

# SMALL-SCALE SINGLE BURNING ITEM FOR THE STUDY OF THE FIRE BEHAVIOR OF BUILDING MATERIALS

GDR FEUX 2021

Alexandre Gossiaux – 3<sup>rd</sup> PhD year

Supervisors : Sophie Duquesne & Séverine Bellayer  
ISP team / UMET (Lille)

By MS TEAMS – 01/07/2021

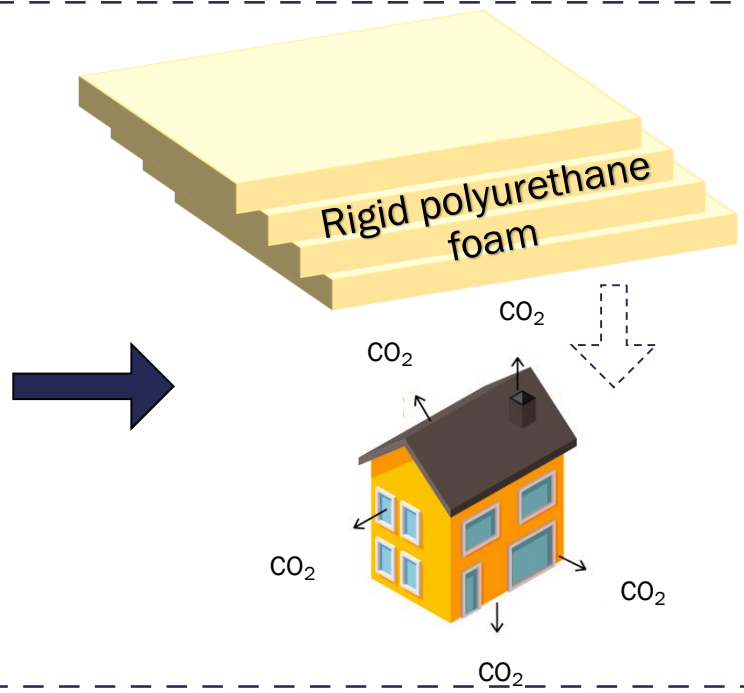


### Context

**BASF**  
We create chemistry

UMET  
Unité Matériaux Et Transformations

centrale lille  
ENSCL



### But...

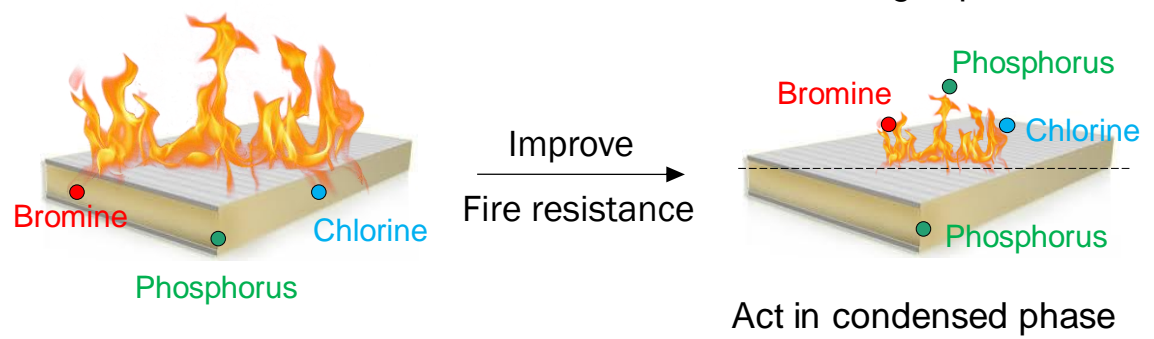


Effective insulating foam



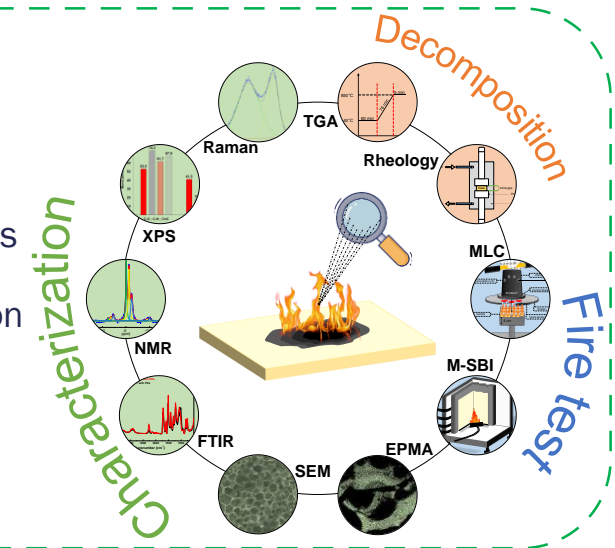
Extremely flammable

### Effect of flame retardants



### Objectives

- Fire behavior of the foams
- Influence of flame retardants
- Mechanism of decomposition
- Design of new effective foams and flame retardants

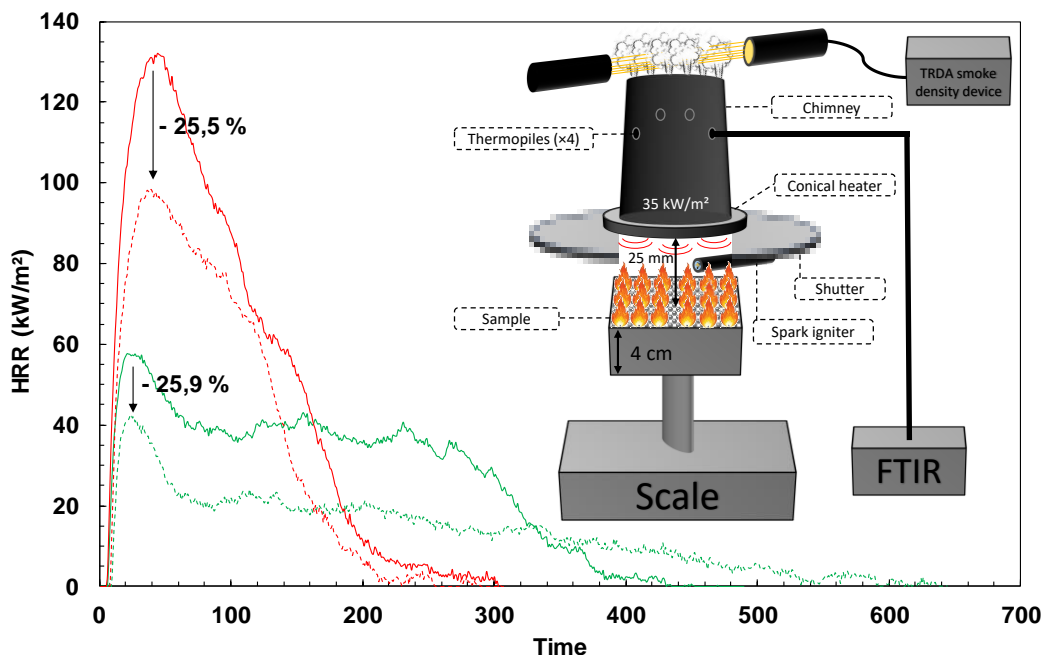


**Fire test**

**Mass loss calorimeter**

Standard: ISO13927

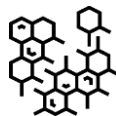
Thermopiles are placed in the chimney and are calibrated with methane



Heat release rate (HRR)



Smoke density

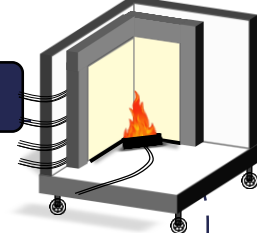


Gas phase



Traditional approach

**Single burning item**



Standard: EN 13823

- Product compliance
- Costly
- High sample size
- More difficult test maintenance
- Non-removable
- Limited versatility

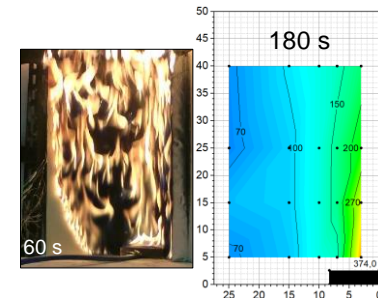


**Downscaling by 3**

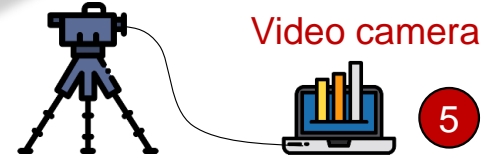
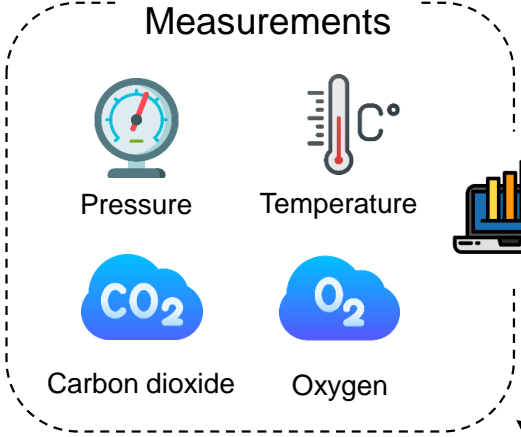


- Research and development
- Less costly
- Possibility to modify

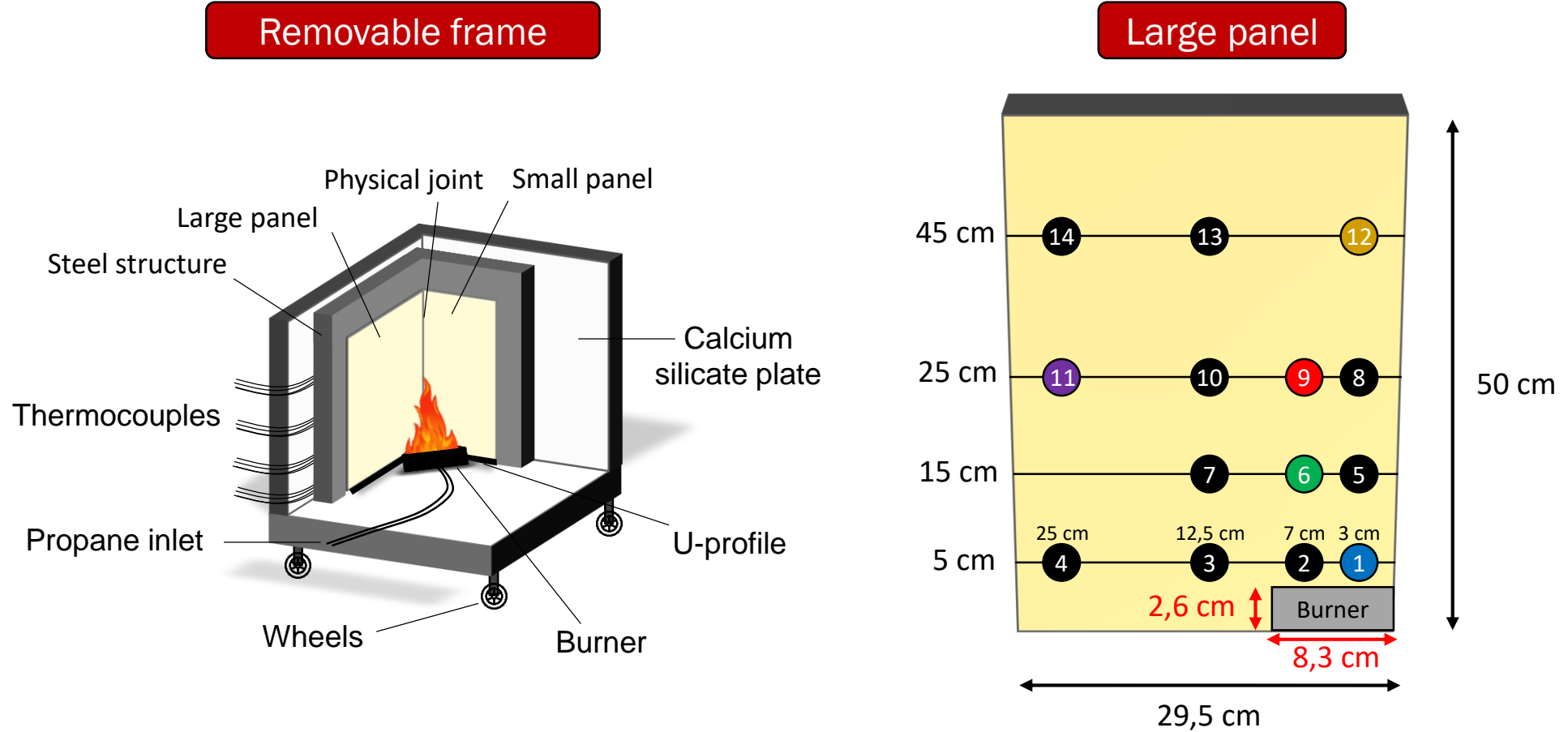
Recorded data



# Setting

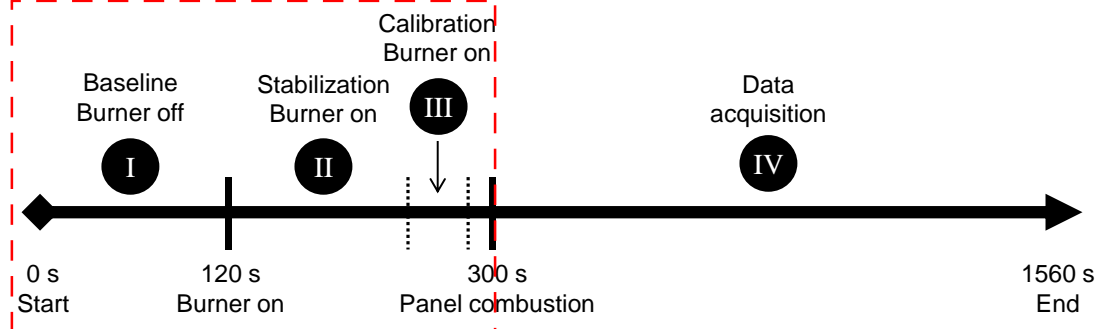


## Dimension of the test

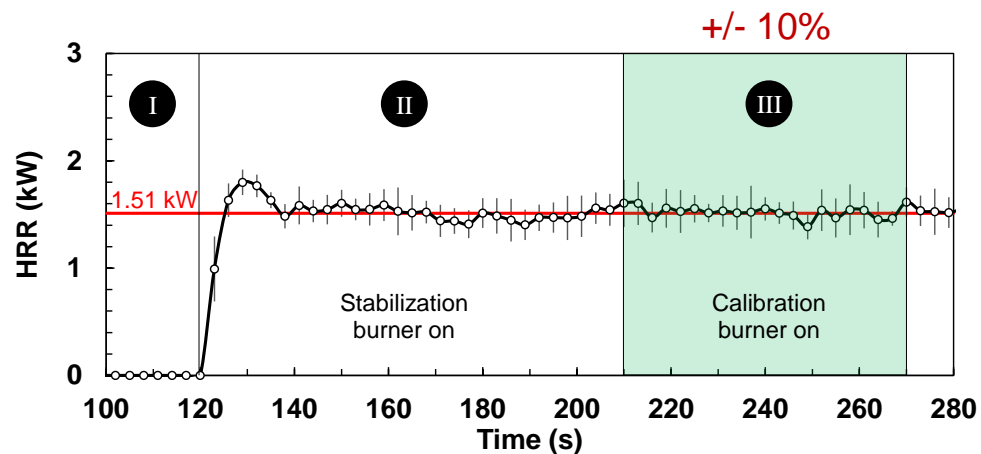


- The size of the structure and the size of the samples were reduced by 3
- The burner power has been reduced from 30.7 kW to 1.51 kW

## Acquisition procedure



### Heat – Burner calibration



$$HRR(t) = E \cdot V_{298K}(t) \cdot x_{a_{O_2}} \cdot \left( \frac{\Phi(t)}{1 + 0.105\Phi(t)} \right)$$

HRR (t): heat release rate (kW)

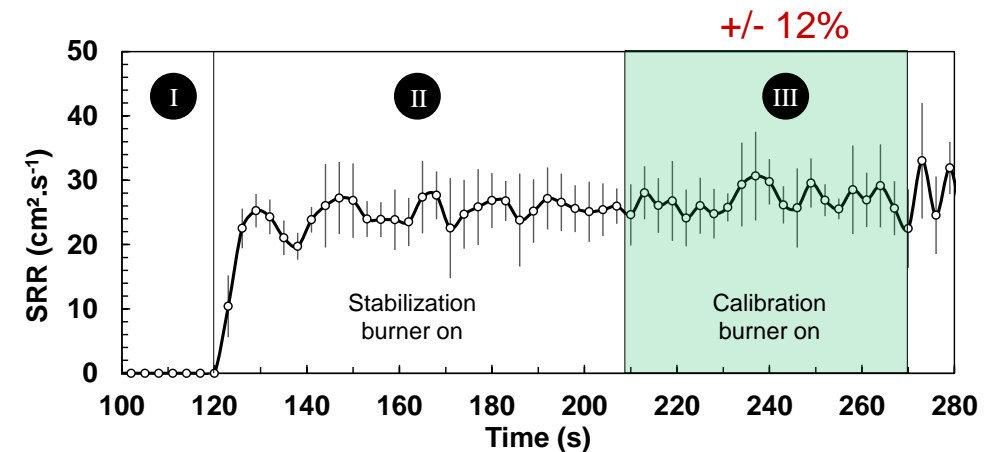
E: energy released per volume of oxygen consumed at 298 K = 17200 kJ·m<sup>-2</sup>

V<sub>298K</sub> (t): normalized extraction flow at 298 K (m<sup>3</sup>·s<sup>-1</sup>)

x<sub>a<sub>O<sub>2</sub></sub>: volume concentration of oxygen in ambient air, including water vapour</sub>

Φ (t): oxygen consumption factor

### Smoke – Burner calibration



$$SRR(t) = \frac{V(t)}{L} \cdot \ln \left[ \frac{\bar{I}_{30s \text{ to } 90s}}{I(t)} \right]$$

SRR (t): smoke release rate (m<sup>2</sup>·s<sup>-1</sup>)

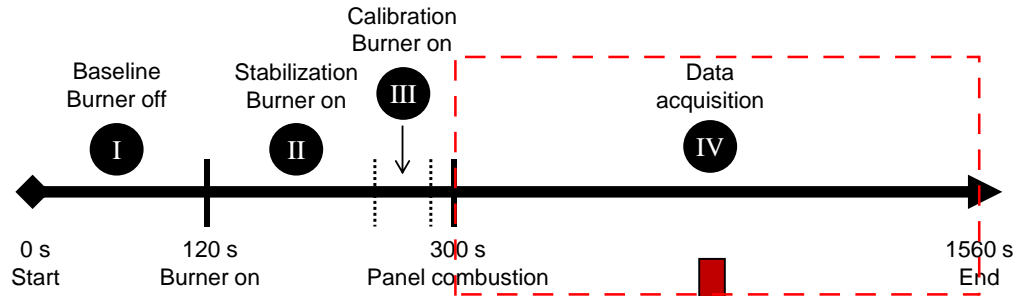
V (t): non-normalized extraction flow

L: length of the light path through the general measuring tube = 0.153 m

I<sub>(30 s to 90 s)</sub>: average value from 30 s to 90 s of the light transmission (%)

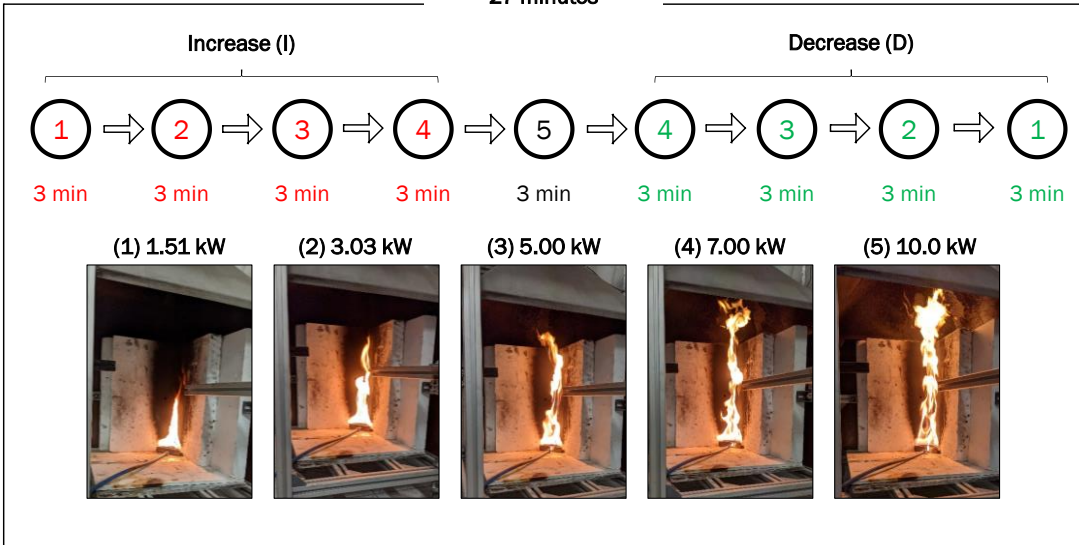
I (t): opacimeter output signal (%)

# Simulation of a combustion

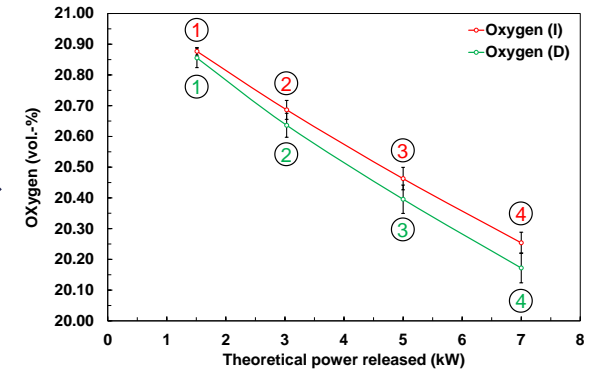


2 series

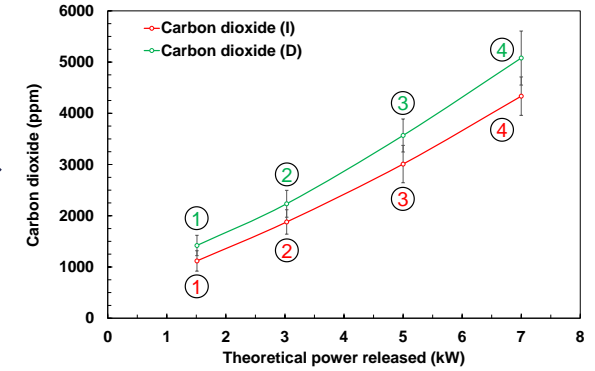
27 minutes



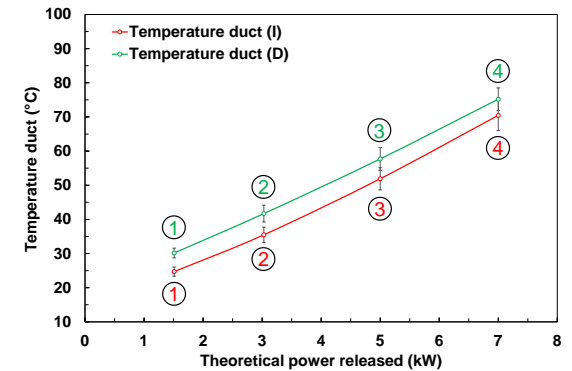
## Oxygen



## Carbon dioxide



## Temperature



Data acquisition

## Application to a case study

No FRs

PUR no FRs  
(Foam 2)

FRs

PUR with FRs  
(Foam 2)

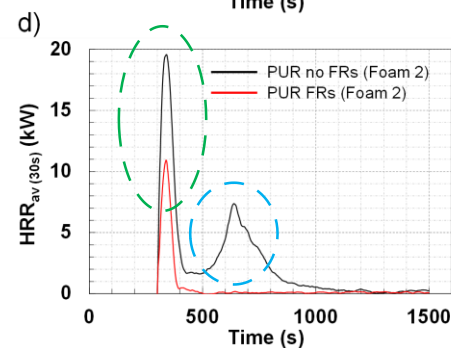
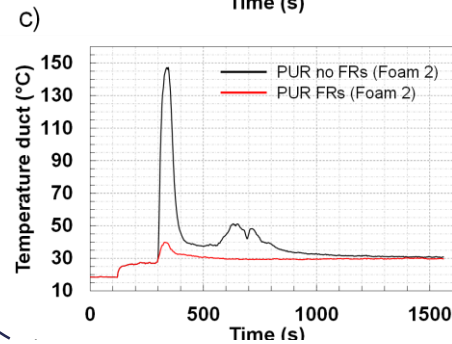
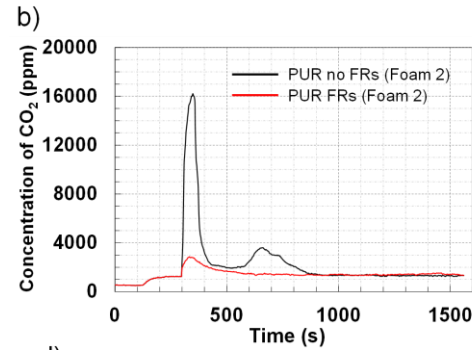
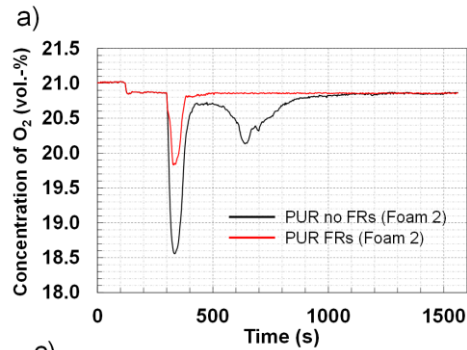
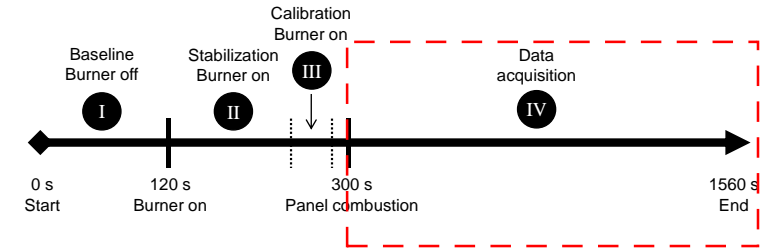
310 s

330 s

360 s

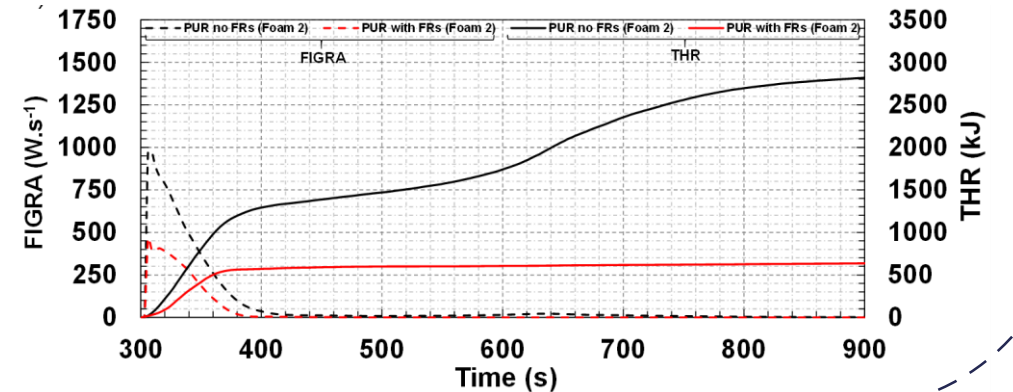
638 s

1560 s



Effective discrimination

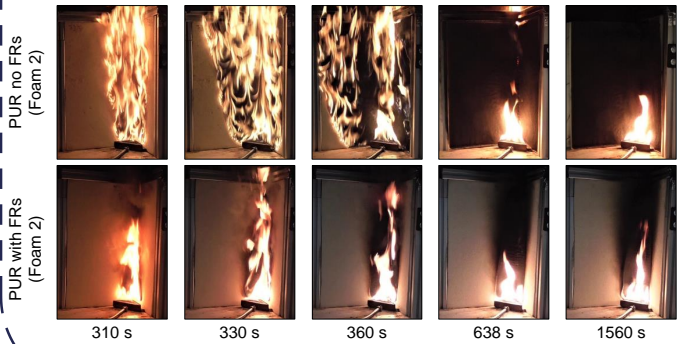
System	$\text{pHRR}_{\text{av}(30\text{ s})}$ (kW)	$\text{THR}_{600\text{ s}}$ (kJ)	$\text{FIGRA}_{0.01\text{ MJ}}$ ( $\text{W}\cdot\text{s}^{-1}$ )	Lateral propagation (cm)
PUR no FRs	19.6	2818	975	29.5 (100.0%)
PUR FRs	10.9	636	460	9.8 (33.2%)



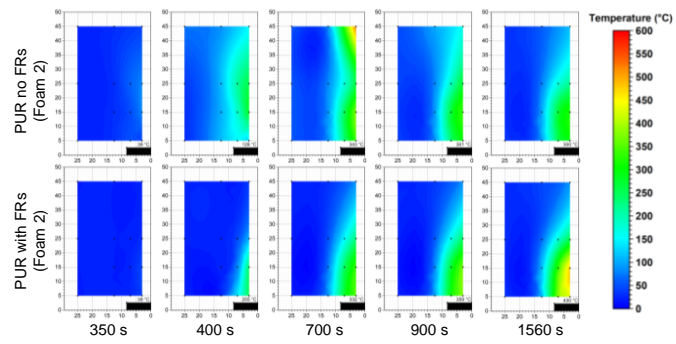


## Additional sensors

### Video camera



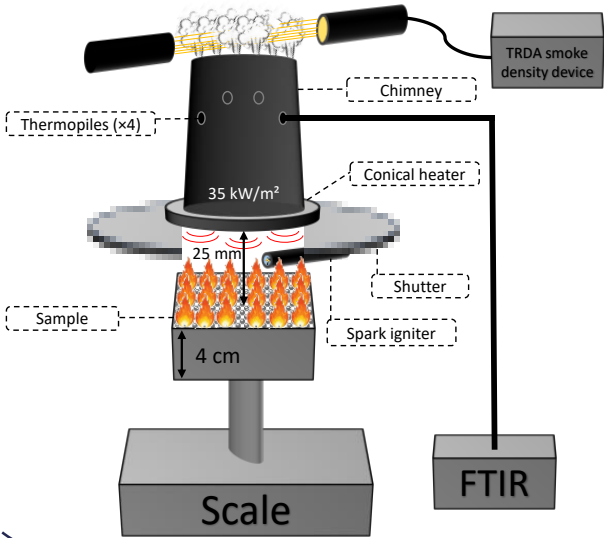
### Thermocouples



## Improvements

- Variation of the power delivered by the burner
- Size of the samples
- Time of acquisition data
- Infrared thermal camera
- Scale under the frame
- Gas analyzer

## Comparison with MLC test



Test	Parameter	PUR no FRs	PUR FRs
MLC (35kW/m <sup>2</sup> )	pHRR (kW.m <sup>-2</sup> )	152	125
	THR (MJ.m <sup>-2</sup> )	17.8	15.2
	Smoke (u.a)	4533	5313
M-SBI	pHRR <sub>av(30 s)</sub> (kW)	19.6	10.9
	THR <sub>600s</sub> (kJ)	2818	636
	TSP <sub>600s</sub> (m <sup>2</sup> )	25.4	31.4



- Complementary test
- Lateral flame propagation taken into account

## Conclusion

- A new reduced scale bench test based on the standard SBI (EN138323) has been developed for research and development purposes
- Discriminates well the effect of flame retardants on this kind of material
  - The test is highly versatile
  - Correlation with SBI → In progress

Thank you for your attention

GDR FEUX 2021

Alexandre Gossiaux – 3<sup>rd</sup> PhD year

Supervisors : Sophie Duquesne & Séverine Bellayer  
ISP team / UMET (Lille)

By MS TEAMS – 01/07/2021

