Experimental investigation into the influence of ignition location on flame spread and heat release rates.

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Outline.

- Objective.
- Background.
- Experimental Methods.
- Results.
- Conclusions.

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Objective-Aim.

- To perform systematic experiments that investigate the changes to the burning behaviour of PU foam slabs when only the ignition point is changed between tests.
- To further develop current data sets for future scaling and flame spread modelling tasks.

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Background.

Mitler and Tu[1] - brief study investigating the dependence of the burning behaviour of upholstered chairs on ignition location.

- ignition location can have a significant effect on the time to reach peak HRR, however no further analysis is given.

Robson, Torvi et. al.[4] and Ezinwa [5] Investigated the effects of thickness and ignition location on flame spread and heat release rates over polyurethane foam (FPUF) slabs.

- only 2 locations were chosen, many of the tested samples were of different proportions

Wang et. al.[6] Investigated the effects of ignition condition on polymer melt flow flammability

- concluding that the ignition location “impacted considerably nearly all the important fire parameters, including peak HRR, time to peak HRR, released heat, smoke temperature, CO concentration and the extinction coefficient” however this was in a vertical flame spread context.

Soderbom et. al.[7] investigated the effects of changing burner size

- concluded that there was little effect to the overall outcomes. However, no change in location.

Pau[8] performed some large-scale foam slab flame-spread tests using a line burner as the ignition source

- however the ignition location was kept static for these experiments.

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Experimental Methods.

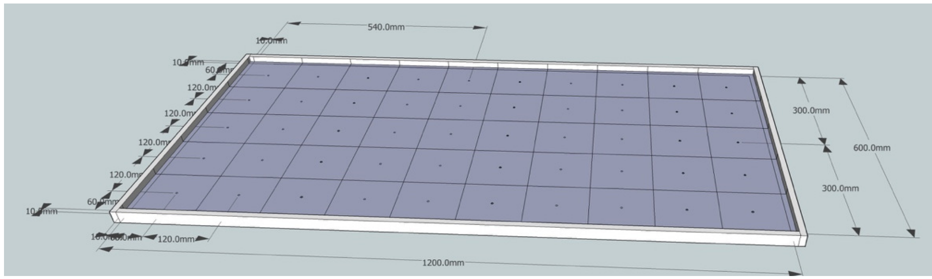
The material slabs.

- Flexible polyether polyurethane foam.
- Dimensions: 1200mm x 600mm x 50mm
- 21m3/kg as approximate density
- Non-fire retarded
- Well characterised material at lower experimental scales

Experimental Methods.

The measurement methods.

- HRR – OCC under ISO 24473 compliant hood
- Mass loss - Sartorius M-177 load cell
- Custom tray with 5x10 TC array



- Video recording

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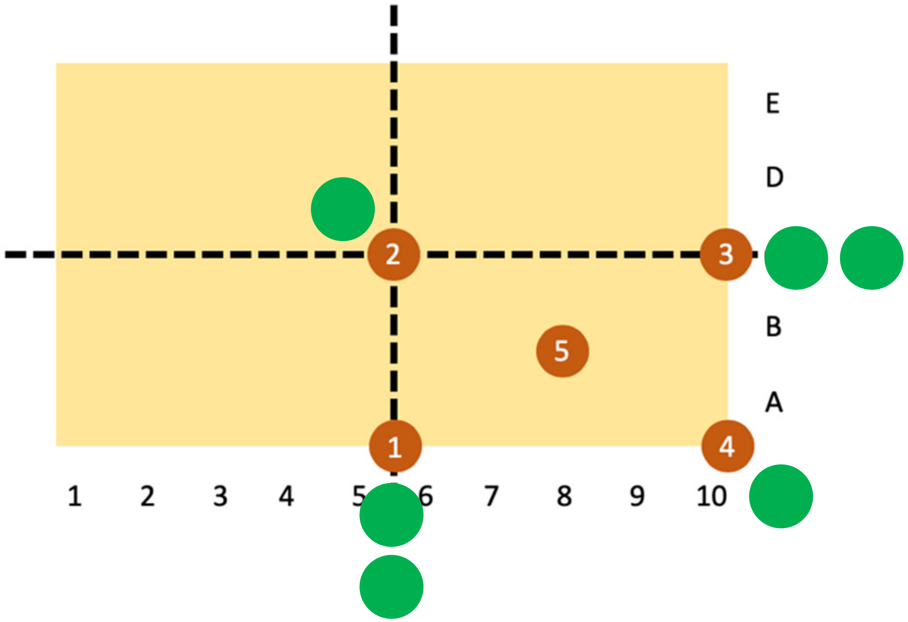
Experimental Methods.

Ignition locations.



Scenario	Ignition location ID
1	IL1
2	IL3
3	IL2
4	IL4
5	IL3
6	IL1
7	IL4
8	IL5
9	IL3
10	IL2
11	IL1

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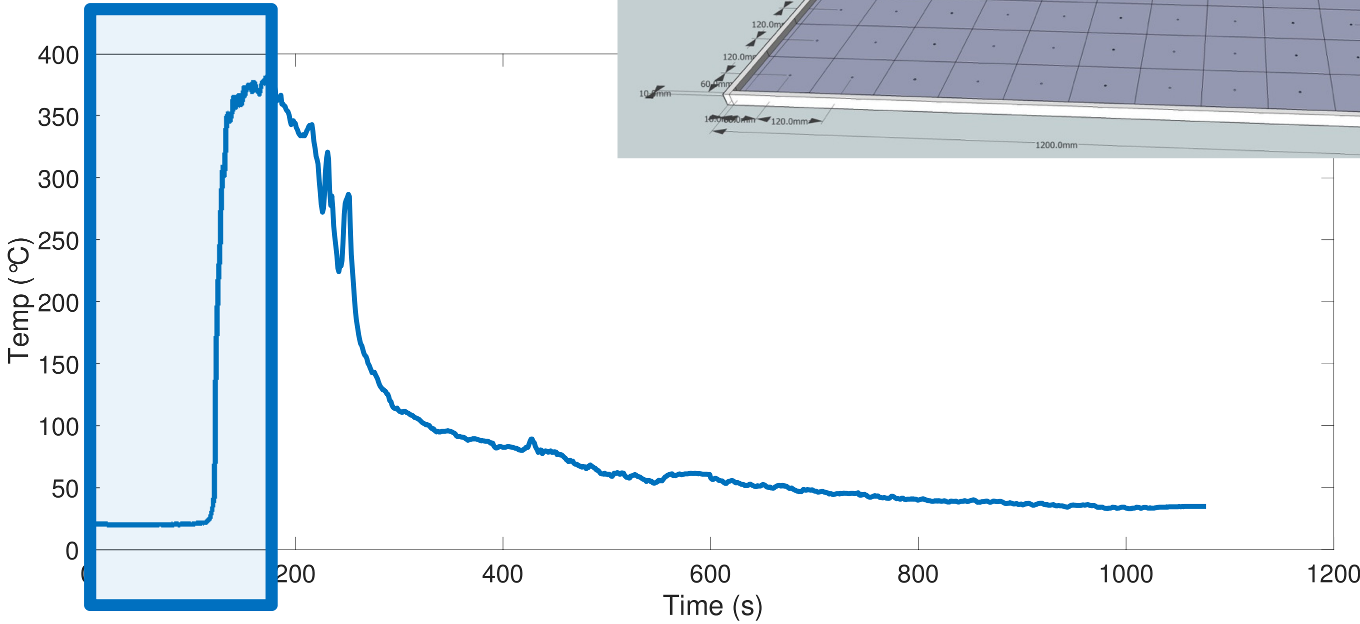
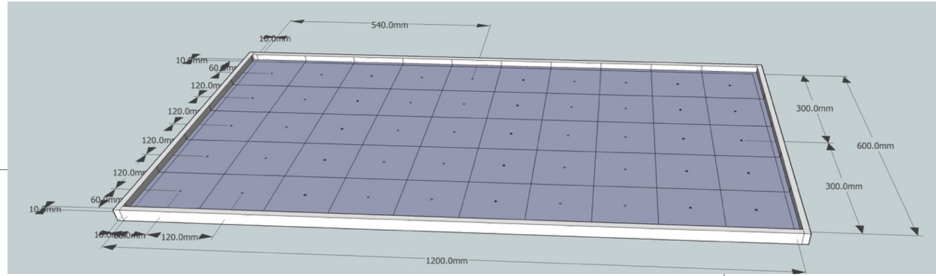
Experimental Methods.

The data analysis.

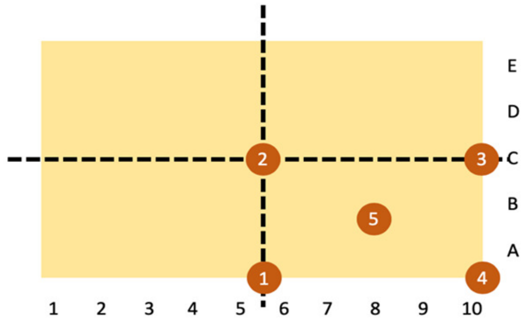


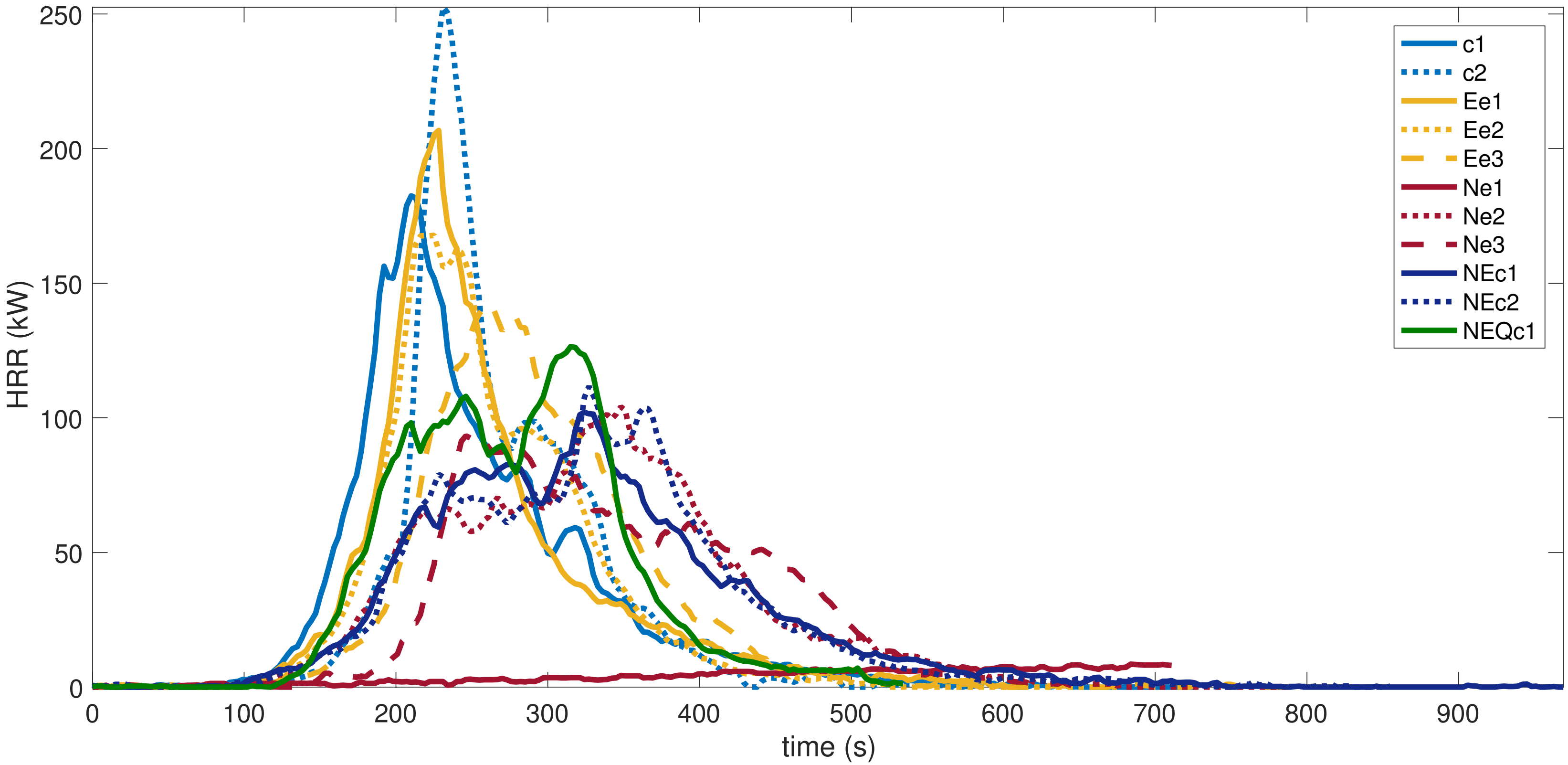


- The TC measurements were filtered/smoothed to dampen any noise that may interfere with the calculations.
- The derivatives were then calculated, and the maximum value from this data was then found within pre-peak region
- The time taken to reach this point was then determined.
- The distance between each TC position from the TC position closest to the ignition location (TCig) was also calculated for each scenario.
- The spread rate (in mm/s) at each TC location could then be determined

Results.

The Heat Release Rates.





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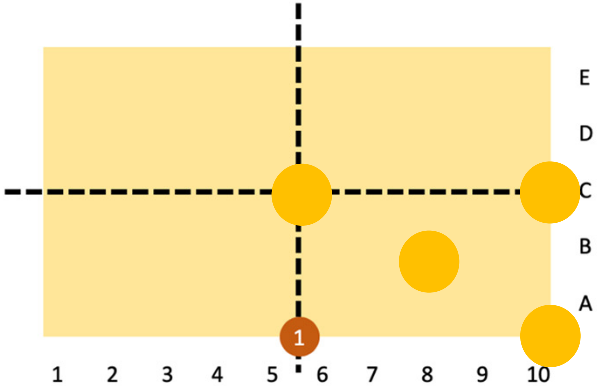
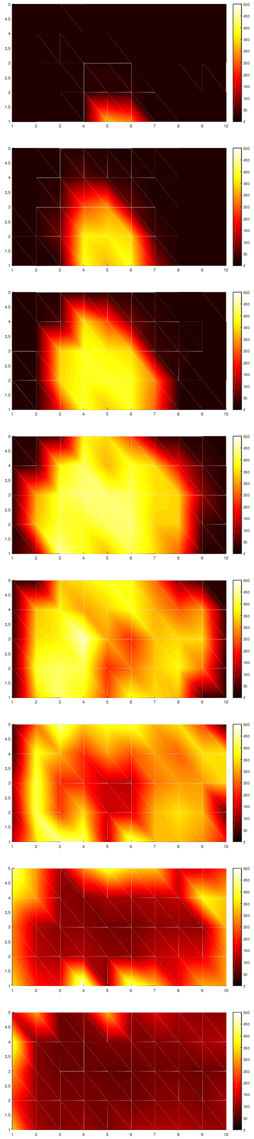
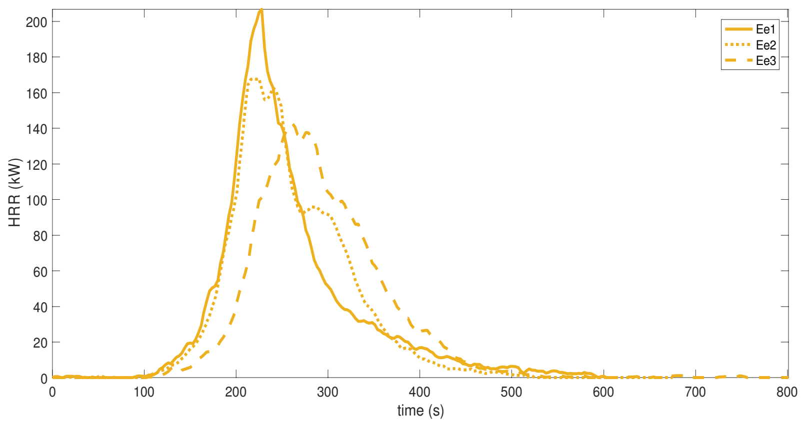
Results.

Flame spread.







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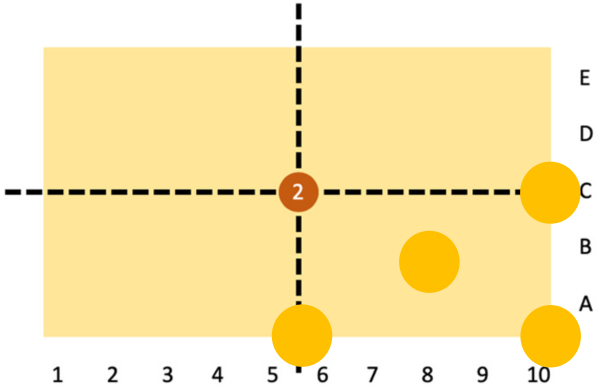

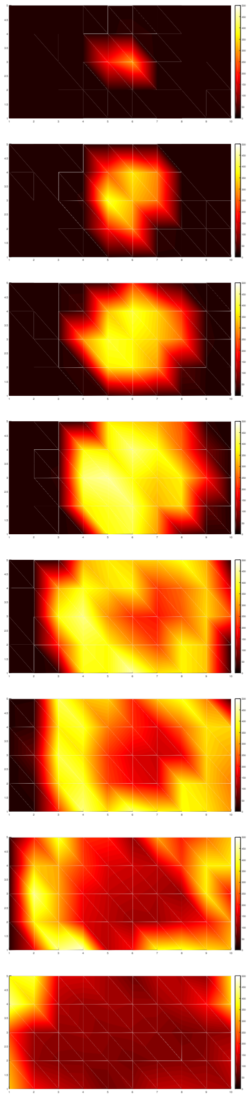

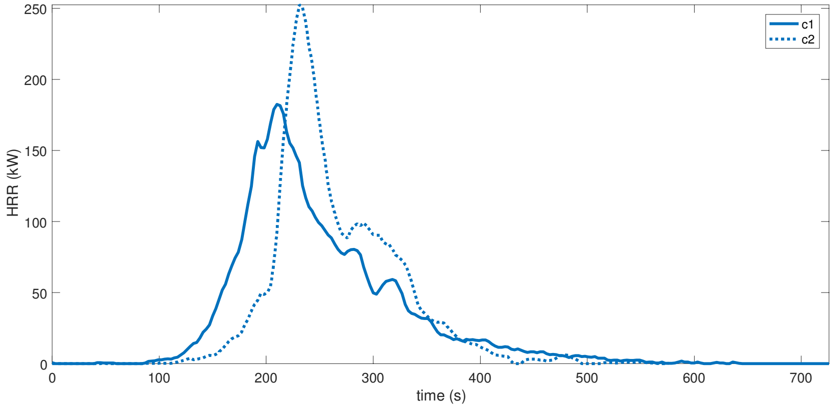

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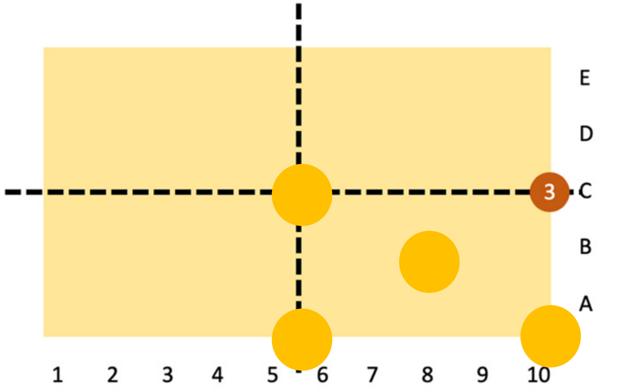

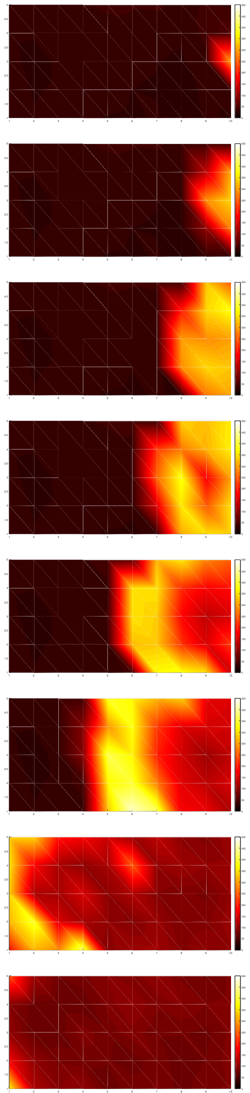

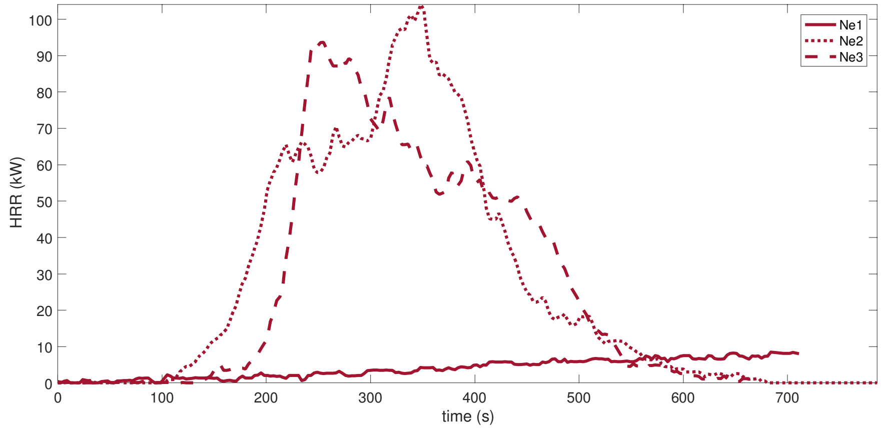

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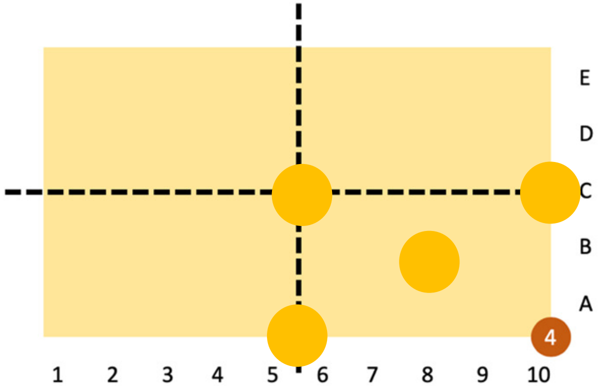

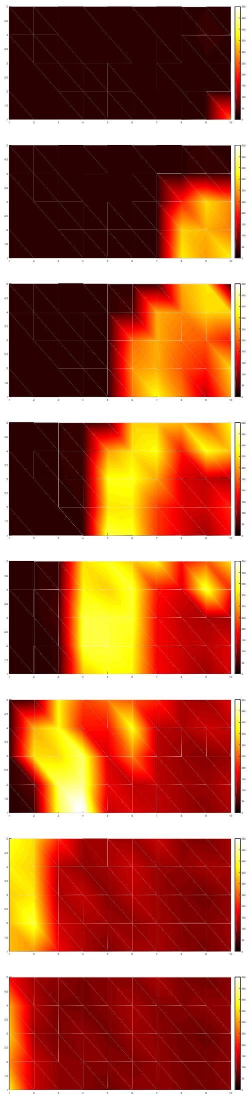

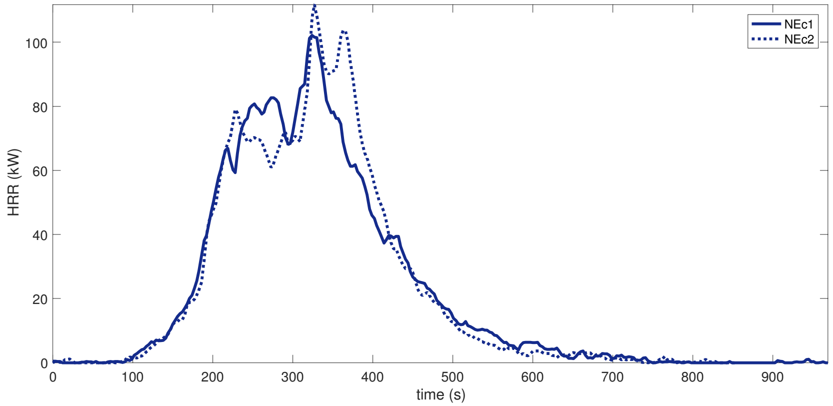

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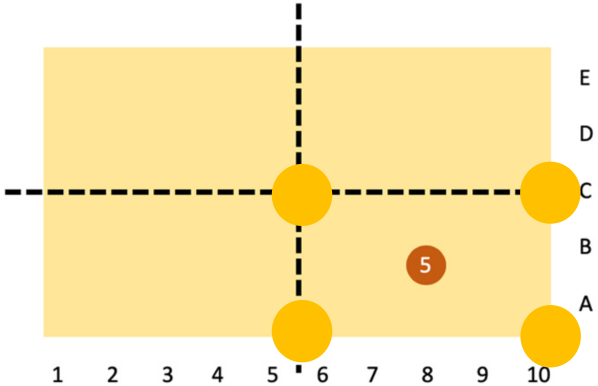

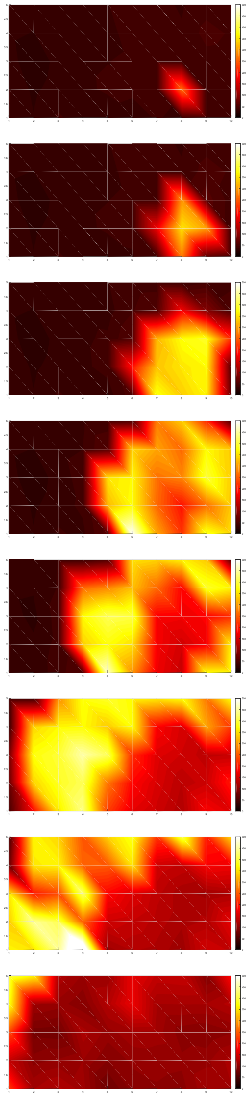

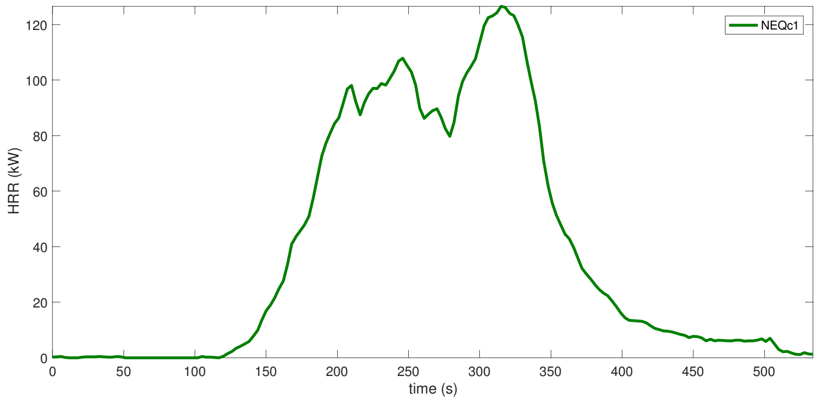

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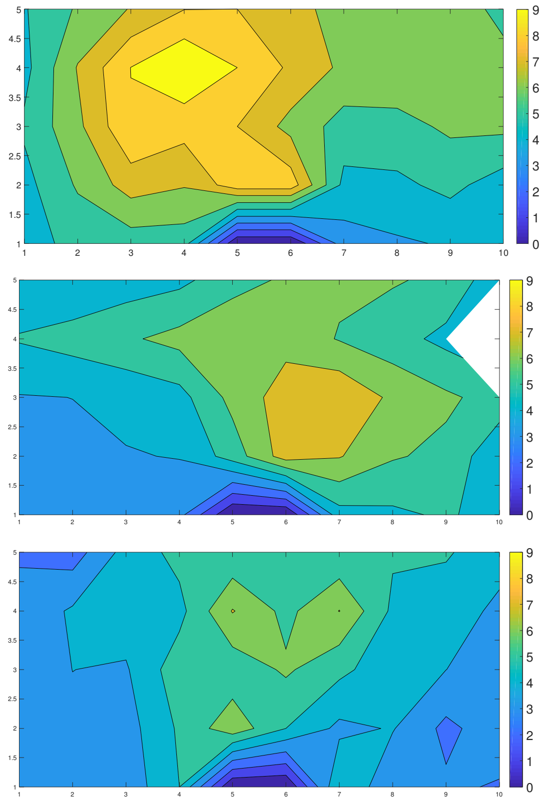

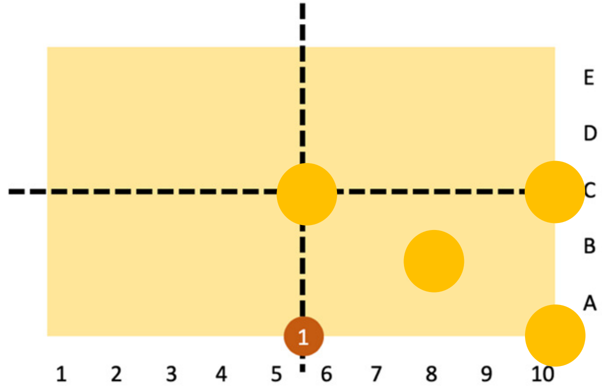

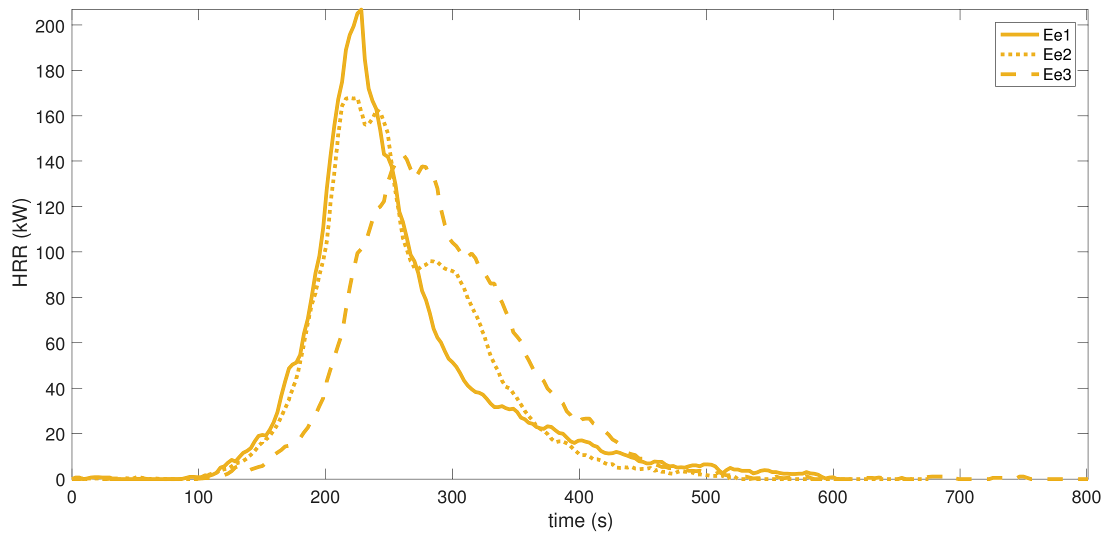

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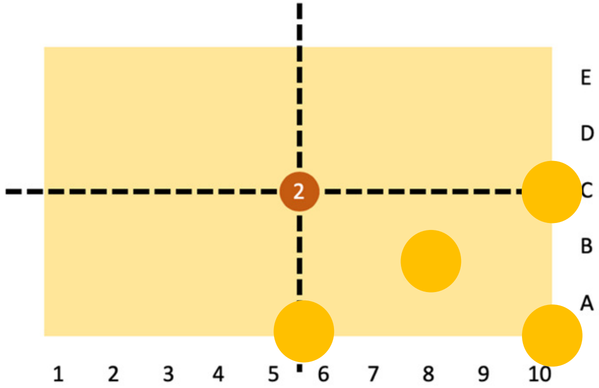
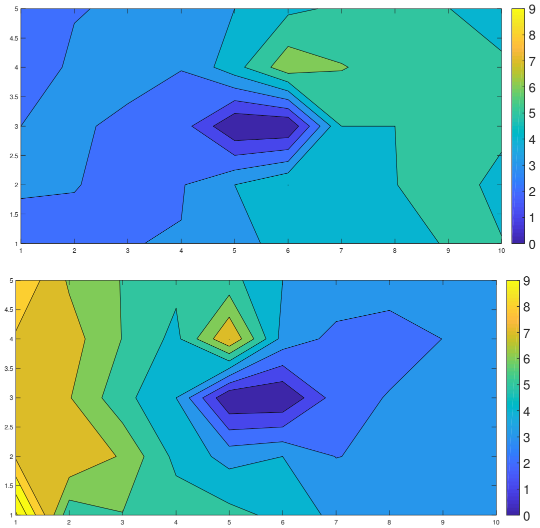
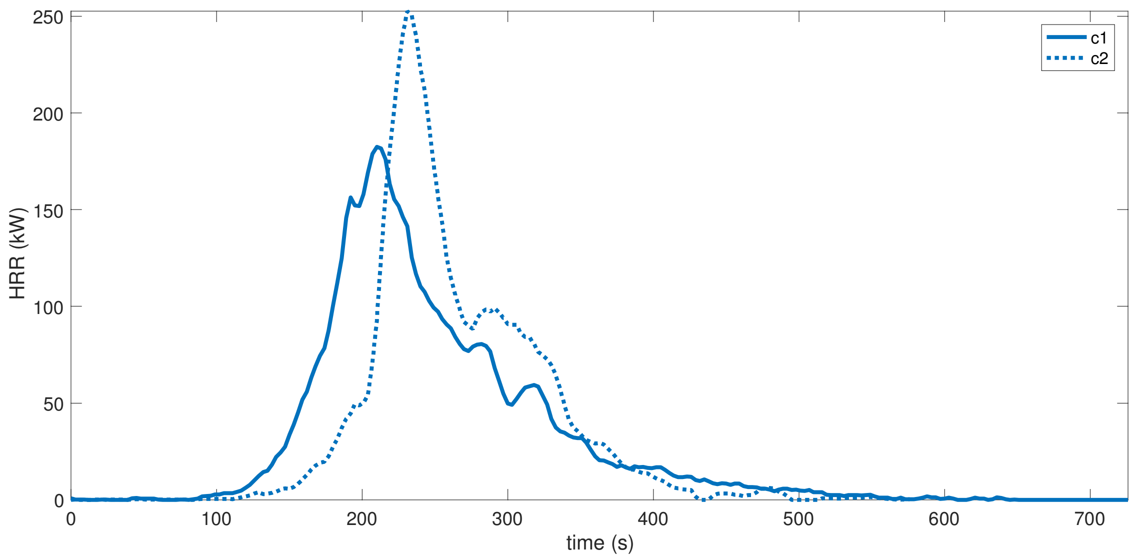
Results.

Flame spread.







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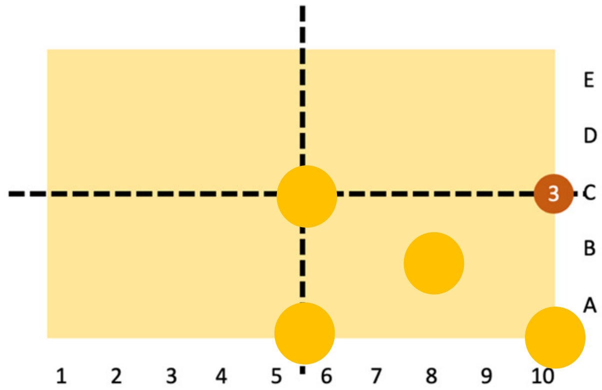

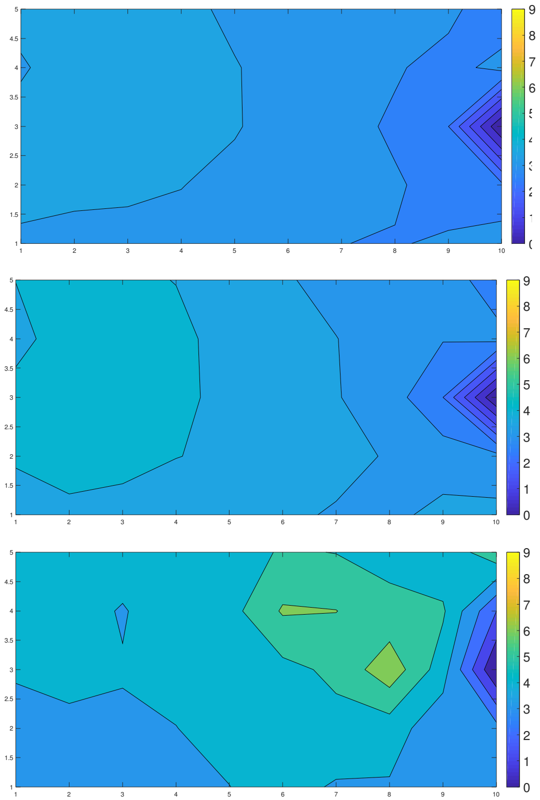

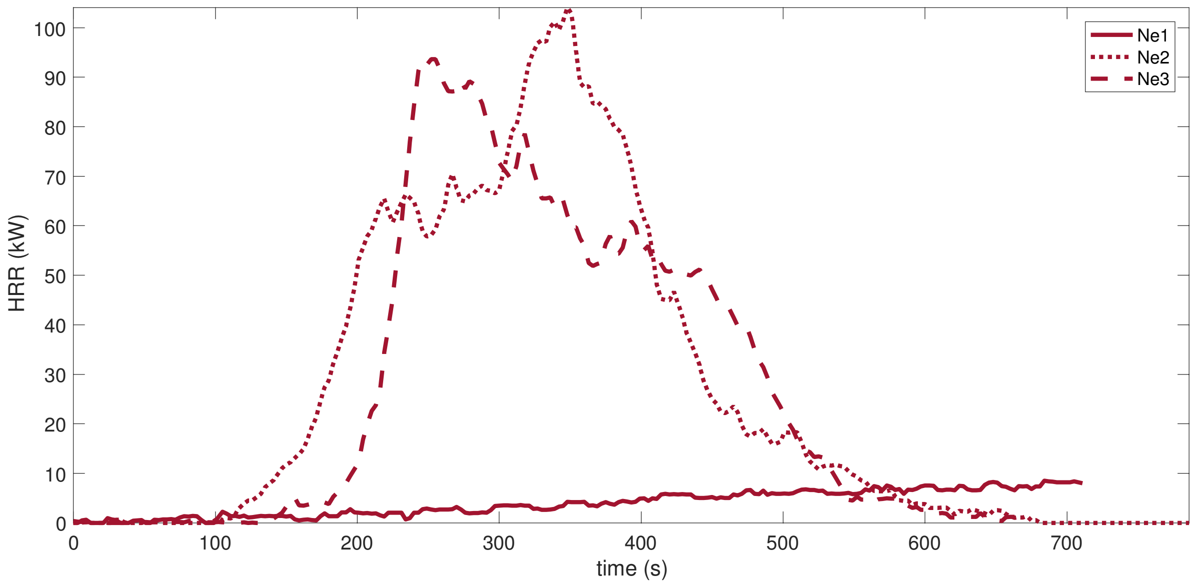

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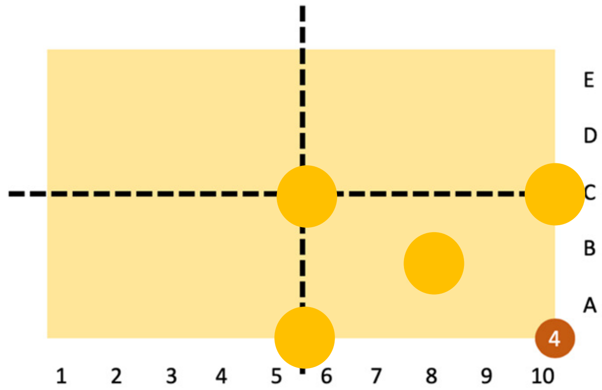

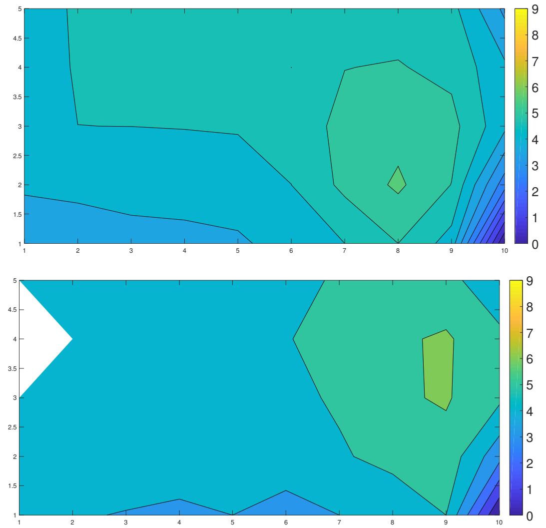

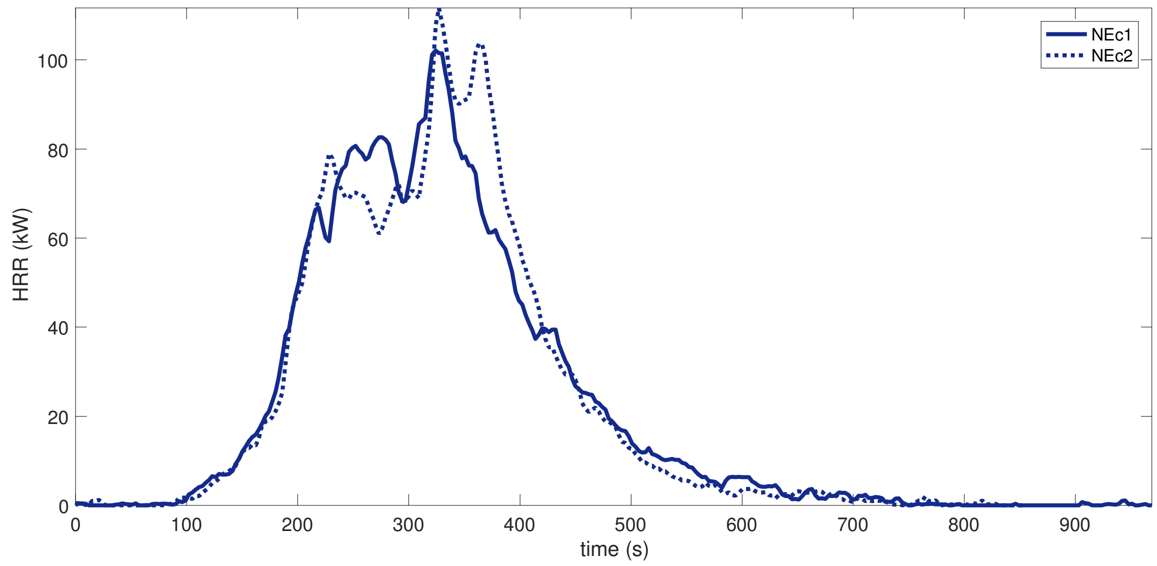

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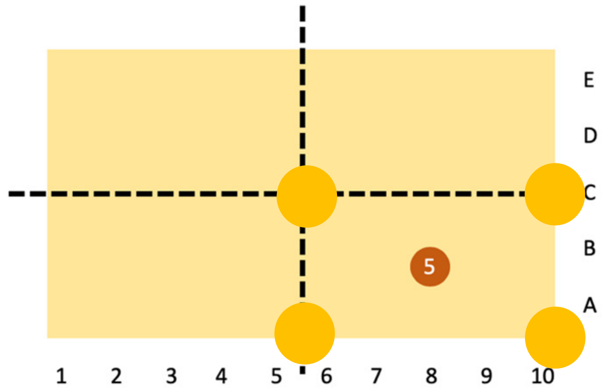

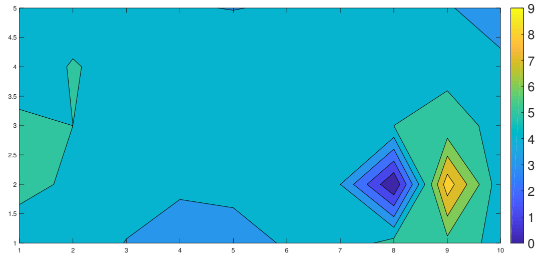

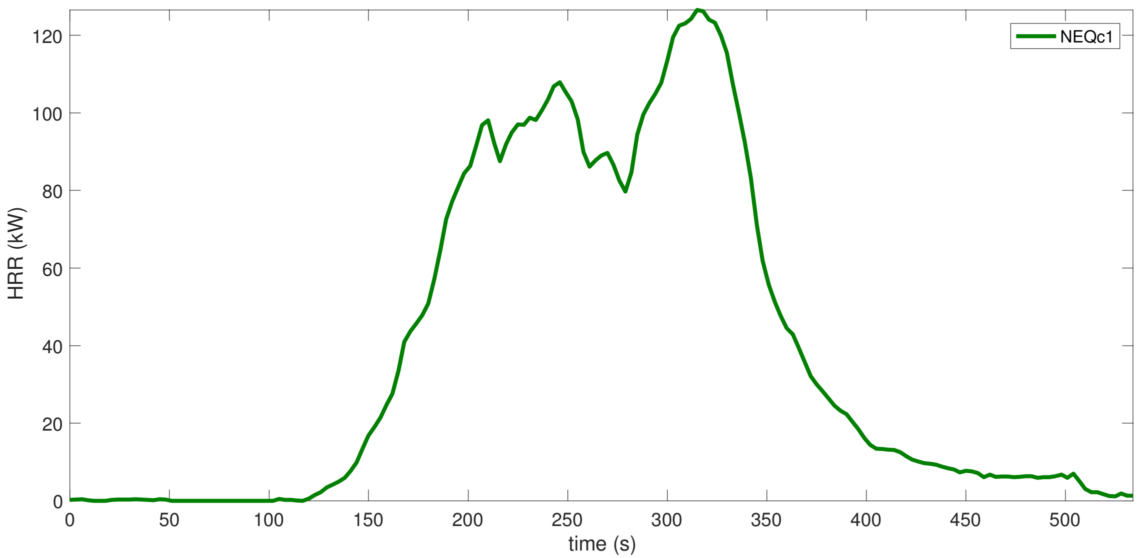

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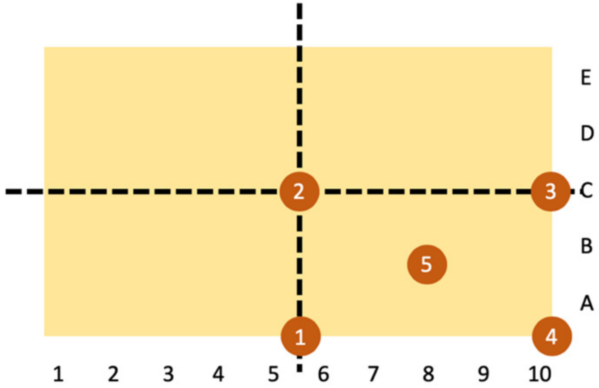

SCENARIO	Ignition Location (IL)	Mean Flame Spread rate (FSR) [mm/s]	Max FSR [mm/s]	Min FSR [mm/s]	FSR range [mm/s]
1	1	6.4161	9.9861	3.53	6.4561
2	3	3.307	3.7792	2.5	1.2792
3	2	4.1275	6.6667	2.5	4.1667
4	4	4.4964	5.5902	2.73	2.8602
5	3	3.6974	4.2857	2.5	1.7857
6	1	5.1289	7.892	3.333	4.559
7	4	4.772	6.1205	3.333	2.7875
8	5	4.5332	8.5714	3.2289	5.3425
9	3	4.2619	6.6667*	2	4.667
10	2	4.7586	11.1803*	2.5	8.6803
11	1	4.2273	7.0588	2.5	4.5588

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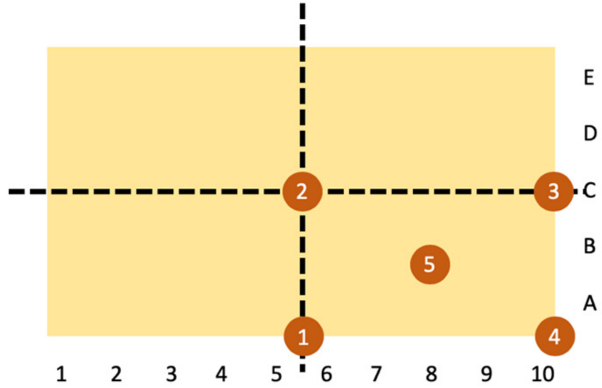
Conclusions.



Summary.

- 11 tests were performed.
- 5 different ignition locations tested.
- Clear differences between ignition locations – HRR and FSR
  - IL1 & 2 faster higher peak HRR and higher FSRs
  - IL3 & 4 lower peak HRR, more steady burning and lower FSRs
- pHRRs ranged from 100 - 250kW
- Mean FSRs ranged from 3 – 7mm/s
- Range of FSRs over slabs varied 1 – 8mm/s
- Max FSR 11mm/s, min FSR 2mm/s

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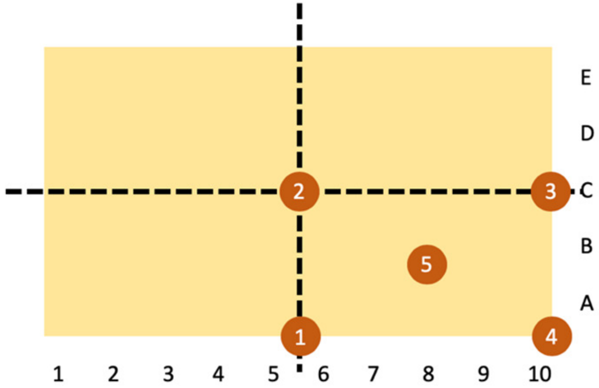
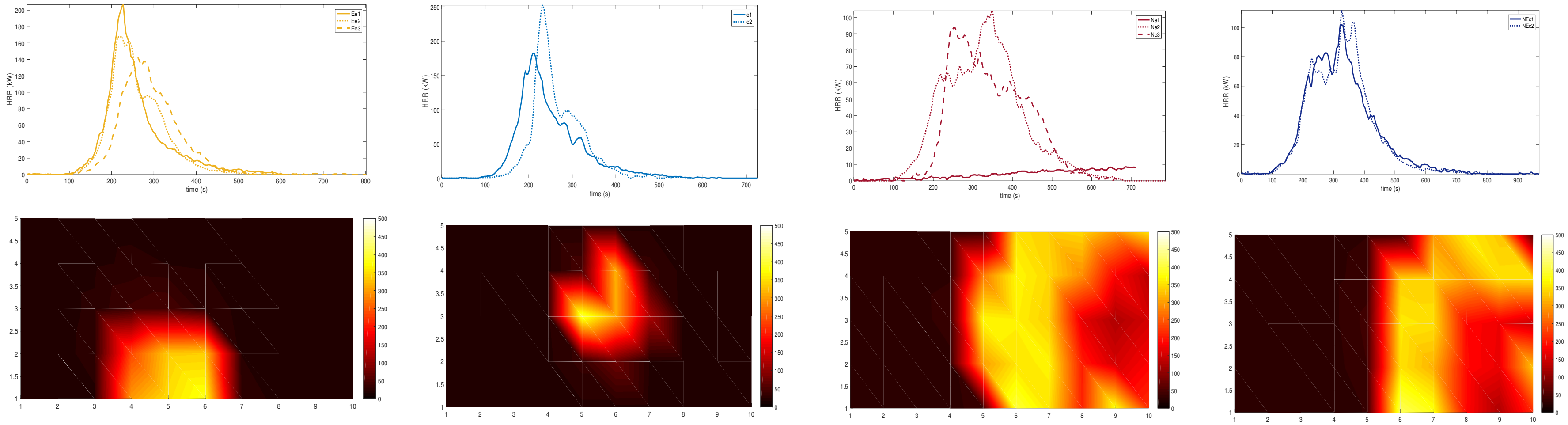
Conclusions.

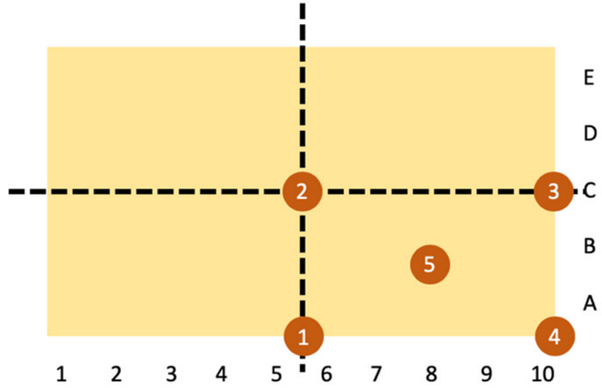
Looking deeper.



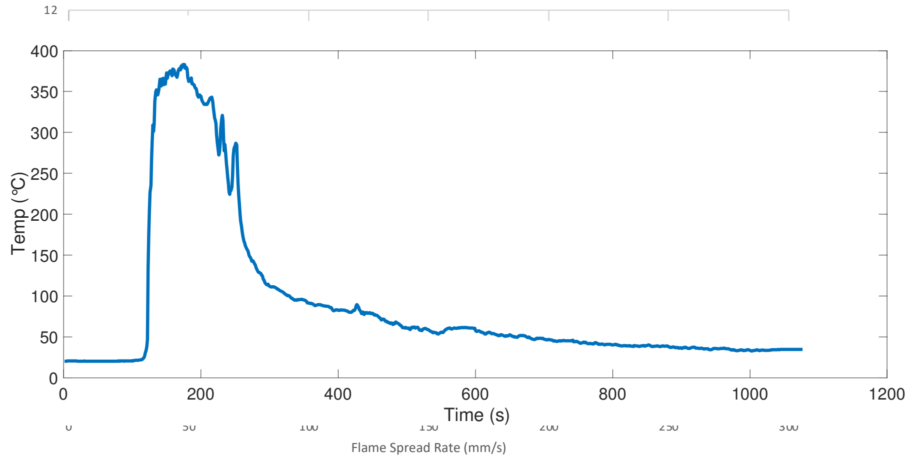


Conclusions.

Looking deeper.



- For twice repeated IL(1), a relationship between peak HRR and mean FSR was shown.
- This did not extend to the whole test series
  - Relationships may be scenario dependent
- It may also be possible to examine burnout rates and burning periods



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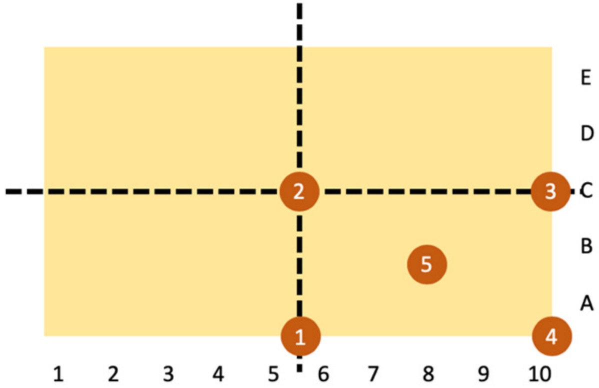
Conclusions.

Limitations.



- Repeatability was poor
  - Peak HRR values changed by 36% in worst case
  - FSR also varied in repeat tests
  - Greatest variation due to different/split testing periods
  - Variation was highest for IL 1 & 2
- Technique used for FSR will likely only work for materials similar to the flexible polyurethane foam used.
- Is it flame spread? Or structural collapse spread rate?

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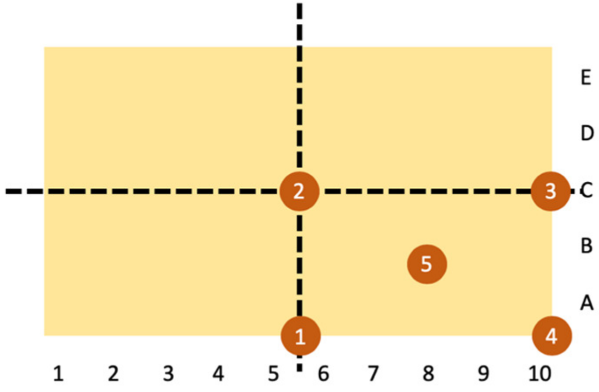
Conclusions.

Future.



- Part of a larger test series
  - Thickness
  - Influence of corner wall - combustible vs non-combustible
- Well defined material to model
  - MCC, TGA, DSC
  - Cone calorimeter
    - Raw foam at 3 different heat fluxes
    - Foam fabric combinations
  - Ad hoc – recession rate experiments
  - Modelling work at micro-scale, and cone levels and higher
- Geometry influence?

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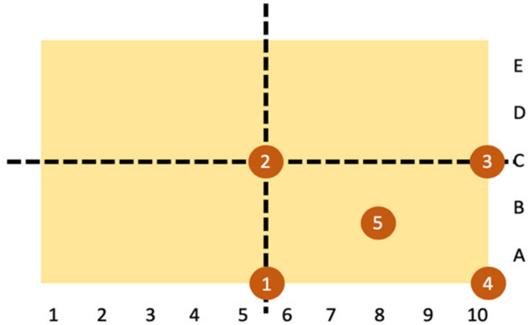
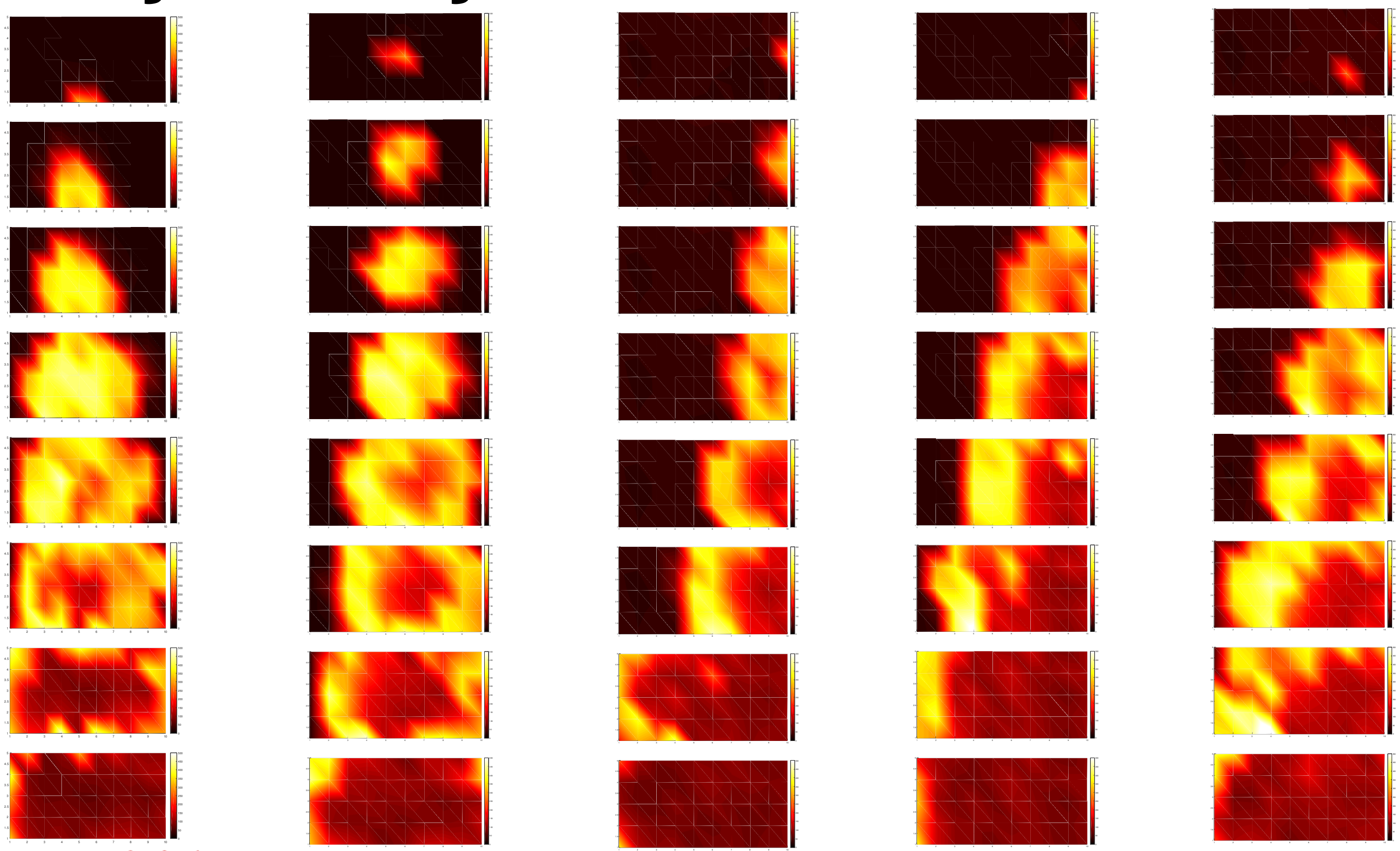
End.

Thank you for your attention.





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