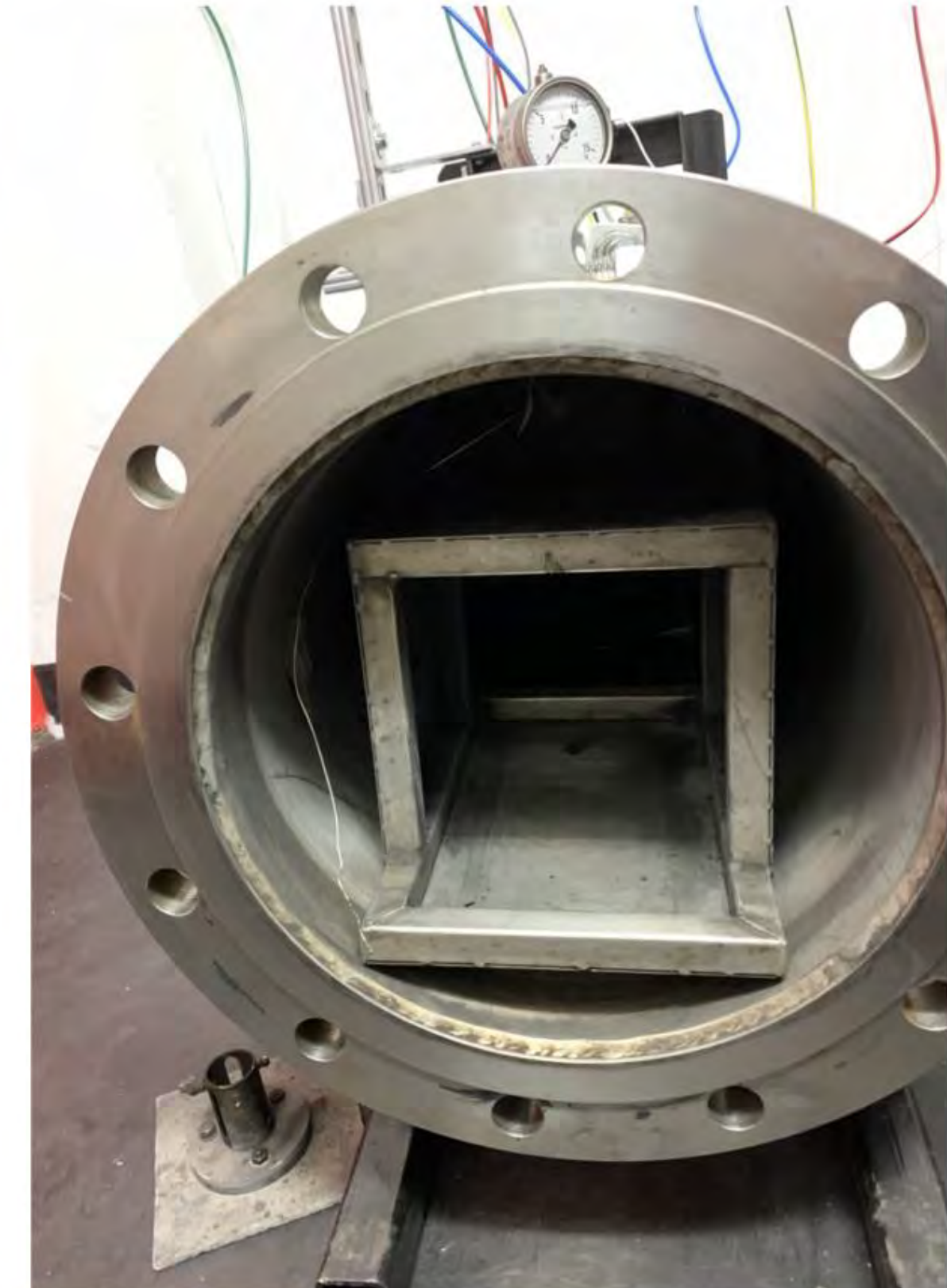
- High Speed
- Thermal (IR)

Cell Temperature

Cell Voltage

Gas analysis

- Real-time
- Compositions
- Volumes



Pressure Vessel

External Heating



High speed footage of event

External Heating



Real time footage of event

Samsung Recalls Phones With Batteries That Catch Fire.

The technology giant Samsung Electronics has issued a recall of all Galaxy Note 7 smartphones equipped with batteries it believes are prone to catching fire.



The explosive problem of 'zombie' batteries

By Ben Morris
Technology of Business editor

🕒 26 October 2020



Tesla Megapack caught fire at Victorian Big Battery site in Australia

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Cells Tested



	Cell 1	Cell 2	Cell 3
Nominal Capacity	5.0 Ah	4.9 Ah	4.7 Ah
Nominal Voltage	3.63 V	3.63 V	3.64 V
Weight	≈ 63 g	≈ 67 g	≈ 67 g

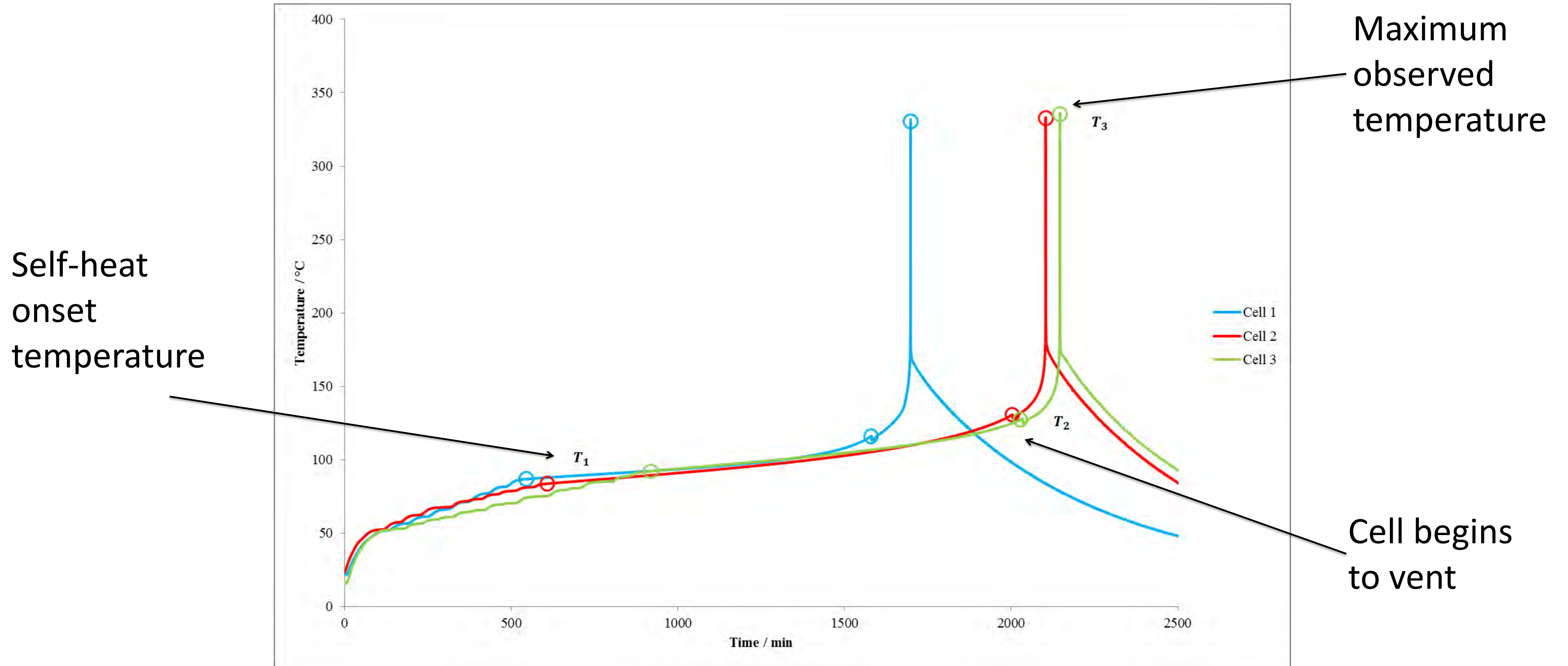
Over-temperature Abuse Tests

ARC

Downward
Force

Projectiles

Accelerating Rate Calorimetry (ARC)



Post-test Photos



Cell 1

*Retains heat
for longer*



Cell 2



Cell 3

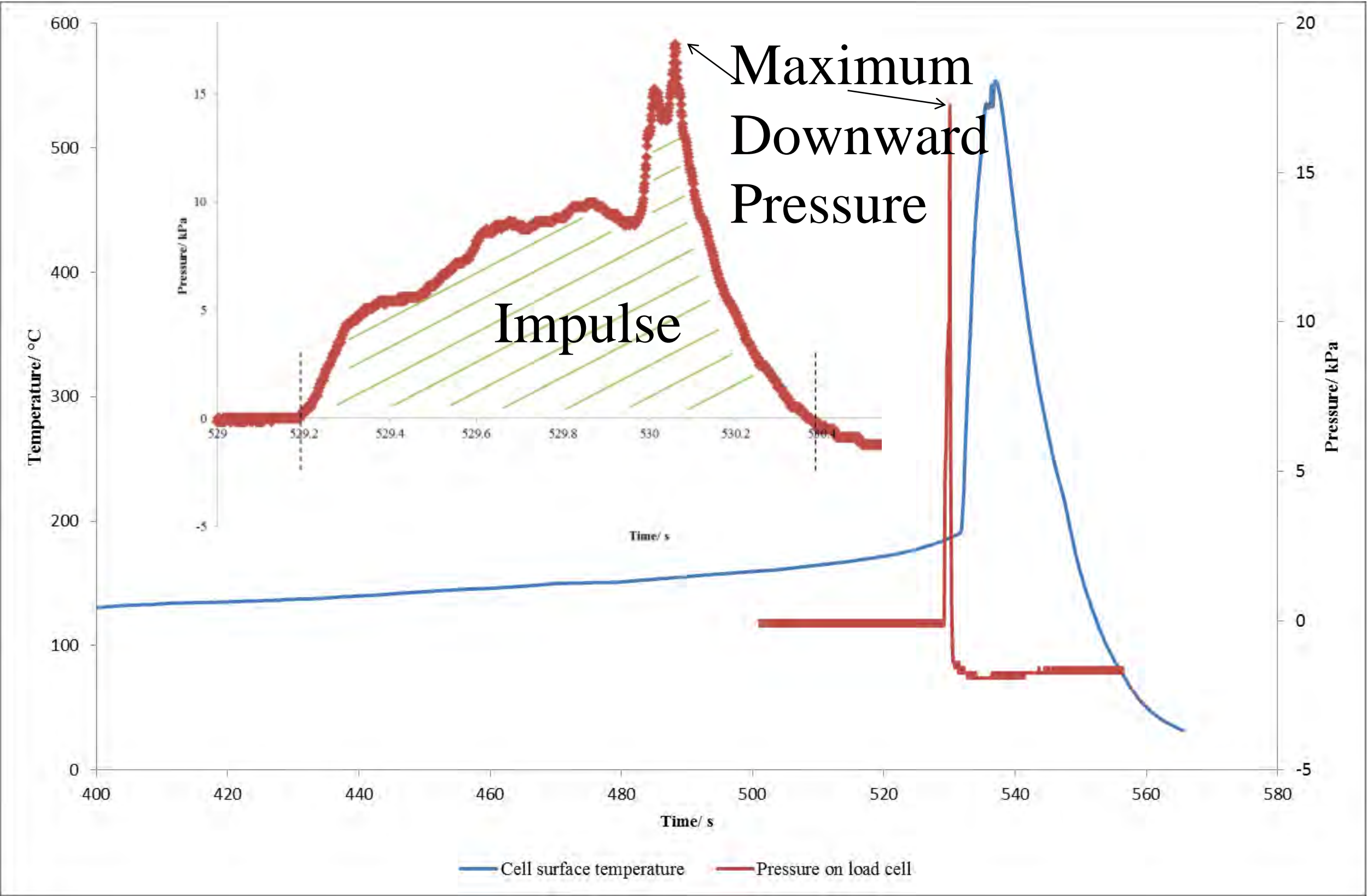
But what does the failure look like?

Downward Force



Load Cell

Heater



Downward Force



- Higher Impulse



- Lower Impulse

Projectiles – Cell Heated by Flame



Capped
metal tube

Negative
terminal of
cell

Bunsen burner

Projectiles – Cell Heated by Flame

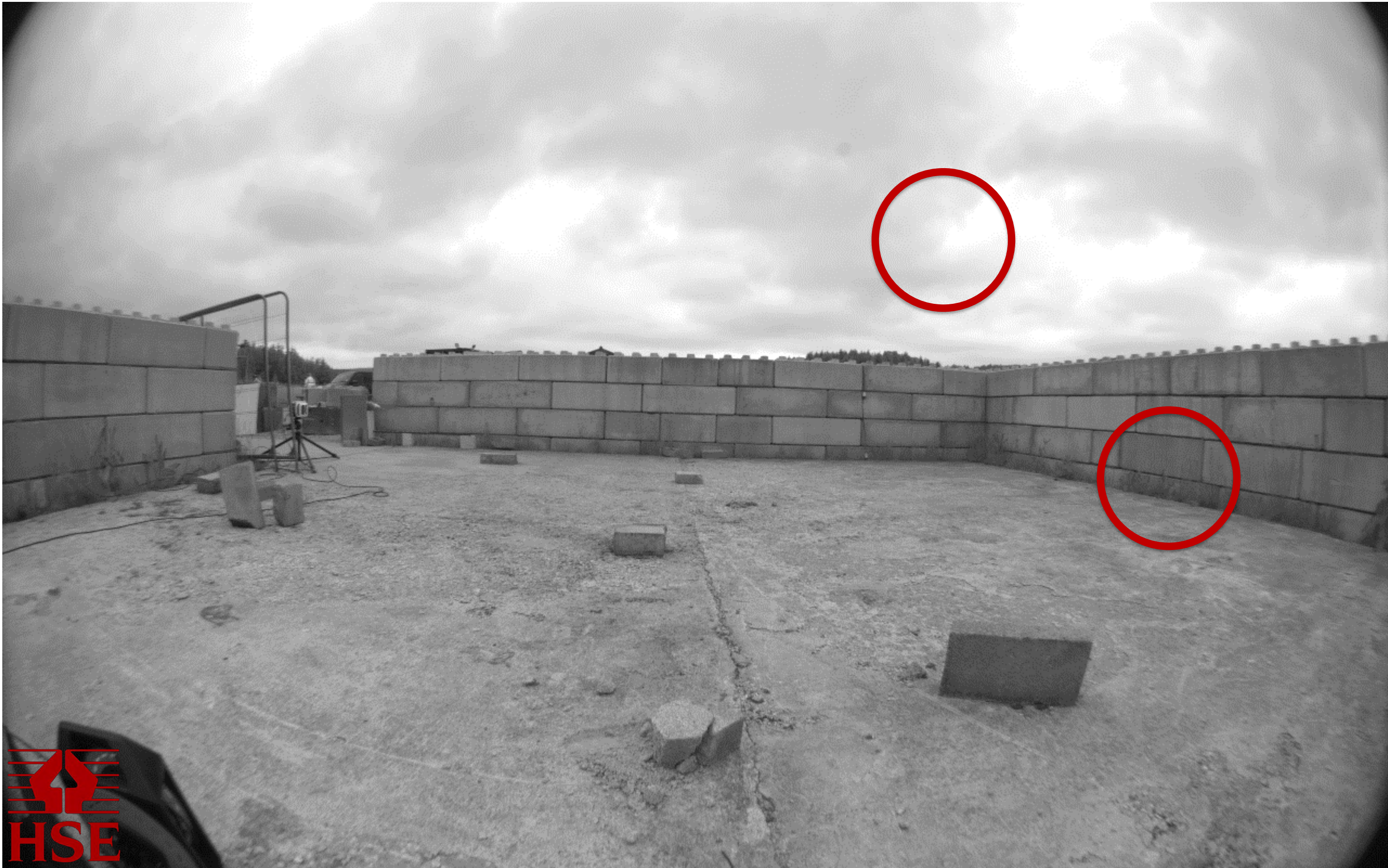


- $\approx 14 \text{ ms}^{-1}$ ($\approx 30 \text{ mph}$)
- Sparks ejecting from both ends
- **Melting Hole**



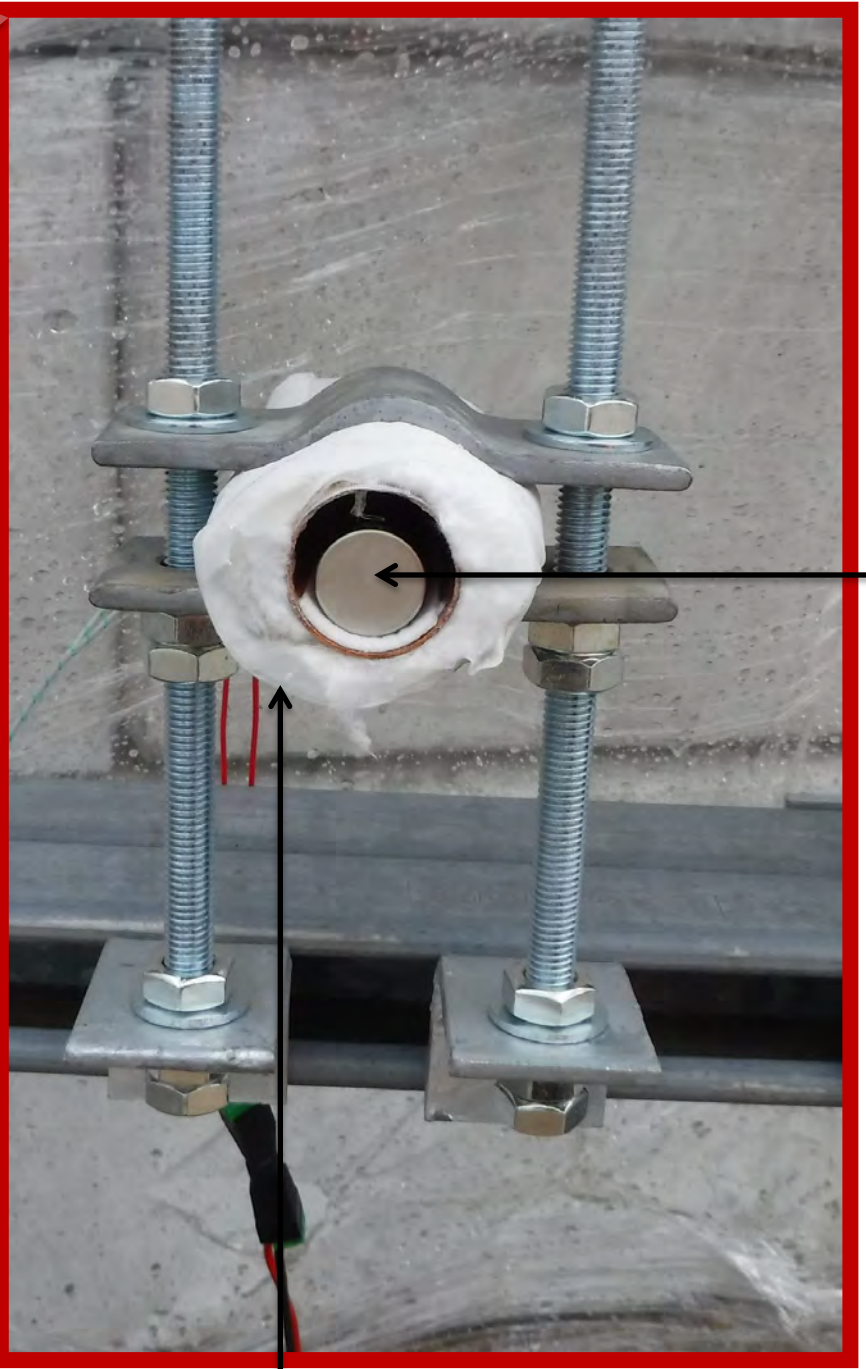
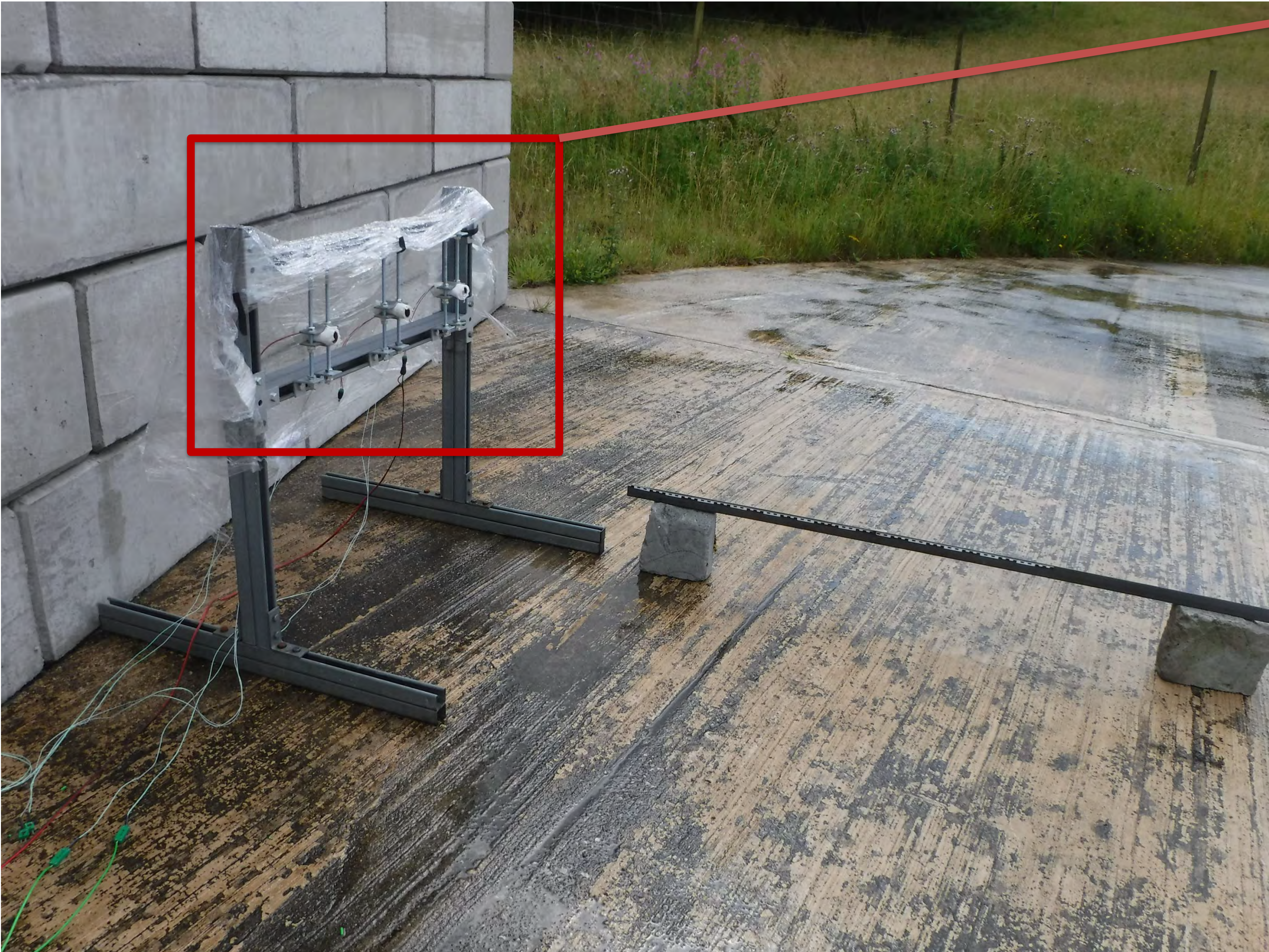
- $\approx 23 \text{ ms}^{-1}$ ($\approx 50 \text{ mph}$)
- Cell contents ejecting
- **Ruptured ?**

Projectiles – Cell Heated by Flame



But how far do they travel?

Projectiles – Cell Heated by Radiant Heater



Negative terminal of cell

Insulated capped copper tube

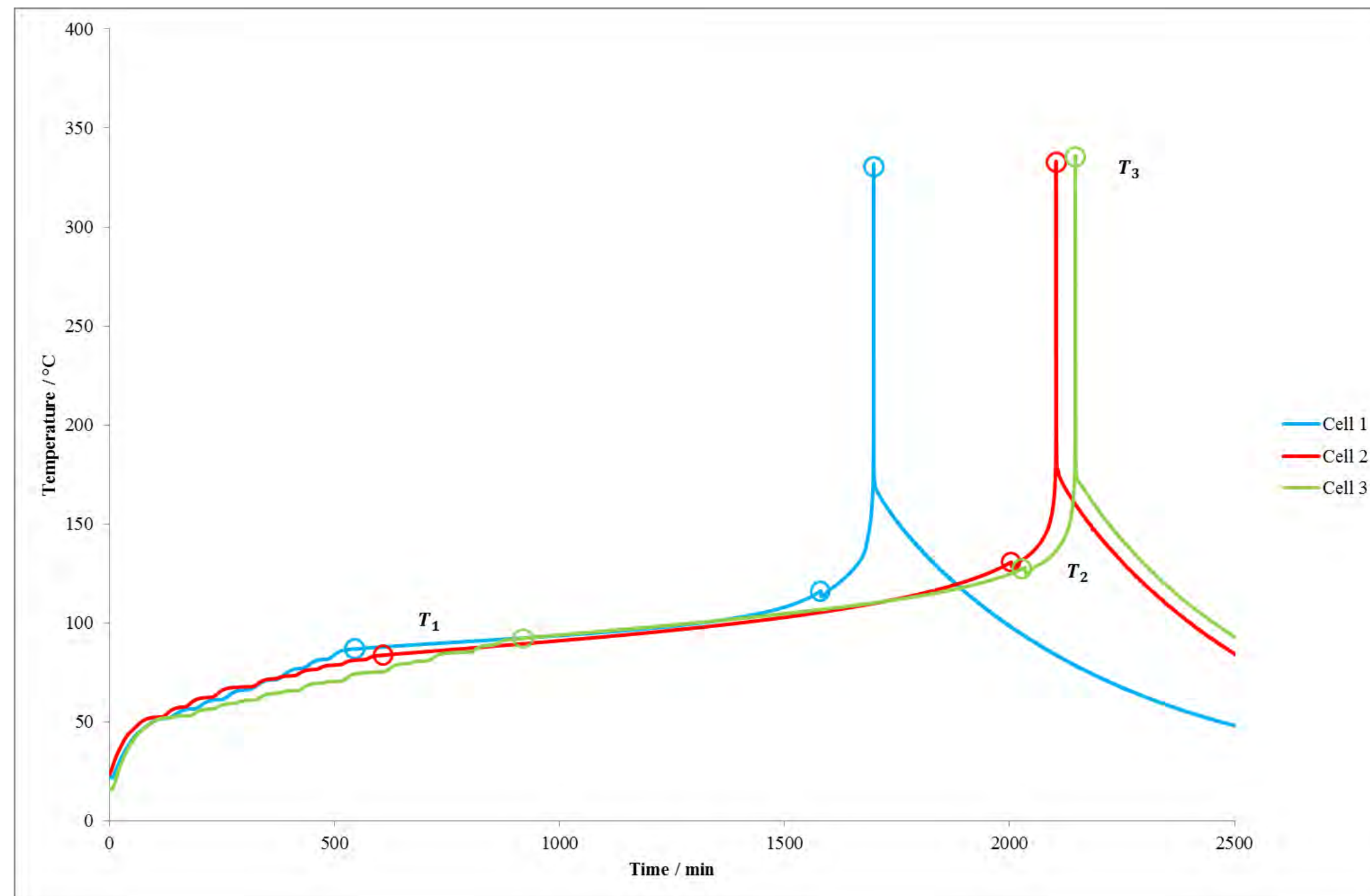
Projectiles – Cell Heated by Radiant Heater



37 m
62 ms⁻¹

Conclusions – ARC

- Comparable parameters



- But two cells ejected their contents



Cell 1



Cell 2



Cell 3

Conclusions – Downward Force

- Visual observations highlighted various failure modes



- Cells that ejected their contents resulted in a lower impulse measurement

Conclusions – Projectiles

- Failure mode depends upon heating method

Flame Heated

Can increase the likelihood of cell rupture



Radiant
Heated

Violent ejection of contents



But both methods cause cells to travel significant distances !

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Questions?

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