International Water Mist Conference

September 21 – 22, 2016
Vienna

IFAB

INSTITUTE FOR APPLIED **FIRE SAFETY RESEARCH**

ASKING - ANALYSING - ANSWERING

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Proof of suitability of a water mist fire protection system in a hotel atrium as compensatory measure combining different engineering methods

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Content

- Introduction
- Description of Methodology
- Results and Discussion

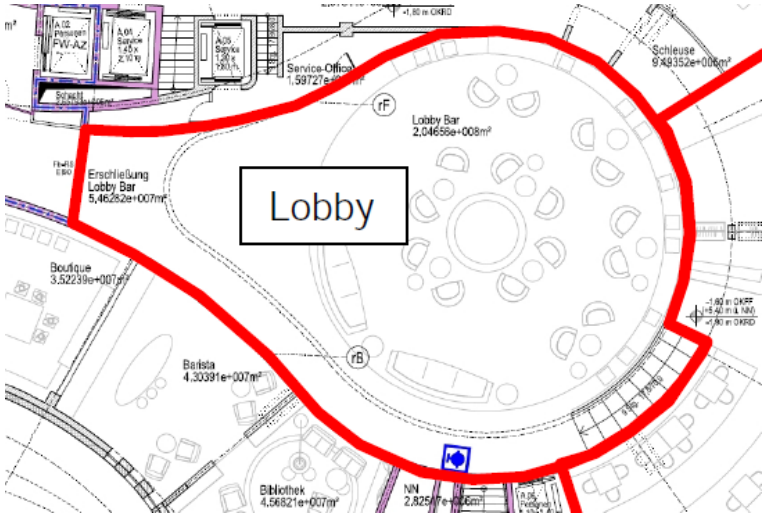
Introduction

- Aim: proof of fire protection for hotel atrium

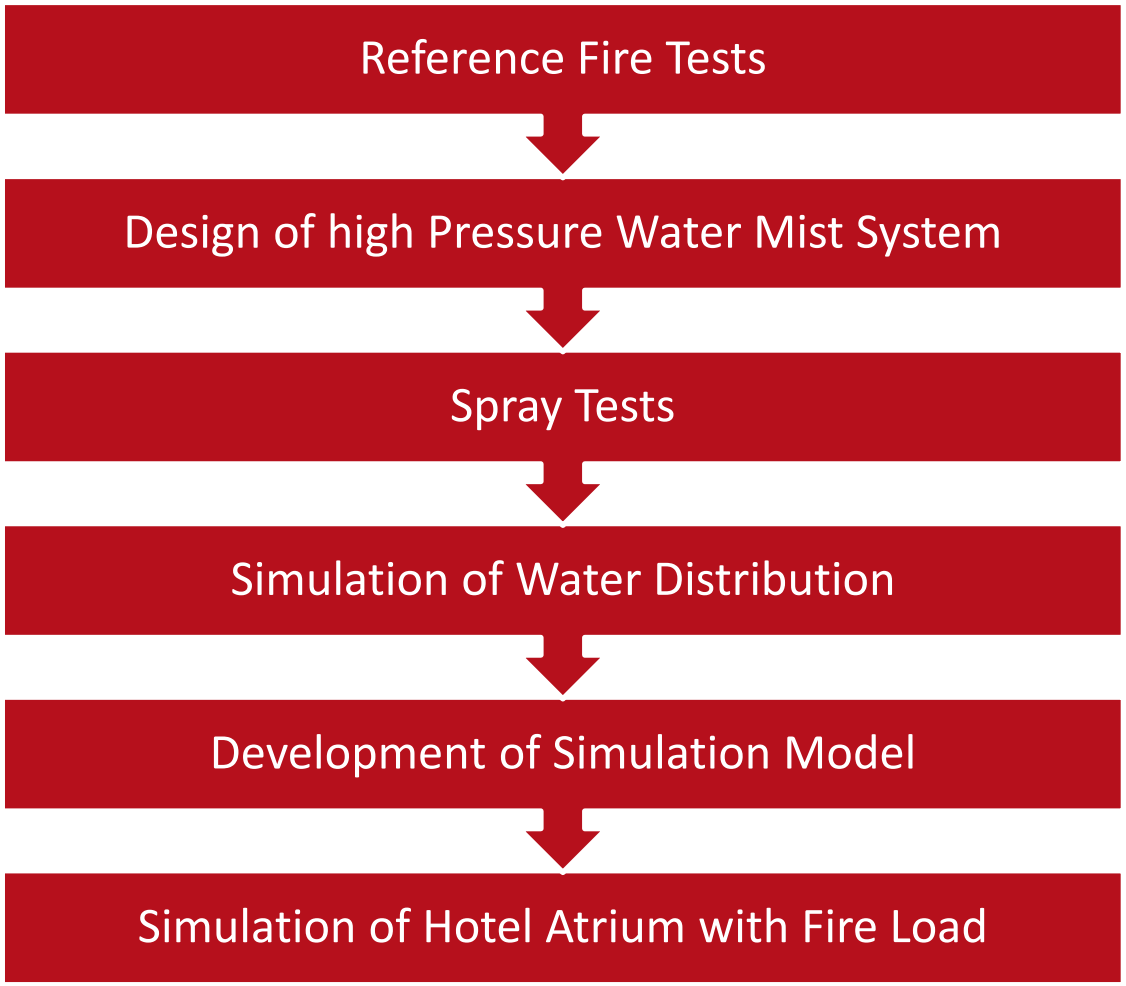
→ Conclusion: water mist system as compensatory measure will be verified using engineering methods

Introduction

- Height of 27m, diameter appr. 16m
- Cross section rejuvenates above 22m
- Glass facade from 5m to 22m

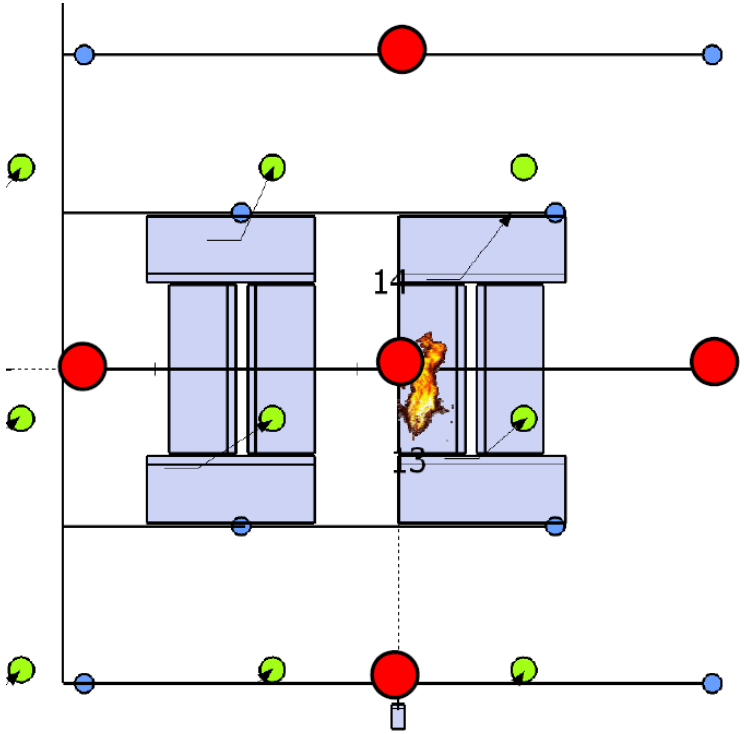


Methodology – Overview



Methodology – Reference Fire Tests

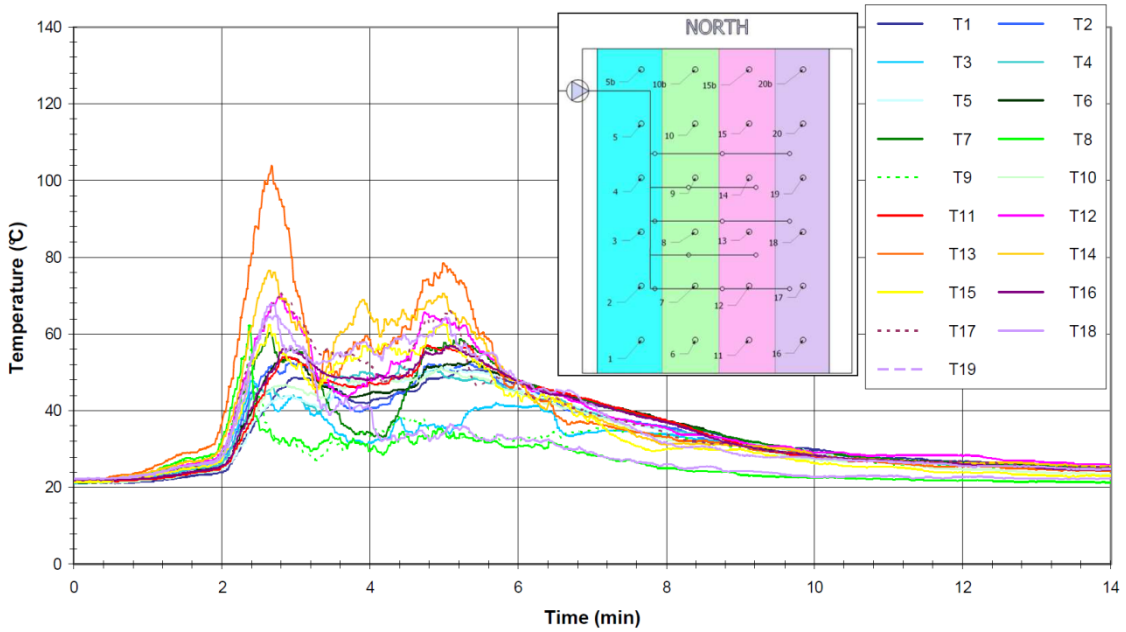
- IFAB has test data for comparable scenario
  - 12m height, uniform nozzle grid
  - Public open space scenario based on IMO RES A.800
  - 8 polyether foam mattresses on sofas



Methodology – Reference Fire Tests

- Performance criteria:
  - No damage to the target
  - Reduction temperature at the ceiling/in vicinity of the fire
  - Reduction of radiative heat
  - Control/suppress fire

→ For evaluation of performance, only ceiling temperatures will be considered



Methodology – Reference Fire Tests

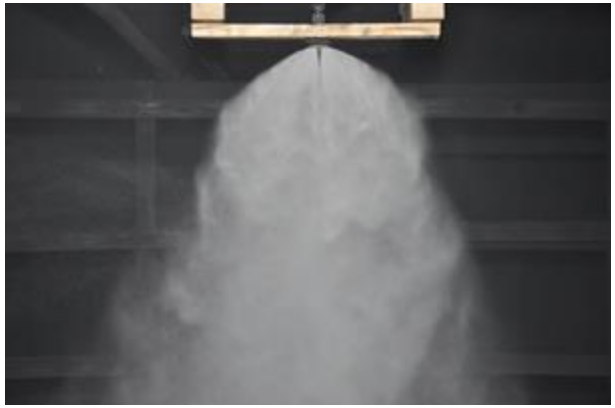
- Design of water mist system was adopted from reference fire tests
  - Similar fire-fighting performance is expected with a system that has comparable design parameters
  - Results of fire tests allow validation and calibration of CFD model used for evaluation

- Differences:
  - Height of room
  - Different orientation of nozzles
  - Nozzle layout is different due to geometrical limitations

- Relevant parameters of HPWM system:
  - Amount of water applied to area
  - Spray dynamics and droplet size (→ quality of water mist)

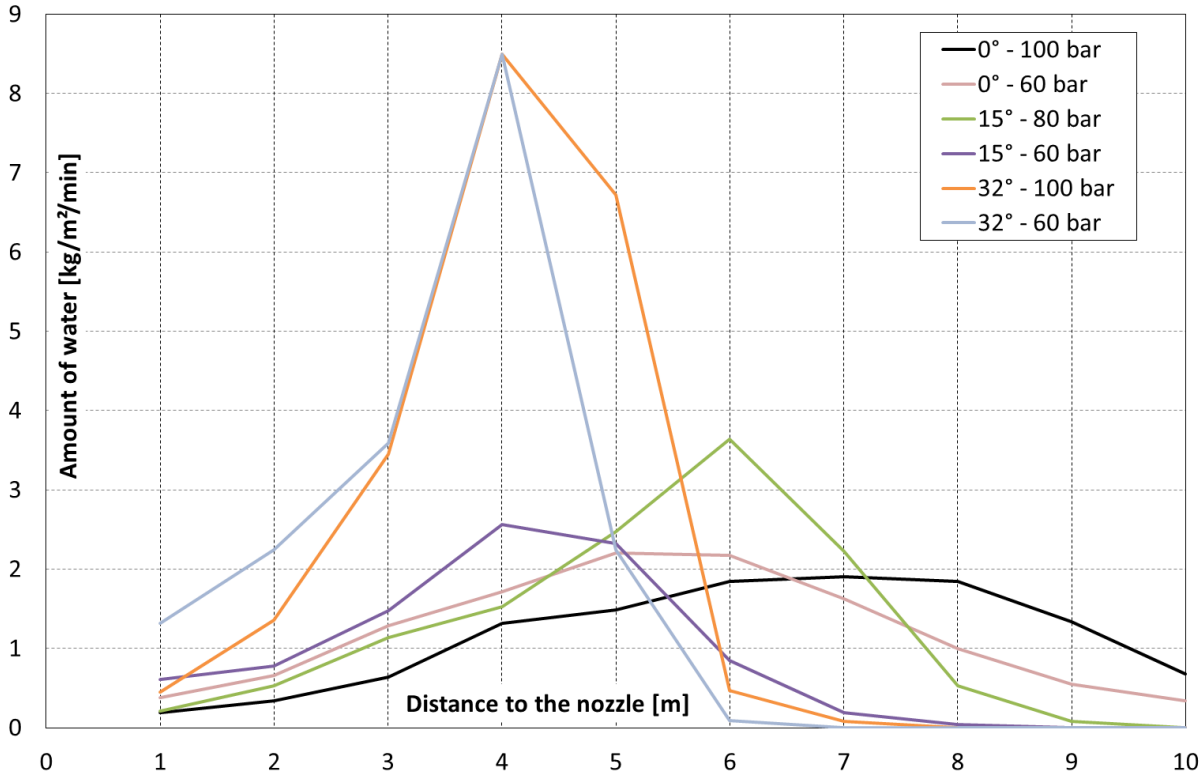
Methodology – Spray Tests

- Spray tests with a single nozzle
- Varied design parameters:
  - Angle of installation
  - Design pressure
- Desired properties of water distribution on the floor:
  - High reach of water mist with high momentum
  - Uniform distribution on the whole range



Methodology – Spray Tests

- Decision: spray angle: 0°; design pressure: 100 bar
- Spray tests also necessary for calibration/validation of CFD model
  - Velocity
  - Spray angle



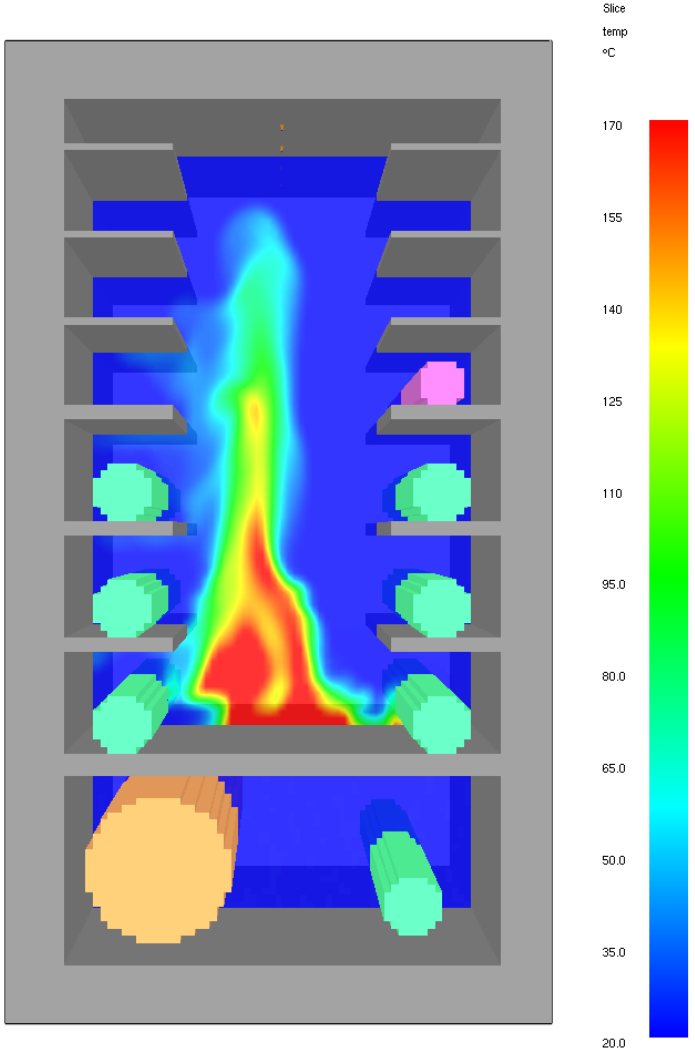
Methodology – Distribution of Water Mist

- Problem: Amount of water is sufficient for atrium, but it needs to be shown, that water is distributed evenly with all nozzles
  - Necessary prerequisite to transfer results from fire tests

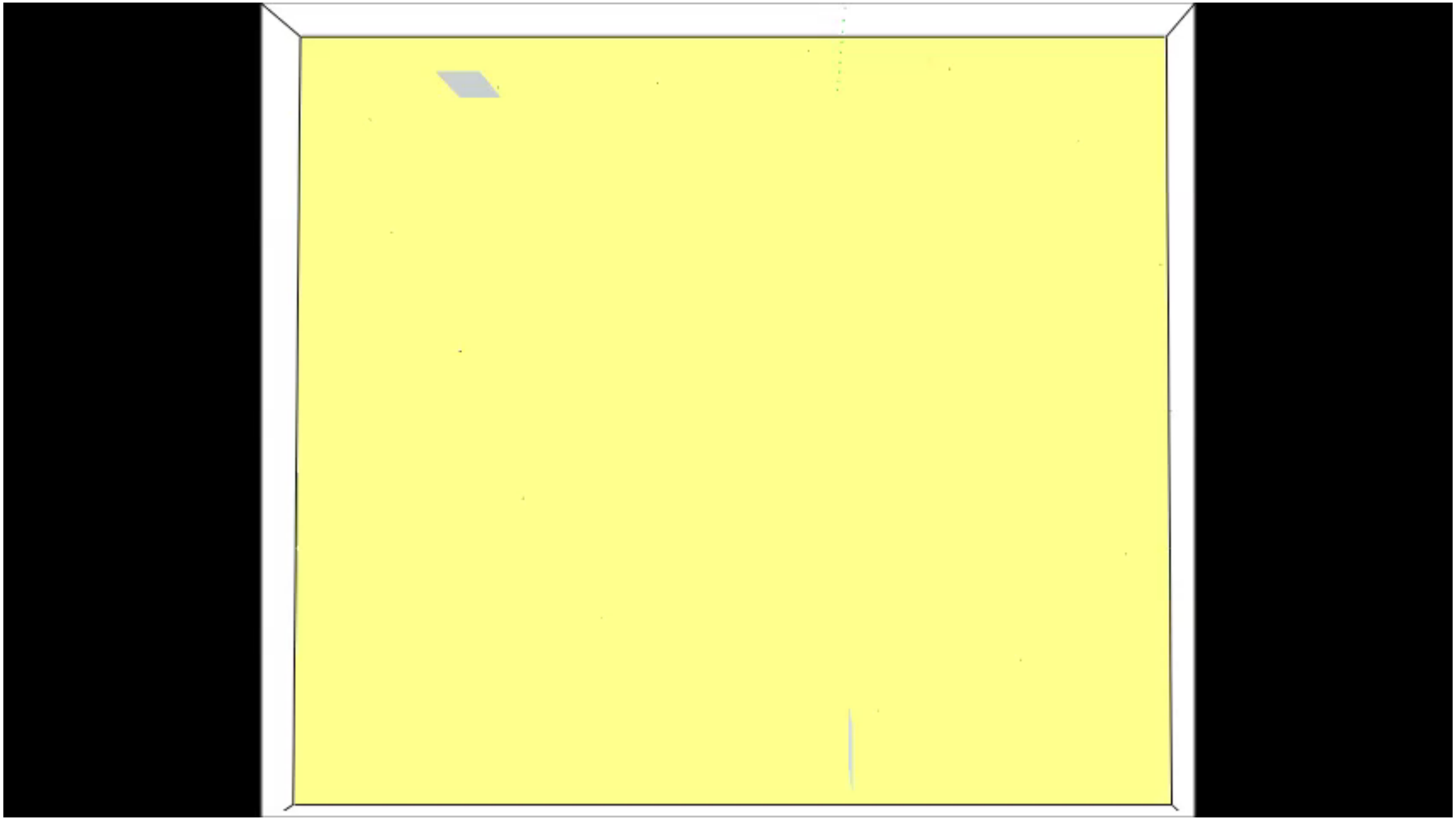
- Approach: Use calibrated nozzle, implement HPWM design in CFD model and simulate water distribution

Excursus – Fire Dynamics Simulator

- Open-source software with huge community and extensive database of validation and verification works
- „FDS 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.“ (FDS User Guide)
- Simulation of particles (water mist) as Lagrangian particles



Methodology – Distribution of Water Mist

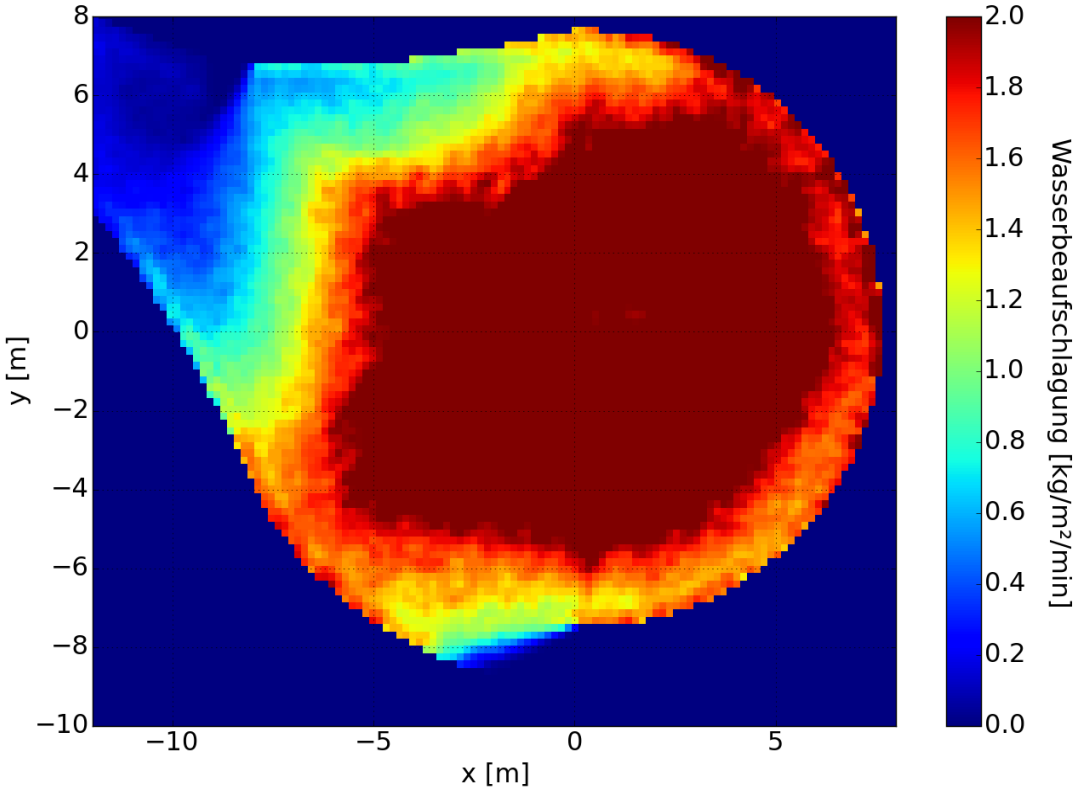


Methodology – Distribution of Water Mist

- Results: Most of atrium is covered well with water

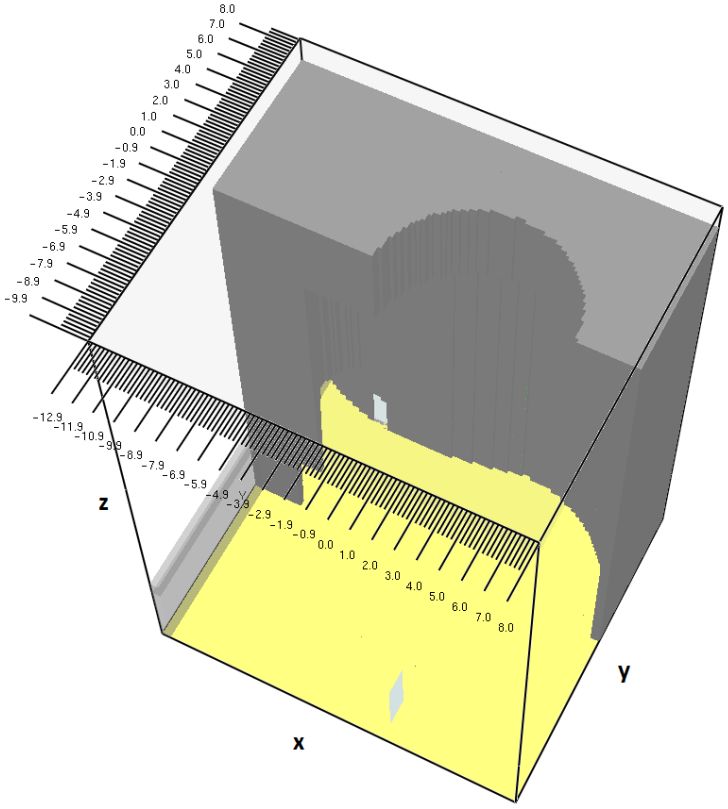
- Areas influenced by ventilation covered with less water

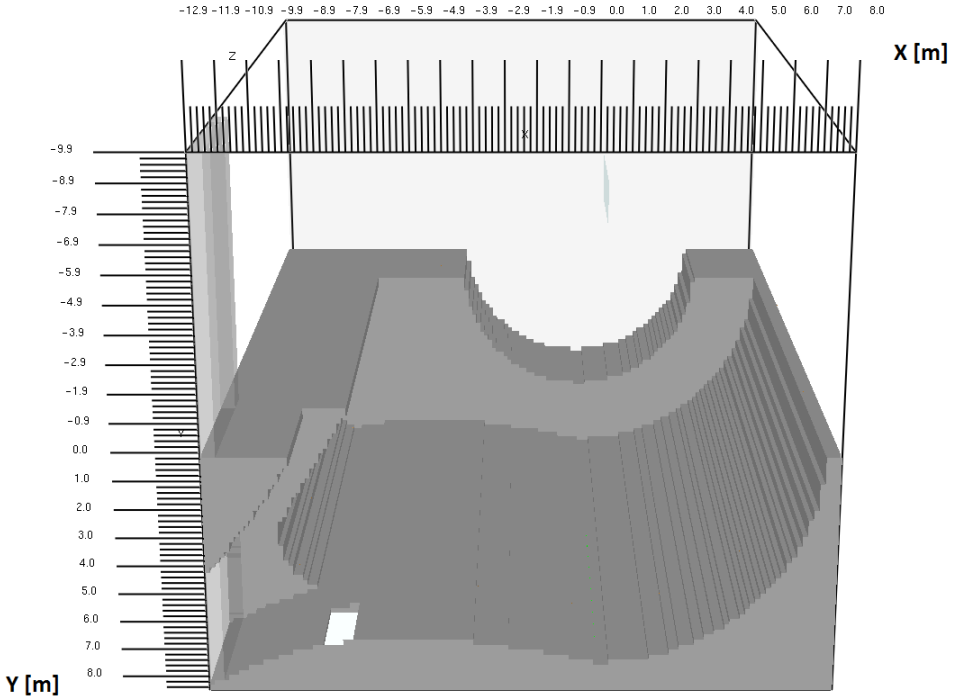
- However: If fire starts in area with less water, flow of hot air will be deflected towards center of atrium, which is covered well with water



Methodology – Development of CFD-Model

- Geometry approximated with block structure

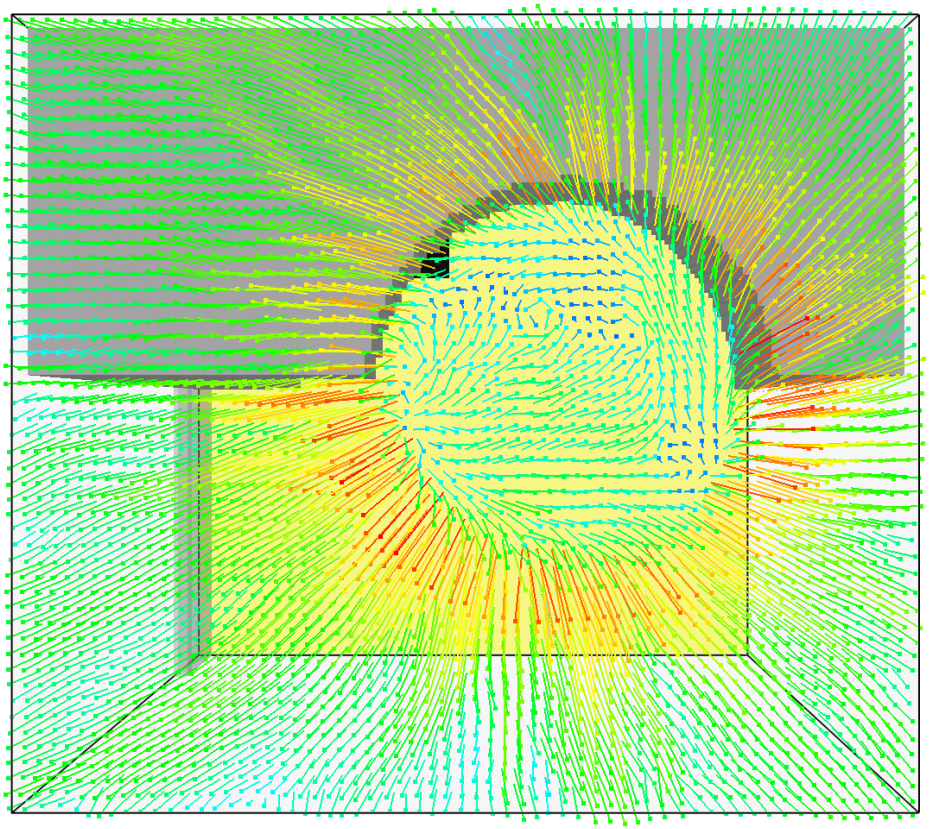




Methodology – Development of CFD-Model

- Smoke evacuator on top of the atrium activates in case of fire, arranged symmetrically on top

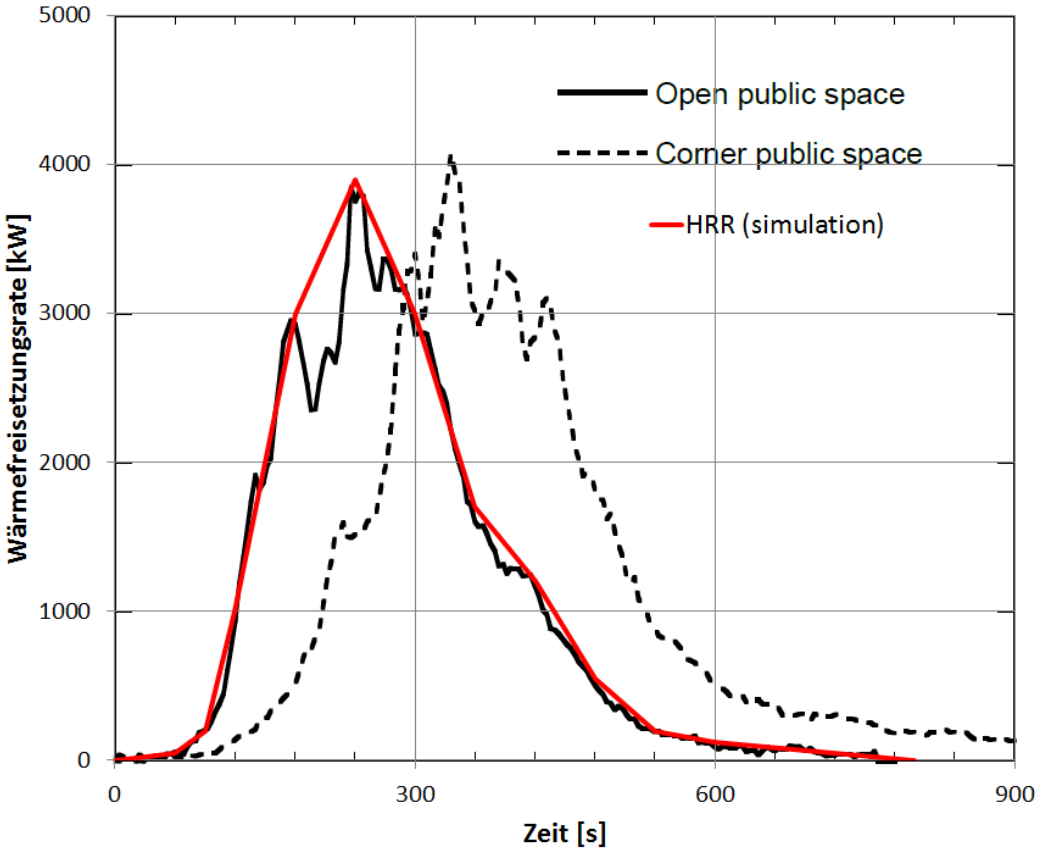
- Ventilation openings (doors) in lobby allow air to move in atrium for balancing air



Methodology – Development of CFD-Model

- Heat release rate of IMO open-space fire load was used (Arvidsson 2014)

- Two different (critical) locations of fire load (with regard of expected thermal stress of glass facade) were assumed

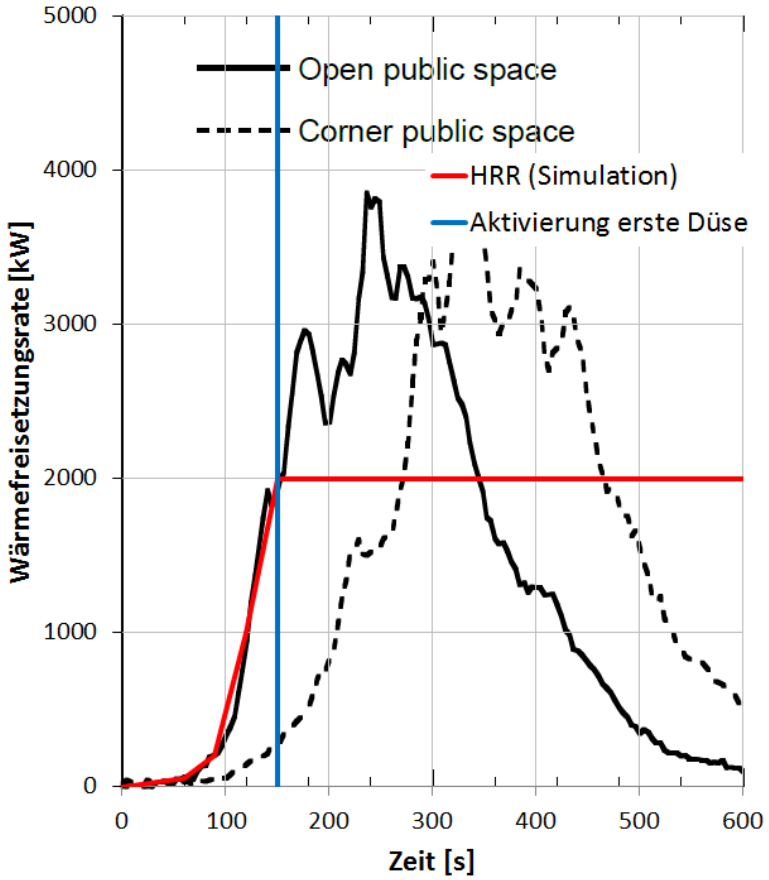


Methodology – Validation of CFD-Model

- Model was used to simulate reference fire tests in order to validate

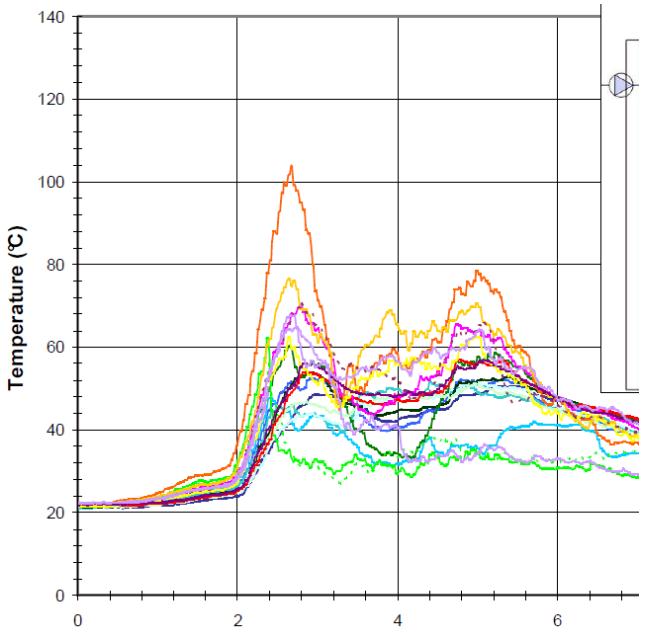
- Reasons:
  - complex case
  - plausibility check for mistakes made by user

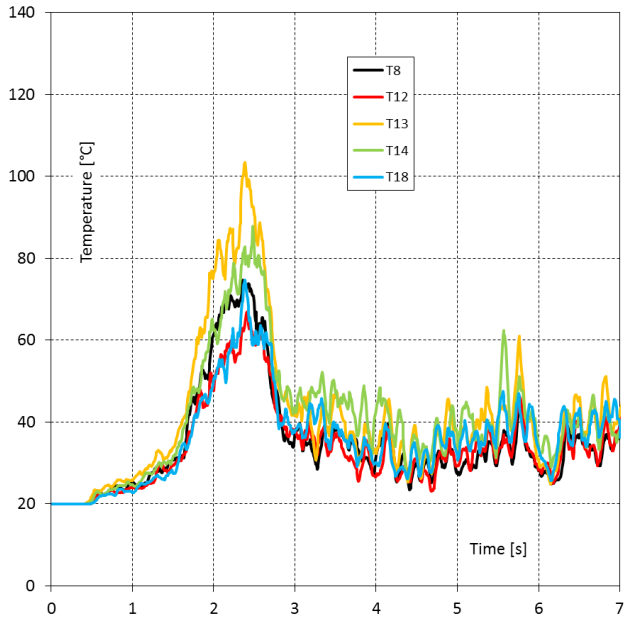
- Assumption: Heat release rate remains constant after activation of first nozzle



Methodology – Validation of CFD-Model

- Results: FDS is sufficiently capable of simulation of suppression of temperature of water mist system using OH1 fire load

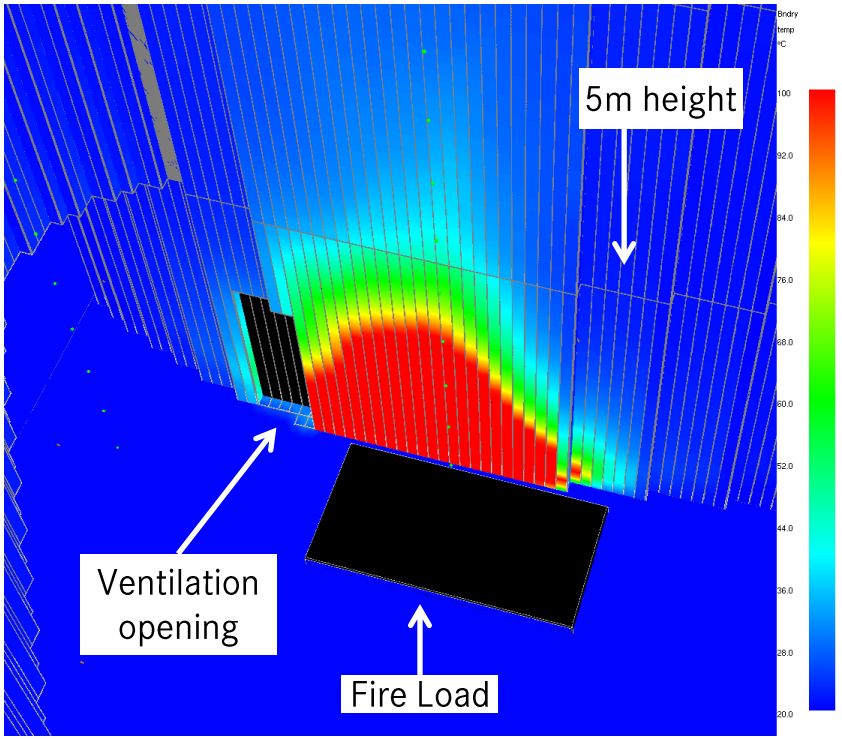




Methodology – Simulation of Atrium

- Surface temperature remains below 60°C throughout whole simulation

→ Design of HPWM is sufficient to protect glass facade of atrium



Results and Discussion

- Succesful approach of proving performance of HPWM system was shown

  → Accepted by German building authority

- Only possible due to fire tests with comparable scenario (experimental data with the same nozzle and similar fire load)

- In general, proving performance of HPWM system is not possible with simulations only

- Strongly recommended, to question results from CFD

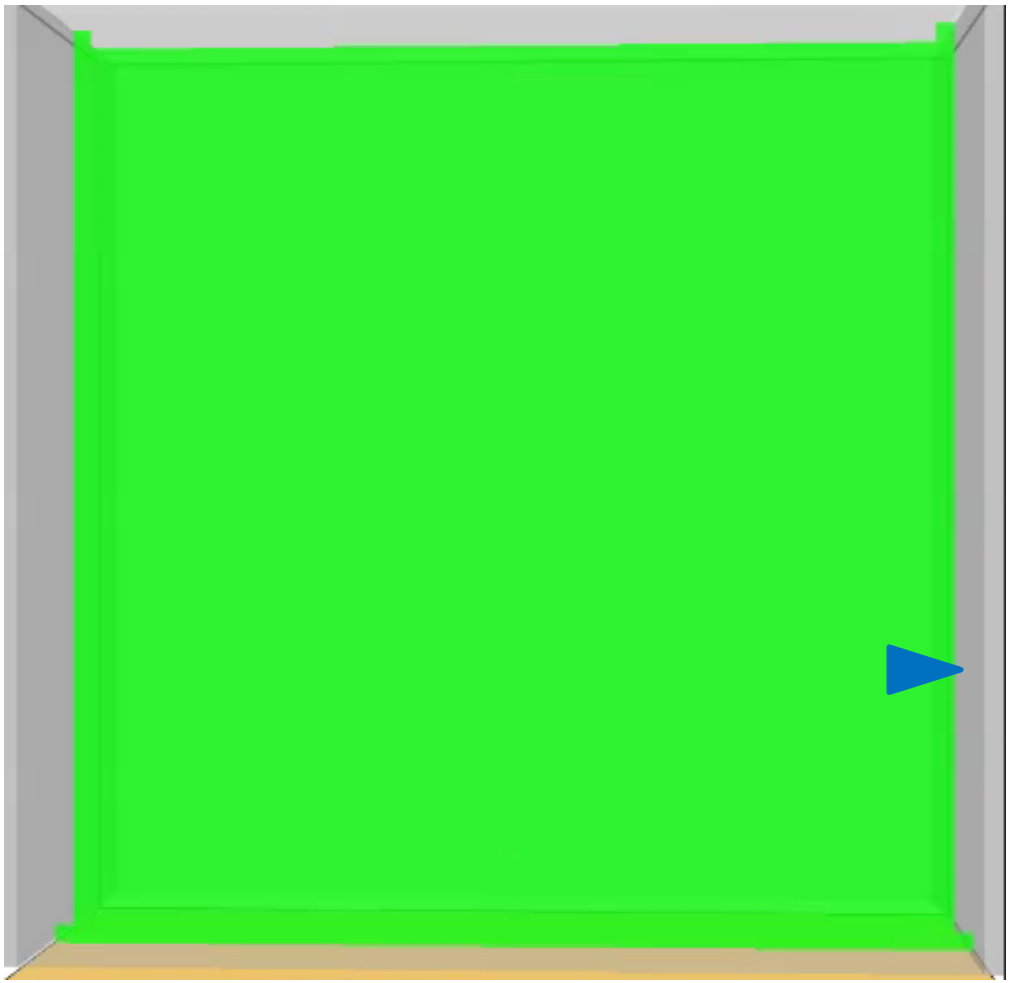
- When in doubt, results of CFD-simulations should be waived

Results and Discussion – Why Validation?

- Due to validation, an error in FDS 6.1.2 was detected
- Simulation of very fine droplets results in too high temperature
- Bug allows temperature of droplets to overshoot ambient air temperature (under discussion with developers)

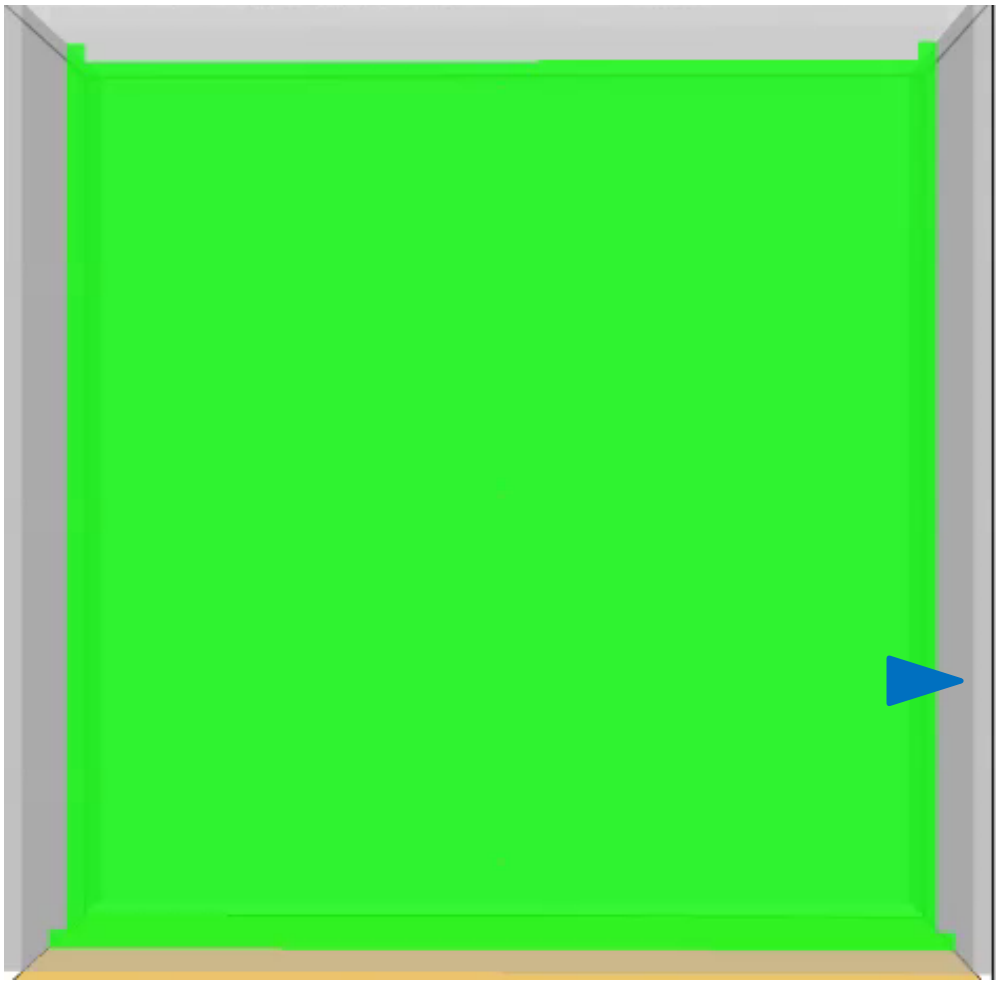
→ Use of FDS 5.5.3 for simulations, which showed good agreement of fire test and simulation

Results and Discussion – Why Validation?



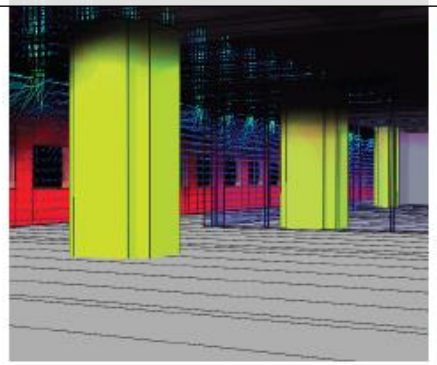
FDS 5.5.3

Results and Discussion – Why Validation?



FDS 6.1.2

THANK YOU FOR YOUR ATTENTION



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