



.....SMOKE.....



Smoke explosions / Fire gas ignitions



Cooling and / or Inertisation ?

Research questions



Literature study



Labscale experiments



Experiments: scale model



Smoke cooling or surface cooling?

Planned: Real scale experiments



PREVIEW

Examples of predicted results:

Temperature	1000
Smoke layer height	2.5
Smoke layer depth	1.5
Smoke layer velocity	0.5
Smoke layer temperature	500

Smoke dispersion



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



.....SMOKE.....



Cooling and / or Inertisation ?

Research questions



Literature study



Labscale experiments



Experiments: scale model



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



Smoke explosions / Fire gas ignitions



Helmond 2015



IJmuiden 2016



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



melen 2016



Obdam 2015

Leiden 2005



De Punt 2008



Den Haag 2011



Woerden 2016





Smoke explosions / Fire gas ignitions



Helmond 2015



IJmuiden 2016



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



Leiden 2005



De Punt 2008



Den Haag 2011

Obdam 2015



Woerden 2016



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**

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.

Quiver BSc

BRANDWEER

TU/e Technische Universiteit Eindhoven University of Technology



Giunta d'Albani
Quiver BSc

BRANDWEER TU/e Technische Universiteit Eindhoven University of Technology

University of Applied Sciences



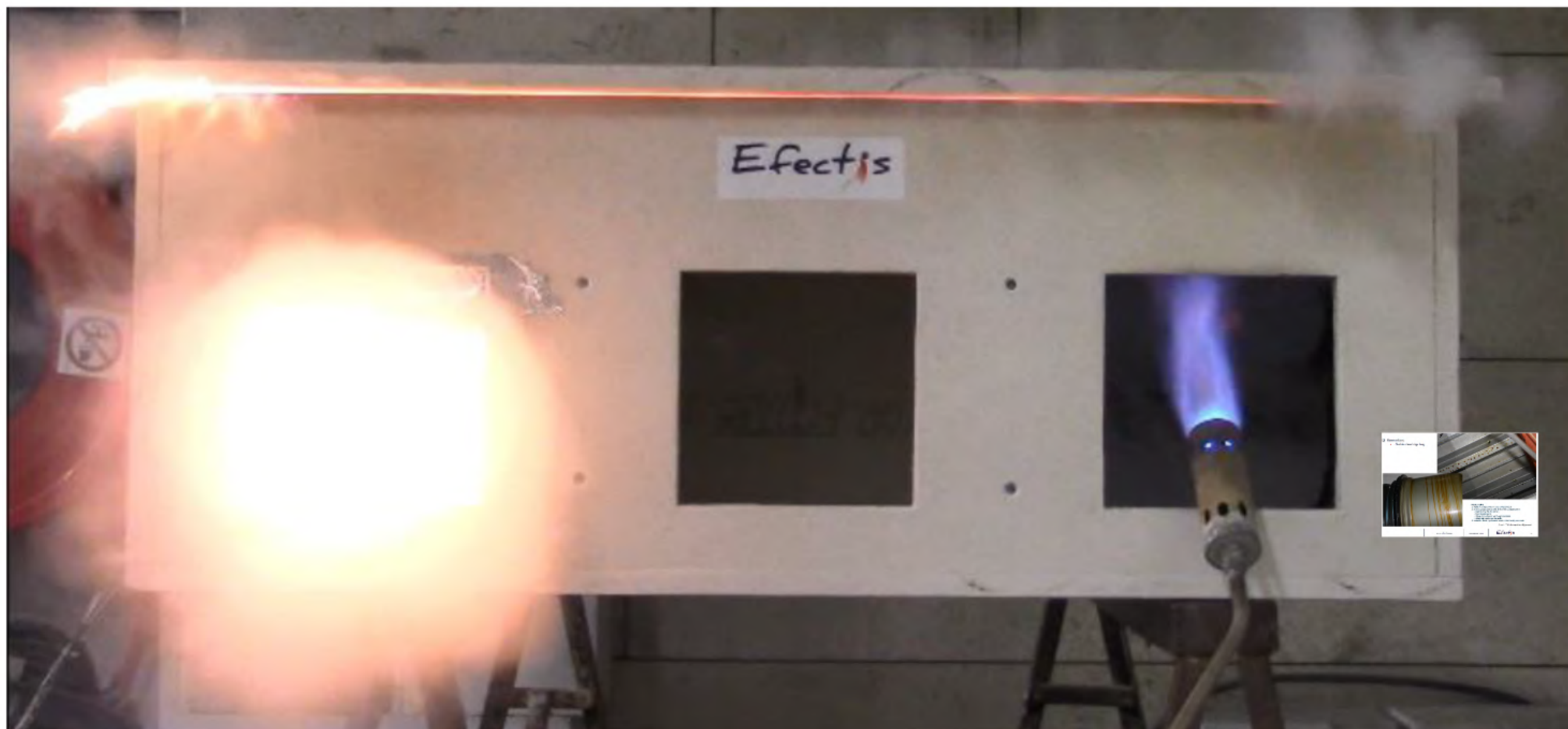
Rookgasexplosies

De invloed van bitumen dakbedekking en dakisolatiematerialen.

Cindy Veerman
Crime Science



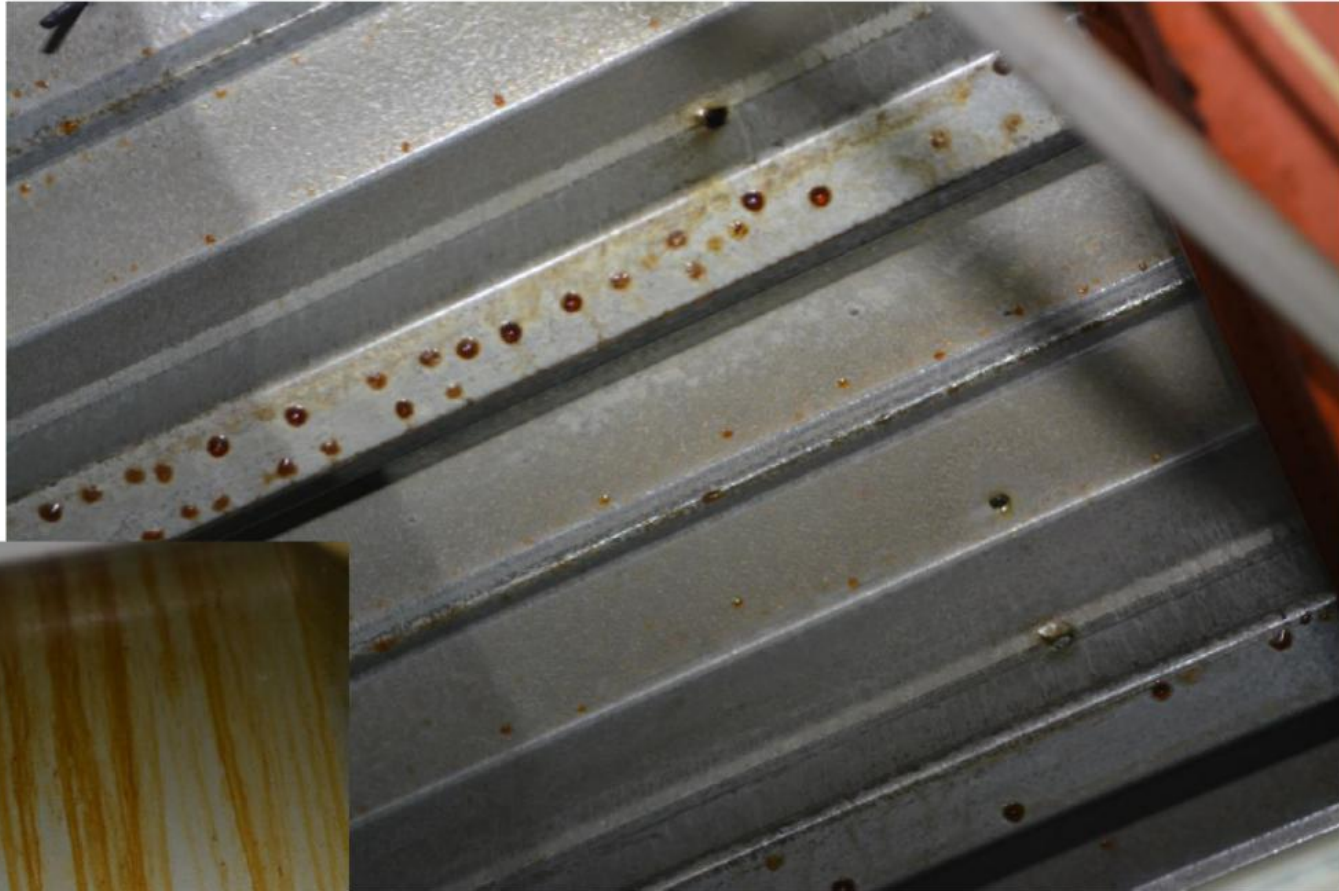
Figuur 15. Stimulatie rookgasexplosie EPS 600-650 °C met ontstekingsbron



Figuur 15. Simulatie rookgasexplosie EPS 600-650 °C met ontstekingsbron

□ Kenmerken:

- Gladde olieachtige laag



INDICATORS

1. Fully developed fire in one compartment
2. In the compartment next to the fire compartment:
 - light yellow /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

INDICATORS

1. Fully developed fire in one compartment
2. In the compartment next to the fire compartment:
 - light yellow /white smoke
 - low temperature
 - slippery sediment on floors and walls
 - dripping tracks on the walls
3. Outside: white / yellowish smoke that hardly ascends

Foto's TBO Rotterdam-Rijnmo

November 2017

Efectis



.....SMOKE.....



Cooling and / or Inertisation ?

Research questions



Literature study



Labscale experiments



Experiments: scale model



Smoke explosions / Fire gas ignitions



Smoke cooling or surface cooling?

Planned: Real scale experiments



PREVIEW



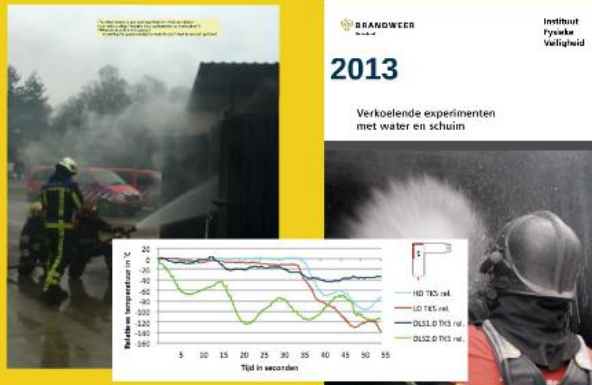
Smoke dispersion



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

Cooling and / or Inertisation ?

Research questions



Literature study

BRANDWEER
Literatuuronderzoek rookgascooling

concept

Interior Advancement
Action: Water Application
Tactics: Interior Advancement - Surface Cooling

Interior Smoke Cooling
Action: Water Application
Tactics: Interior Smoke Cooling

Studie van de prestaties van naburige gas cooling technieken

6.700 BUILDING FIRE Survivors in the Firepath
Euro Firefighter 2
Firefighting Tactics and The Firefighter's Handbook

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

Experiments: scale model



Labscale experiments

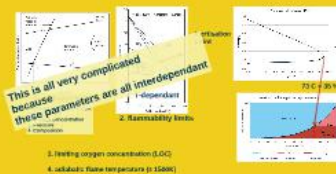


ca. 343 litre
25,8 liter propane =
7,5 vol %

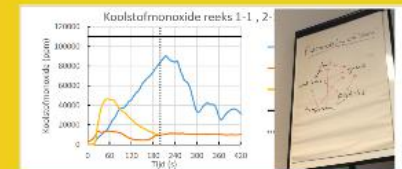
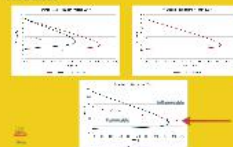
ca. 166 litre
8 liter propane = 4,8 vol %

droplet size = 3-8 µm

4 criteria to consider for (in)flammability:



Results:



Research questions

- 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?

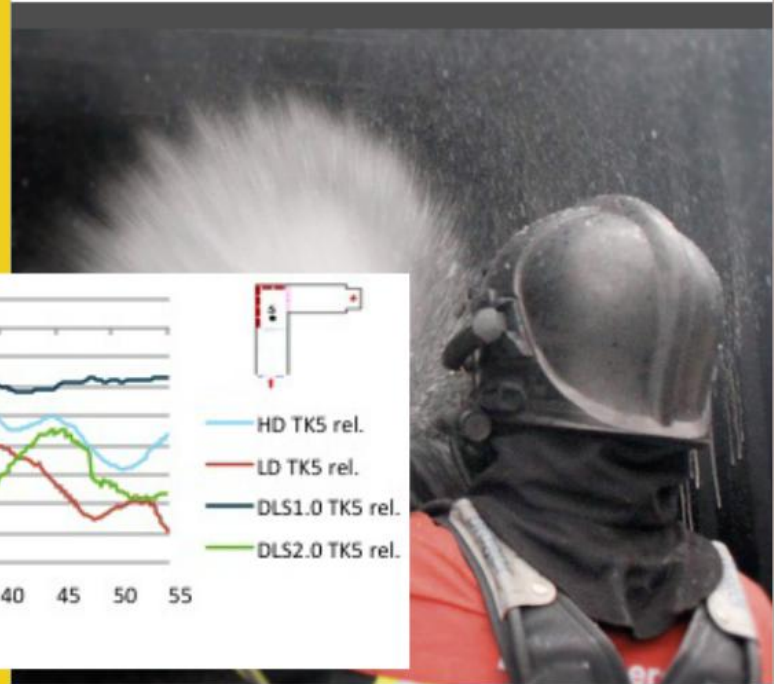
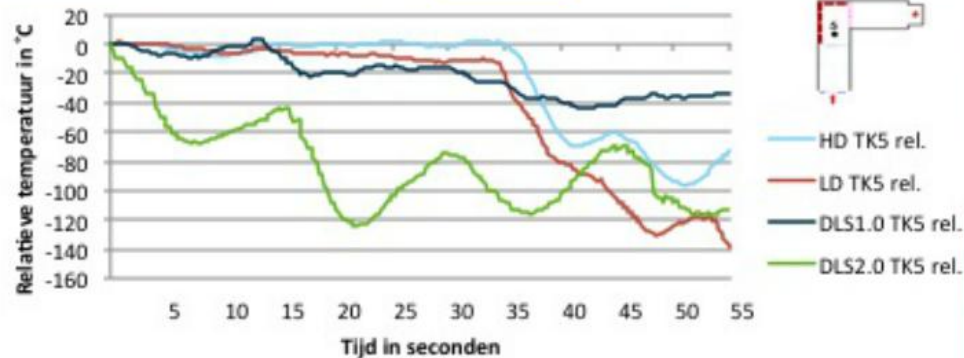


 **BRANDWEER**
Nederland

Instituut
Fysieke
Veiligheid

2013

Verkoelende experimenten
met water en schuim



- **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?**

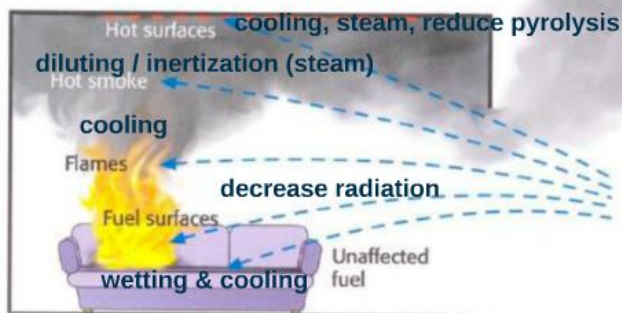
Literature study



Literatuuronderzoek rookgaskoeling

concept

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



Abbeelding 5.2 Vijf manieren waarop water tijdens brandbestrijding kan worden aangebracht

Action: Water Application

Tactic: Interior Advancement – Surface Cooling



Interior Advancement

Tactical Objective

- Reduce and control smoke flammability, radiation and HRR until effective water is applied to the source fire.



Action: Water Application

Tactic: Interior Smoke Cooling



Interior Smoke Cooling

Tactical Objective

- Reduce and control smoke flammability and radiation until effective water is applied to the source fire.



Studies on the performance of firefighter's gas cooling technique

Matthias Van de veire
Fire Safety Engineering
Lund University
Sweden

Report 5515, Lund 2016

Master Thesis in Fire Safety Engineering



6,701 BUILDING FIR
Survive in the Flow-path

Euro Firefighter 2
Firefighting Tactics and Fire Engineer's Handbook

Paul Grimwood PhD, FIFireE
Kent Fire and Rescue Service

Cooling and / or Inertisation ?

Research questions



Literature study

BRANDWEER
Literatuuronderzoek rookgascooling

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

Interior Advancement
Action: Water Application
Tactics: Interior Advancement - Surface Cooling

Interior Smoke Cooling
Action: Water Application
Tactics: Interior Smoke Cooling

Study on the performance of neighbor's gas cooling technique:

6.700 BUILDING FIRE
Survive in the Downpath
Euro Firefighter 2
Firefighting Tactics and The Engineer's Handbook

Experiments: scale model



Labscale experiments

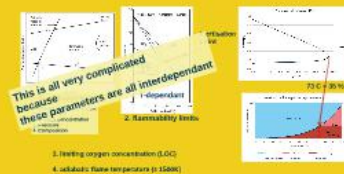


ca. 343 litre
25,8 liter propane =
7.5 vol %

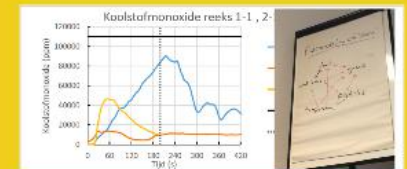
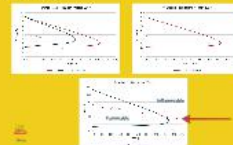
ca. 166 litre
8 liter propane = 4.8 vol %

droplet size = 3-8 µm

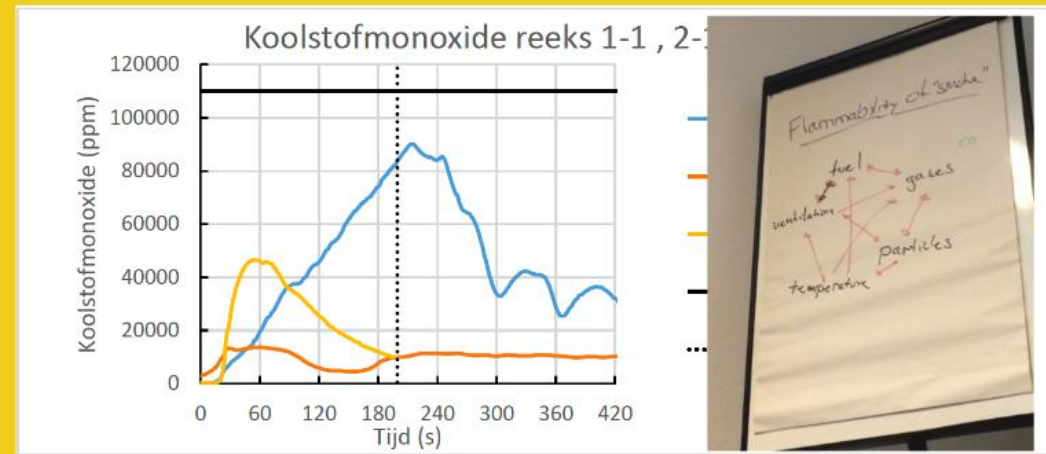
4 criteria to consider for (in)flammability:



Results:



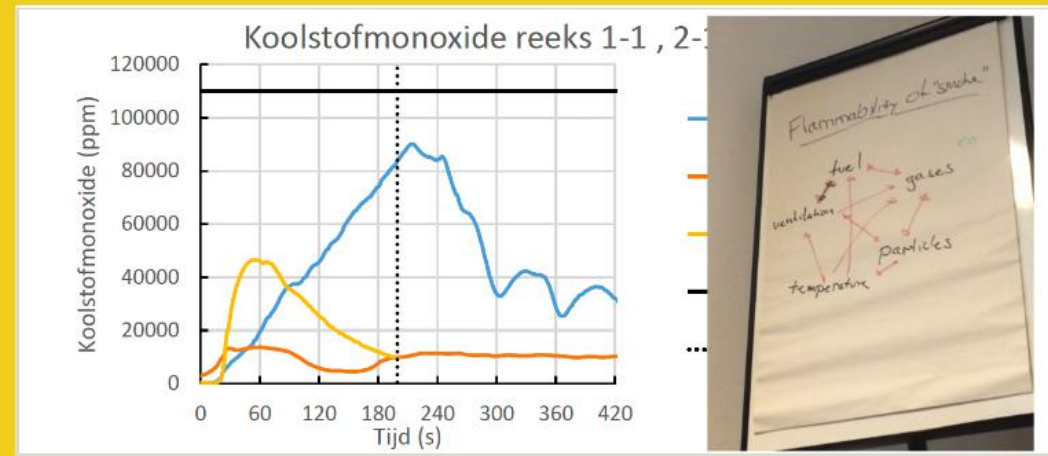
Experiments: scale model







Experiments: scale model

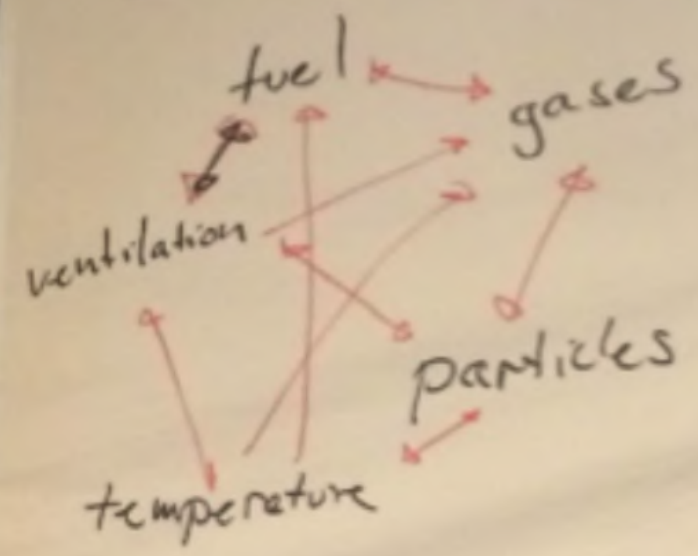


s 1-1, 2-1



420

Flammability of "smoke"



...

Cooling and / or Inertisation ?

Research questions



Literature study

BRANDWEER
Literatuuronderzoek rookgascooling

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

Interior Advancement
Action: Water Application
Tactics: Interior Advancement - Surface Cooling

Interior Smoke Cooling
Action: Water Application
Tactics: Interior Smoke Cooling

6.700 BUILDING FIRE Survivors in the Firepath
Euro Firefighter 2
Firefighting Tactics and The Engineer's Handbook

Experiments: scale model



Labscale experiments



ca. 343 litre
25,8 liter propane =
7,5 vol %

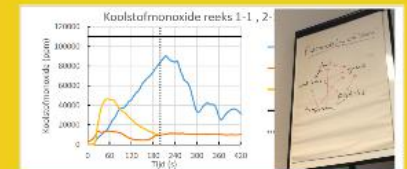
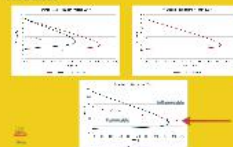
ca. 166 litre
8 liter propane = 4,8 vol %

droplet size = 3-8 µm

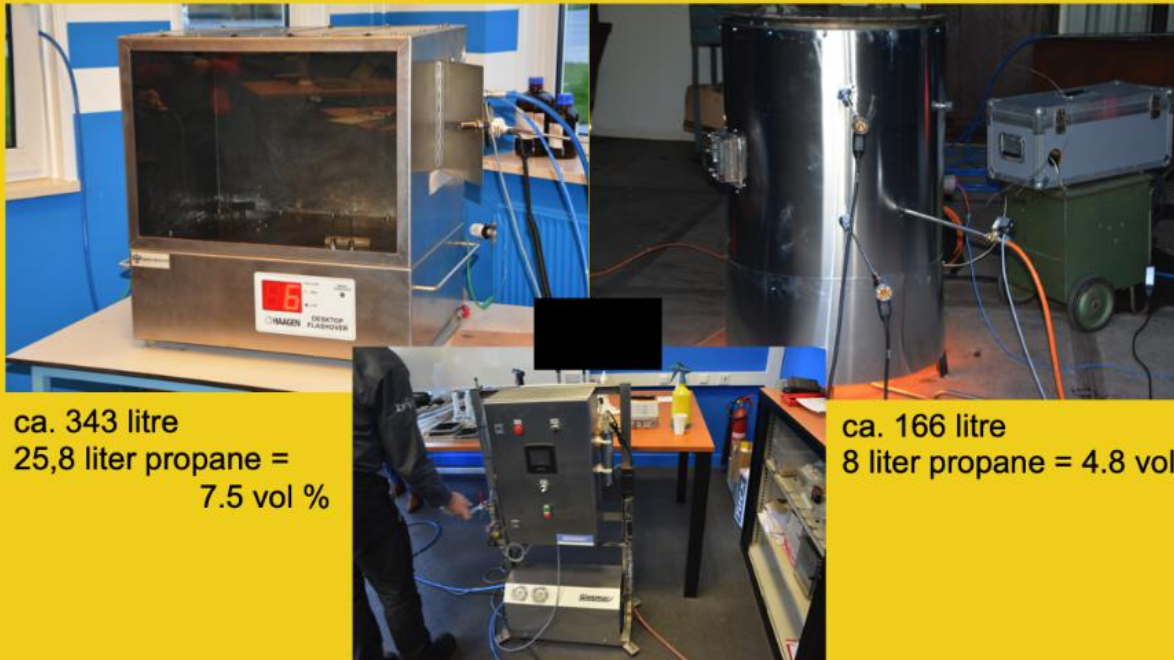
4 criteria to consider for (in)flammability:



Results:



Labscale experiments

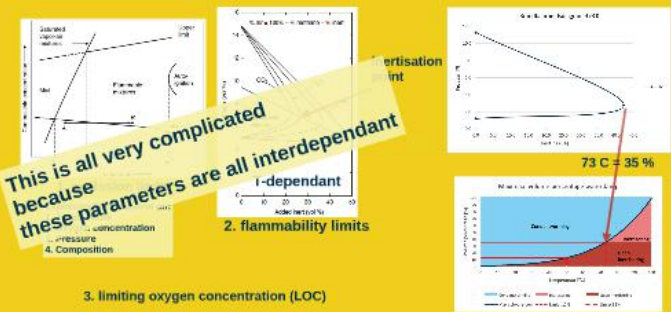


ca. 343 litre
25,8 liter propane =
7.5 vol %

ca. 166 litre
8 liter propane = 4.8 vol %

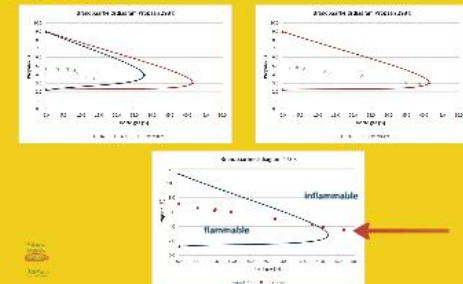
droplet size = 3-8 μm

4 criteria to consider for (in)flammability:



1. limiting oxygen concentration (LOC)
2. flammability limits
3. limiting oxygen concentration (LOC)
4. adiabatic flame temperature ($\pm 1500\text{K}$)

Results:

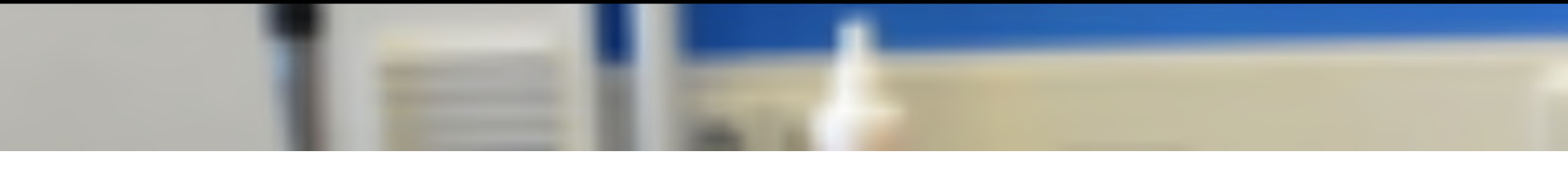
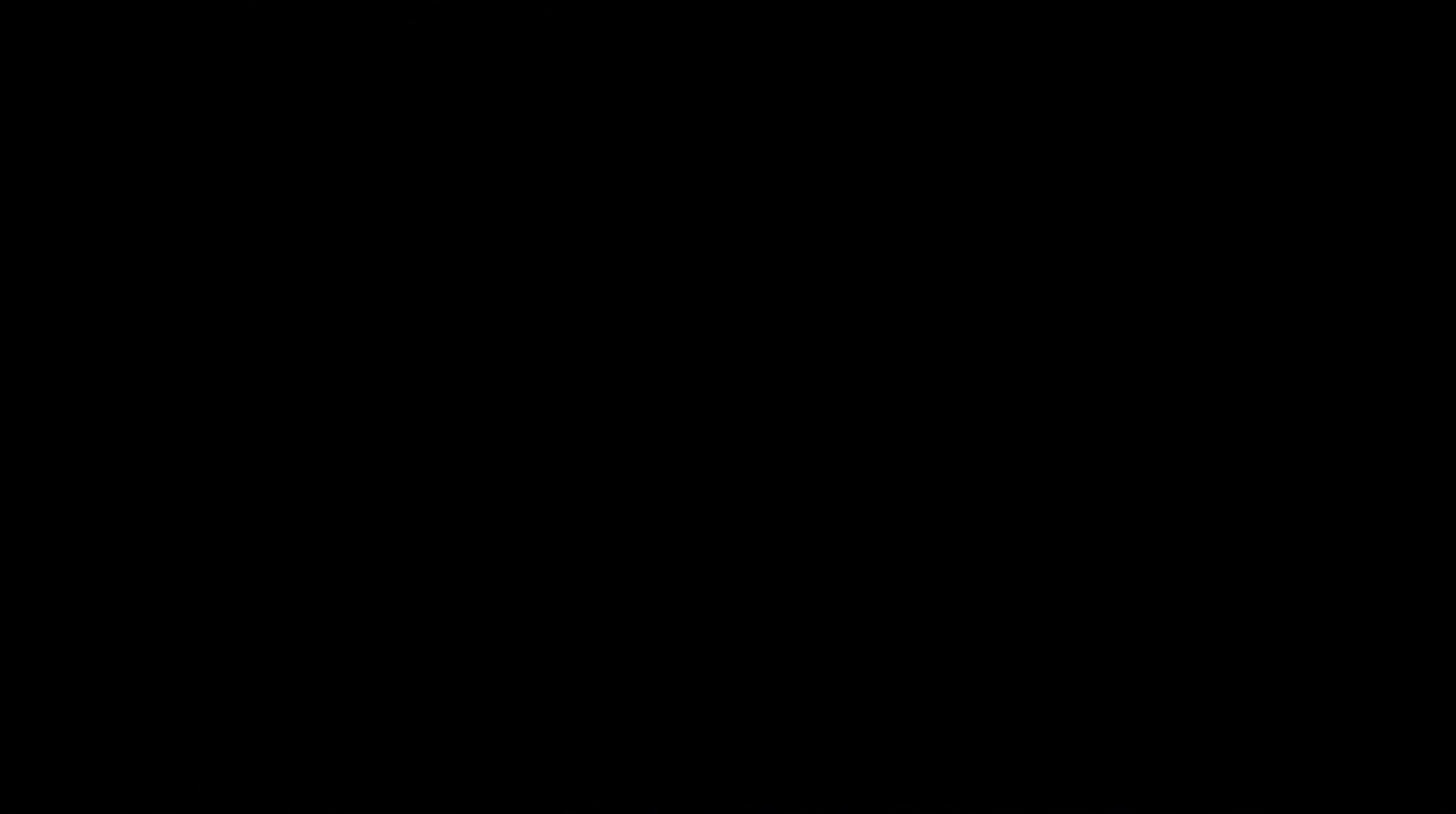
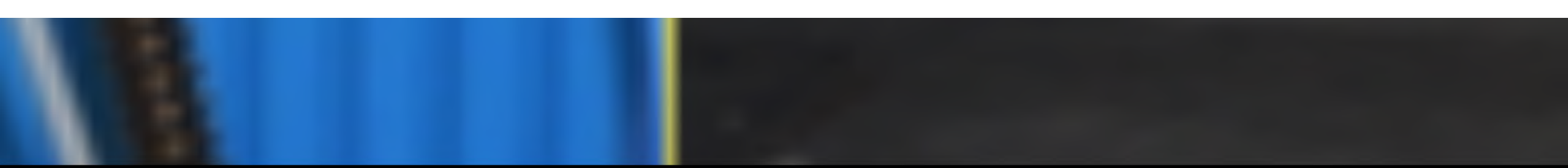




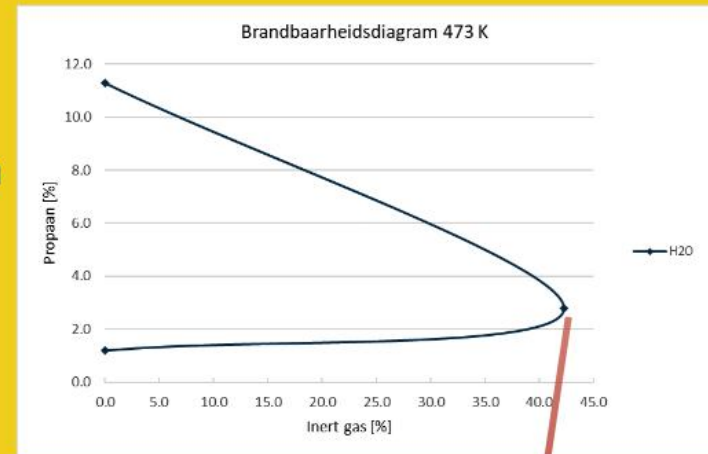
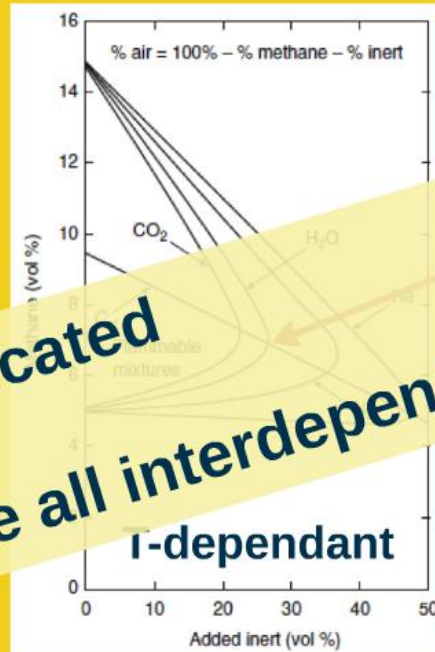
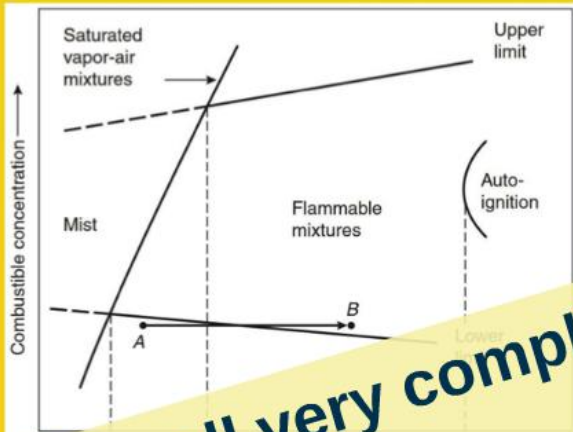
ca. 343 litre
25,8 liter propane =
7.5 vol %

ca. 166 litre
8 liter propane = 4.8 vol %

droplet size = 3-8 μm

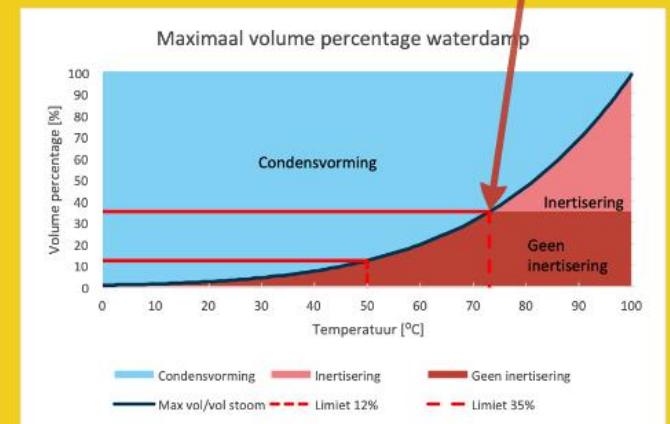


4 criteria to consider for (in)flammability:



This is all very complicated because these parameters are all interdependent

73 C = 35 %



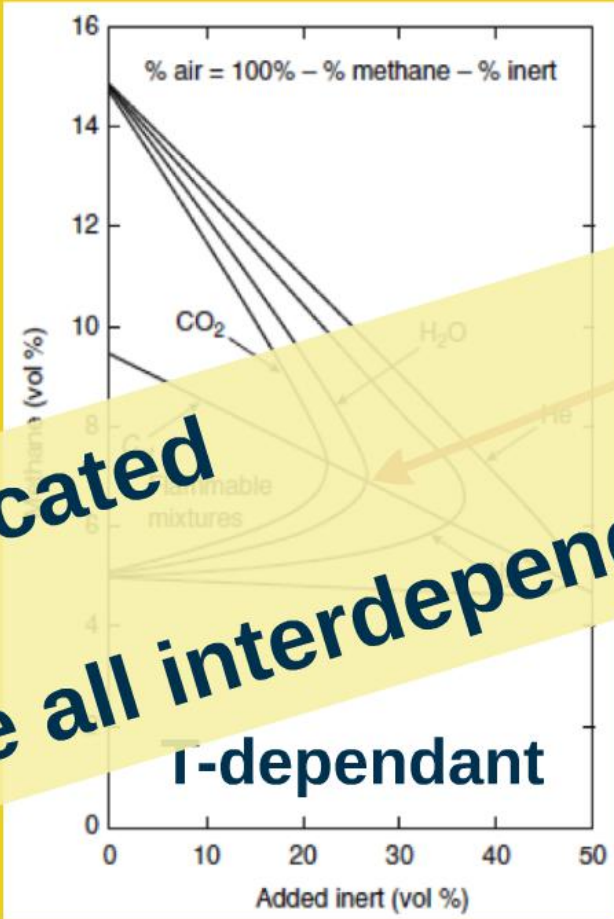
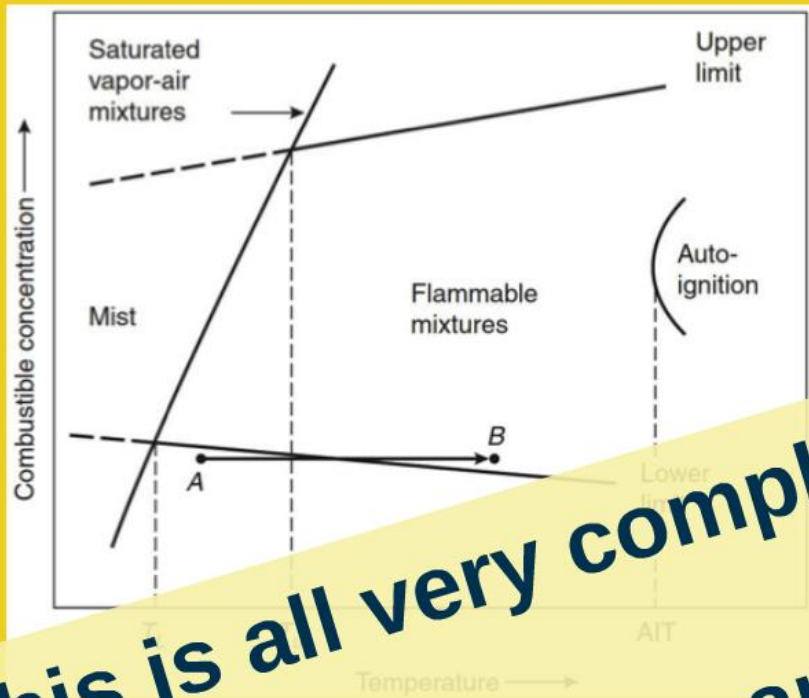
3. limiting oxygen concentration (LOC)

4. adiabatic flame temperature ($\pm 1500\text{K}$)

2. flammability limits

Inertisation point

I-dependant



This is all very complicated because these parameters are all interdependant

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

2. flammability limits

3. limiting oxygen concentration (LOC)

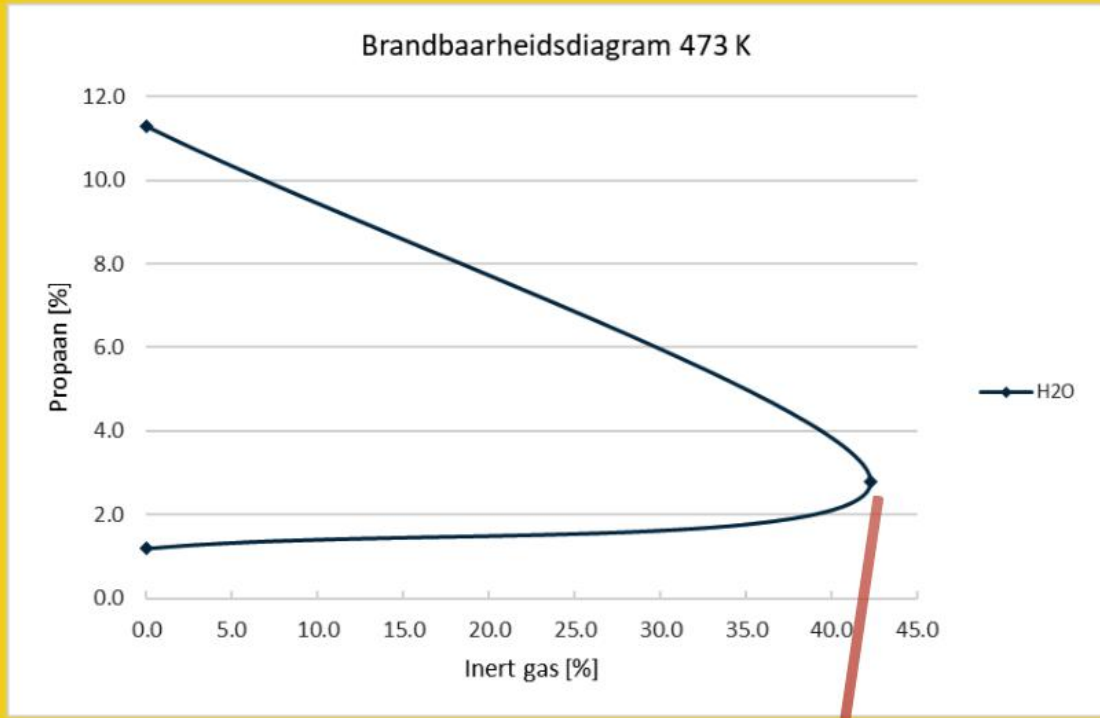
4. adiabatic flame temperature ($\pm 1500K$)

Propanen [%]
Volume percentage [%]

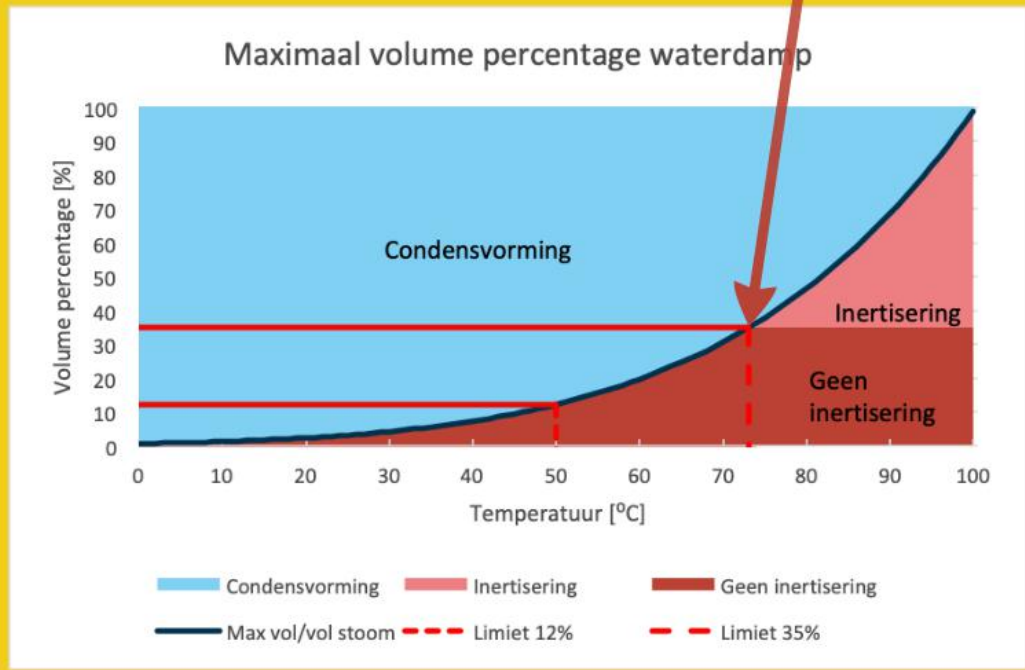
Inertisation point

ndant

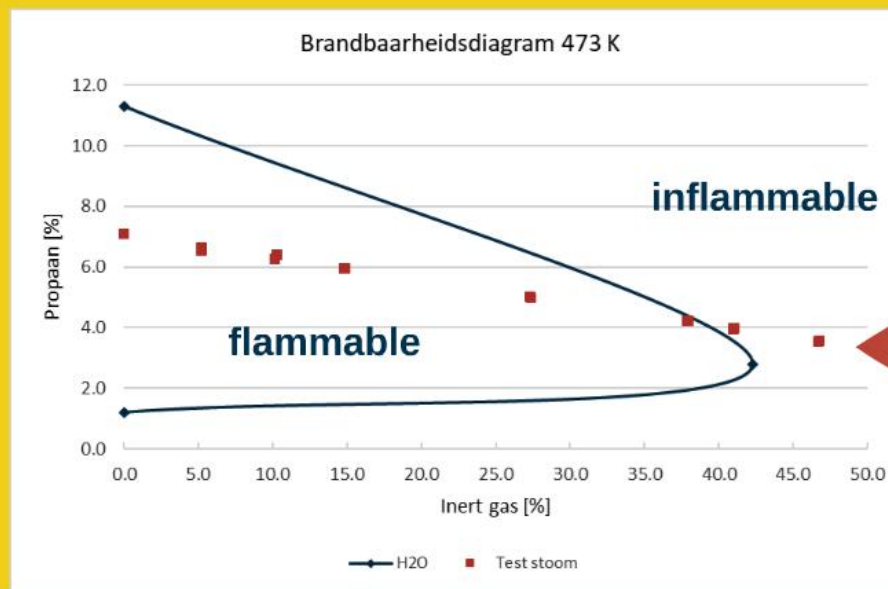
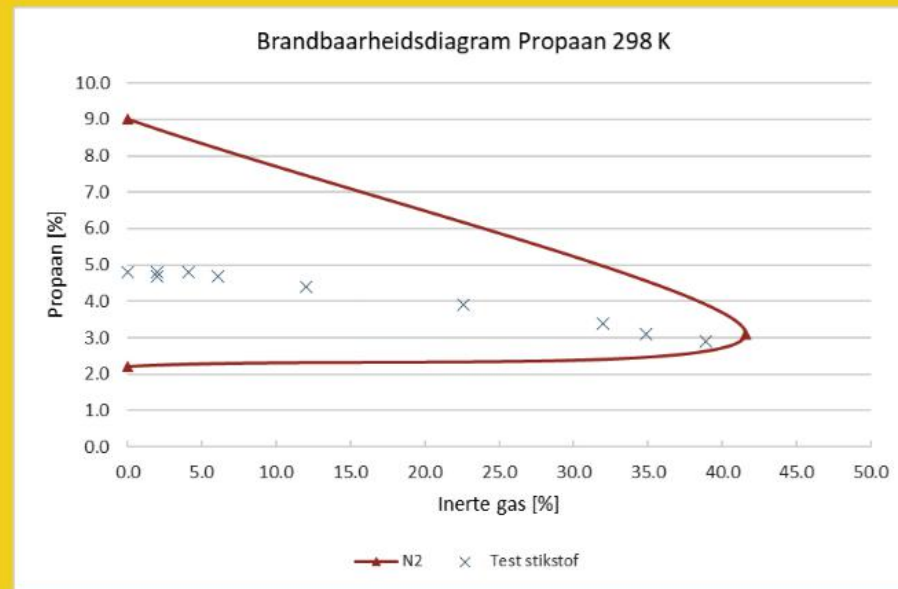
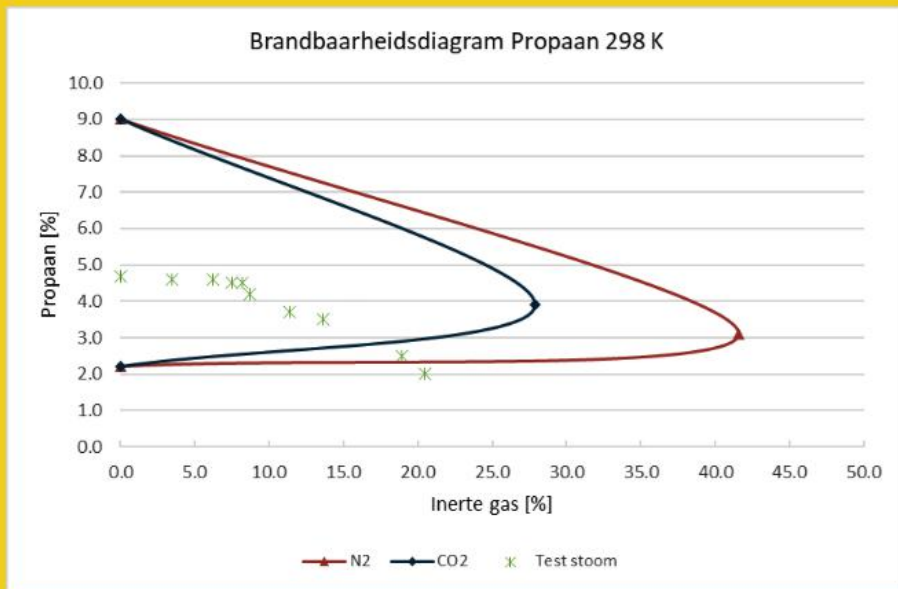
imits



73 C = 35 %



Results:



490C: 42% stroom =
 100% efficiëntie
 78 m/s = 170 m/s
 42% H2O 82% efficiëntie
 = 28.1%

490C: 42% stroom =
 100% efficiëntie
 78 m/s = 170 m/s
 42% H2O 82% efficiëntie
 = 28.1%

490C: 42% stroom =
 100% efficiëntie
 78 m/s = 170 m/s
 42% H2O 82% efficiëntie
 = 28.1%



**400C: 42% steam =
inertisation point**

**70 m³ = 70m² x 1m
42% H₂O 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**



.....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



Examples of previous results

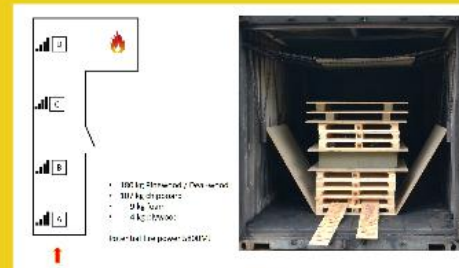
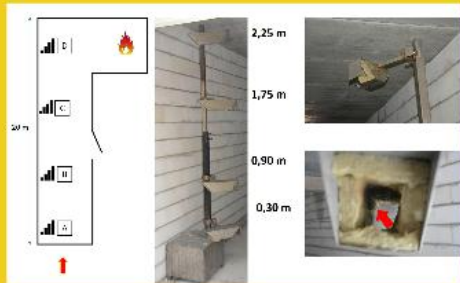
Parameter	Value
Temperature	...
Smoke concentration	...
...	...



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

Smoke cooling or surface cooling?

Planned: Real scale experiments

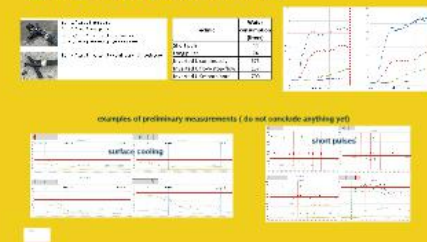


PREVIEW

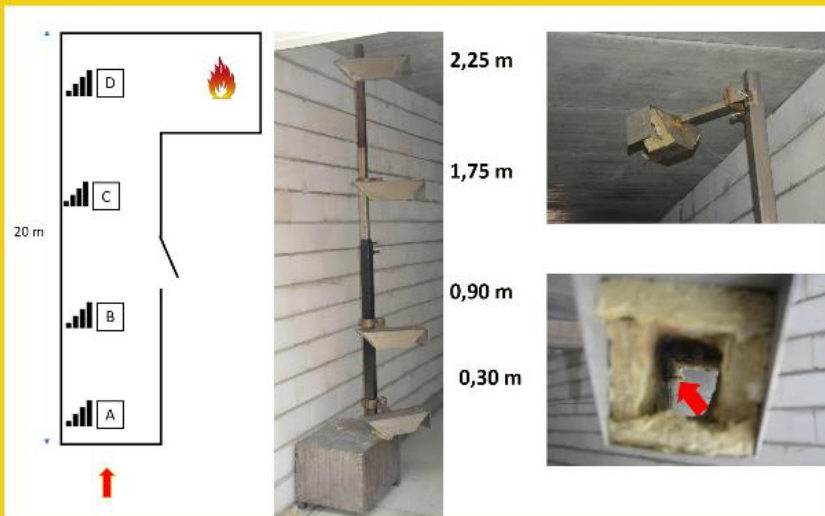


- surface cooling with
 - straight stream 400 l/min
 - straight stream 250 l/min
 - high pressure 125 l/min
 - CAFS
- half circle method
- smoke cooling
 - short pulses 250 l/min
 - long pulses 250 min

Examples of pretest results



Planned: Real scale experiments



- 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

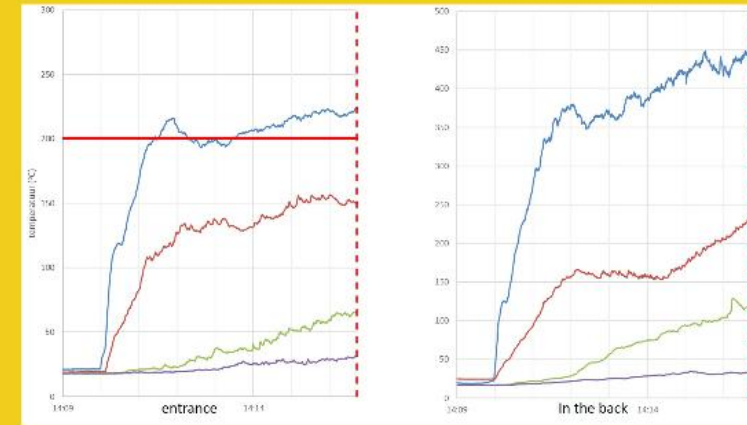


Burn 1 / test 1 Short pulse
 Burn 2 / test 2 Long pulse
 Burn 3 / test 3 Inverted U - continuously
 Burn 3 / test 4 Inverted U- stop and flow

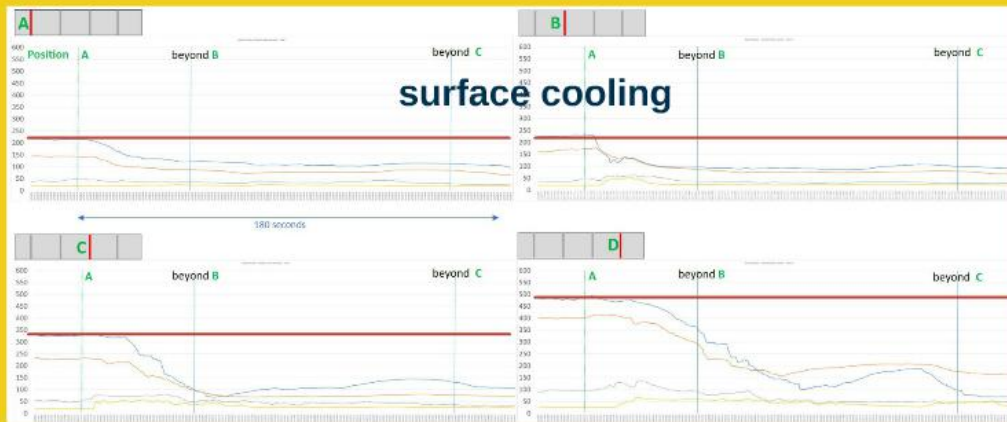


Burn 4 / test 5 Inverted U – continuously - Smooth bore

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

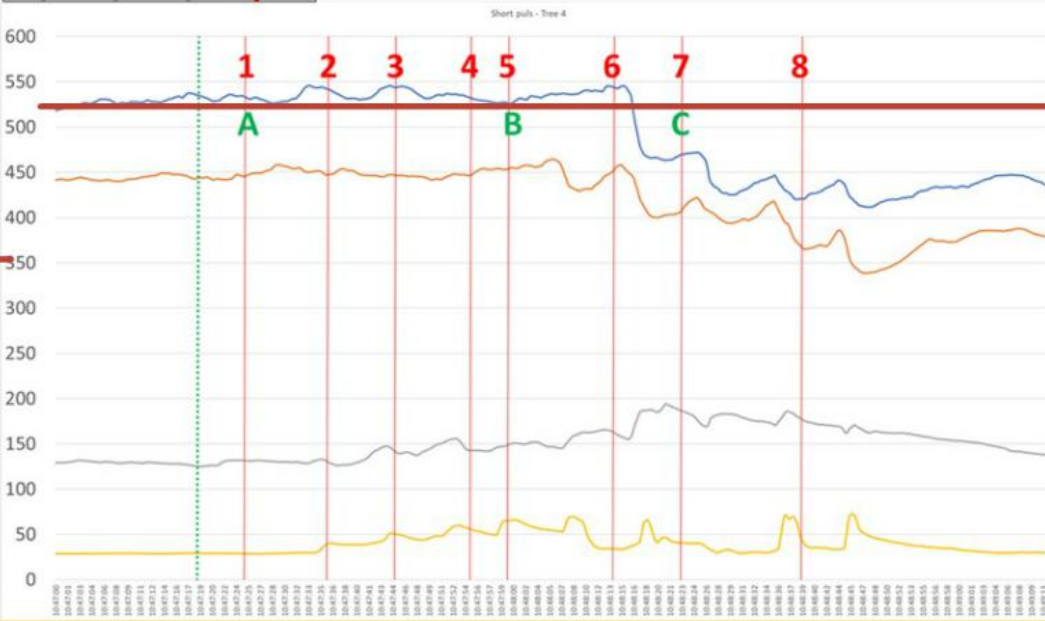
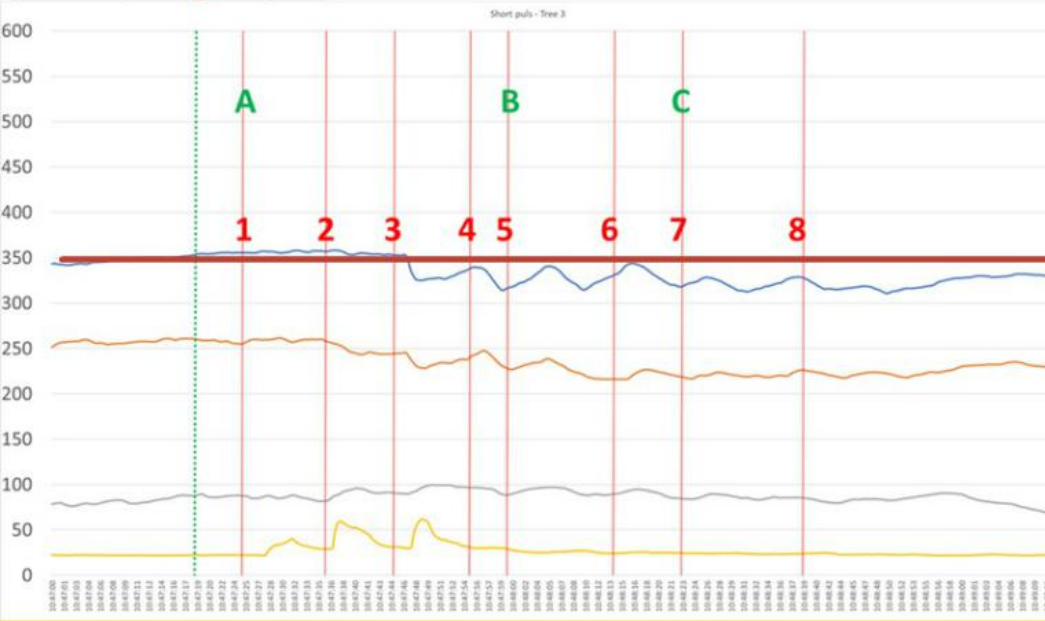
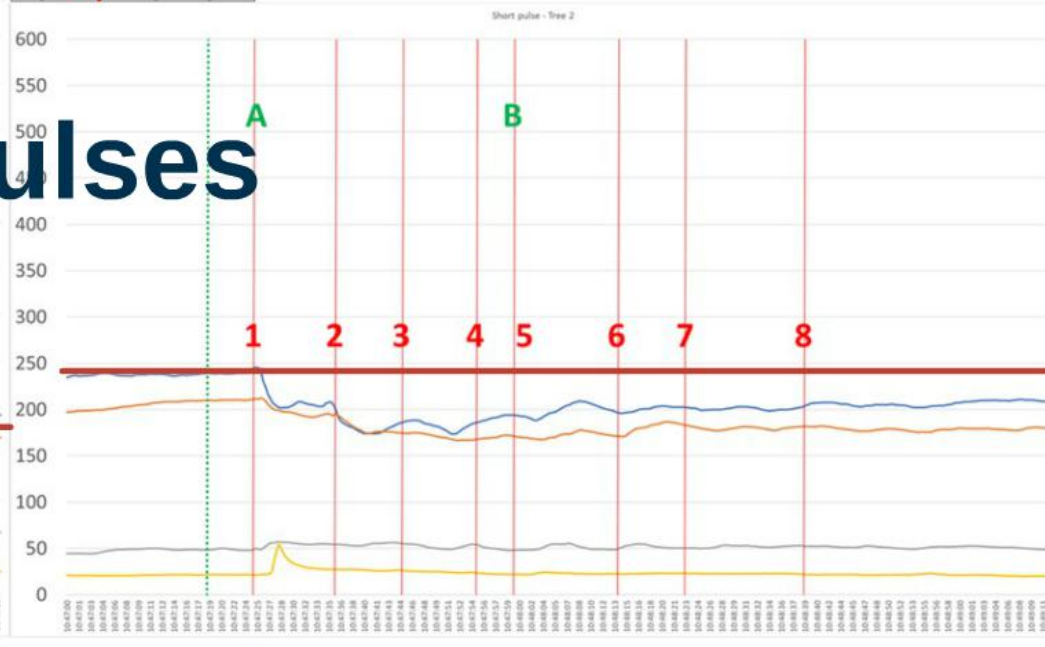


examples of preliminary measurements (do not conclude anything yet)



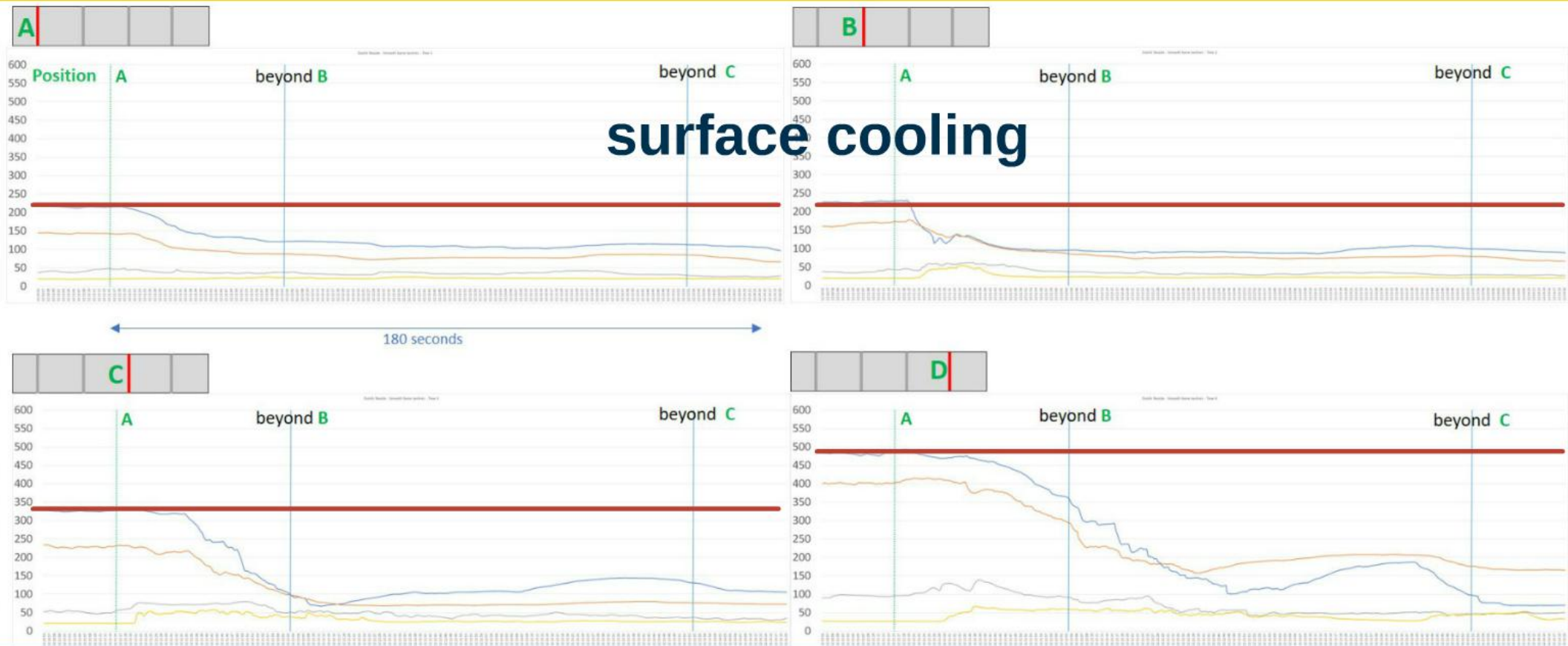
Conclude anything yet?

short pulses



examples of preliminary measurement

surface cooling





.....SMOKE.....



Cooling and / or Inertisation ?

Research questions



Literature study



Labscale experiments



Experiments: scale model



Smoke explosions / Fire gas ignitions



Smoke cooling or surface cooling?

Planned: Real scale experiments



PREVIEW



Smoke dispersion



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

Smoke dispersion



Casuïstiek uit brandonderzoek

TRENDS OM VAN TE LEREN



Summary

Summary of the report, including key findings and conclusions. The text is too small to read accurately.



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

© 2020
Schuilenburgh
Alle rechten voorbehouden.
Het verspreiden, kopiëren of anderszins openbaar maken van dit document is strafbaar.
Schuilenburgh is niet aansprakelijk voor schade van welke aard ook voortvloeiende uit het gebruik van de informatie op deze website.
Schuilenburgh aanvaardt geen aansprakelijkheid voor schade van welke aard ook voortvloeiende uit het gebruik van de informatie op deze website.
Schuilenburgh aanvaardt geen aansprakelijkheid voor schade van welke aard ook voortvloeiende uit het gebruik van de informatie op deze website.



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**
 - apartments next to and above**
- temperature, visibility, concentrations of gases, radiation**

2019-05-21 11:15:55



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 apartment buildings: experiments next week



.....SMOKE.....



Cooling and / or Inertisation ?

Research questions



Literature study



Labscale experiments



Experiments: scale model



Smoke explosions / Fire gas ignitions



Smoke cooling or surface cooling?

Planned: Real scale experiments



PREVIEW



Formulation of general results



Smoke dispersion



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