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.......SMOKE.....

Cooling and / or Inertisation ?

Research questions

Literature study

Experiments: scale model

Labscale experiments

Smoke explosions / Fire gas ignitions

Smoke dispersion

Smoke cooling or surface cooling?

Planned: Real scale experiments

PREVIEW

IFIW 2019 Arnhem
Ricardo Weewer, professor Fire Service Science
the Netherlands Fire Service Academy

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.......SMOKE.....
Cooling and / or Inertisation ?
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2013
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Labscale experiments
Smoke explosions /
Fire gas ignitions
Helmond 2015
IJmuiden 2016
Leiden 2005
Obdam 2015
De Punt 2008
Den Haag 2011
Woerden 2016
Smoke cooling or surface cooling?
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Smoke dispersion
TRENDS OM
VAN TE LEREN
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Smoke explosions / Fire gas ignitions

Smoke explosions / Fire gas ignitions

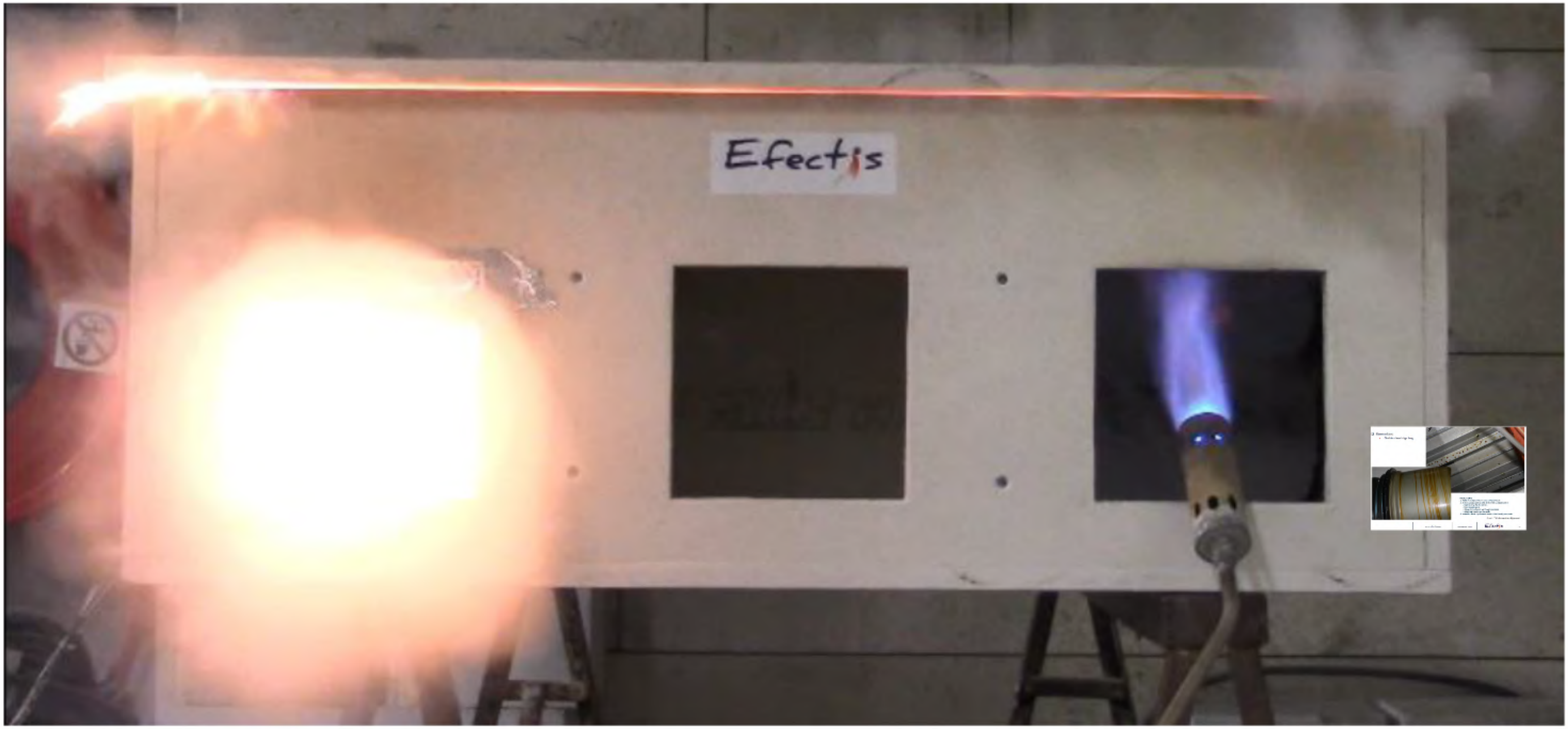
What do we want to know?

- **What causes smoke explosions?**
- **(How) can we recognize / predict them**
- **What can we do to prevent them / stay safe**

Obdam 2

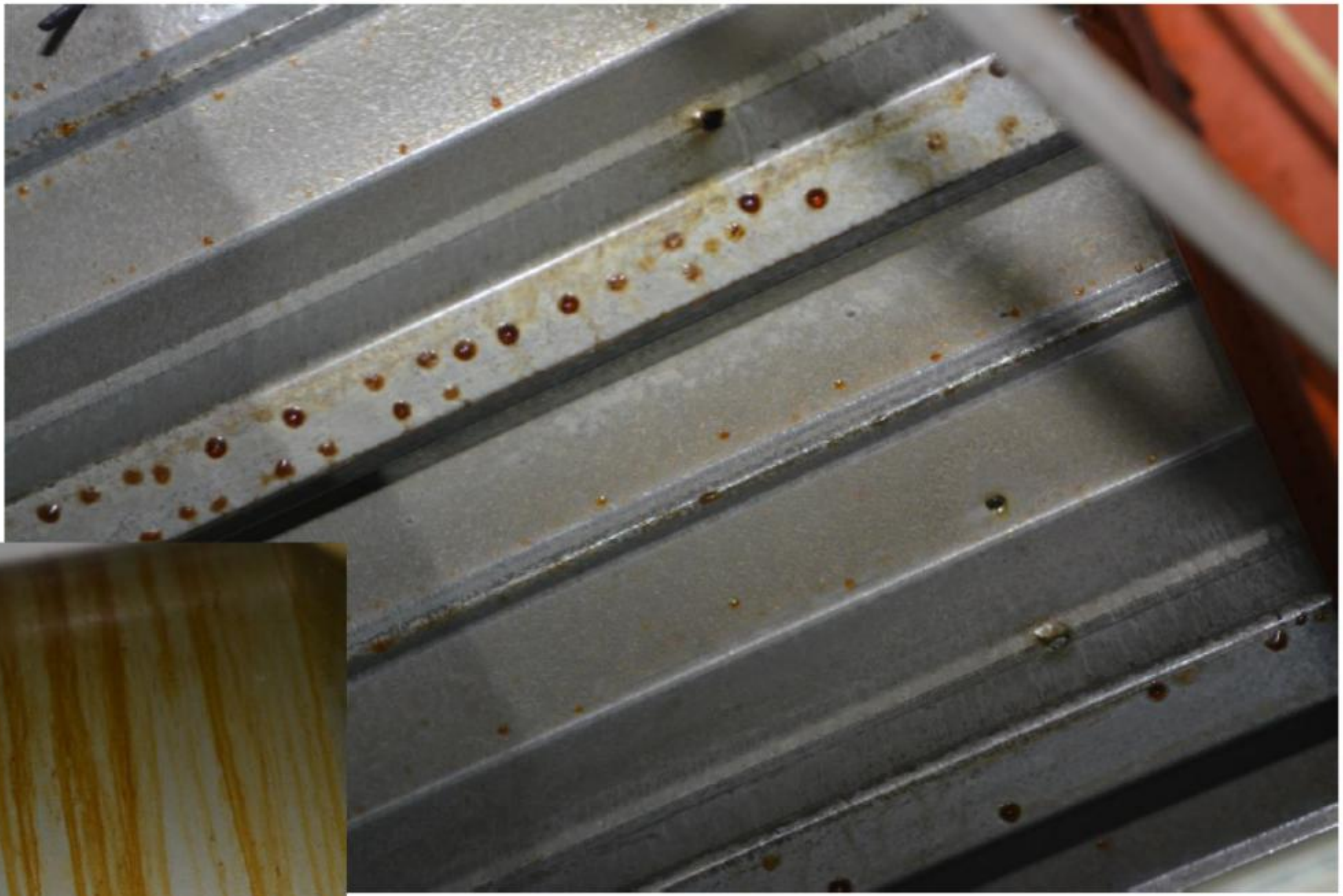

Establishing flammability ranges of building insulation materials
Graduation study
Fire Behavior Of Sandwich Panel Core Materials In The Pre-flashover Phase
Indicative research
Fire behavior of synthetic insulation materials in building constructions
Literature study
THESIS
BUILDING
TECHNOLOGY
SAFETY DURING AN INTERVENTION OF THE FIRE SERVICE |
An experimental research to the influence of pressure build-up on the pane behaviour during fire in well insulated dwellings.
luiver BSc
RANDWEER
TU/e
Giunta d'Albani
luiver BSc
BRANDWEER
TU/e
Technische Universiteit Eindhoven University of Technology


Rookgasexplosies
De invloed van bitumen dakbedekking en dakisolatiematerialen.
University of Applied Sciences
SAXION
Cindy Veerman
Crime Science



Figuur 15. Simulatie rookgasexplosie EPS 600-650 ℃ met ontstekingsbron

- Kenmerken:
  - Gladde olieachtige laag



INDICATORS

1. Fully developed fire in one compartment

2. In the compartment next to the fire compartment:

- light yelow /white smoke

- low temperature

- slippery sediment on floors and wals

- dripping tracks on the walls

3. Outside: white / yellowish smoke that hardly ascends

Foto's TBO Rotterdam-Rijnmond

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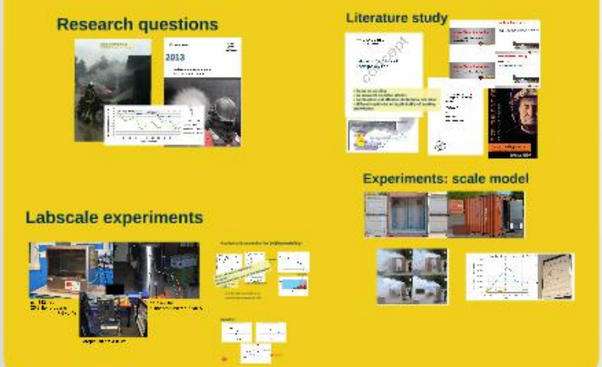

Smoke explosions / Fire gas ignitions

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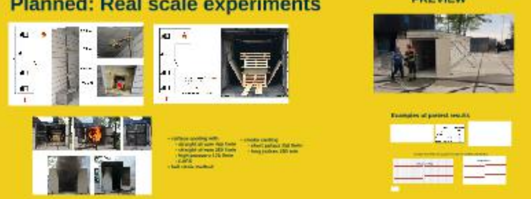
Smoke cooling or surface cooling?



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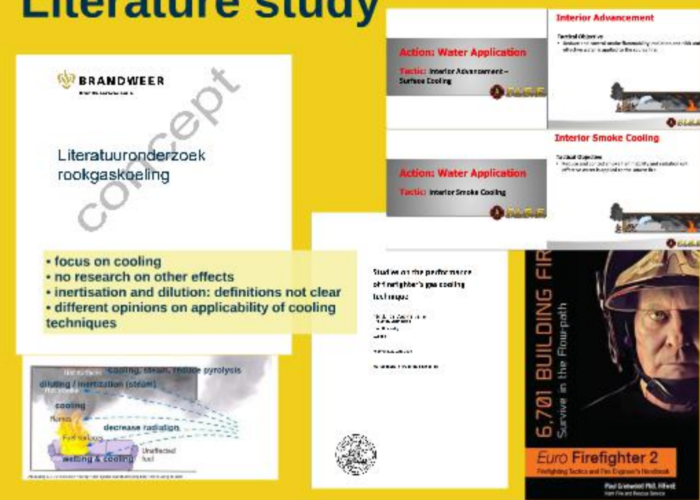
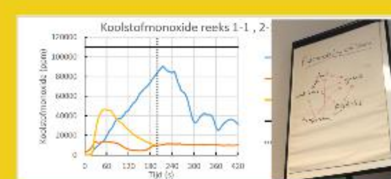


Experiments: scale model



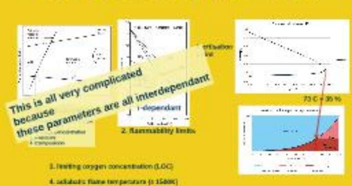
Labscale experiments

ca. 343 litre
25,8 liter propane = 7.5 vol %

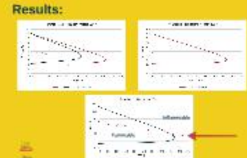
ca. 166 litre
8 liter propane = 4.8 vol %

droplet size = 3-8 µm

4 criteria to consider for (in)flammability:



Results:



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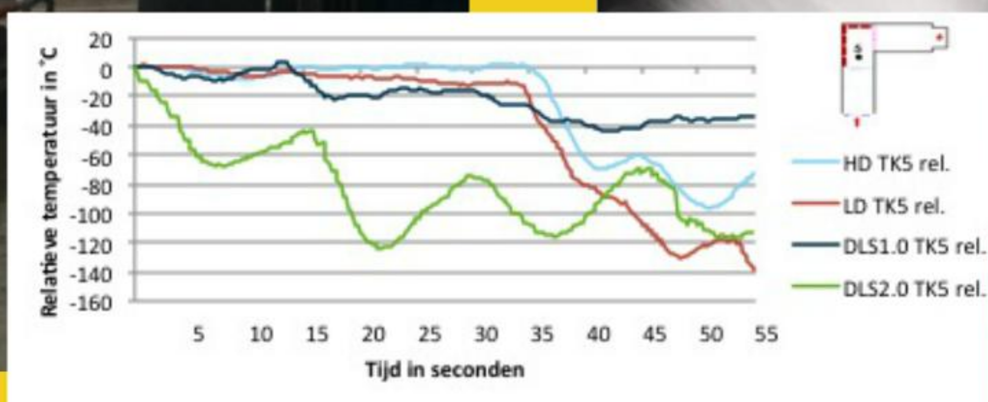
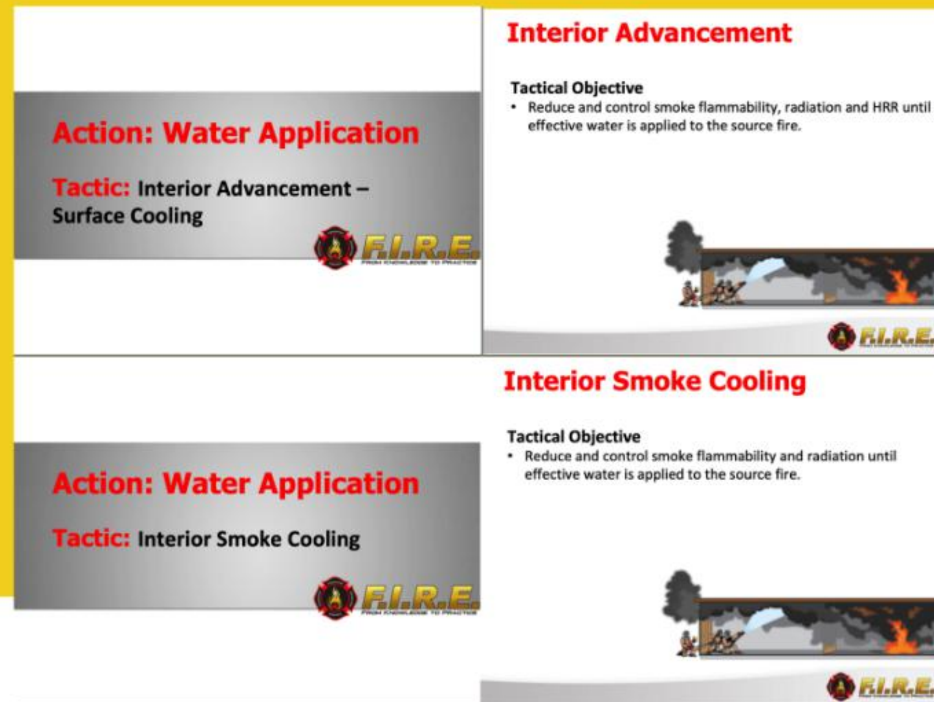
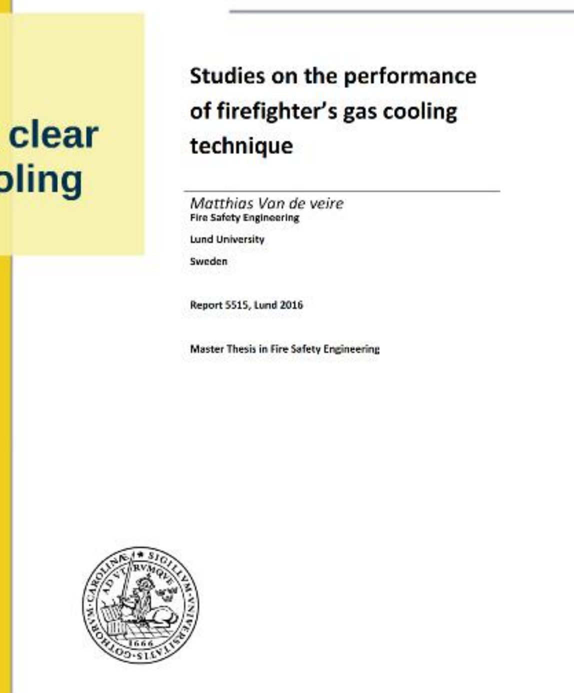


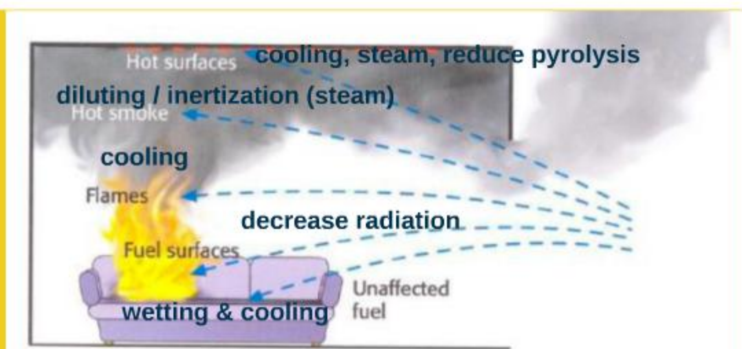
- To which extent is gas cooling effective? What are limits?
- Is it only cooling ? (maybe also asphyxiation or inertization?)
- What about cold smoke gases?
  Is cooling the gases enough to make it safe? How to prevent ignition?

Literature study

- focus on cooling
- no research on other effects
- inertisation and dilution: definitions not clear
- different opinions on applicability of cooling techniques







Afbeelding 5.2 Vijf manieren waarop water tijdens brandbestrijding kan worden aangebracht

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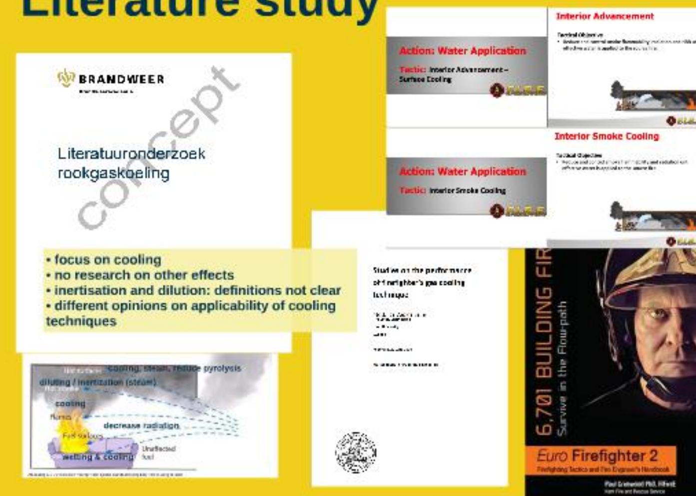

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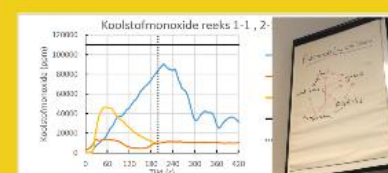

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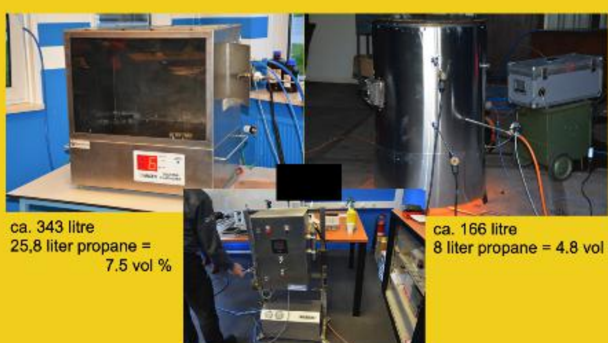

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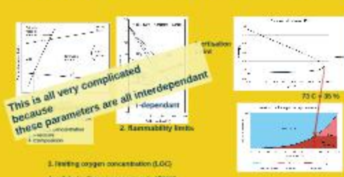
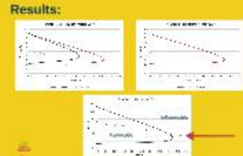


Results:



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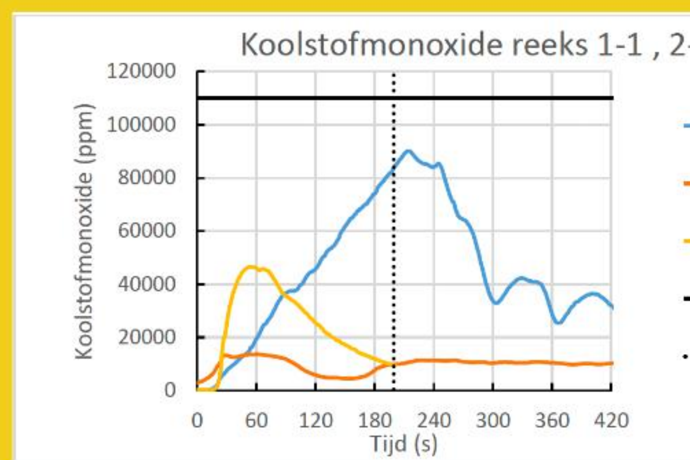

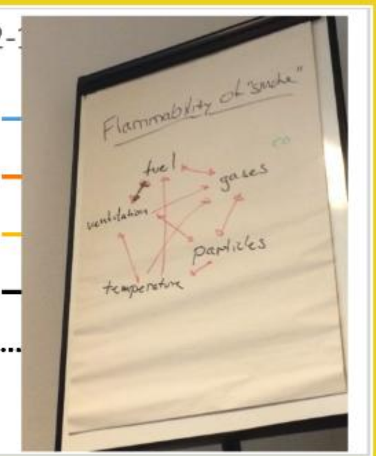

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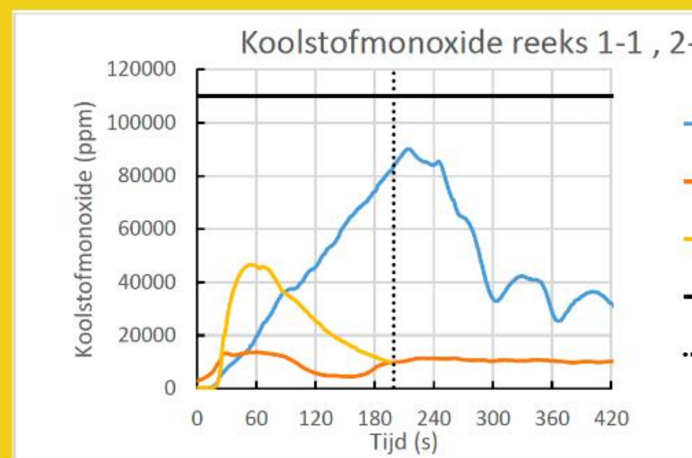
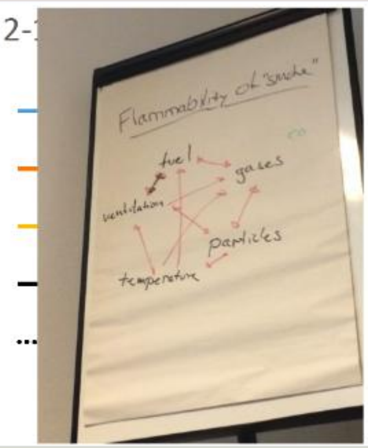
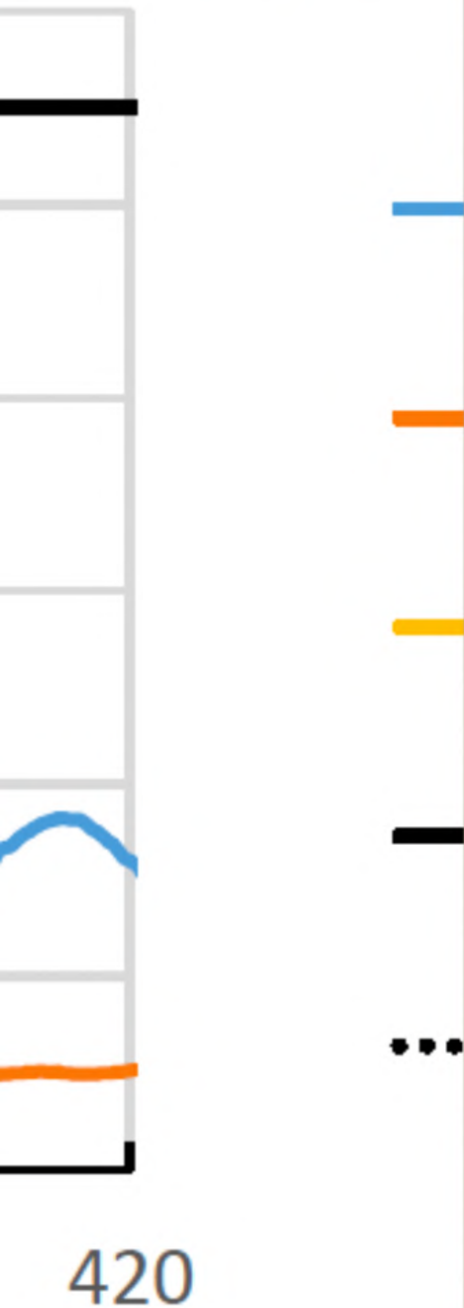
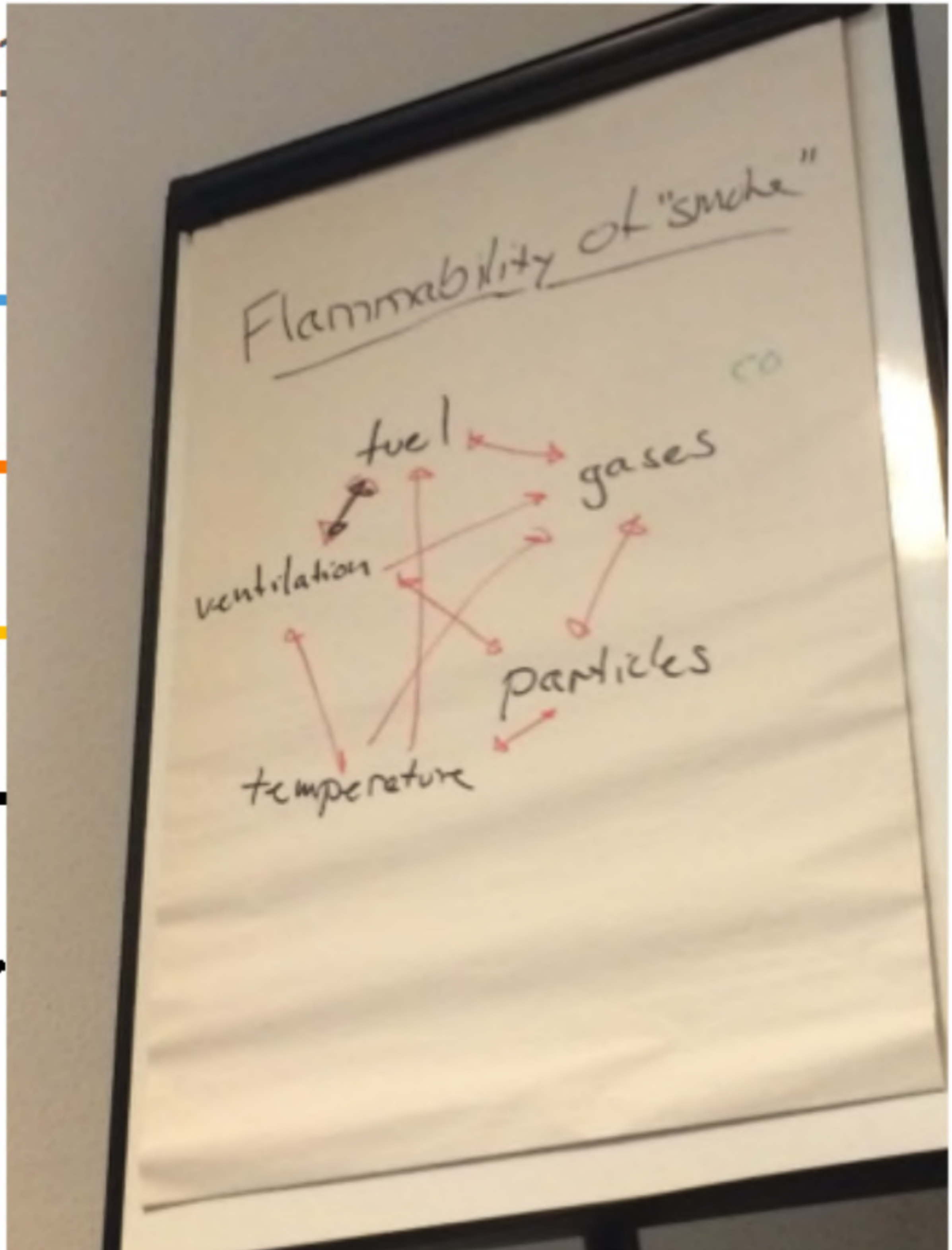




s 1-1 , 2-


420


Flammability of "smoke"
fuel
gases
ventilation
particles
temperature

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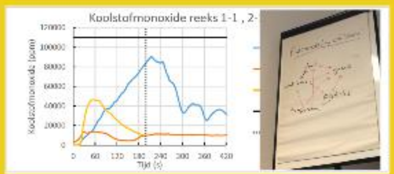

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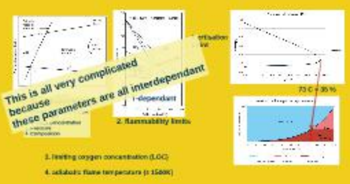

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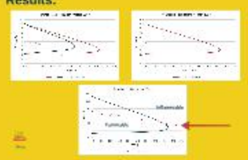

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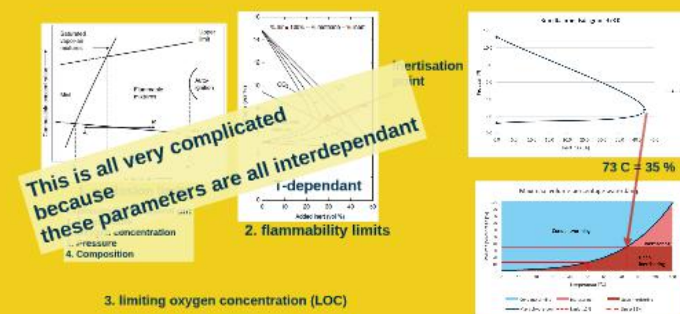
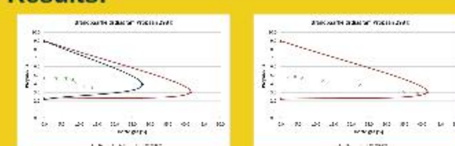
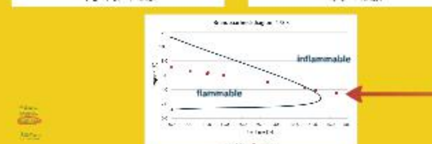


3. limiting oxygen concentration (LOC)

4. adiabatic flame temperature (± 1500K)

Results:





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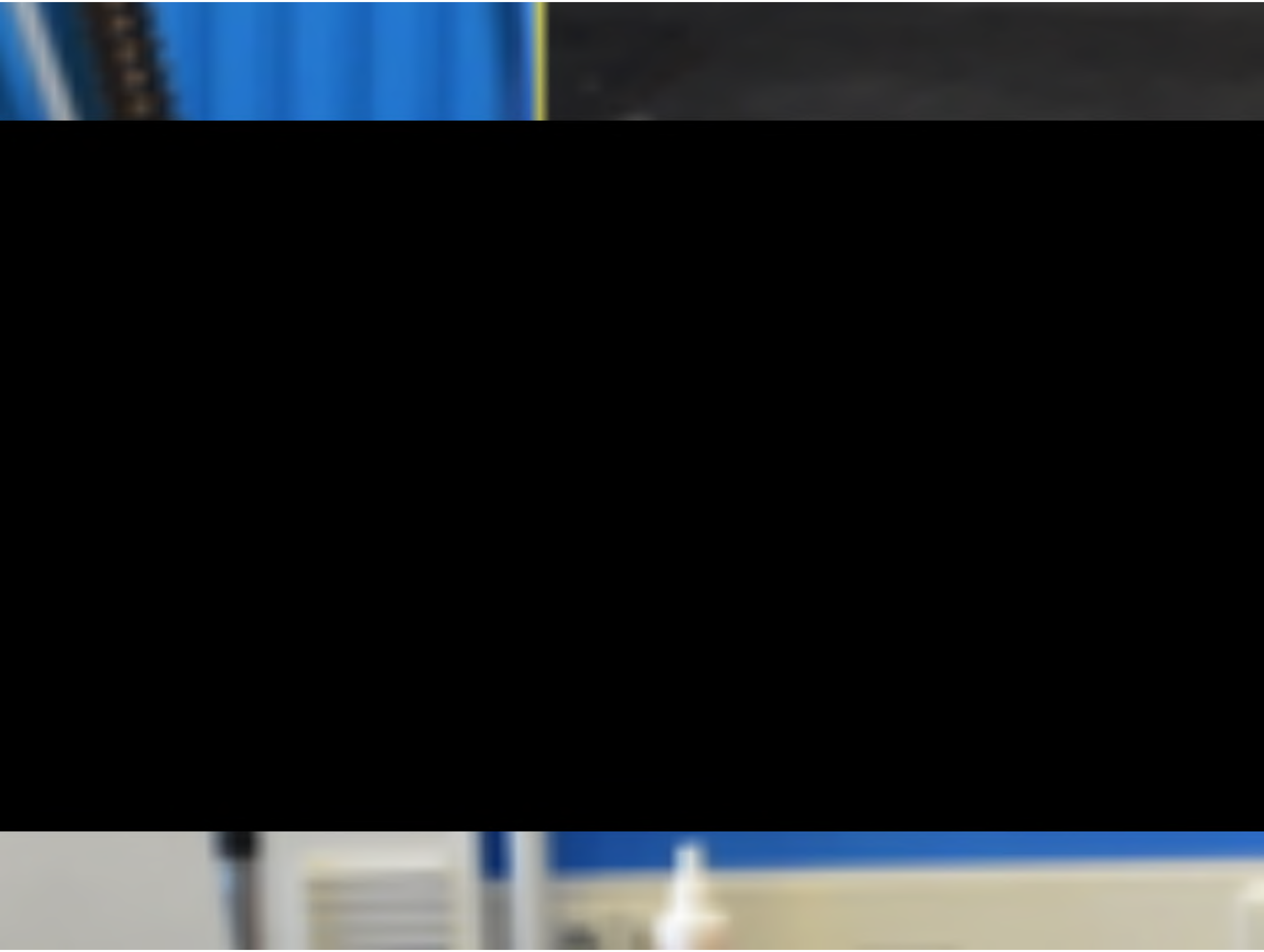

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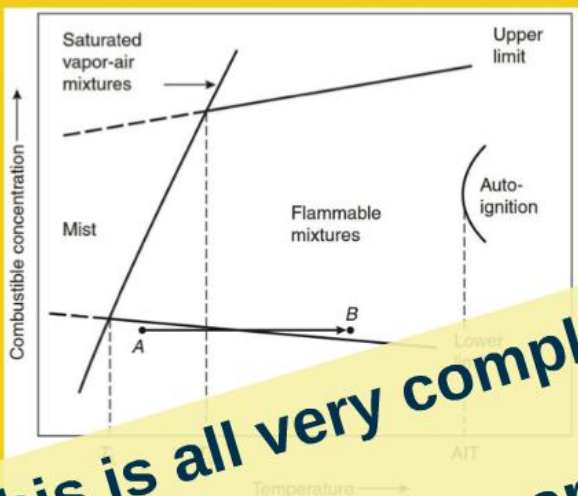
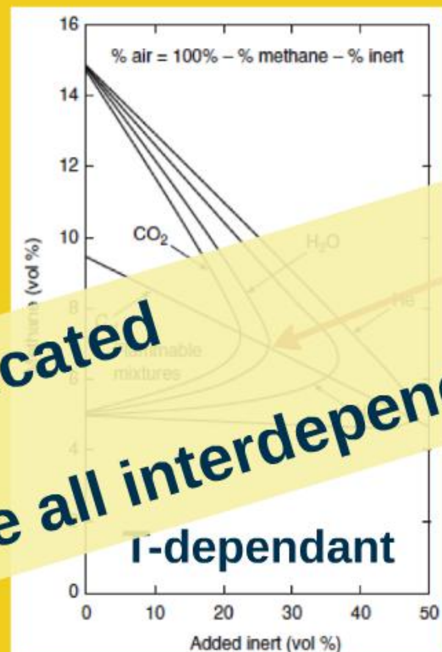


1. explosion limits

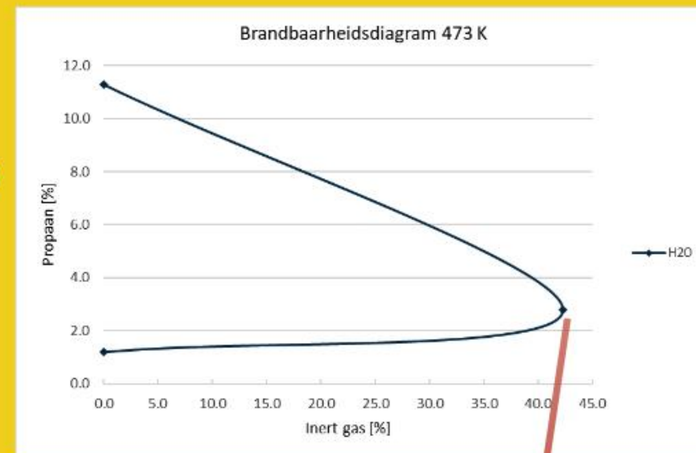
Explosion limits depend on:
1. Temperature
2. Oxygen concentration
3. Pressure
4. Composition



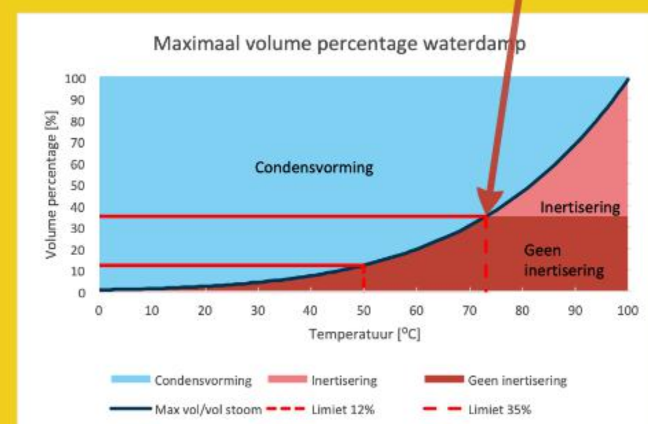
T-dependant

2. flammability limits

inertisation point



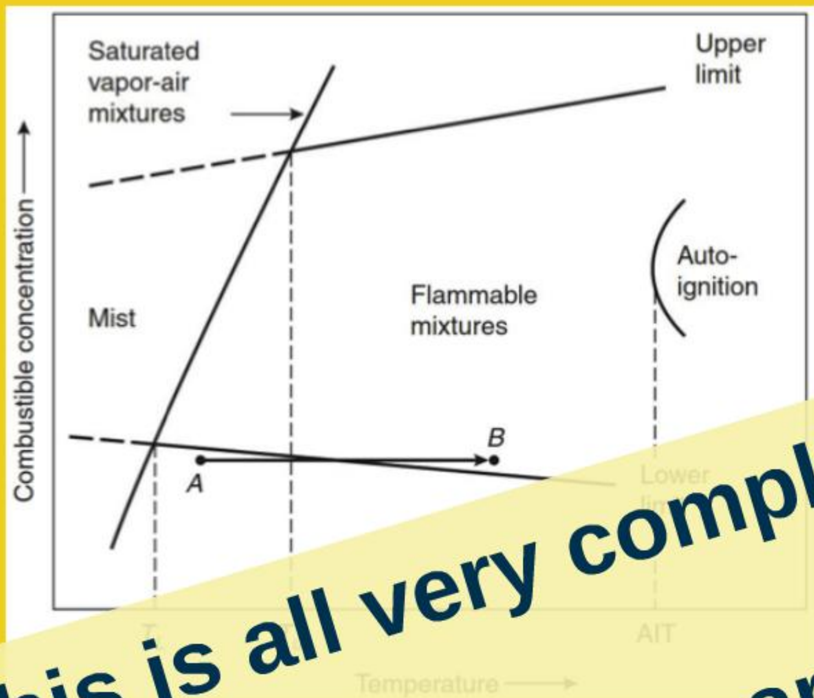
73 C = 35 %



This is all very complicated because these parameters are all interdependant

3. limiting oxygen concentration (LOC)

4. adiabatic flame temperature (± 1500K)



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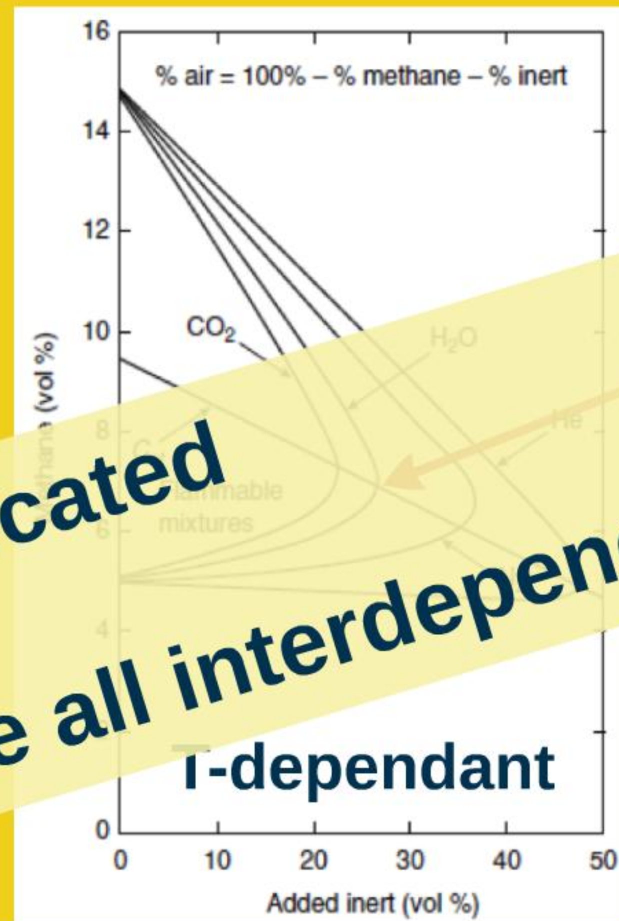

inertisation point

T-dependant

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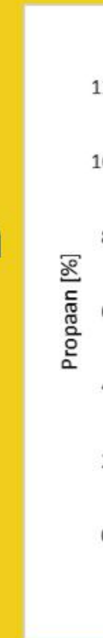

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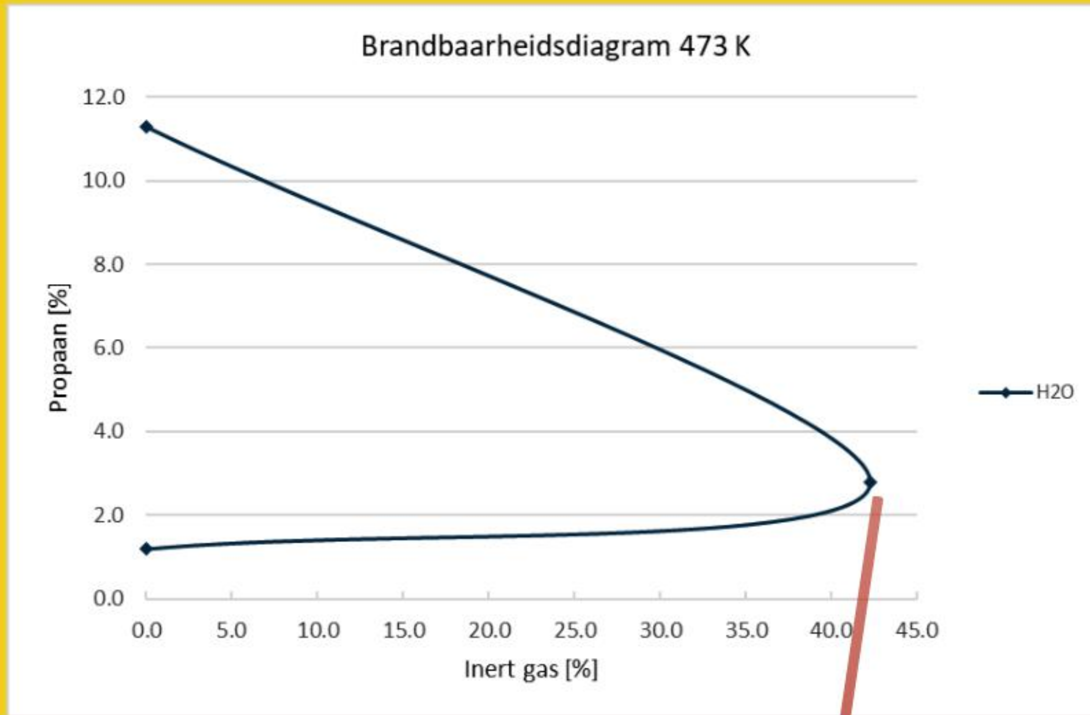
inertisation point

ndant

mits



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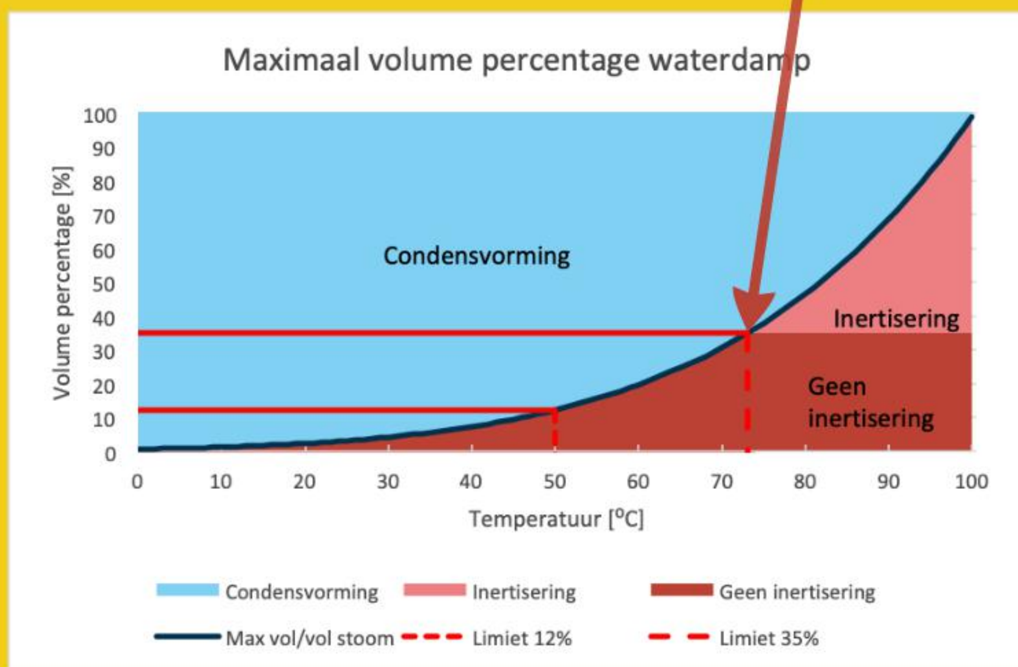

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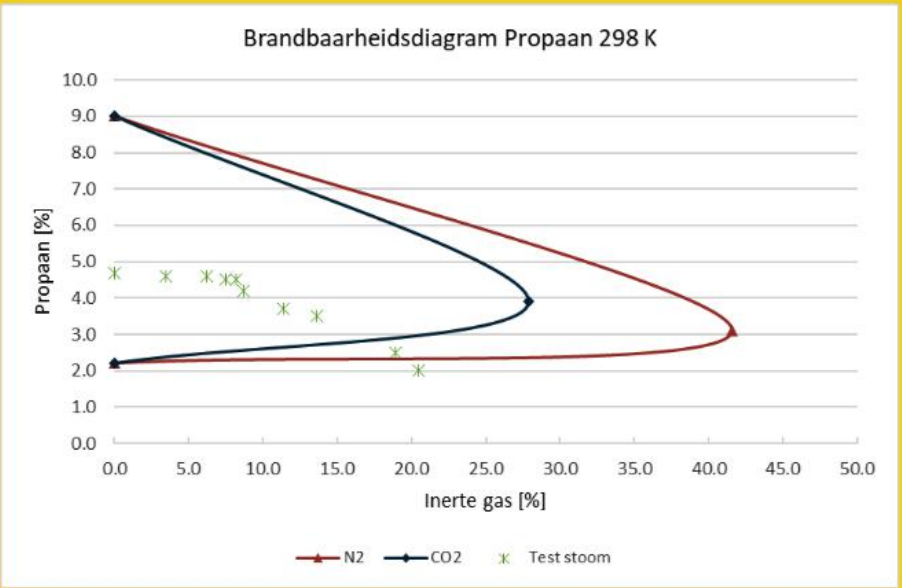
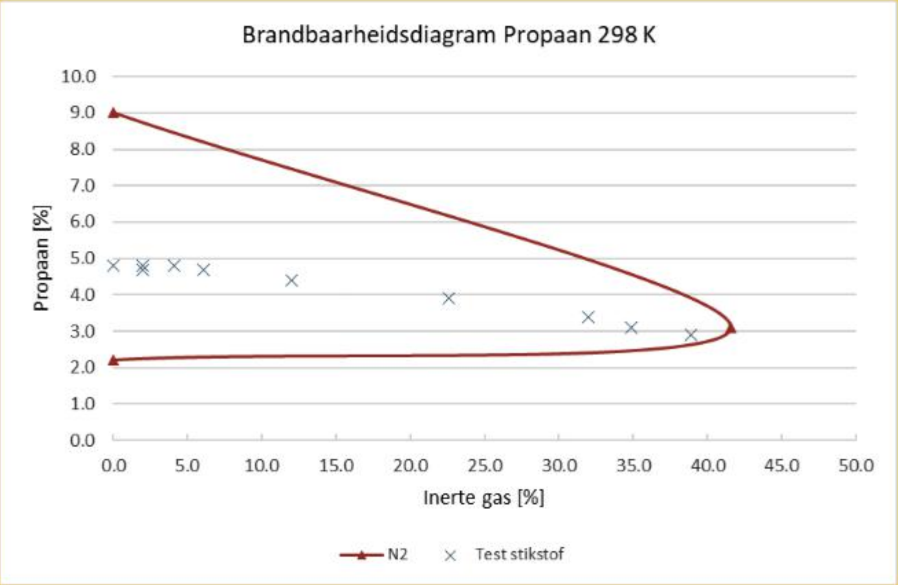
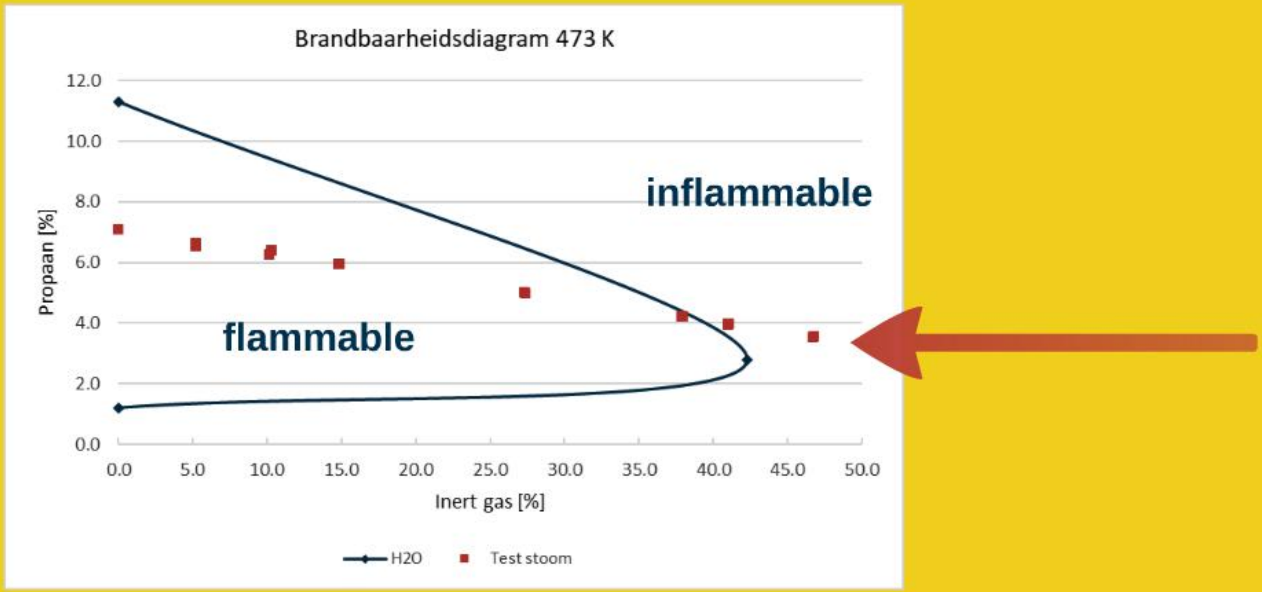


Brandbaarheidsdiagram Propaan 298 K
Propaan [%]
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0.0 5.0 10.0 15.0 20.0 25.0 30.0 35.0 40.0 45.0 50.0
Inerte gas [%]
N2
CO2
Test stoom



Brandbaarheidsdiagram Propaan 298 K
Propaan [%]
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0.0 5.0 10.0 15.0 20.0 25.0 30.0 35.0 40.0 45.0 50.0
Inerte gas [%]
N2
Test stikstof



Brandbaarheidsdiagram 473 K
Propaan [%]
12.0
10.0
8.0
6.0
4.0
2.0
0.0
0.0 5.0 10.0 15.0 20.0 25.0 30.0 35.0 40.0 45.0 50.0
Inert gas [%]
inflammable
flammable
H2O
Test stoom

400C: 42% steam =
inertisation point

70 m3 = 70m2 x 1m
42% H_2O 50% effective
= 20 liter

HD 100 l/min : 12 s pulse
LD 250l/min : 5 s pulse

But:

- **smoke is not propane**
- **smoke consists of many products**
- **during cooling temperature changes**

- **this goes for stationary situation**

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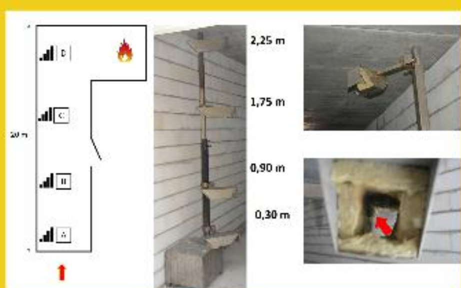

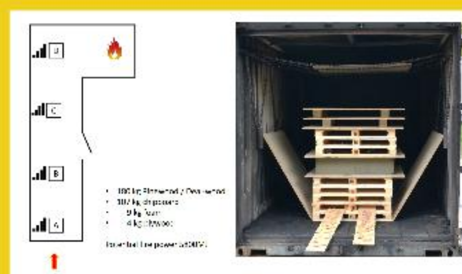

- surface cooling with
  - straight stream 400 l/min
  - straight stream 250 l/min
  - high pressure 125 l/min
  - CAFS
- half circle method

- smoke cooling
  - short pulses 250 l/min
  - long pulses 250 min

PREVIEW

Examples of pretest results

examples of preliminary measurements (do not conclude anything yet)

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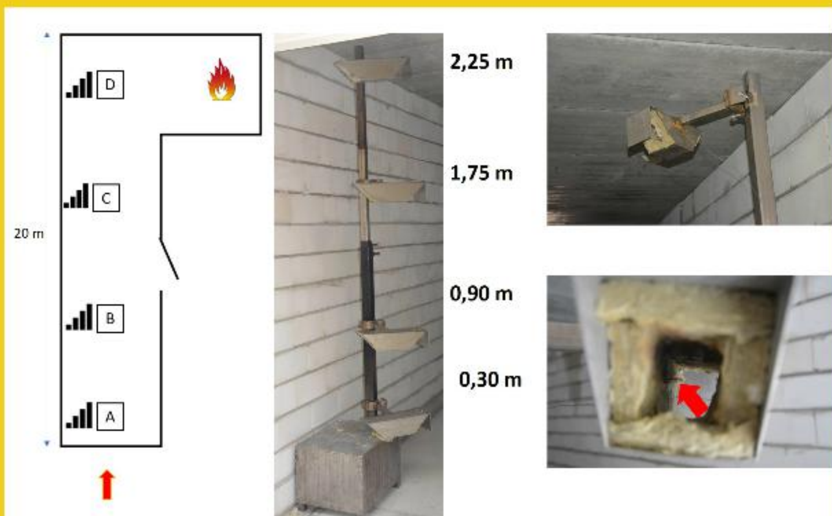
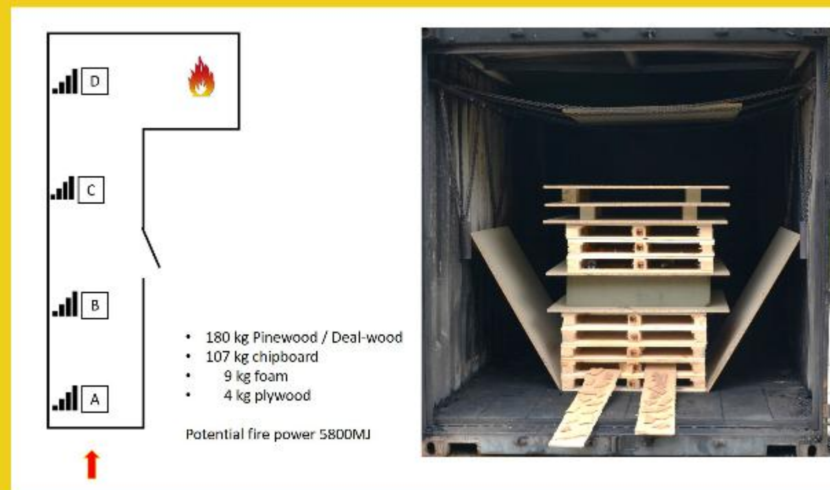
Planned: Real scale experiments





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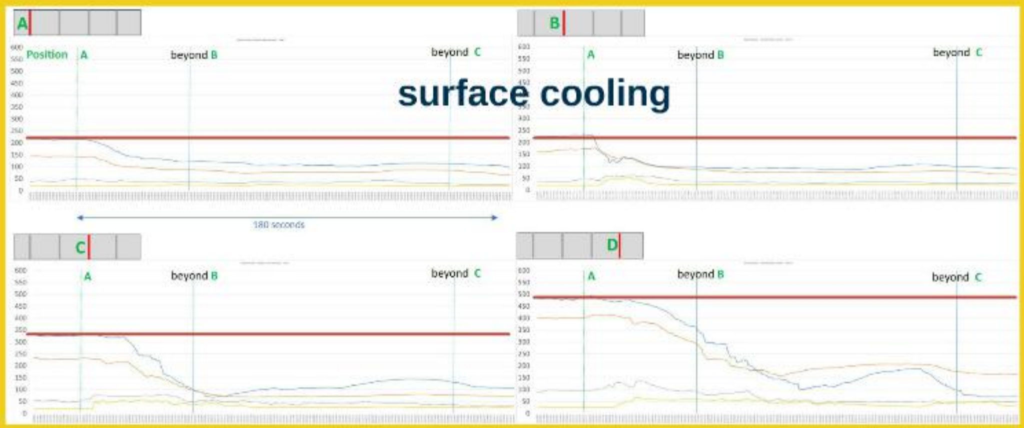
Examples of pretest results

Burn 1 / test 1 Short pulse
Burn 2 / test 2 Long pulse
Burn 3 / test 3 Inverted U - continuosly
Burn 3 / test 4 Inverted U– stop and flow

Burn 4 / test 5 Inverted U – continuosly - Smooth bore

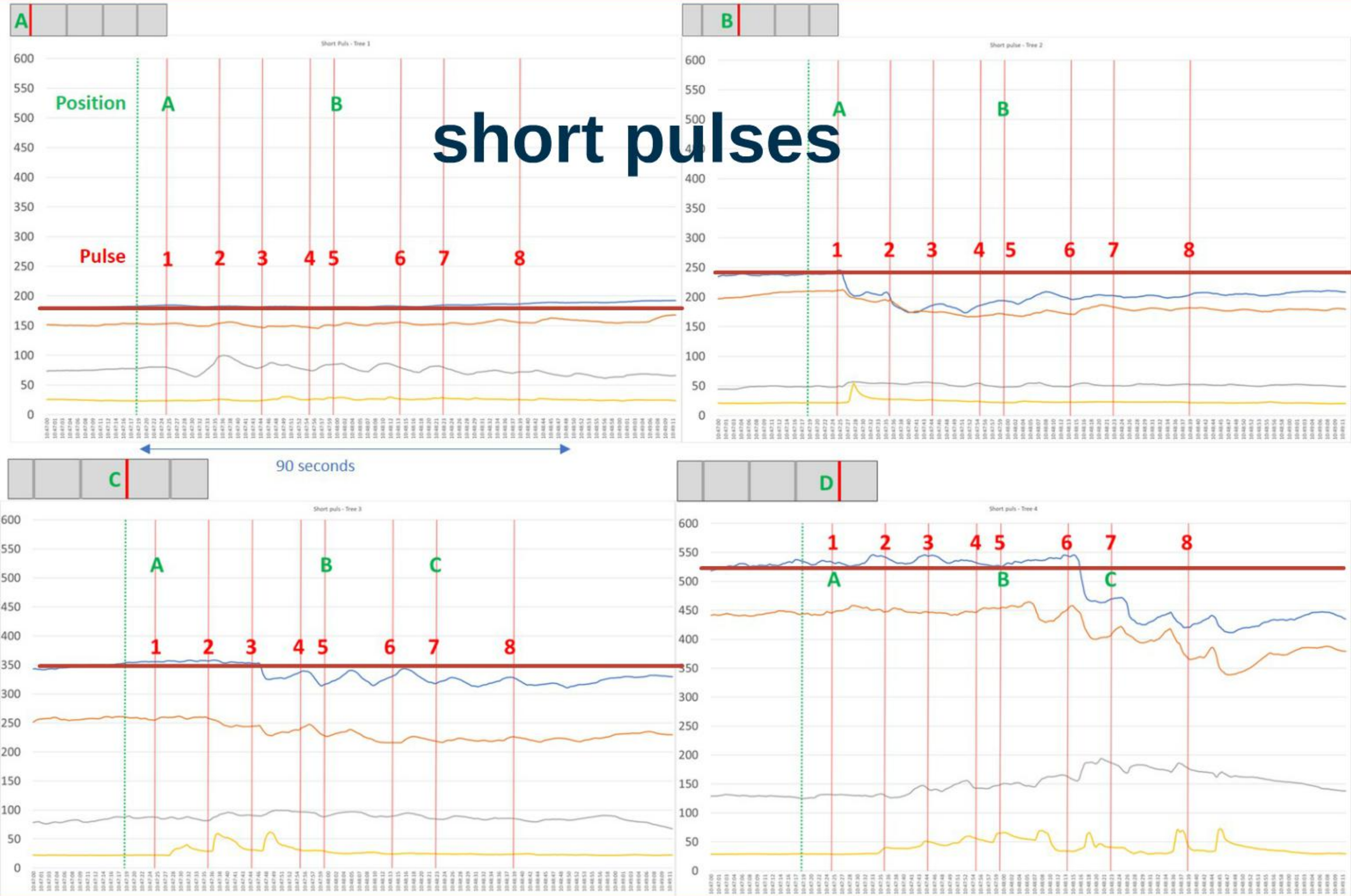
Technic	Water consumption (liters)
Short puls	44
Long pulse	74
Inverted U continuosly	575
Inverted U flow-stop-flow	157
Inverted U Smooth bore	700

examples of preliminary measurements (do not conclude anything yet)



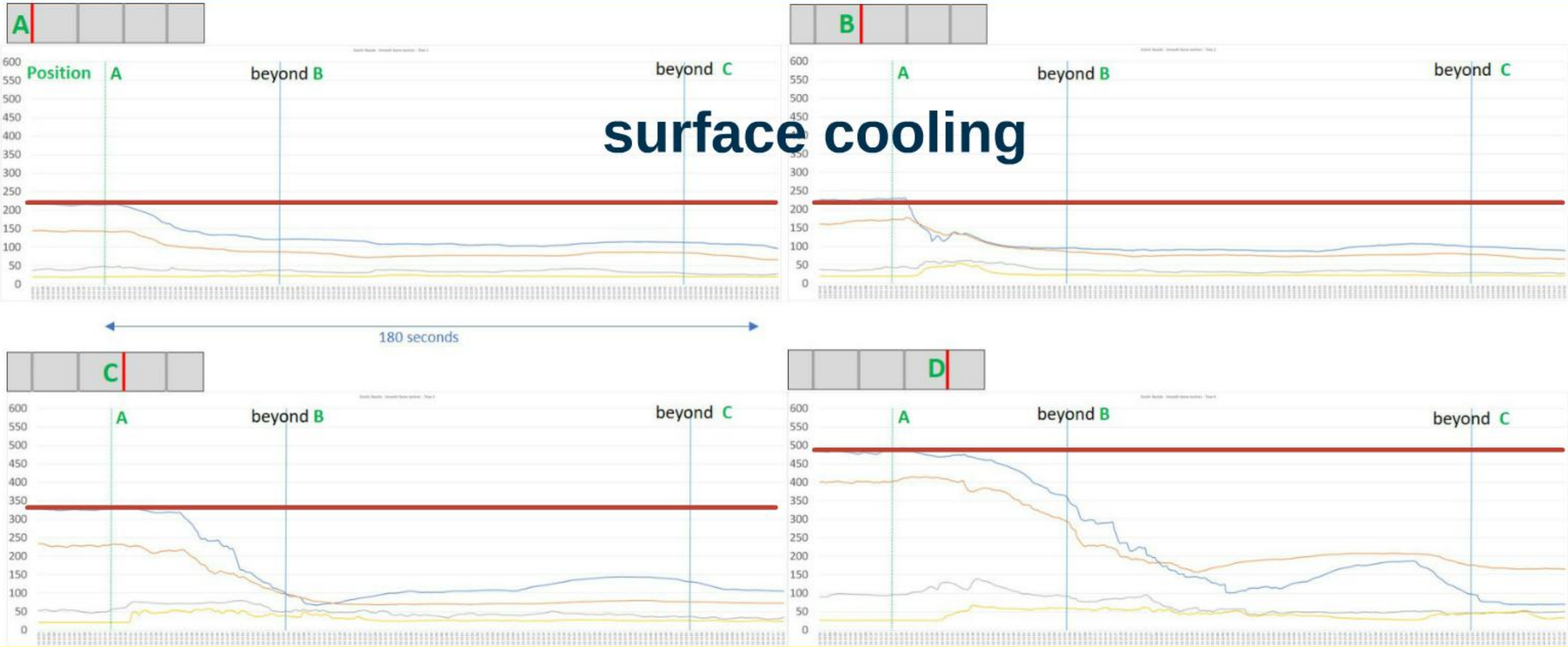
conclude anything yet)

short pulses



examples of preliminary measurement

surface cooling



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Smoke dispersion

Summary


experiments 23rd june - 5th juli
report: 2020 (parts)

Objective:

1. smoke spread
2. possible escape time
3. effect of door / sprinkler / new type of door / fire service action

- 19 experiments in two weeks
- scenario: sofa in living room at night
- measurements
    - in hallways (3 levels)
    - staircase
    - appartments next to and above
- temperature, visibility, concentrations of gases, radiation


2019-05-21 11:15:55
2

Summary

- Flammability of smoke is a very complicated process
- Inertisation of smoke with water does not seem very likely
  --> creation of more steam (42%) is necessary --> surface cooling?
- Cooling is still a good idea:
  --> reduce radiation and
  --> prevent auto-ignition
- Prevention of a smoke explosion using water spray or steam is not an option

- Indicators for smoke explosion still "under construction"
- Effects of smoke versus surface cooling: experiments in october
- Smoke spread in appartment buildings: experiments next week

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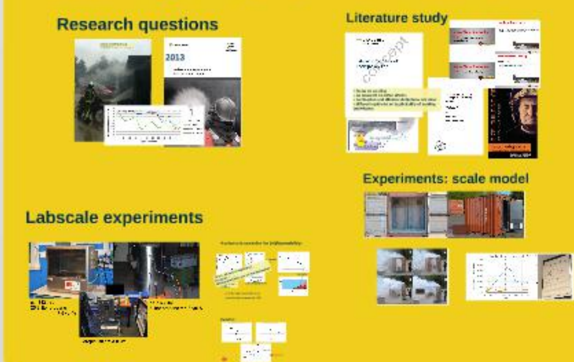
.......SMOKE.....

Cooling and / or Inertisation ?



Smoke explosions / Fire gas ignitions

Smoke dispersion

Smoke cooling or surface cooling?

IFIW 2019 Arnhem
Ricardo Weewer, professor Fire Service Science
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