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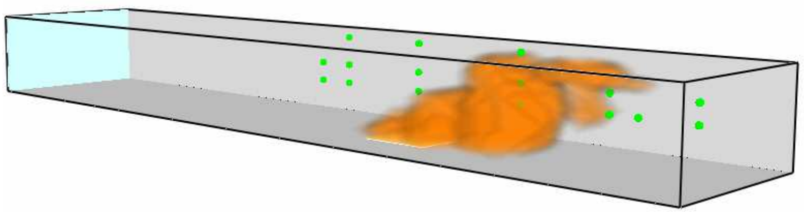
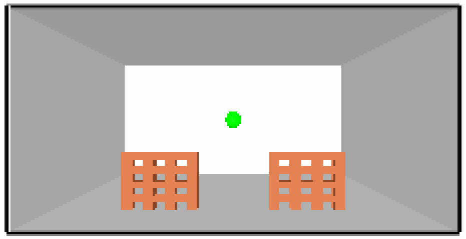
Research into the use of **small scale tests** combined with **CFD simulations** to assess the efficiency of **water mist** in **tunnels**





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Thanks to…

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- Carly Noordermeer & Christian Verduyn
  - 2 students applied physics
  - Internship of 22 weeks at Efectis Nederland
  - Carly: focus on calculations
  - Christian: focus on experiments

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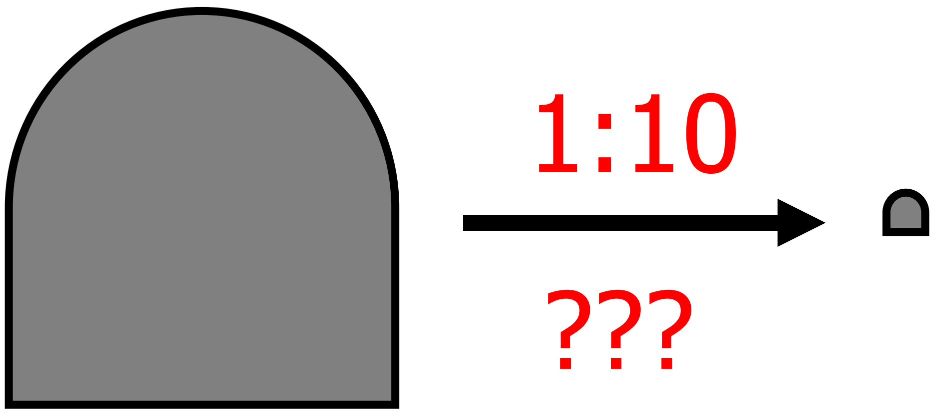
Introduction

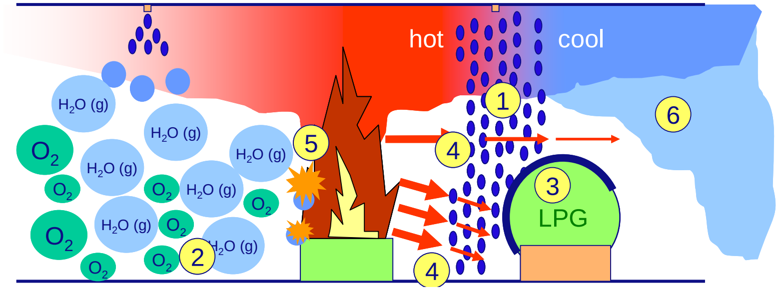
- Increased attention for active systems in tunnels
- Full scale tests are expensive
- Full scale tests are unsuitable for parameter studies

➔ Assess feasibility of 1:10 scale testing



Objectives

- Investigate the possibility of 1:10 scale tests
  - Relevant physical phenomena
  - Tunnel fire dynamics
  - Watermist



- Investigate the use of CFD simulations and small scale tests as an educational tool for students
  - Physics of fire
  - Influence of active systems

Scale tests

Challenges:

- Create scaled tunnel geometry with realistic ventilation conditions
- Create scaled fire source
- Create scaled watermist

Scale tests - challenges

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Geometry (1:10)

- Concrete tunnel
- L x W x H = 5m x 1m x 0.50m
- Longitudinal ventilation by fans

Longitudinal ventilation

- Value based on critical velocity
- ~1m/s
- Turbulent profile created by grid

Scale tests - challenges

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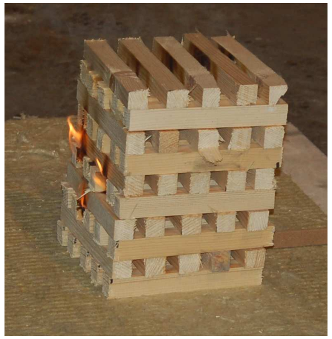
Fire source

- 30MW on real scale ➔ ~100kW in scale tunnel
- wooden crib fires: ~50kW (per crib)
- N-heptane pool fire: 300kW (!)
- Plastics (for smoke experiments)
- Reasonable gas temperatures needed for watermist



Scale tests - challenges

Watermist

- small droplets needed (<50μm)
- Relatively small flow rate needed (~1 lpm)
- Limited throw required due to limited height
- High pressure needed

Result

→ high pressure cleaner + general purpose nozzles:

→ Droplet size: 20 μm @ 80 bar

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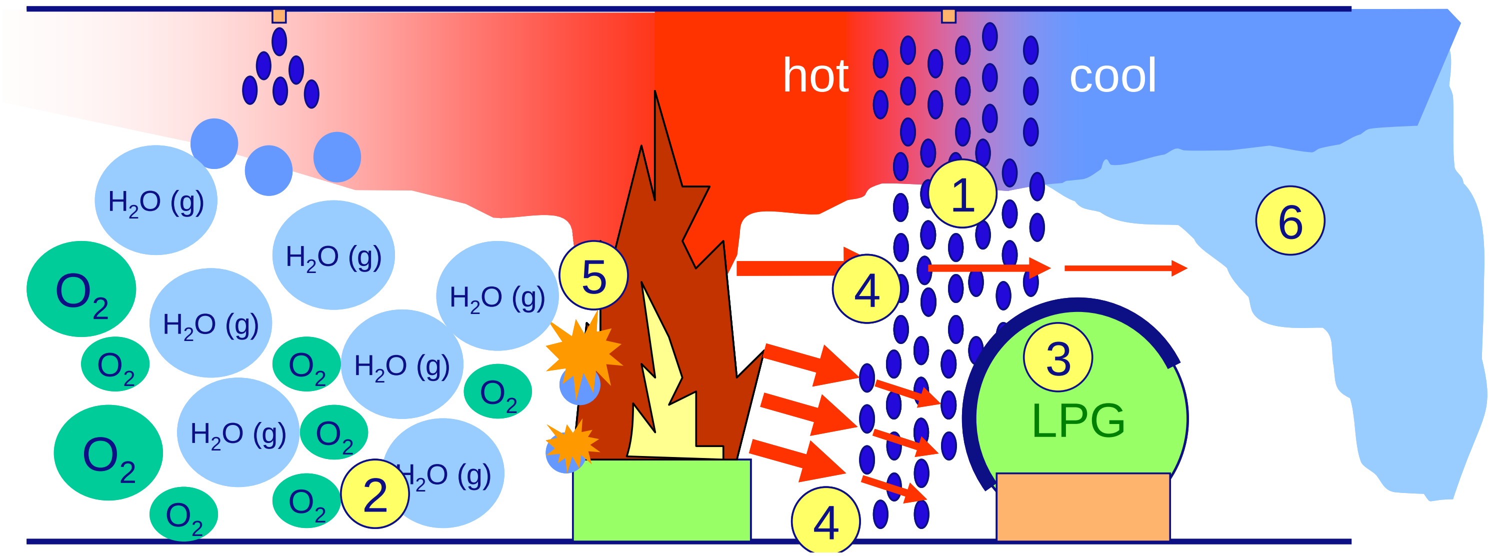
Some experiments

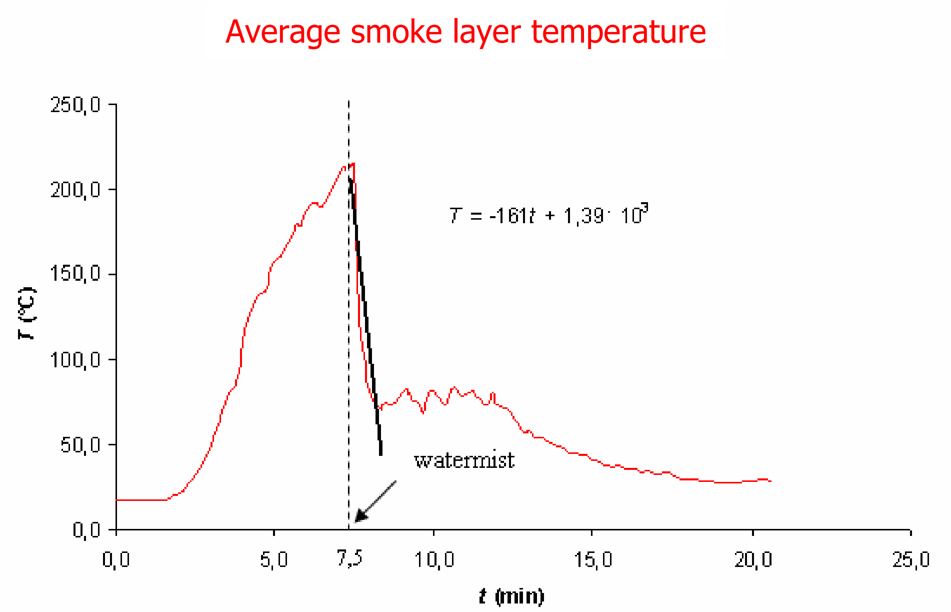
- Effects of watermist on smokelayer temperature (1)
- Prevention of a BLEVE (3)
- Effects of watermist on visibility (6)



Scale tests - results

Effects on smoke layer temperature:

- Proportional to flow rate
- Depends on nozzle positioning
- Can be investigated perfectly in scale tunnel



Scale tests - results

BLEVE (failed)

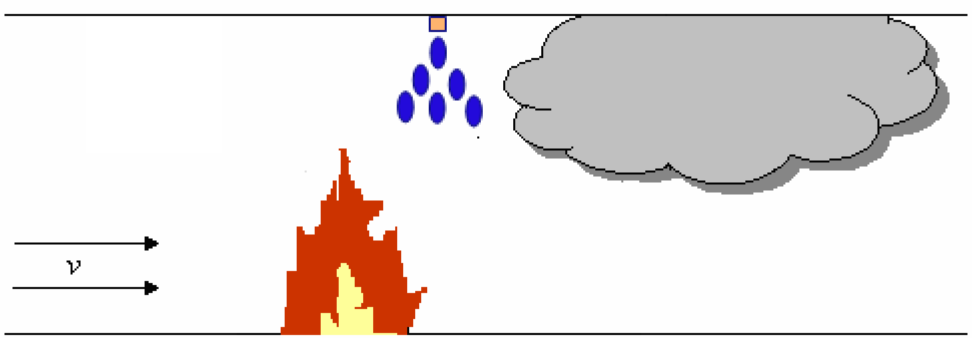
- 300kW fire
- Paint can filled for 10% (water) and covered with the lid
- Lid blew off after a few seconds ➔ air expansion?
- Other sealing methods failed up to know

➔ TO DO: find a suitable scaled 'tanker'

Scale tests - results

Effects on smoke

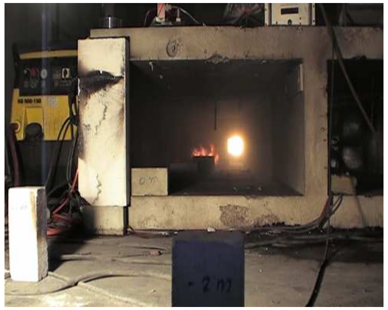
- Fire source is not influenced by watermist (in test setup!)
- Visibility decrease at activation
- Visibility increases rapidly!



Pre-burning

Activation of nozzle

20 seconds after act.



40 seconds after act.

Scale tests - conclusion

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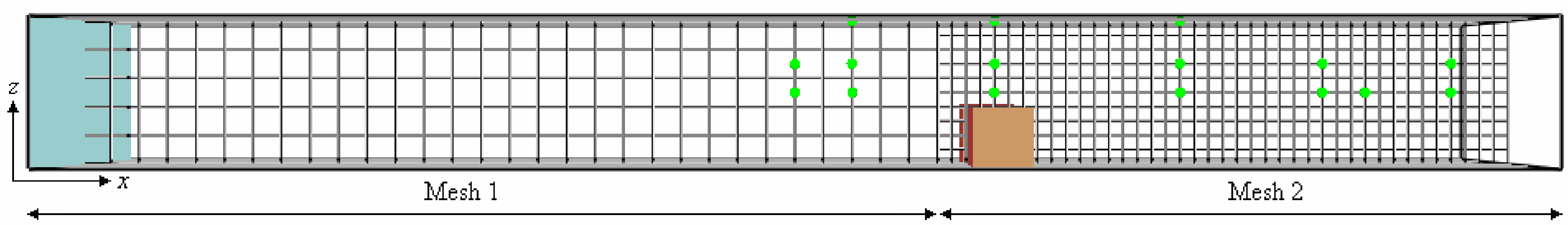
- Key effects of watermist can be reproduced in the small scale setup
- Suitable tool for demonstration and education purposes
- For serious (fundamental) research a larger scale should be considered

CFD

- 3D modelling of fluid flow, heat transfer etc.
- Based on physical conservation laws (mass, momentum, energy, ..)
- Division of 3D space in small volumes needed (mesh)
- On the discrete volume level the conservation laws apply



Computer simulations

Simulations:

- Ongoing!

- Use of FDS to model scale tests (no watermist involved)
  - Compare results with experiments
  - Compare different ways to model fires

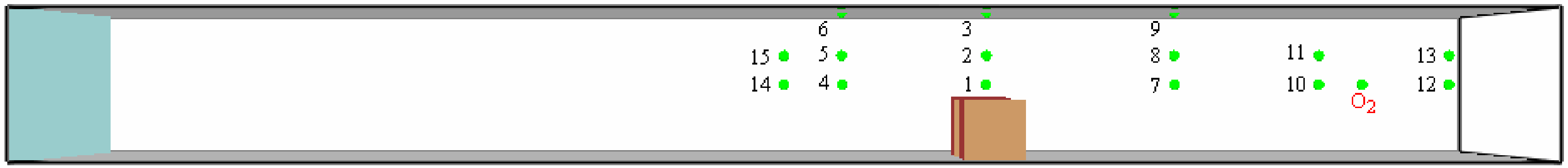
- Use of watermist in FDS (without fire)
  - Study droplet modelling
  - Study influence of input parameters

➔ TO DO: combination of watermist and fire

Compare FDS results with experiments

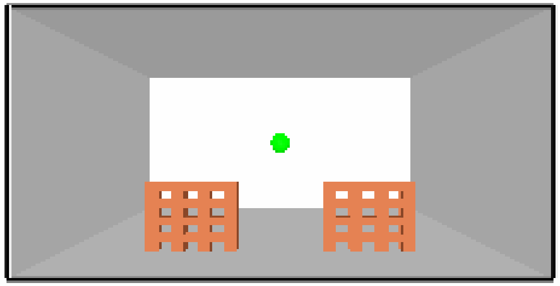
- “Small-size” FDS model (also 1:10)
- Heat release rate from experiment is known
- Fire source modelled on faces of a cube
- Tunnel walls are modelled as concrete (thermally)

➔ (Averaged) temperatures on TC-locations are in good agreement with measurements



Fire source modelling

- Variation in shape, surface area, model:
  - → wooden *cubes* with burning surface (applied RHR)
  - → wooden *cribs*: fire spread with piloted igniton
    - → failed to ignite (fire development) in FDS
    - → effect of watermist on fire development…???



Computer simulations - results

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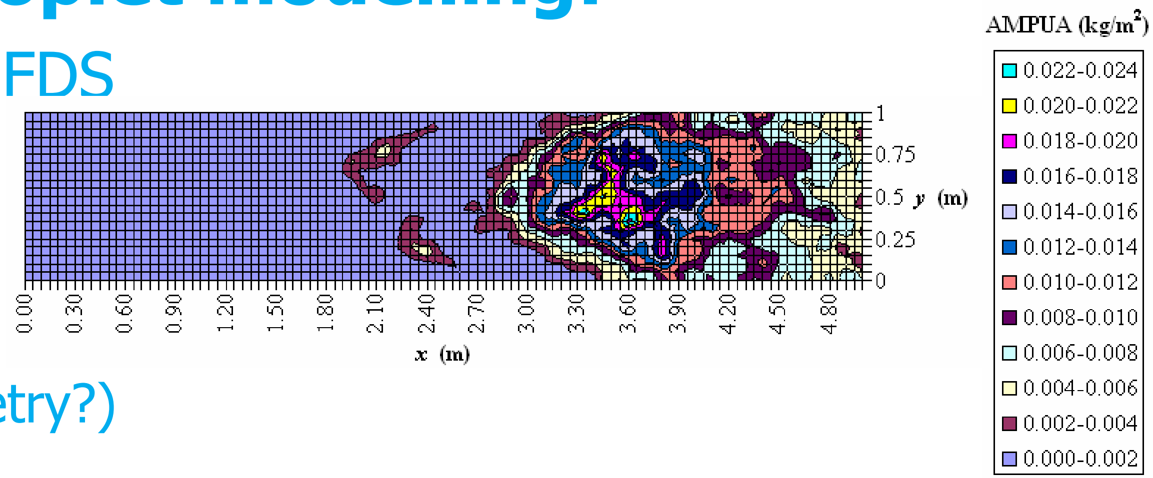
Study/check droplet modelling:

- User validation of FDS
- Simple checks:
  - Applied flow rate
  - Mass balances
  - Foot print (symmetry?)



Study influence of input parameters

- Non physical parameters: # droplets, ..
- Physical parameters: nozzle properties, ..

Computer simulations - conclusions

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Watermist modelling in FDS

- Virtually unlimited possibilities for parameters
- Easy to do.. but a challenge to do it *correct!*
- Do not trust the results, before you checked them thoroughly

- To model extinguishing effects → control pure fire development

Conclusions

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Scale tests

- Key effects of watermist can be reproduced ➔ suitable tool for demonstration and educational purposes
- For serious (fundamental) research a larger scale should be considered

Simulations using FDS

- Extensive knowledge needed to use watermist in FDS
- To model extinguishing effects → control pure fire development