BUS FIRE SAFETY

6th meeting of the informal group on
"Behaviour of M2 & M3 general construction in case of Fire Event (BMFE)"

Oslo 2019-02-27/28

Michael Försth

RISE Research Institutes of Sweden

Fire Research

Outline

- 5.1 Simulation and experiment
- 5.2 Full scale test, experiences from previous test
- Fire detection

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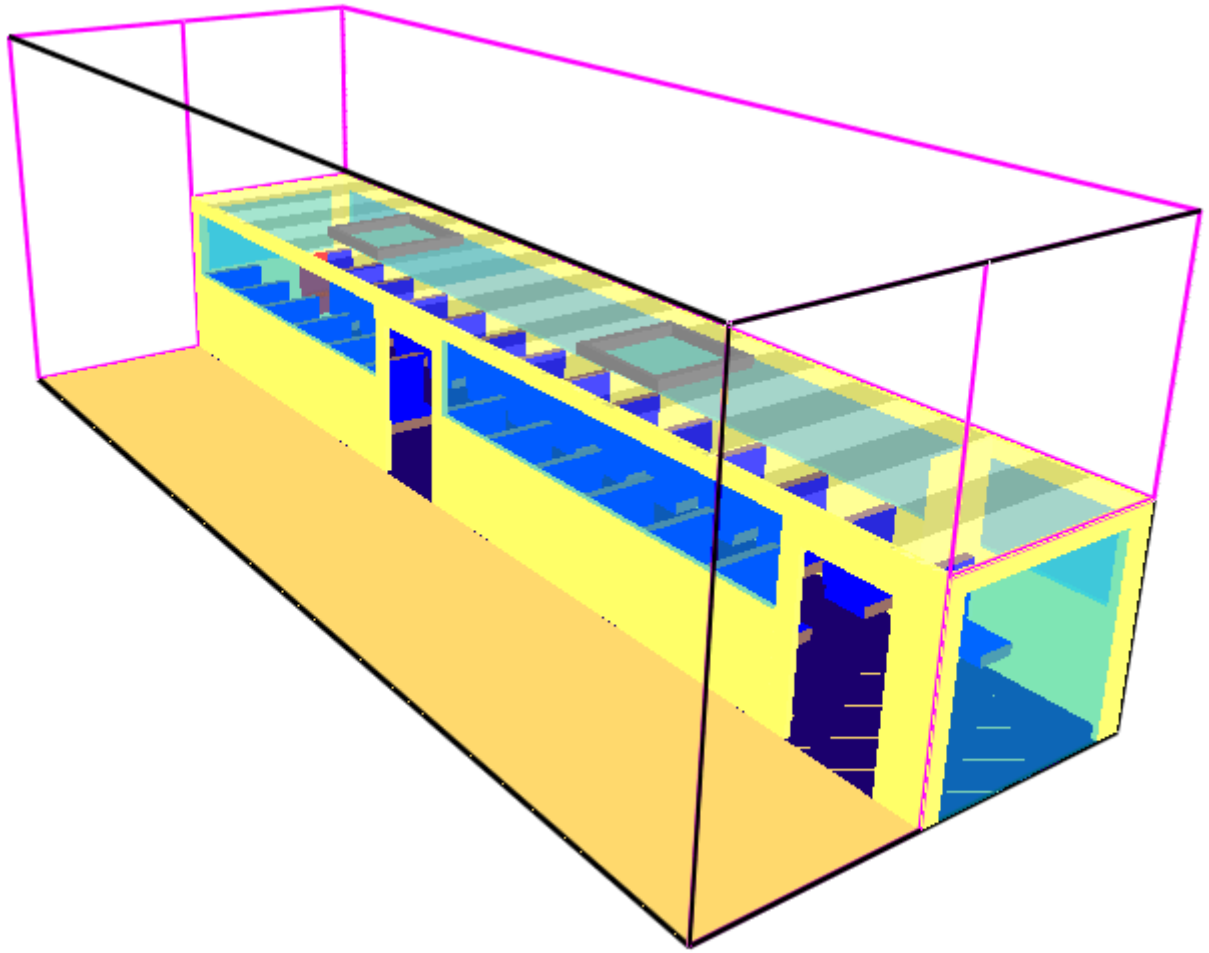
- 5.1 Simulation and experiment
  - FDS model
  - Material data
  - Smoke spread
    - open vs closed doors, open roof hatches
    - open vs closed doors, closed roof hatches
    - open vs closed roof hatches
  - Flame spread

- 5.2 Full scale test, experiences from previous test
- Fire detection

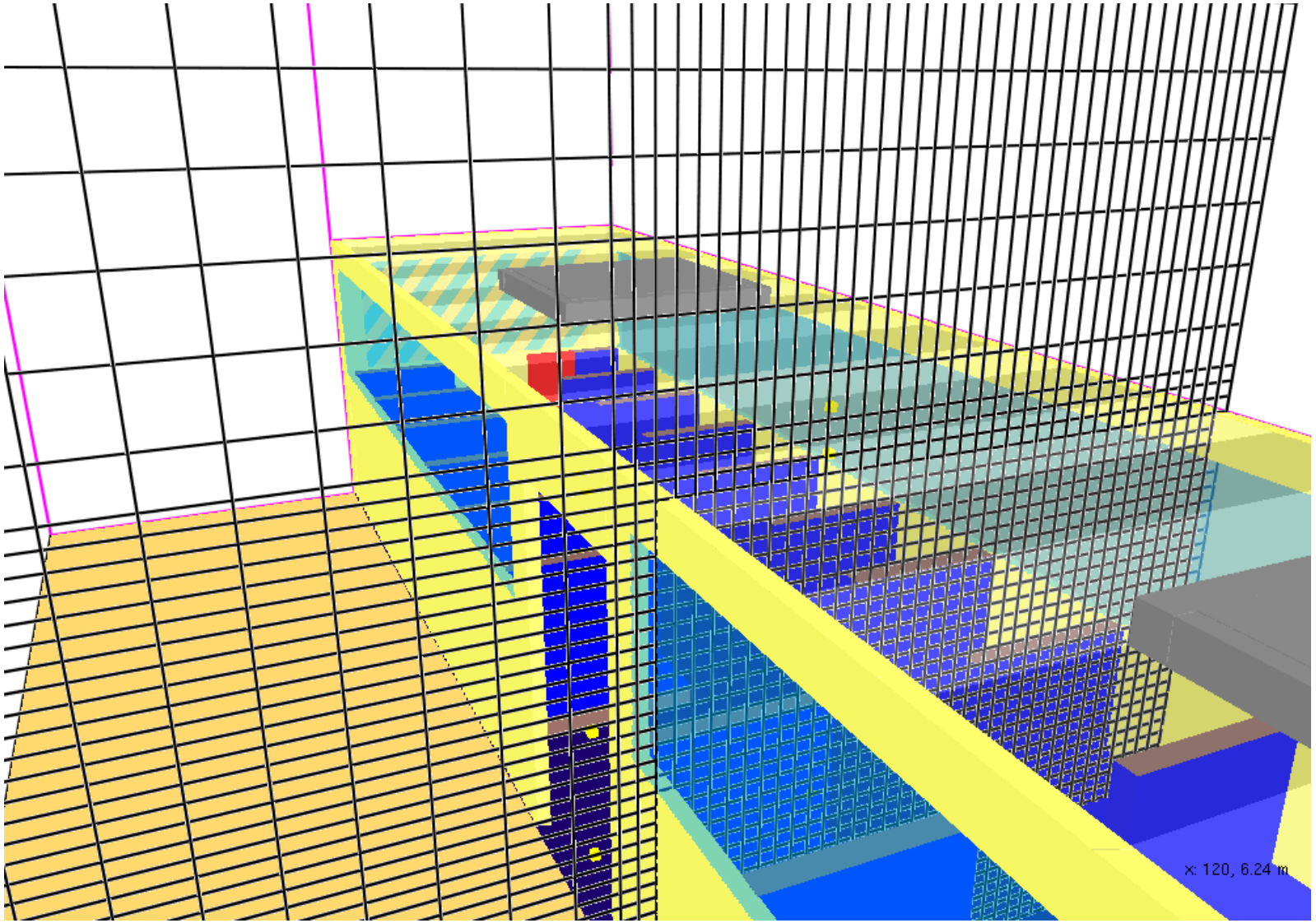
FDS-model

- FDS: Fire Dynamics Simulator
- Developed by NIST in the U.S.A. in cooperation with VTT Technical Research Centre of Finland
- FDS is a CFD (Computational Fluid Dynamics) model of fire-driven fluid flow. The program solves numerically a form of the Navier-Stokes equations appropriate for low-speed, thermally-driven flow, with an emphasis on smoke and heat transport from fires.
- Smokeview, also developed by NIST, is used to visualize the results.

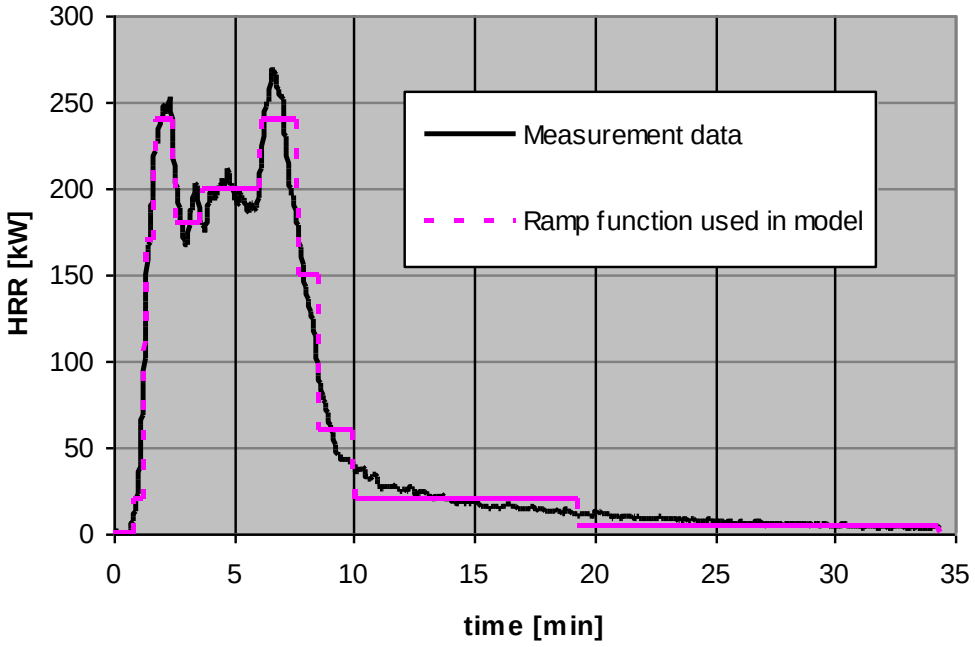
The bus:



The bus:

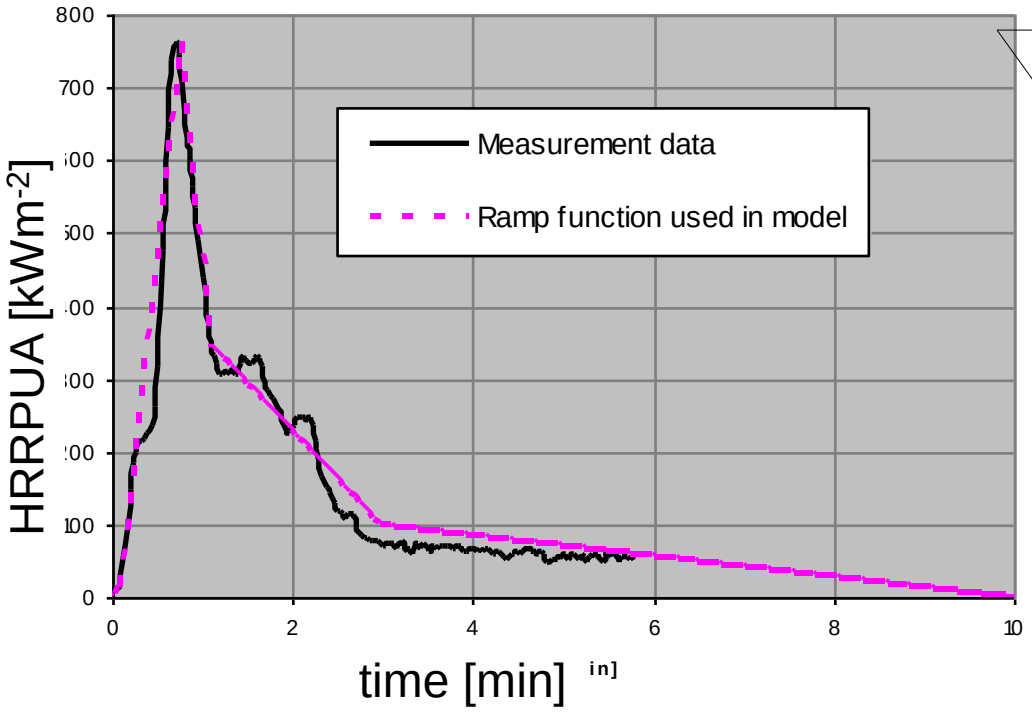


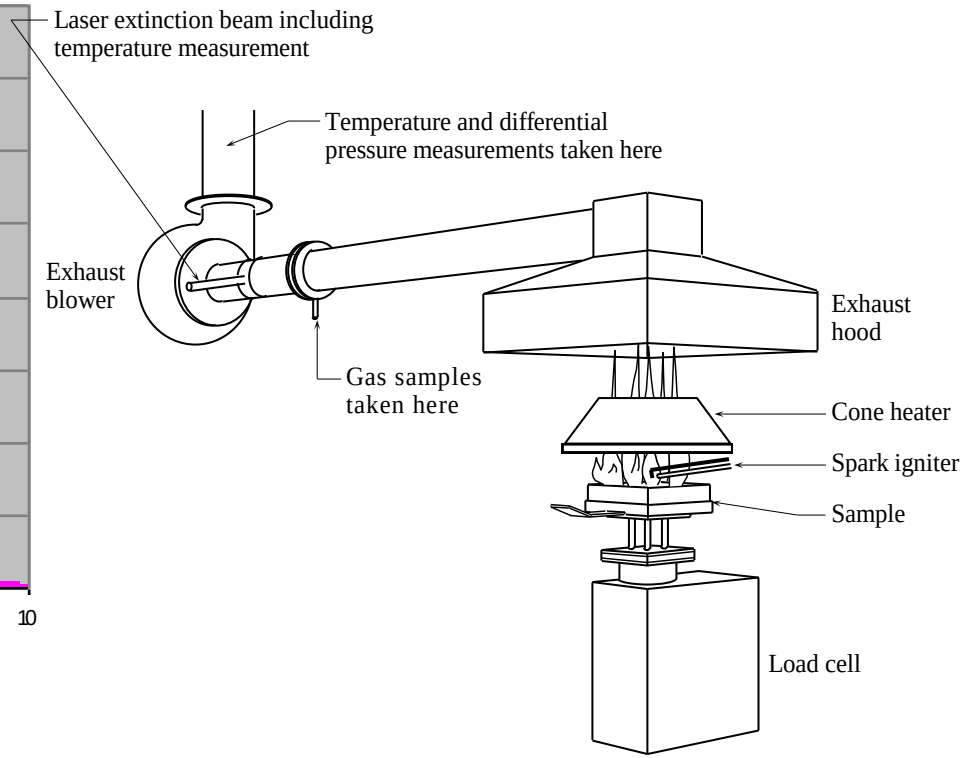
Ignition source: implementation of heat release curve in FDS



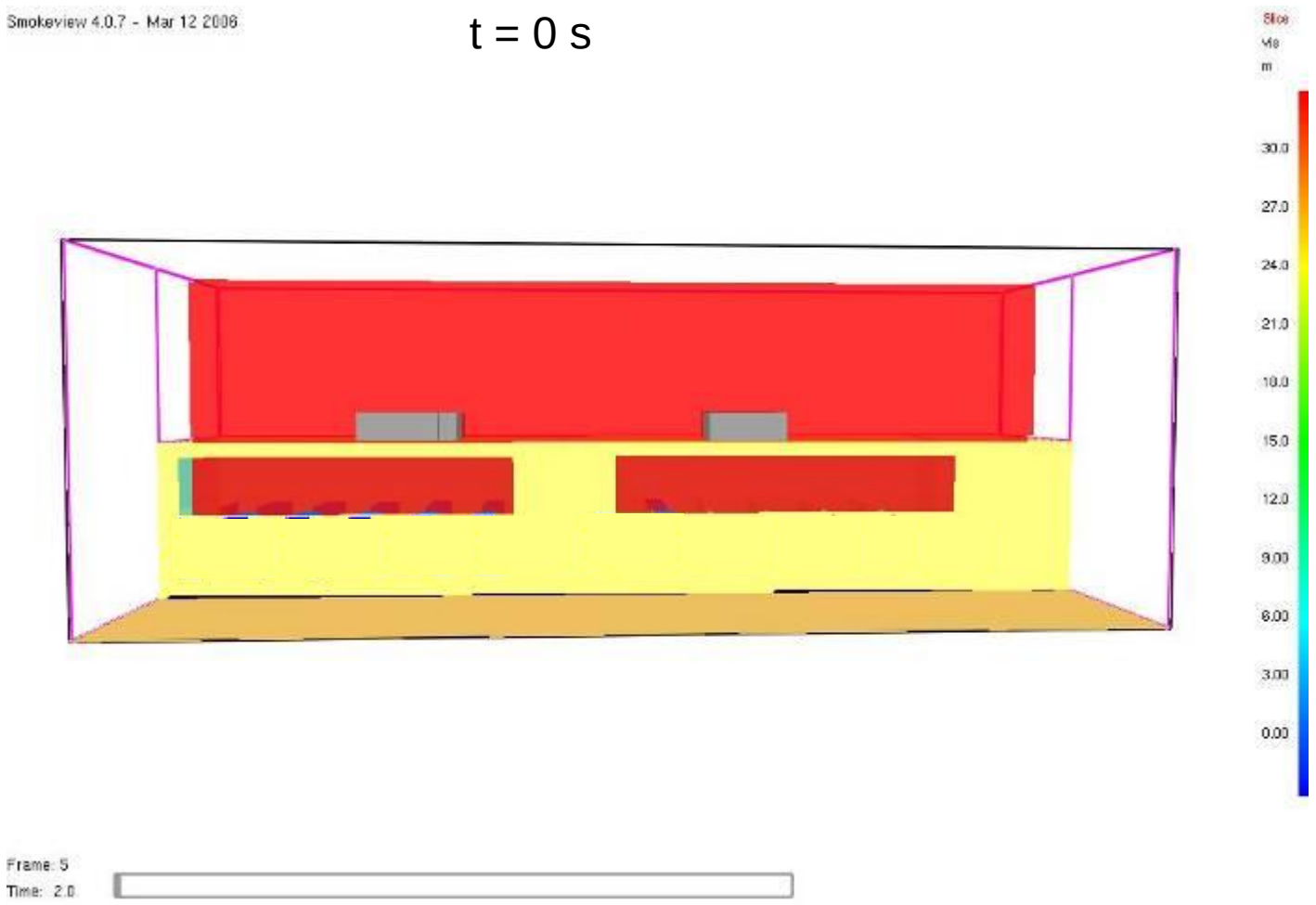
Needle felt in ceiling plays a decisive role in flame spread

Needle felt: Implementation of heat release curve in FDS



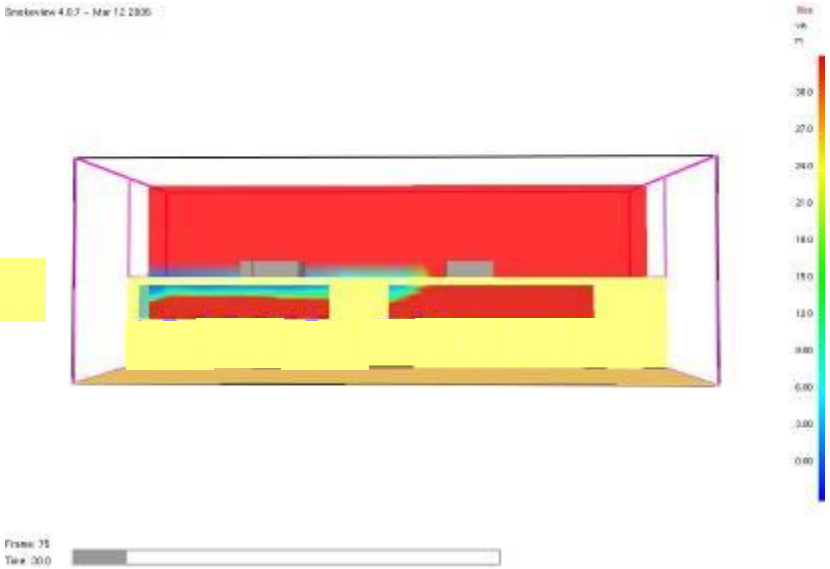


Smoke spread: open vs closed doors, open roof hatches



Smoke spread: open vs closed doors , open roof hatches

t = 30 s

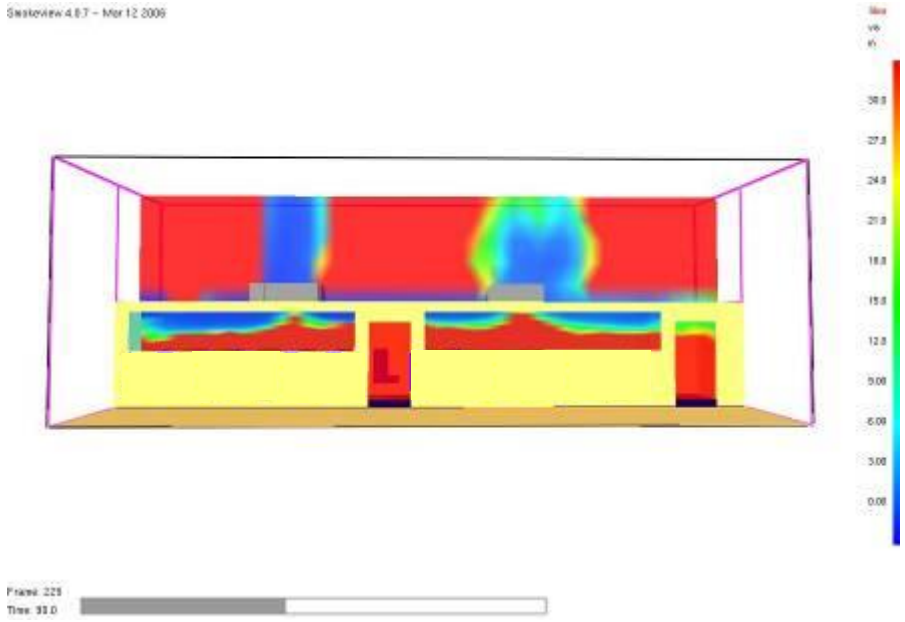


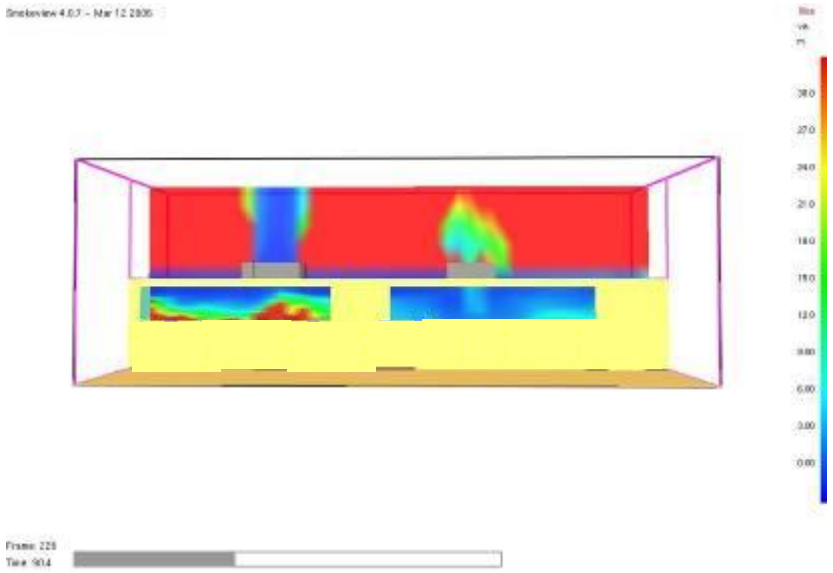
Smoke spread: open vs closed doors , open roof hatches

t = 60 s

Smoke spread: open vs closed doors , open roof hatches

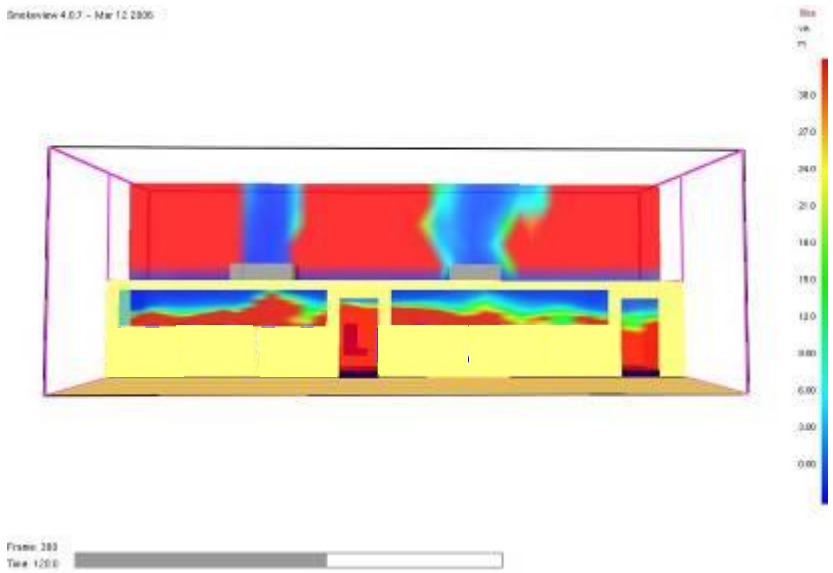
t = 90 s

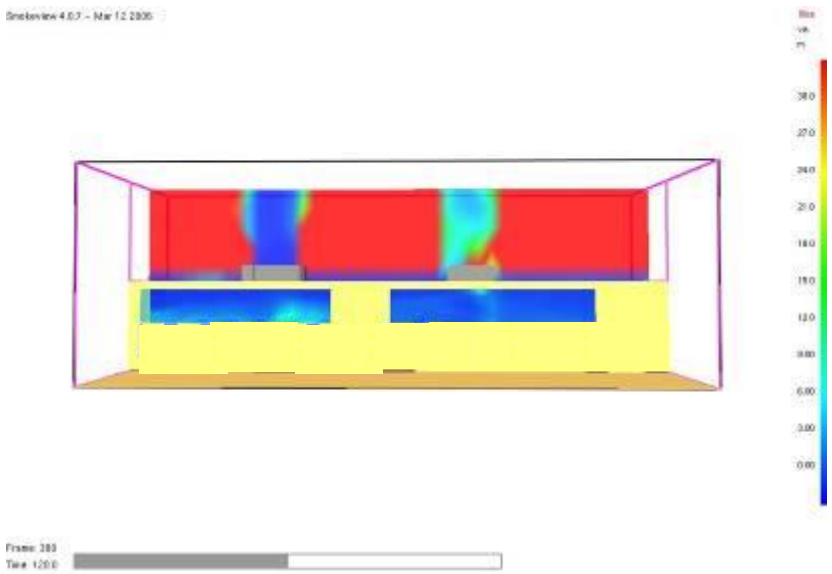




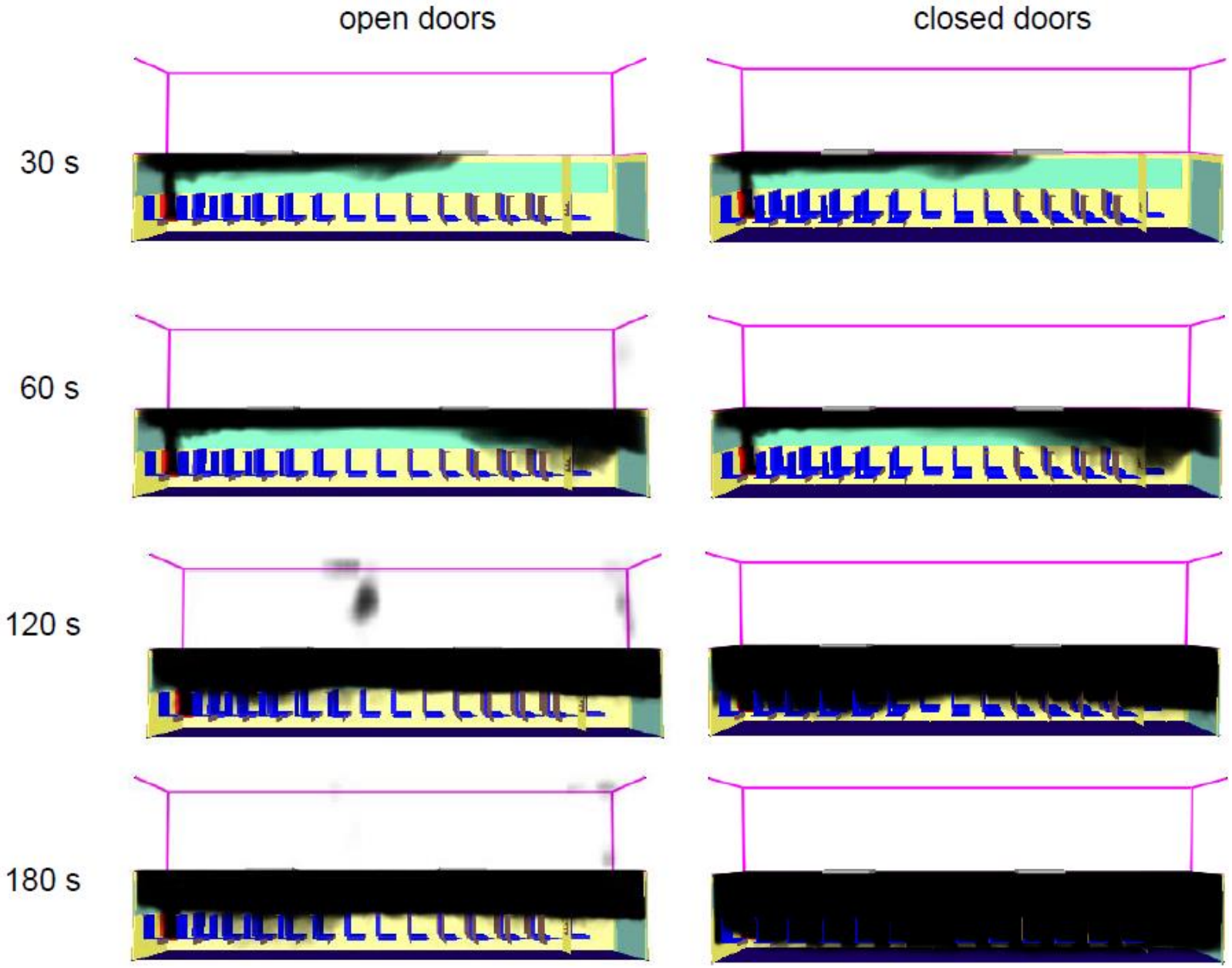
Smoke spread: open vs closed doors , open roof hatches

t = 120 s

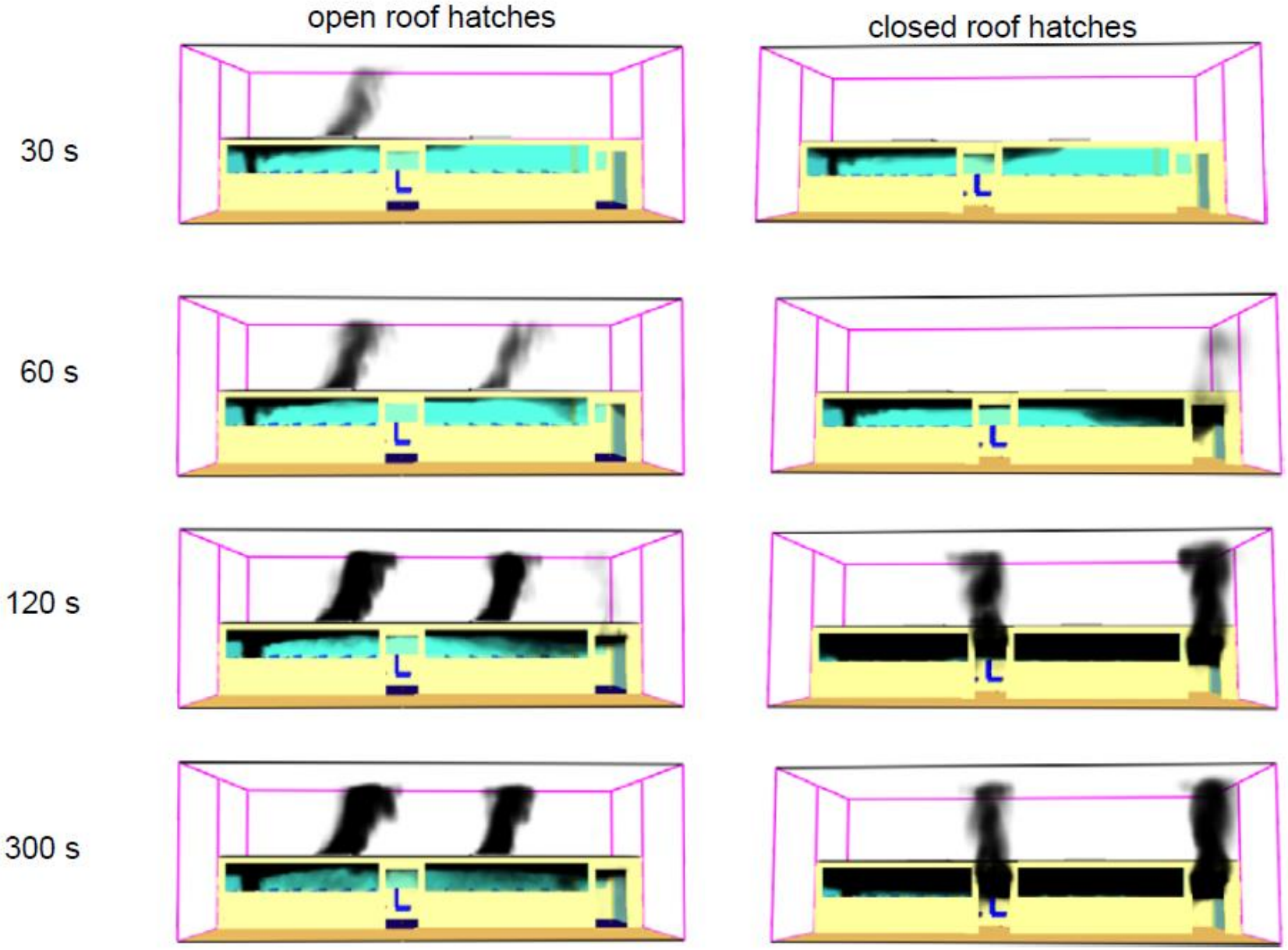




Smoke spread: open vs closed doors, closed roof hatches

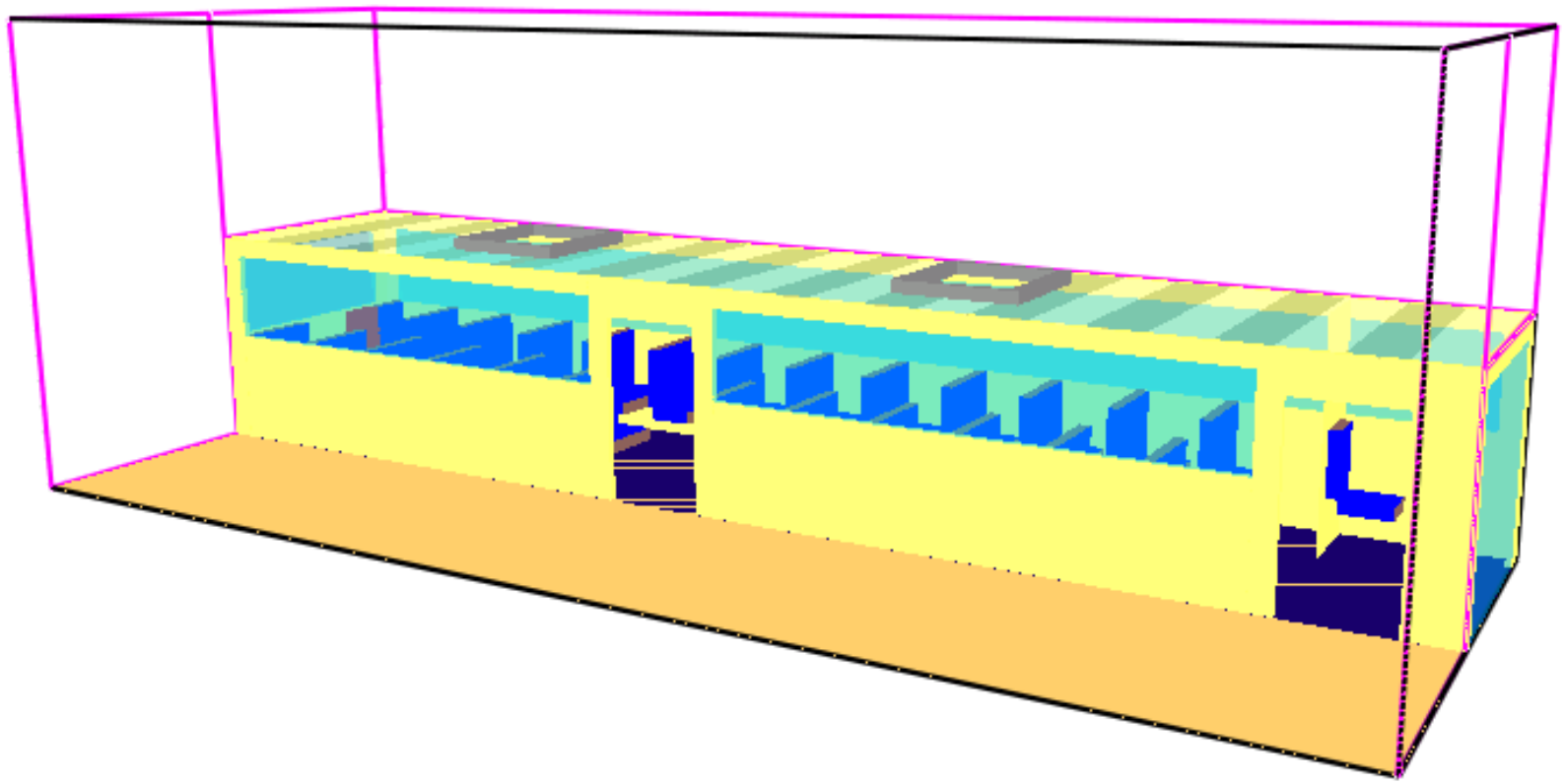


Smoke spread: open vs closed roof hatches



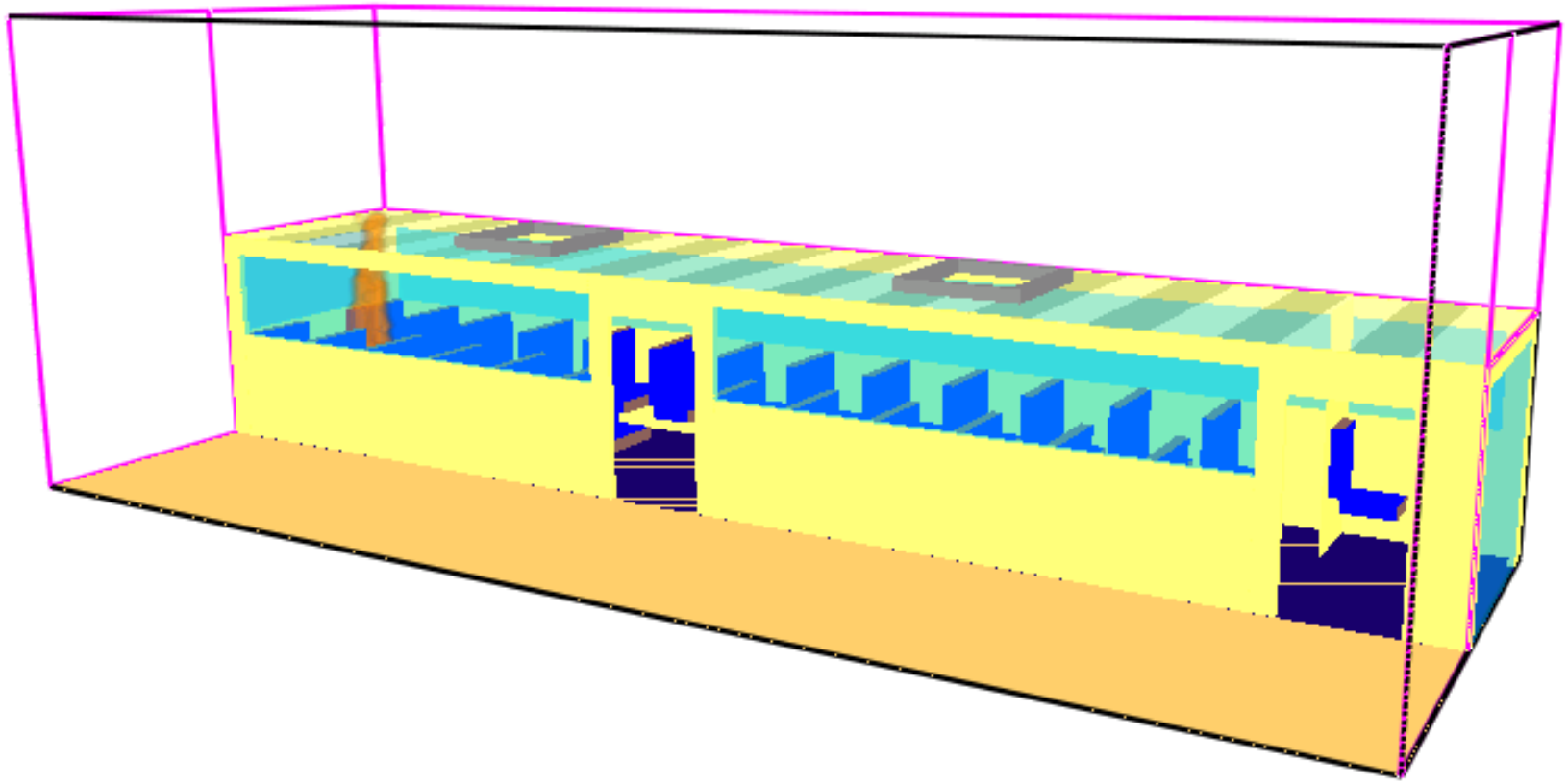
Flame spread

t = 60 s



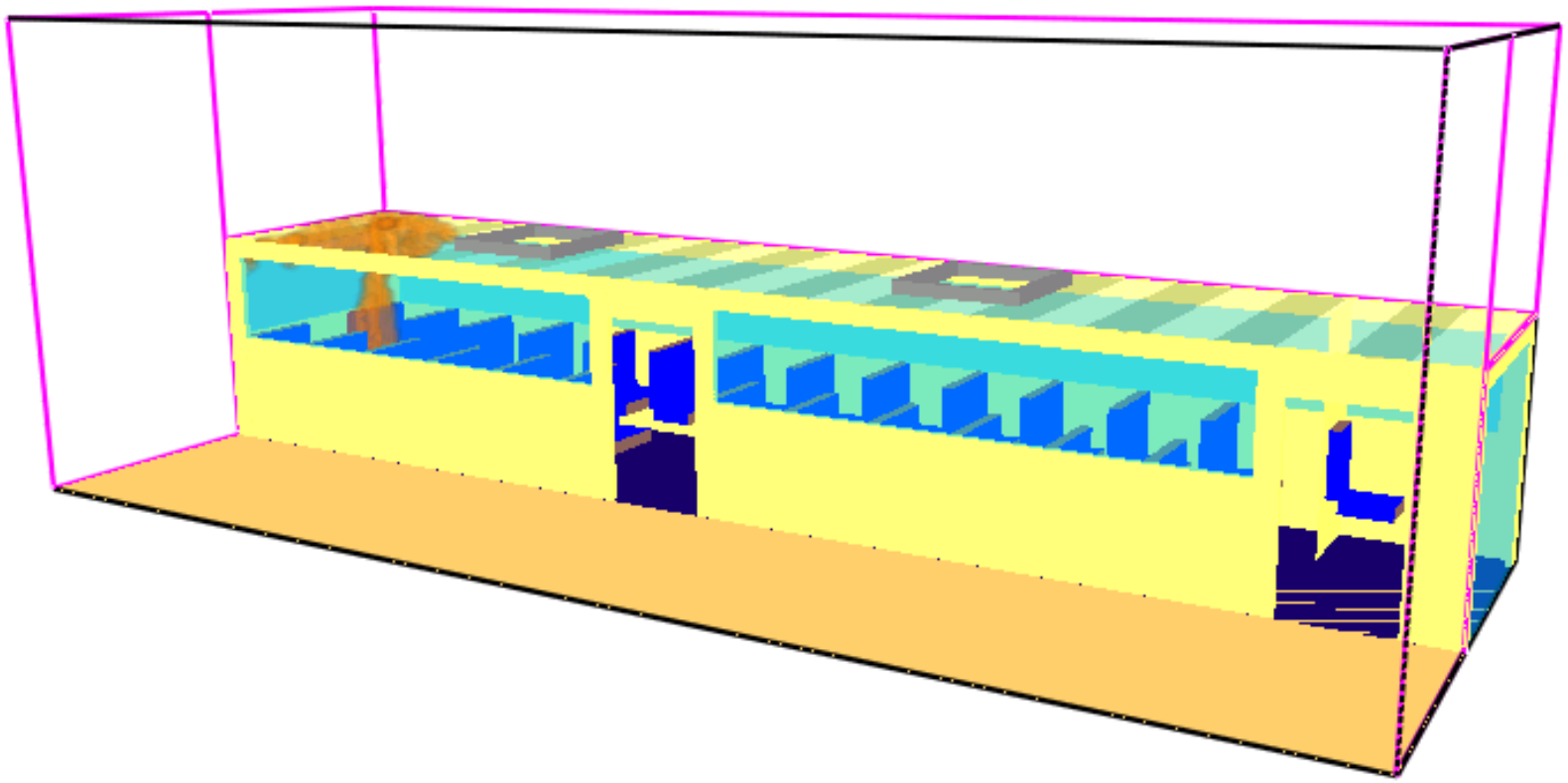
Flame spread

t = 120 s



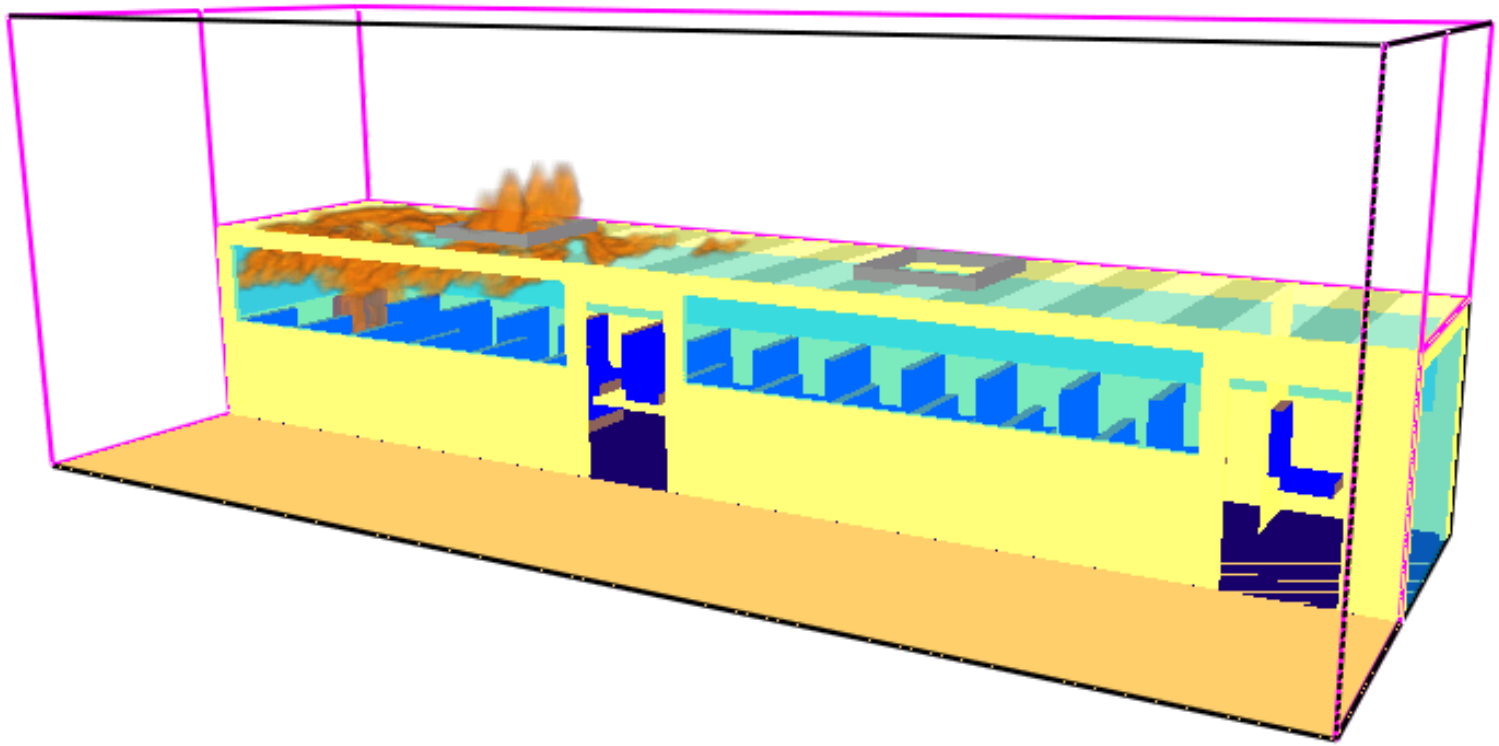
Flame spread

t = 180 s



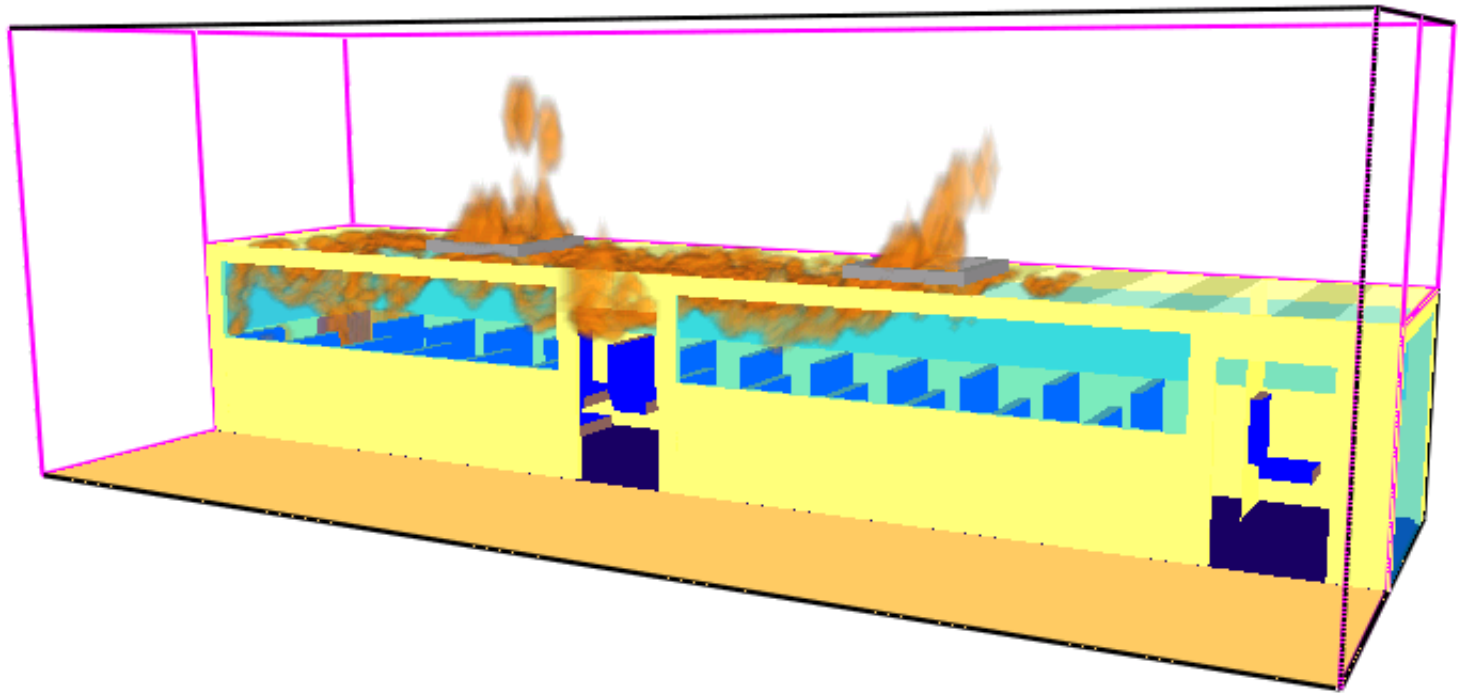
Flame spread

t = 240 s



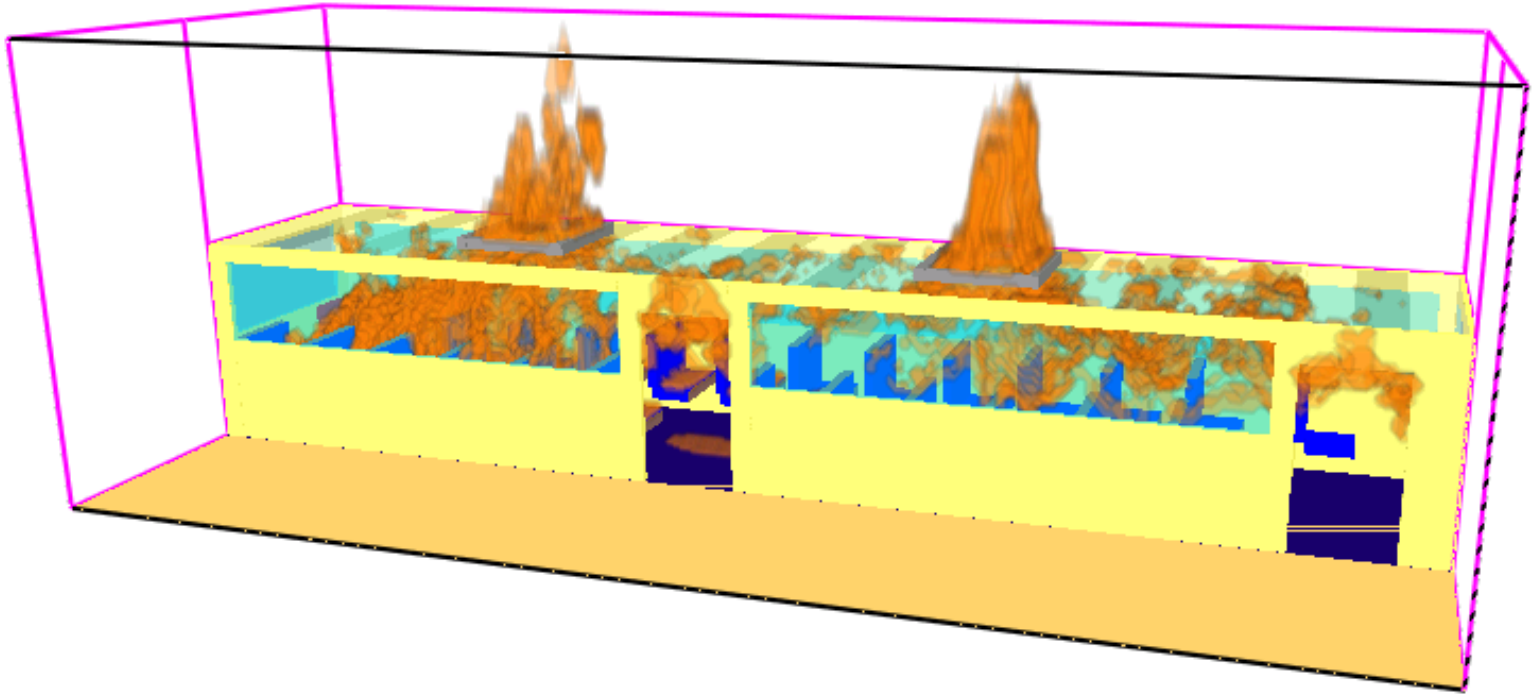
Flame spread

t = 300 s



Flame spread

t = 360 s



5.1 Simulation and experiment, Conclusions

–Visibility drops rapidly in upper part of the bus, where for example emergency opening handle is located!

–Opening roof hatches is efficient for removing smoke.

–Flame spread models are sensitive to distribution of combustible material in the ceiling and upper walls

–Results sensitive to input (e.g. soot production and combustion data)

–Report available here (or contact Michael Försth)

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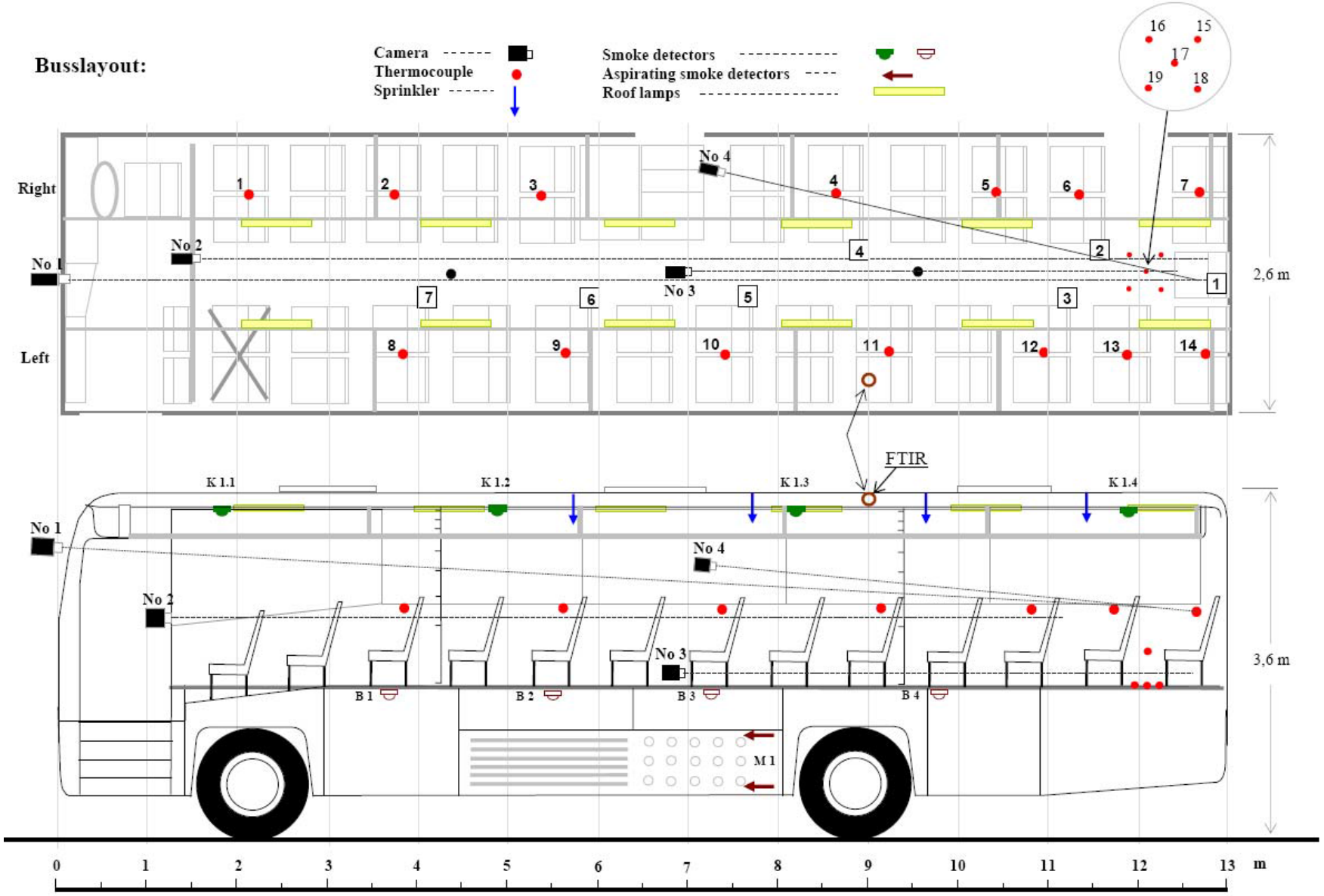


5.2 Full scale test, experiences from previous test

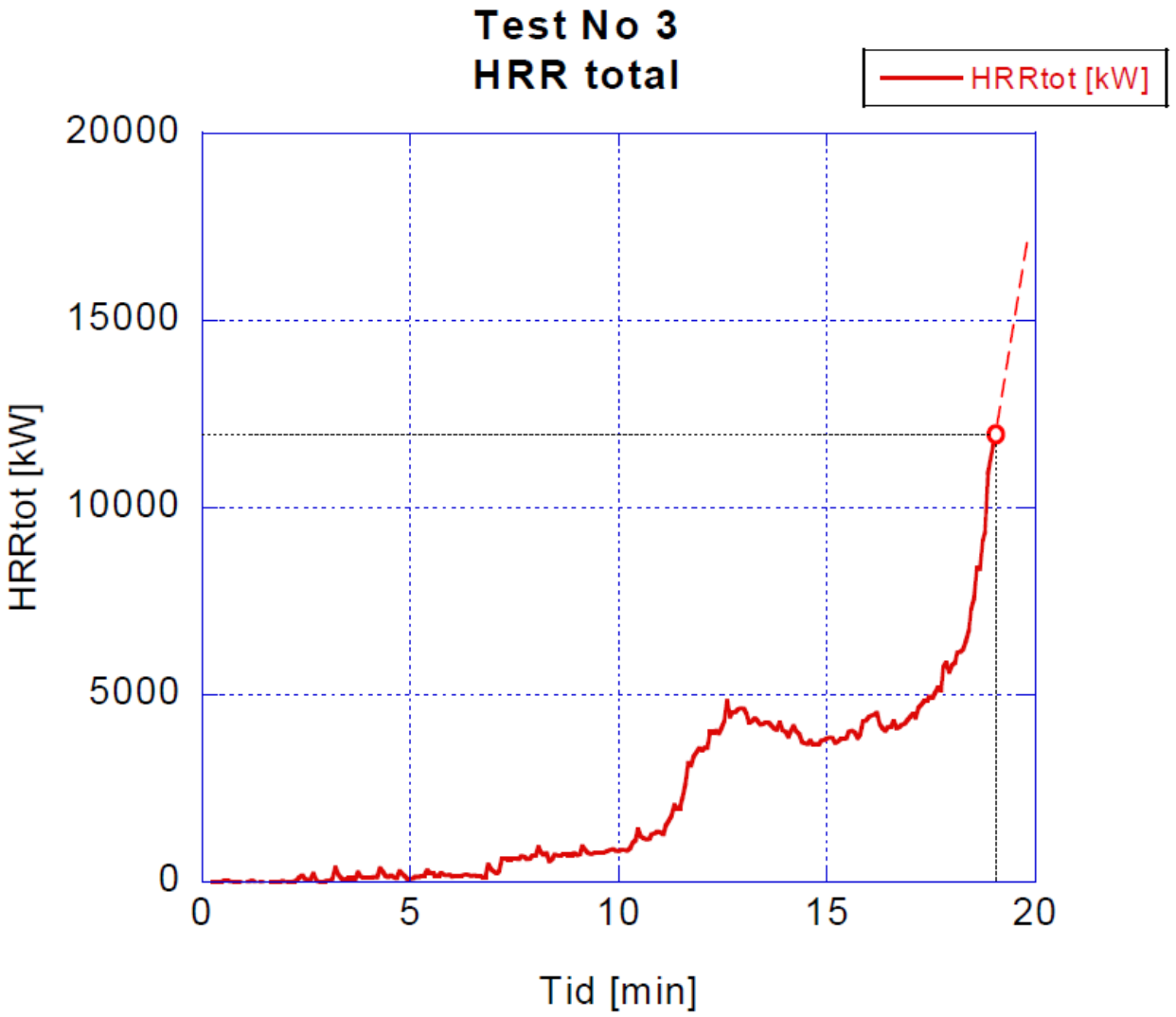
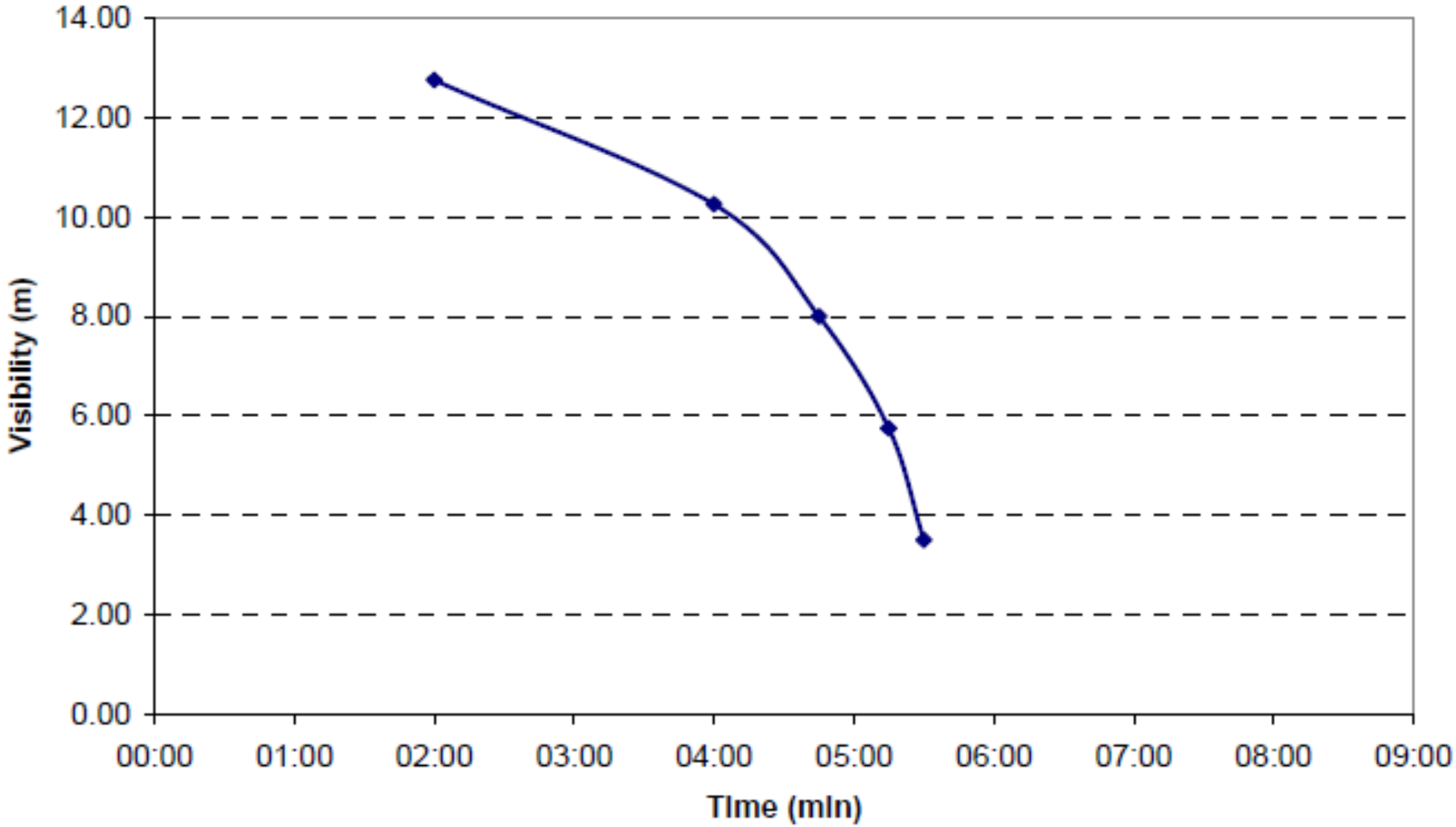


Figure 63. The heat release rate from the burning coach during the test. Estimation of the total HRR at 20 minutes is ~ 15 - 20 MW. The extinction of the fire started after 20 minutes.

5.2 Full scale test, experiences from previous test



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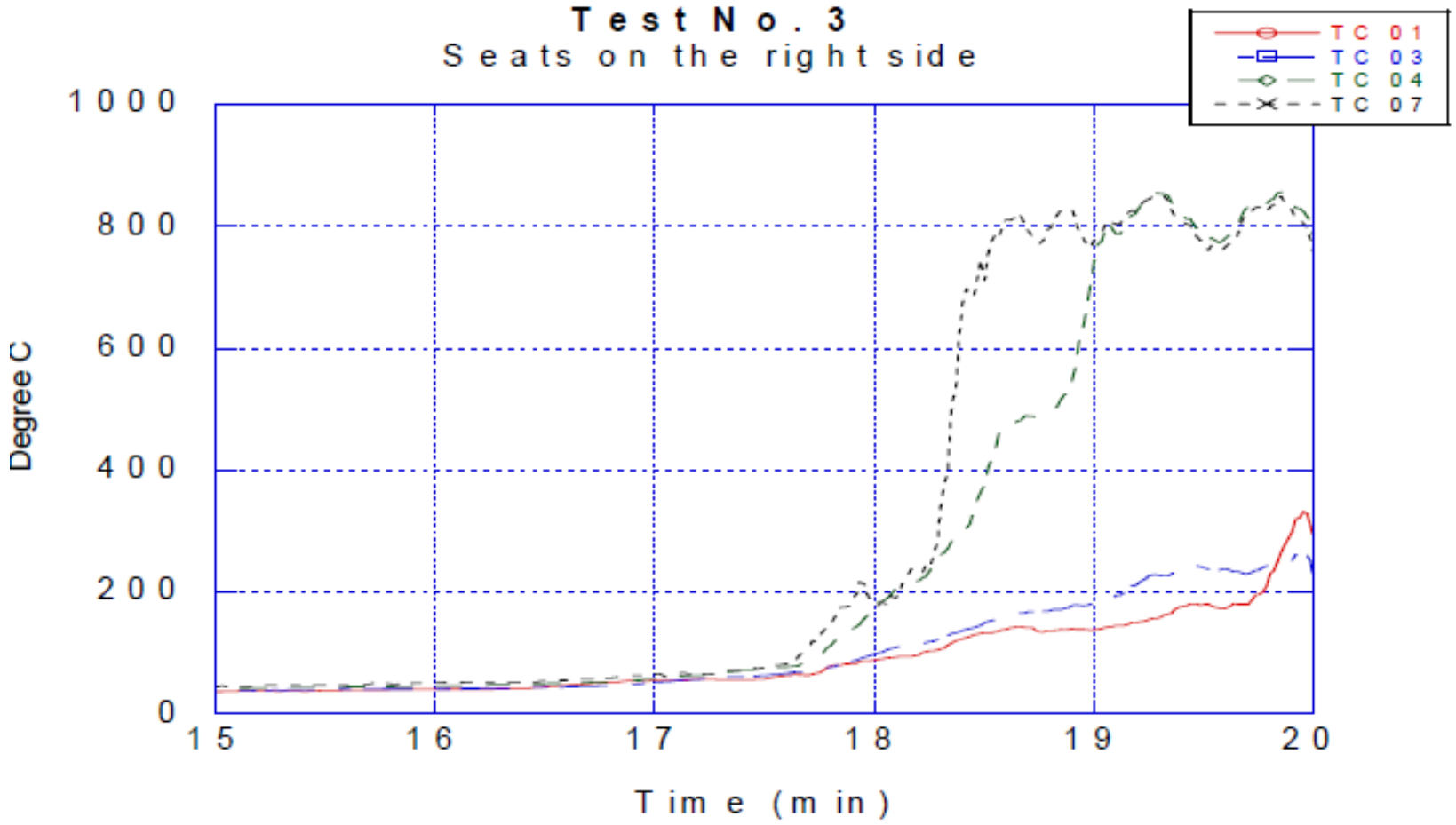


Temperatures above the seats on the right side of the bus.
See also Figure 56 and Figure 62.

5.2 Full scale test, experiences from previous test

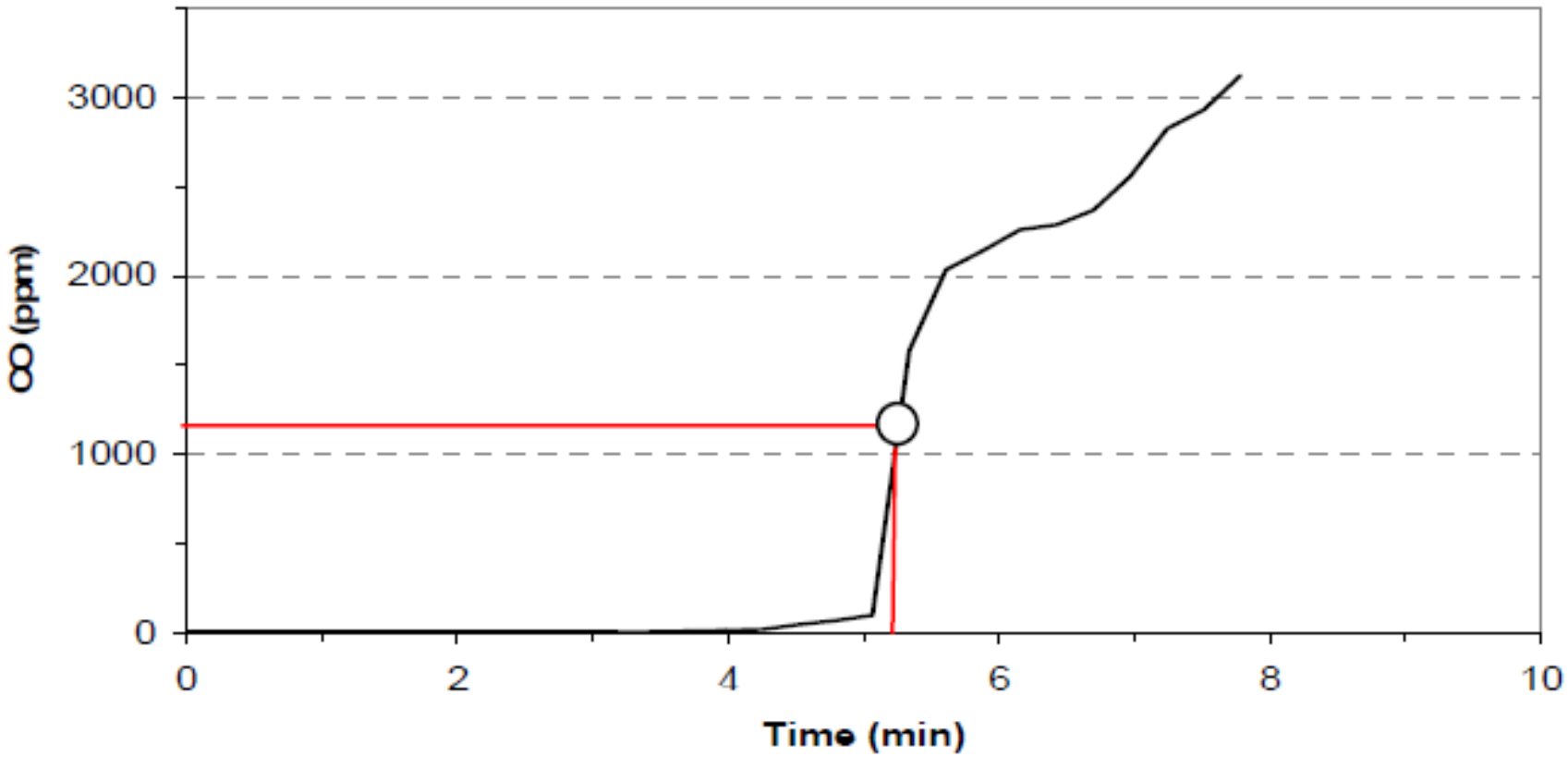
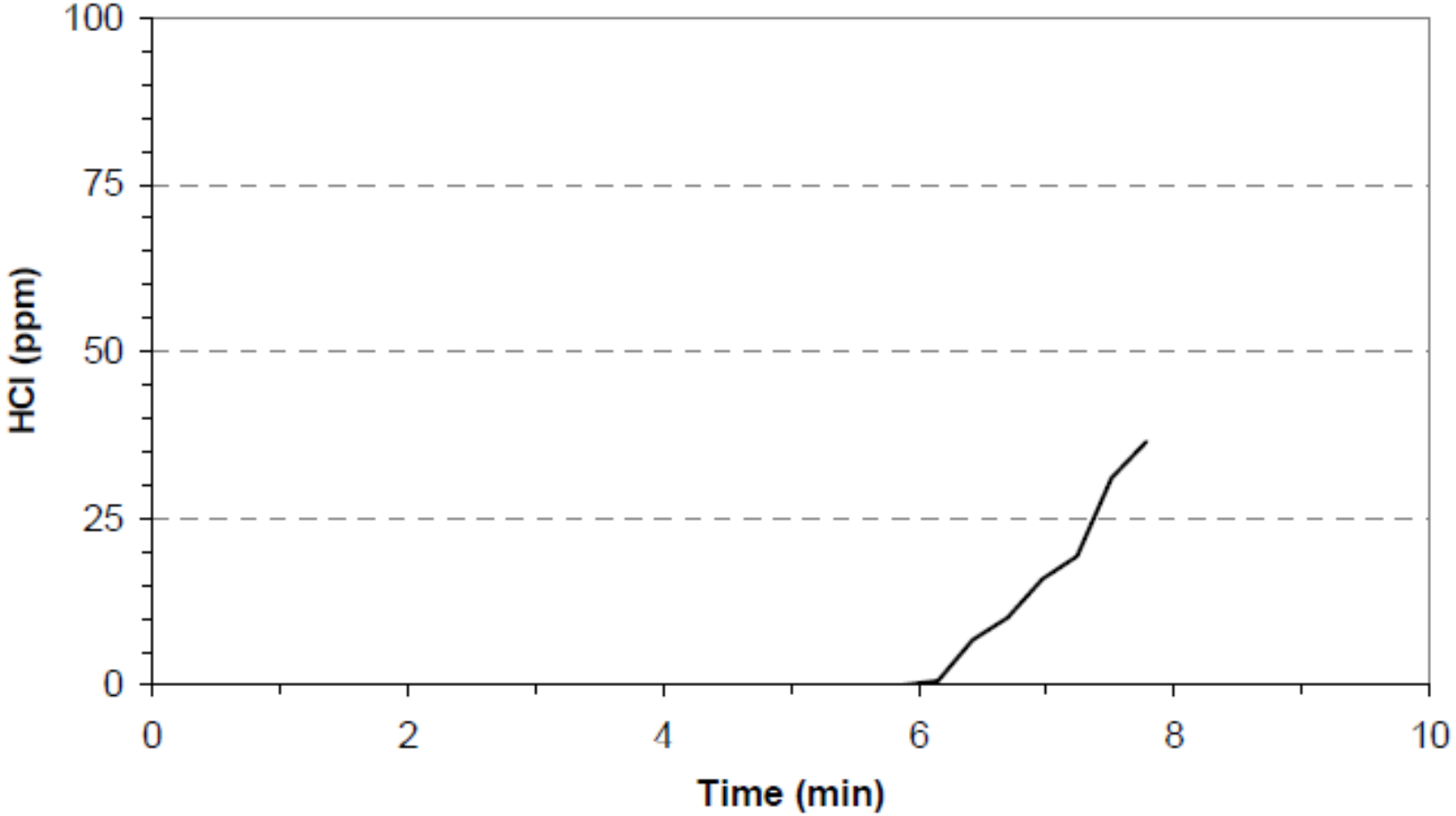


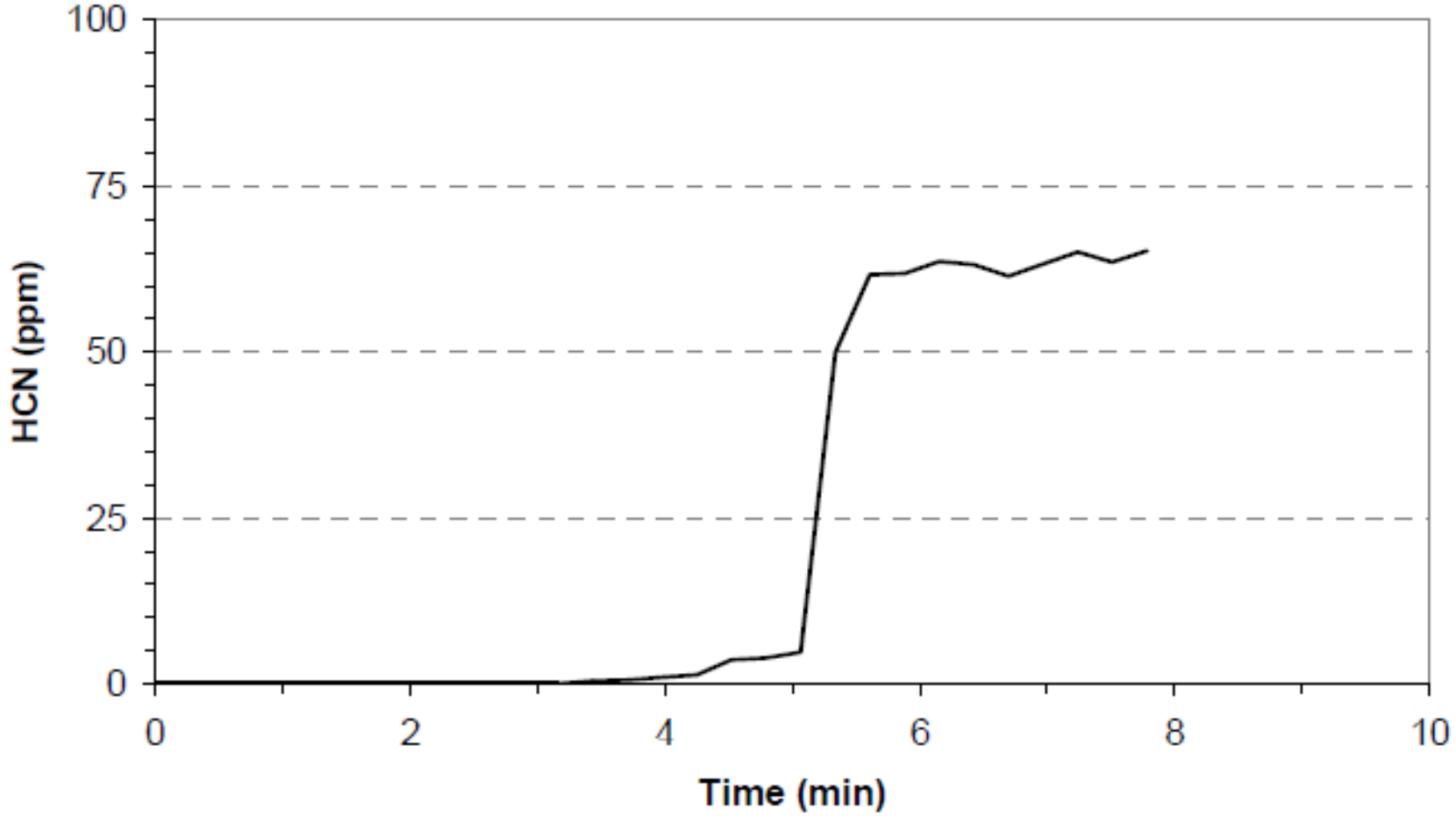
Figure 72. The concentration of CO in the passenger compartment during the first 8 minutes. Dangerous concentrations after ~ 5 minutes.

5.2 Full scale test, experiences from previous test



- **The concentration of HCl in the passenger compartment during the first 8 minutes.**

5.2 Full scale test, experiences from previous test



The concentration of HCN in the passenger compartment during the first 8 minutes.

5.2 Full scale test, Conclusions

–Hazardous toxic levels in passenger compartment after ~5 minutes for a fire with origin in engine/luggage-compartment.

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UNECE Reg. 107

Proposal for new requirements on fire detection

- Prepared by Ola Willstrand
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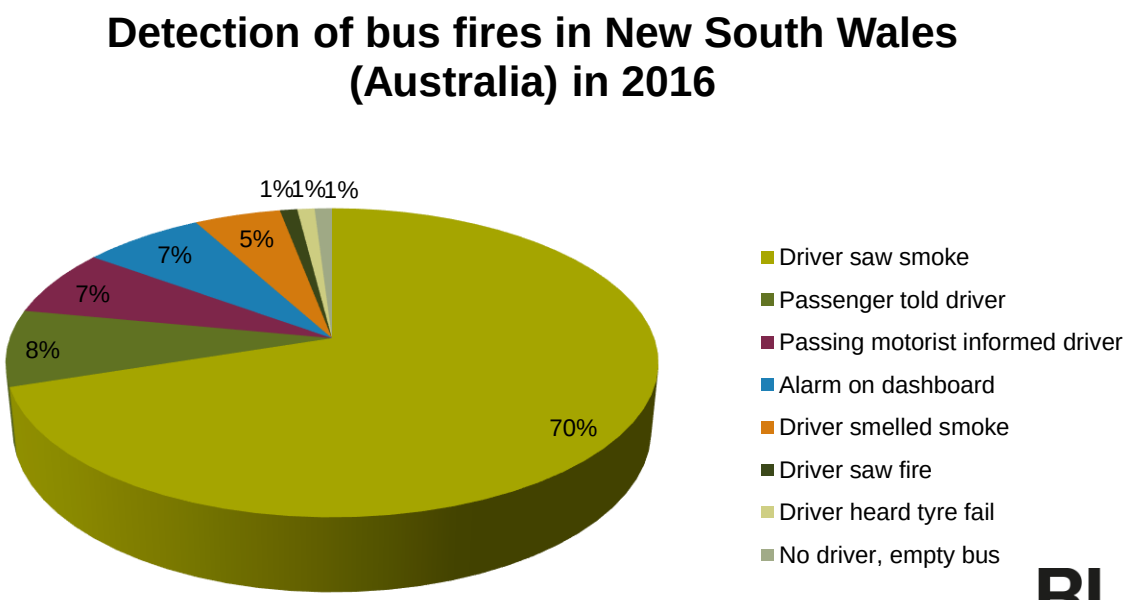
  ola.willstrand@ri.se

Justification

- Current requirements on fire detection in engine compartments are insufficient/absent with respect to performance and response time.
- Statistics[1, 2] indicate that fires are first detected by the driver, passengers or other persons nearby. Below 10% of the fires are first detected by a fire detection system.
  - This can be crucial for safe evacuation of the bus.
- The proposed changes will assure that fire detection systems are tested for response time and coverage of the engine compartment, resulting in fast detection for various fire scenarios.
- Fast detection will increase evacuation time and ensure that the suppression system can be activated before the fire has spread and grown too much.



1. Office of Transport Safety Investigations (OTSI), "*Bus Safety Report – Bus fires in New South Wales in 2016*", Sydney, Australia, 2017.
2. E. Kokki, "*Bus Fires in 2010-2011 in Finland*", Proceedings of FIVE - Fires in Vehicles, Chicago, USA, 2012.

Justification

- Most vehicle components are tested and evaluated rigorously, however, there are no current requirements on the performance of fire detection, a vital safety system.
- The implemented requirements on fire suppression systems will be complete only when similar requirements are implemented for fire detection systems.
- The suggested tests will be in consistency with the implemented tests for fire suppression systems, using the same test apparatus.
- 3-year research project is the basis for the proposal.

Technology neutral

Current requirements

- ”…an alarm system providing the driver with both an acoustic and a visual signal in the event of **excess temperature** in the engine compartment and in each compartment where a combustion heater is located.”

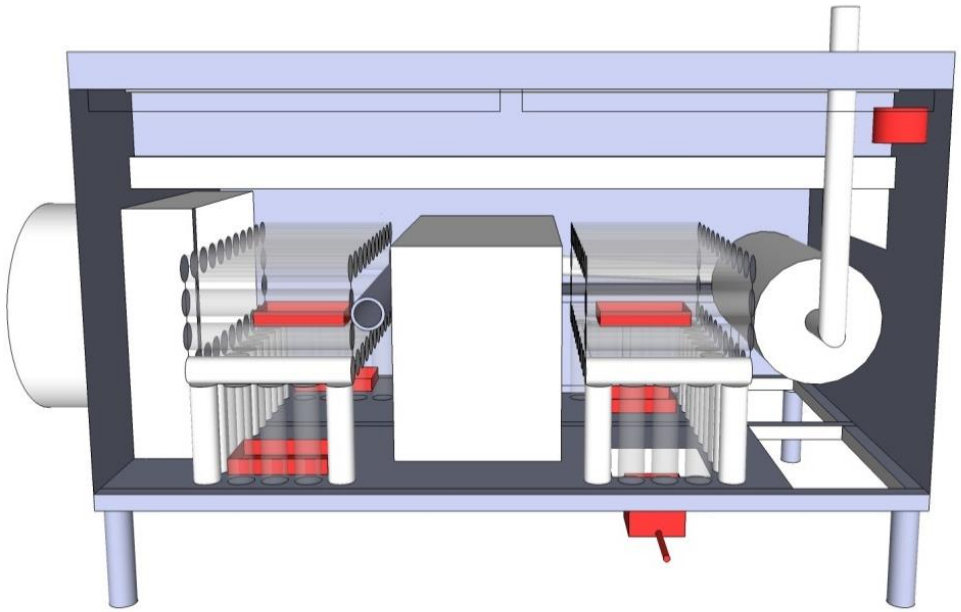
Proposed changes

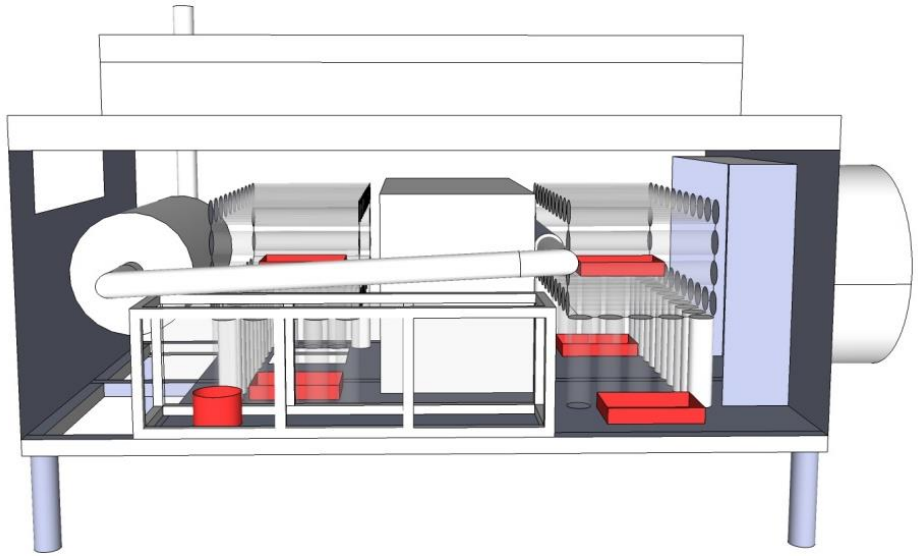
- ”…an alarm system providing the driver with both an acoustic and a visual signal in the event of **a fire** in the engine compartment and in each compartment where a combustion heater is located.”

- Tests must be implemented to verify new solutions and new technologies!
- The tests are designed such that a detection system may include different types of sensors (e.g. a combination of heat, flame and smoke sensors)

Performance tests

- 8 fire locations shall be covered by the fire detection system.
  - Scaling of the system is accomplished based on these tests in the same way as for fire suppression systems
- One slow growing fire (3 kW/min) for evaluation of e.g. rate-of-rise heat detectors and flame detectors
- Air flow up to 3 m^3/s (same as for suppression tests)
- Response time requirements:
  - 20 s for at least one fire
  - Before 30 kW (10 min) for the slow growing fire
  - Before 2 min for remaining fires





Other requirements/changes

- “An analysis shall be conducted prior to the installation in order to determine the location of detection point(s).”
  - Same procedure as for suppression systems

- “The number of detection point(s) or length of linear sensor(s) shall be scaled up or down from the tested system, based on the total gross volume of the engine and combustion heater compartments where the system is to be installed.”
  - Same procedure as for suppression systems

- Include requirements that the system shall trigger a warning signal in case:
  - flame detector lens is obscured,
  - contamination of smoke/gas chamber reduces the sensitivity or
  - sampling filters of aspirating systems are clogged

Acknowledgements

- Norwegian Public Roads Administration (Statens vegvesen)
- Swedish Transport Agency (Transportstyrelsen, formerly Vägverket (Swedish Road Administration))
- FFI Strategic vehicle research and innovation (Fordonsstrategisk forskning och innovation, a partnership programme run jointly by the Swedish state and Swedish automotive industry)
- Brandforsk
- RISE

THANK YOU, QUESTIONS?

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Fire Research