Fire Suppression Physics for Sprinkler Protection

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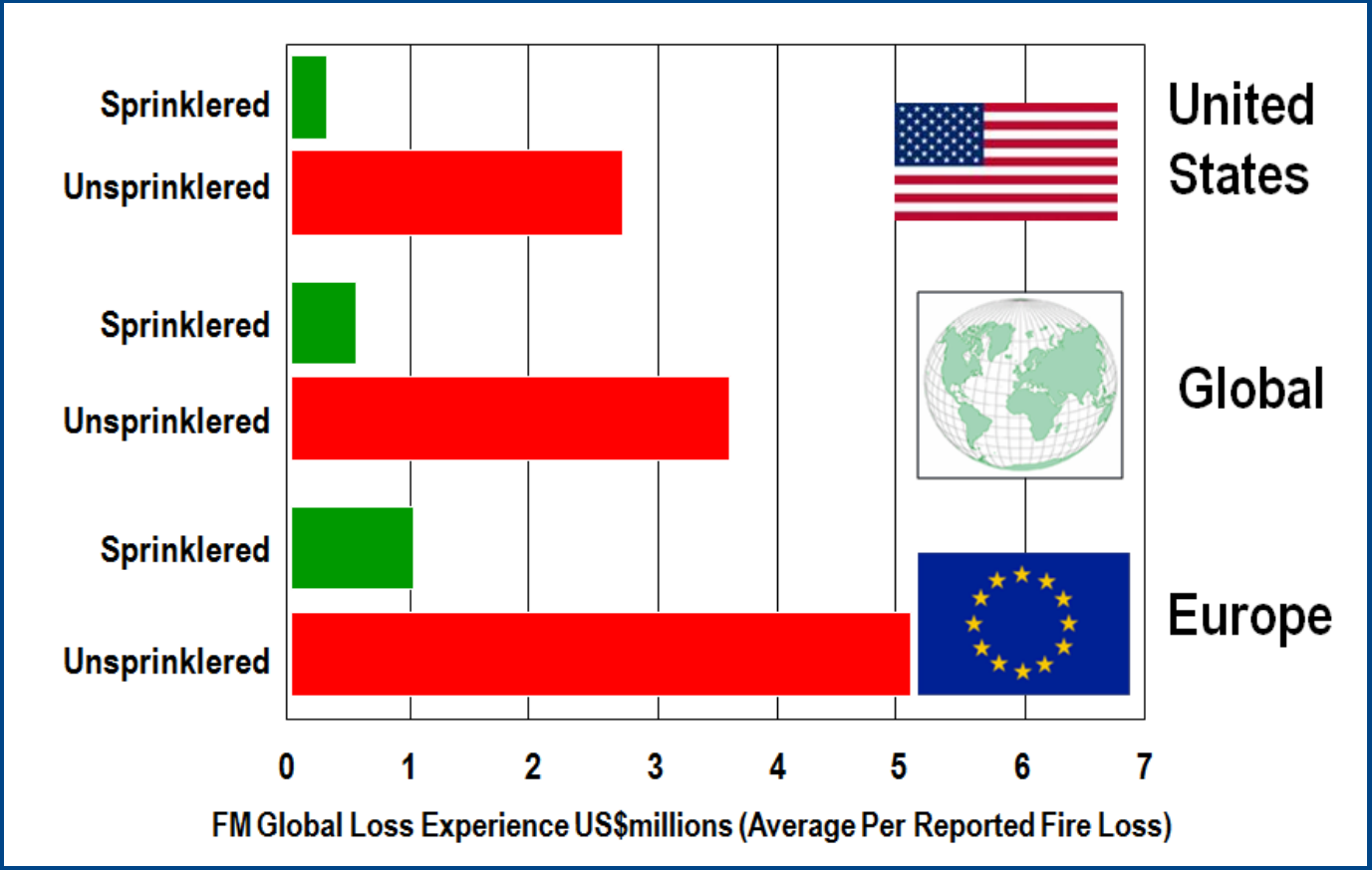
Overview

- Introduction: sprinkler technology
- Motivations: why model sprinkler suppression?
- Technical approach: numerical & experimental
- Numerical models: FireFOAM
- Exploratory studies of key phenomena
- Summary & future work

Effectiveness of Sprinkler Protection



Motivations: Model Sprinkler Suppression

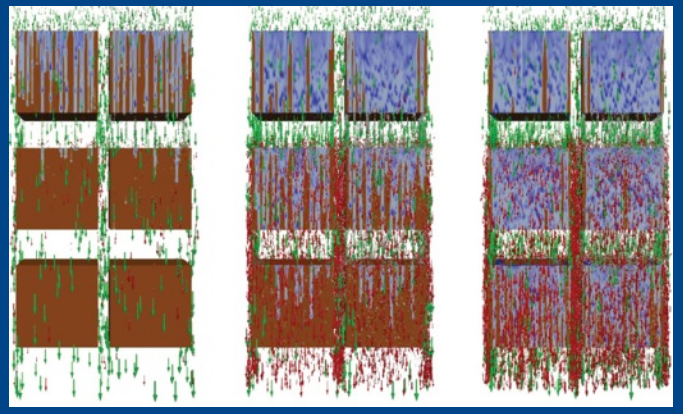
- Beyond test limit
  - physical dimensions
  - temperature, flow rate, pollution
- Beyond cost limit
  - trend/parametric analysis
  - generalization

What's in the toolbox?

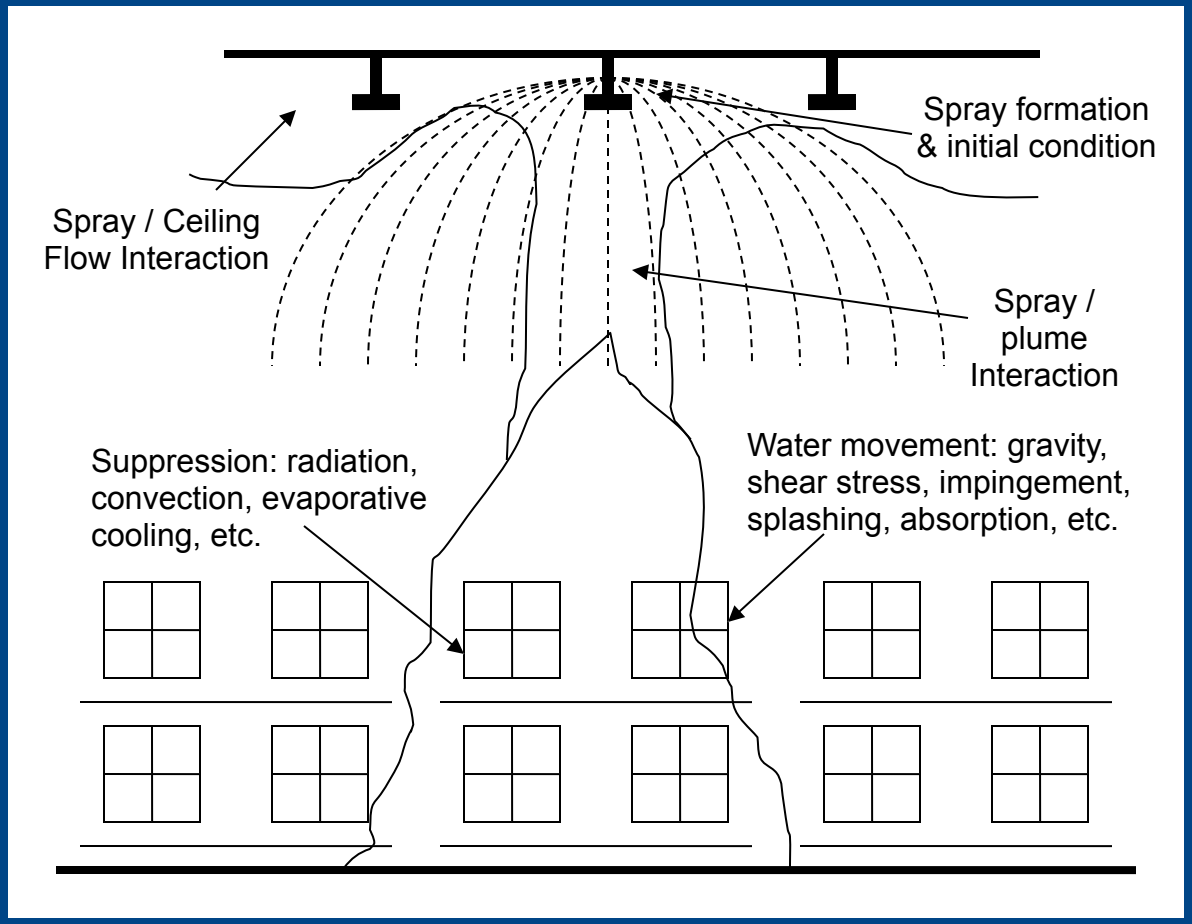
Full-scale test

Commodity classification

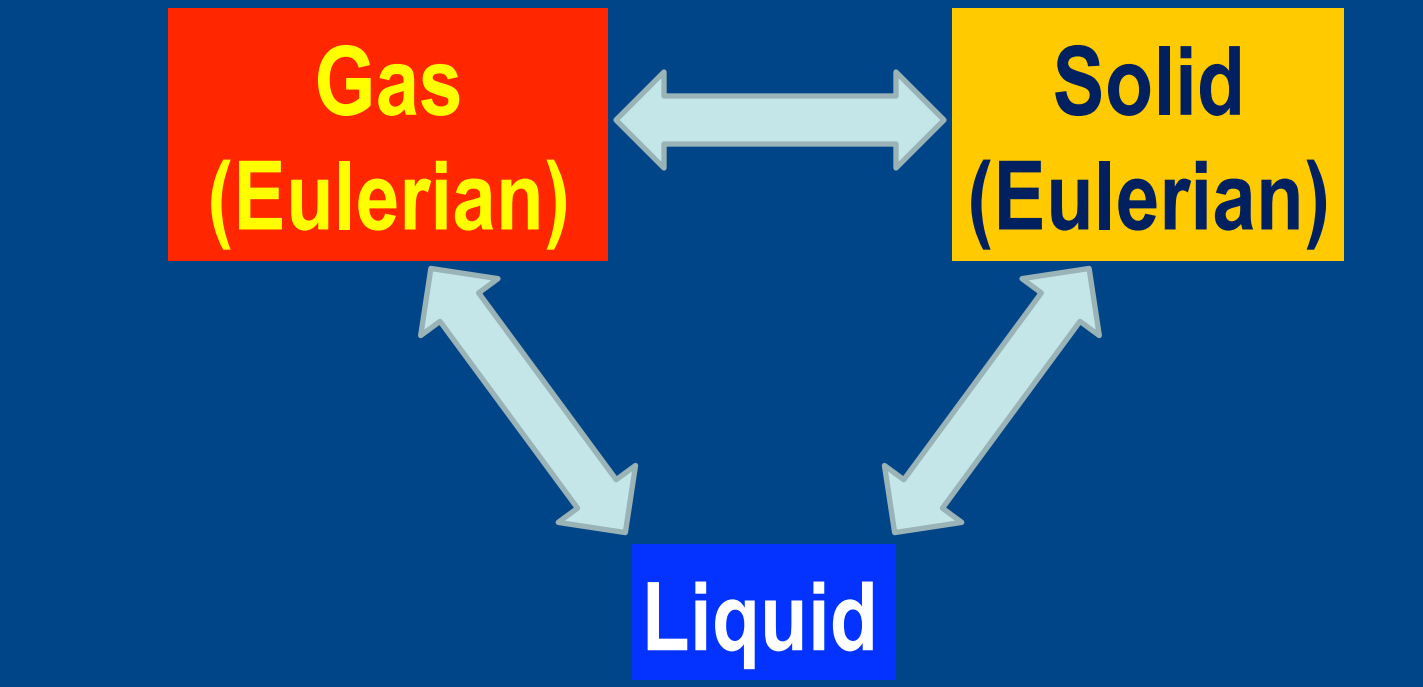
Numerical modeling



Key Phenomena in Sprinkler Suppression

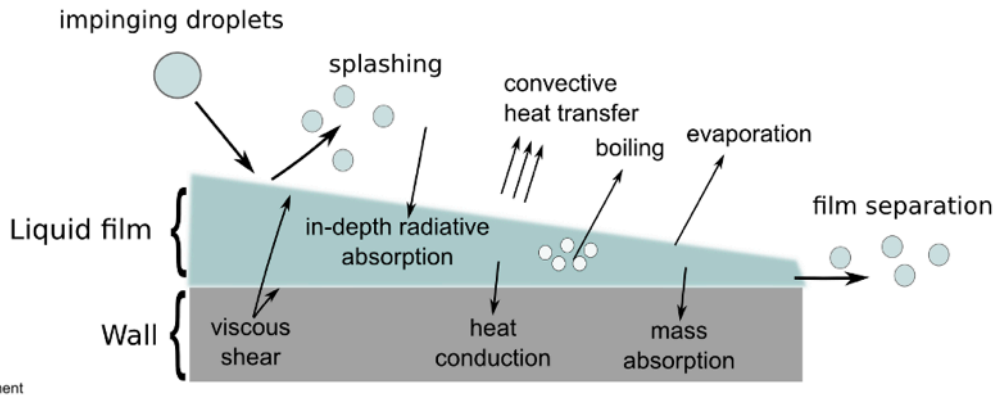


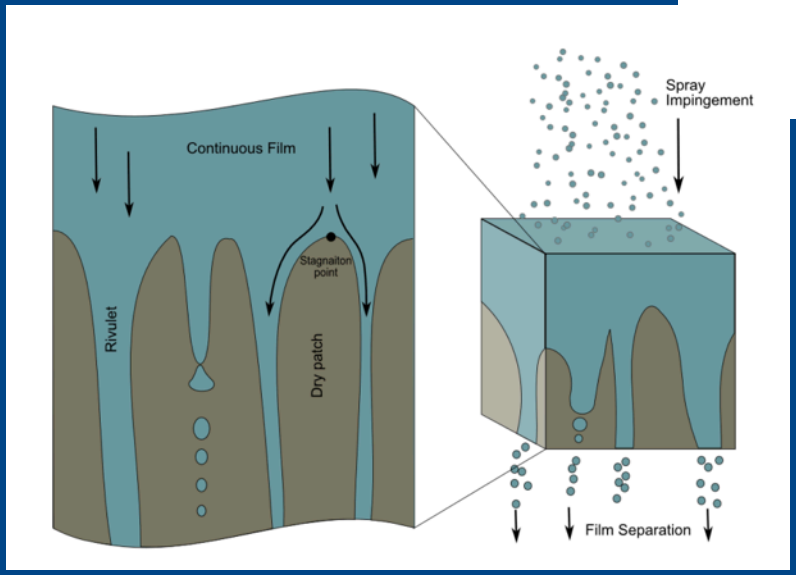
FireFOAM: General Model Framework

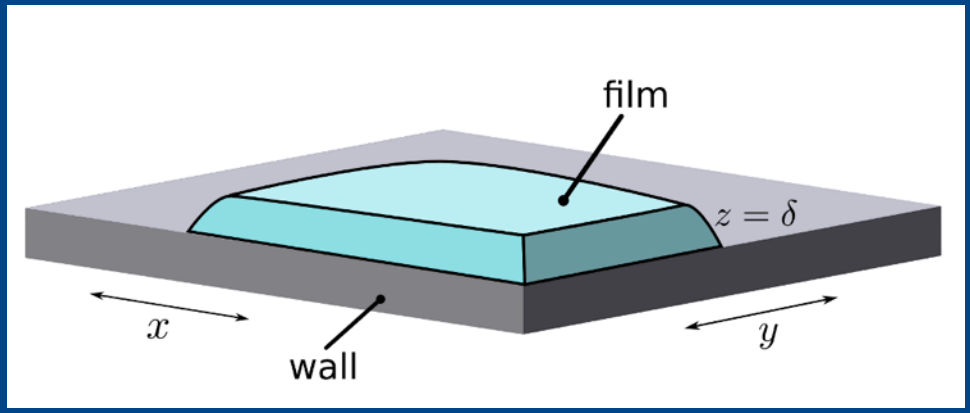


FireFOAM: Water Transport Model

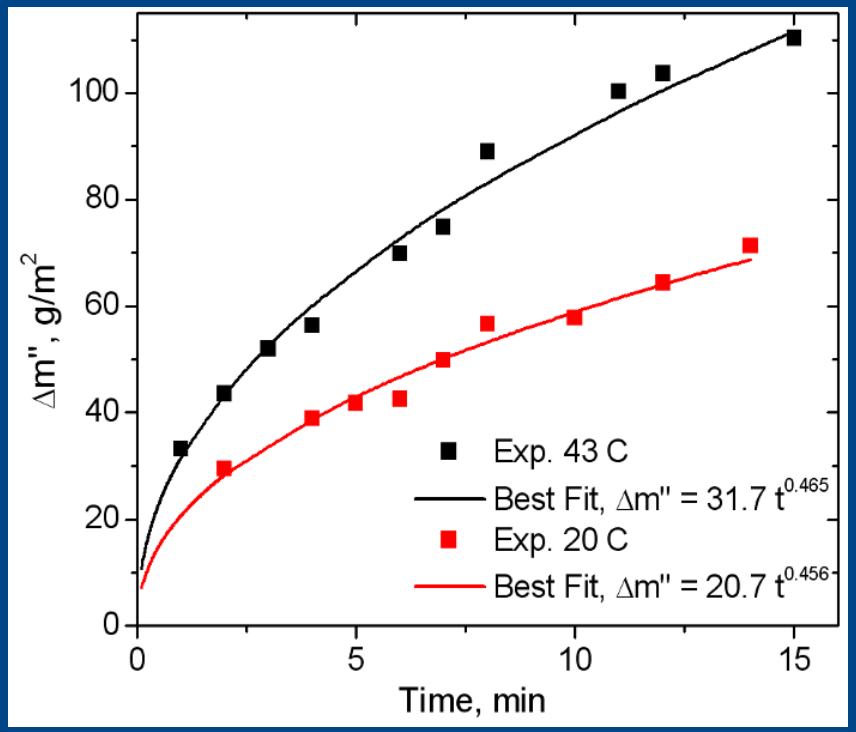
- Thin-film assumption
- Multiphase transport
- Film & rivulet flows

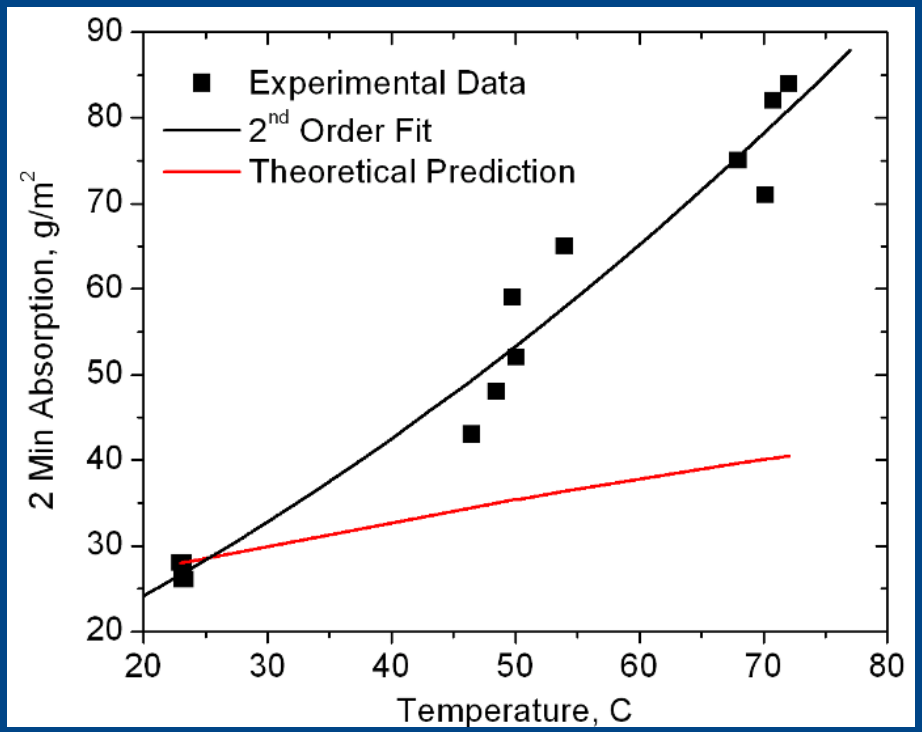




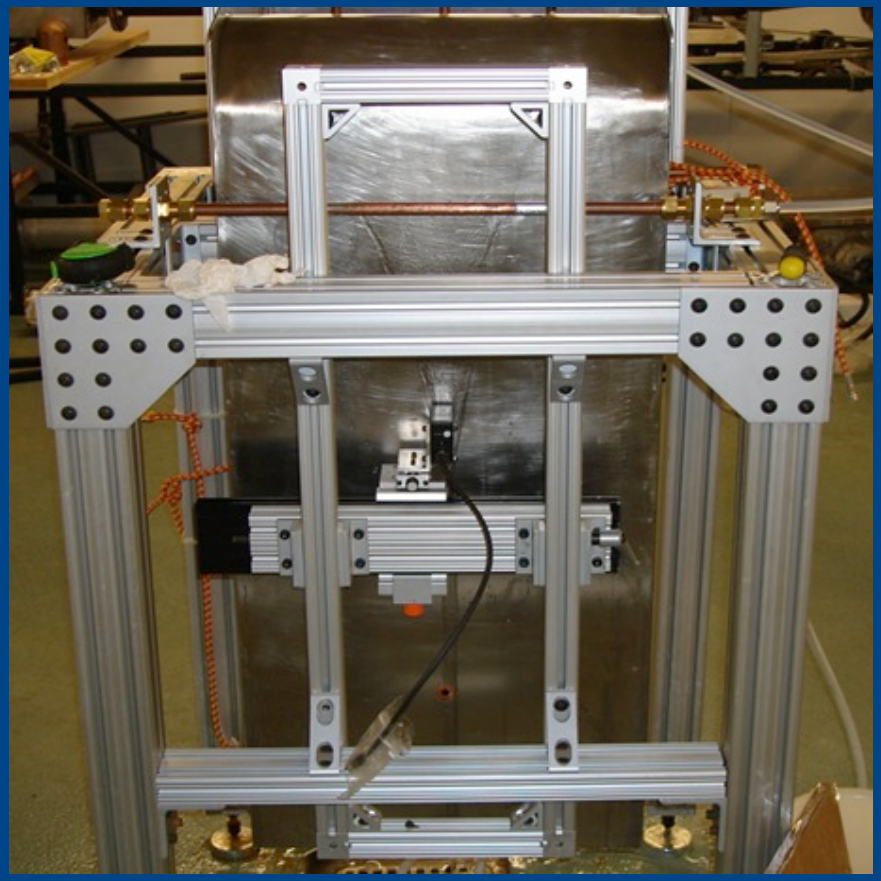


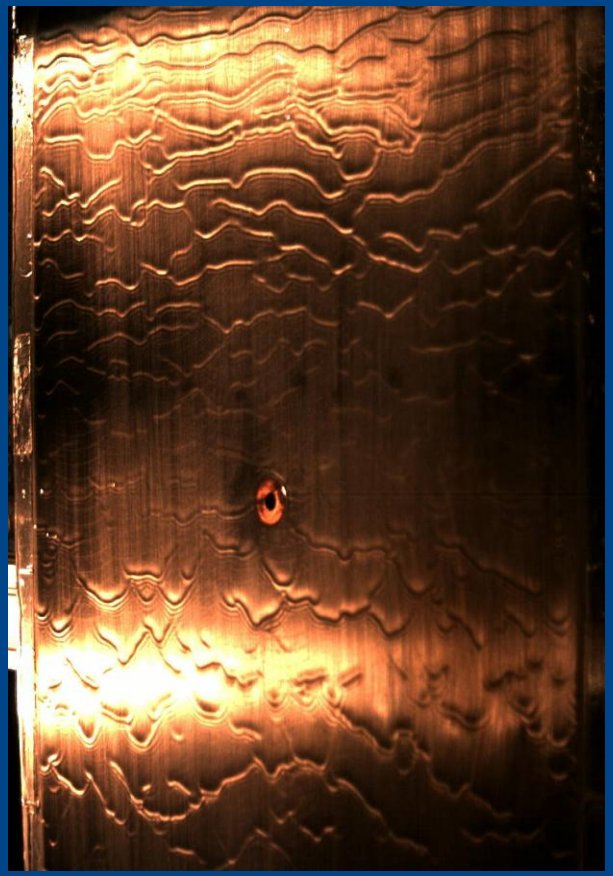
Experimental Study: Water Absorption



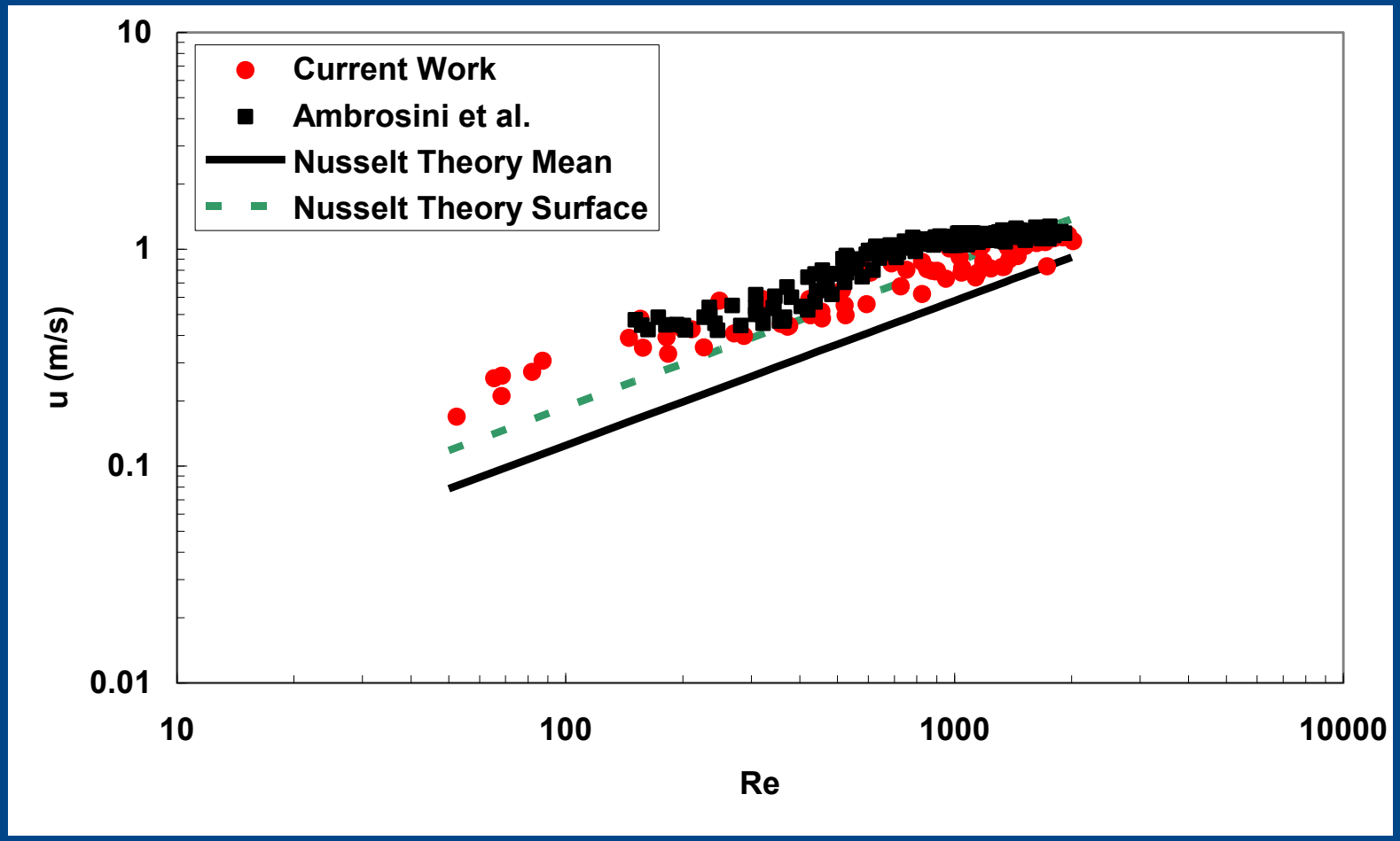


Experimental Study: Vertical Surface Flow

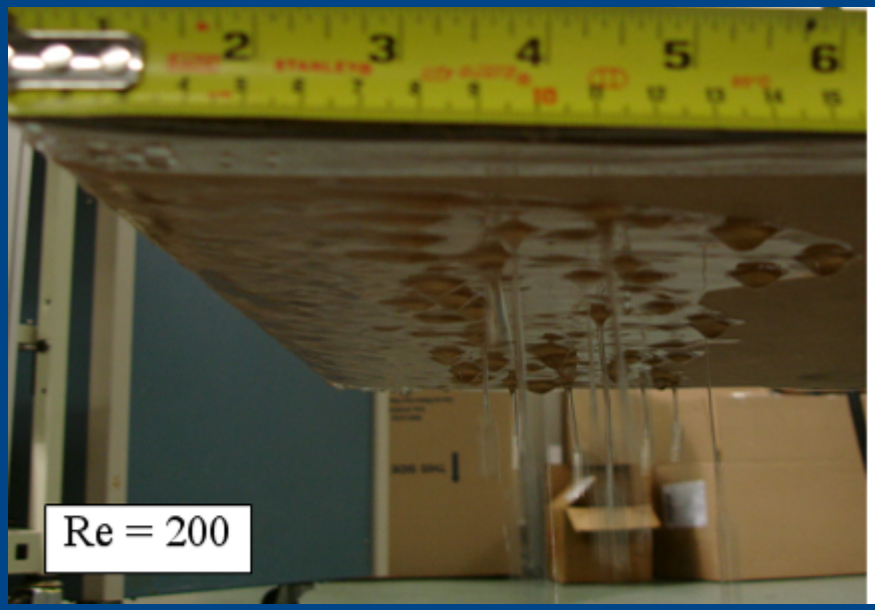


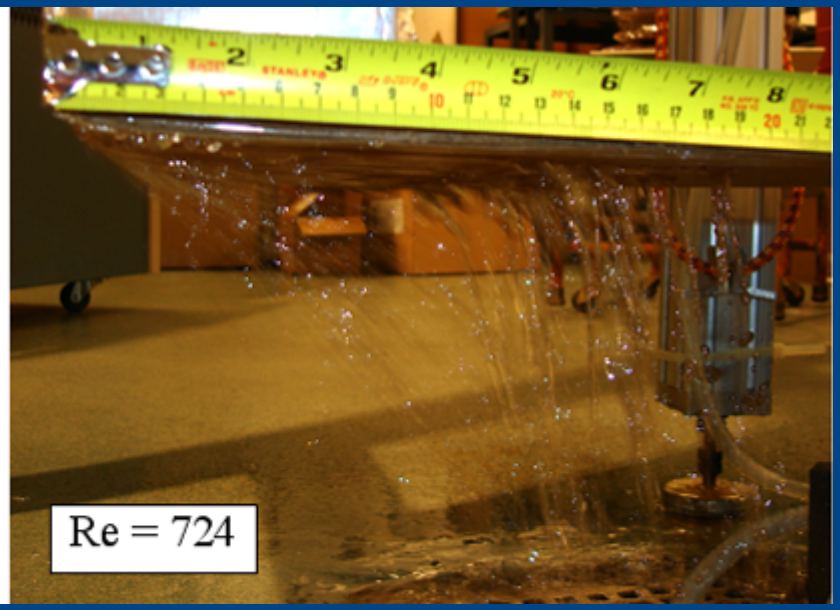


Experimental Study: Vertical Flow Velocity

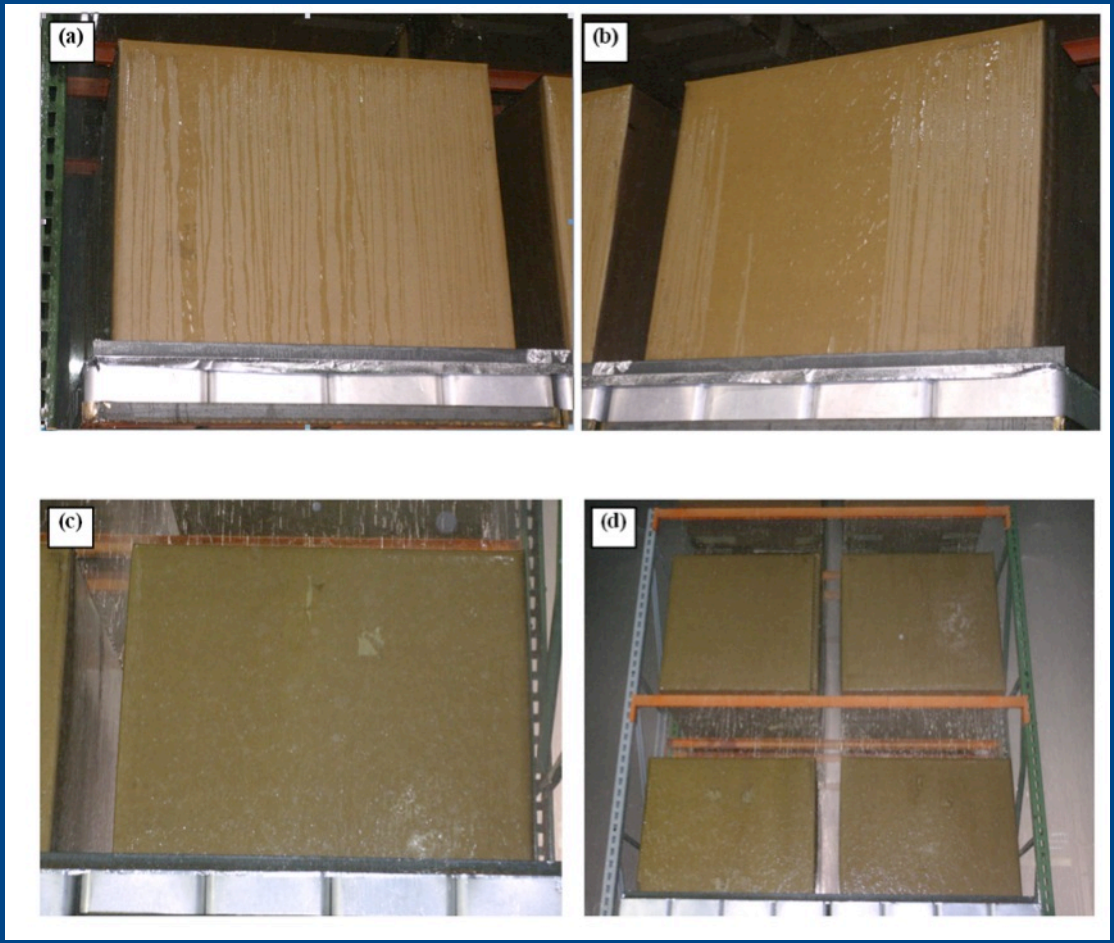


Experimental Study: Corner Flow Separation

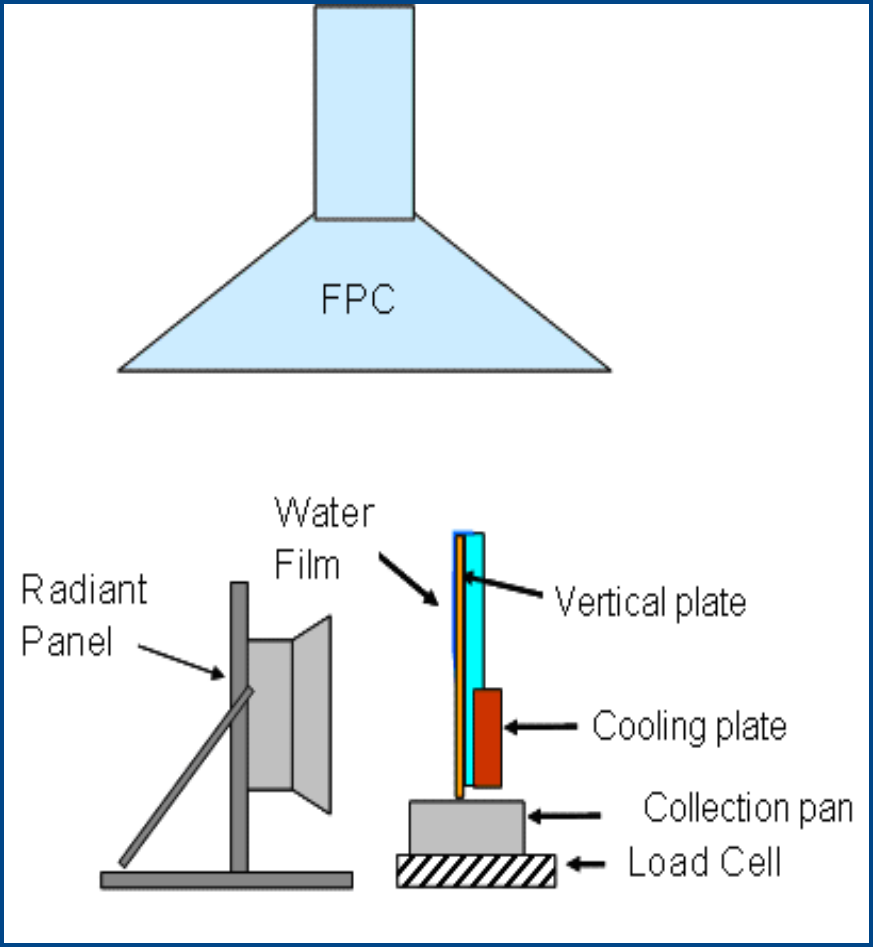


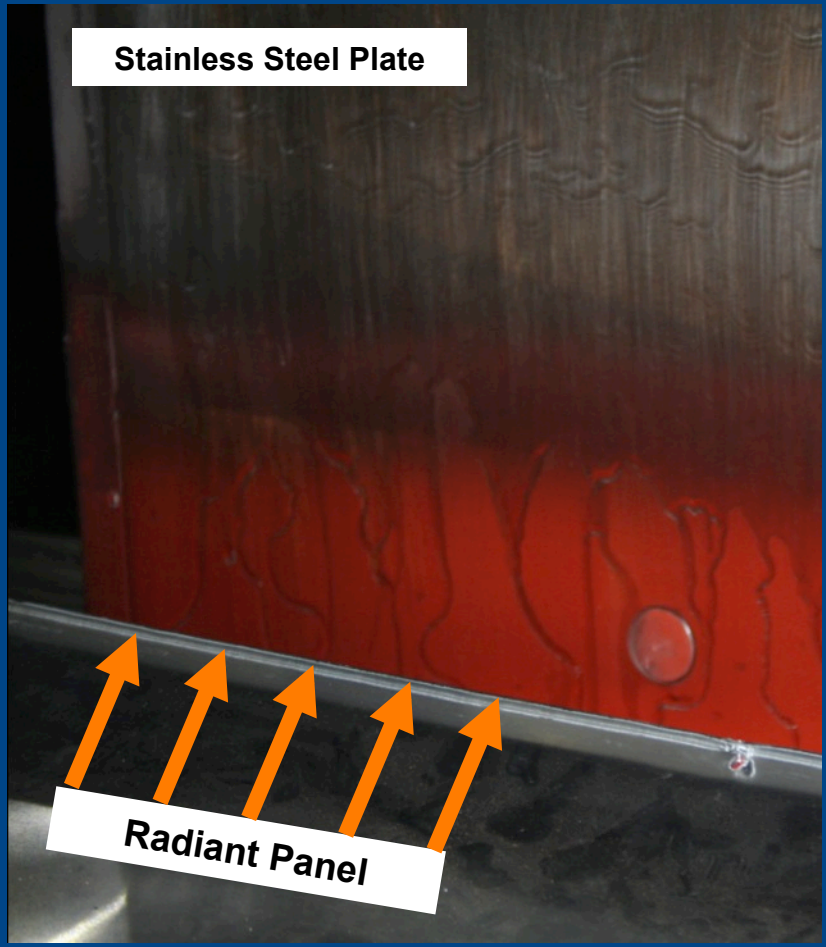


Experimental Study: Water Flow in Rack Storage

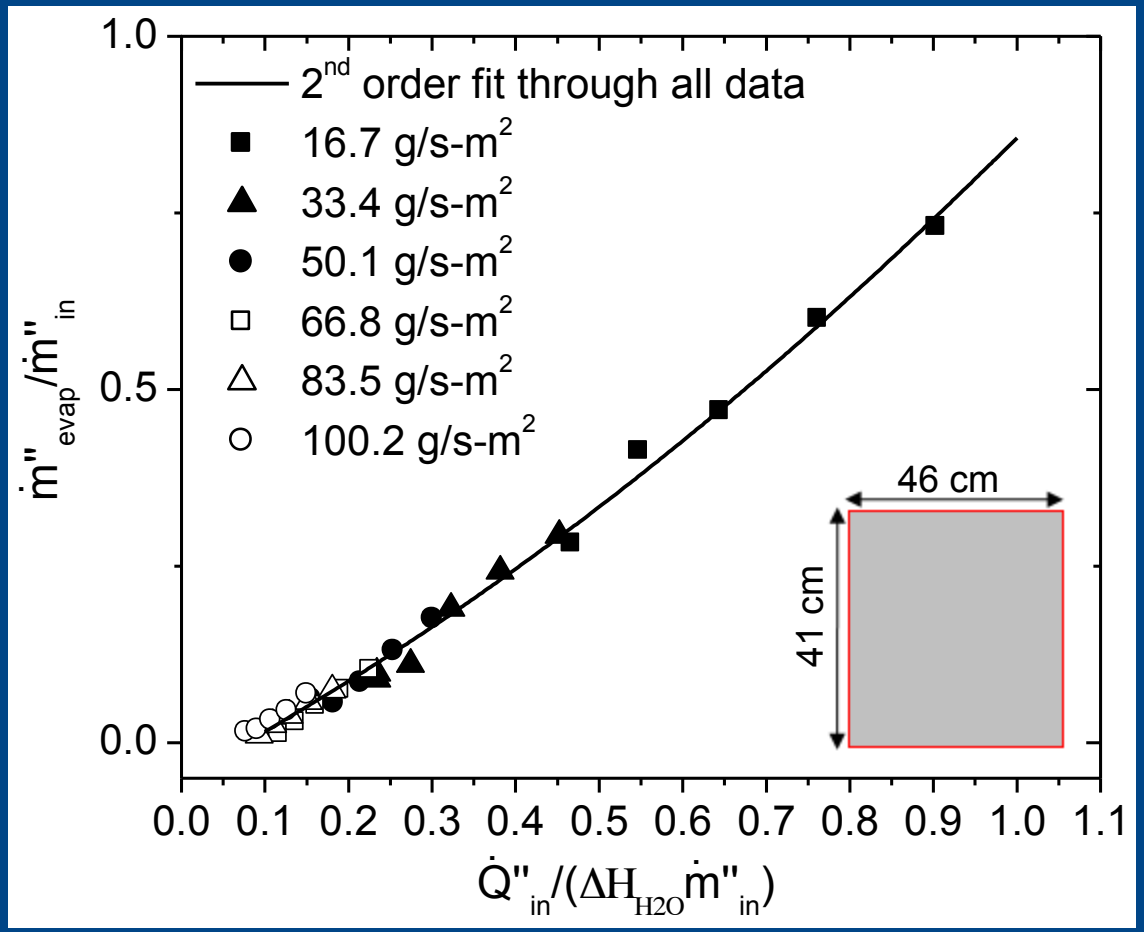


Experimental Study: Single-Wall Evaporation

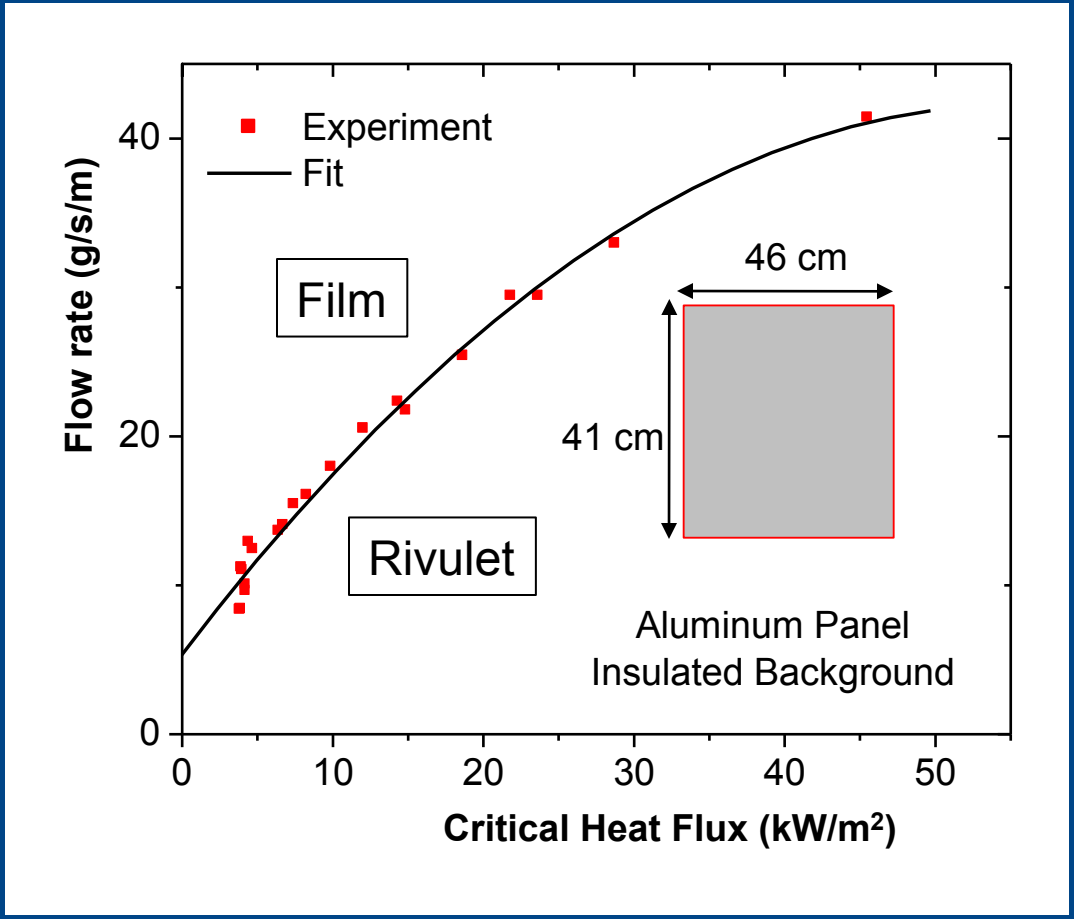




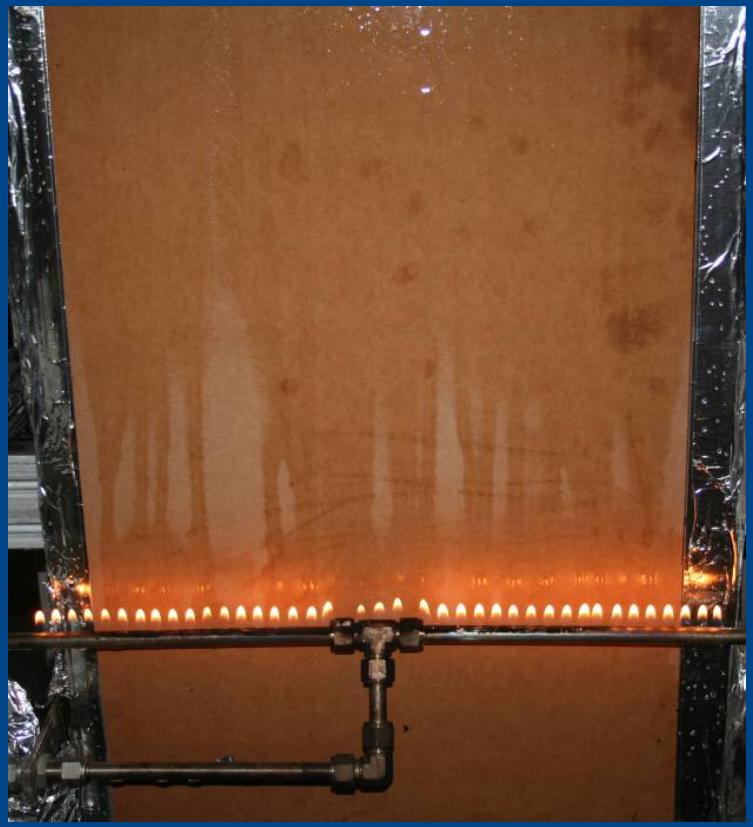
Experimental Study: Evaporation Rates



Experimental Study: Film-Rivulet Transition

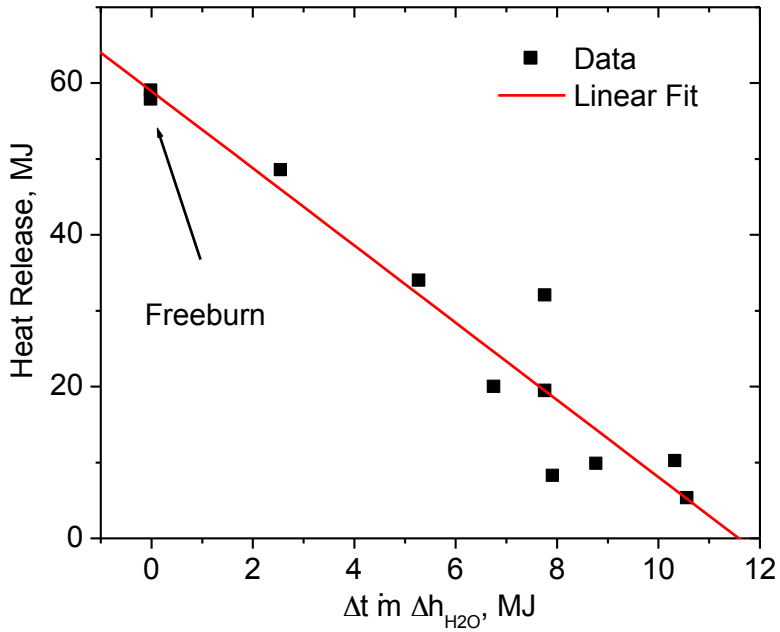


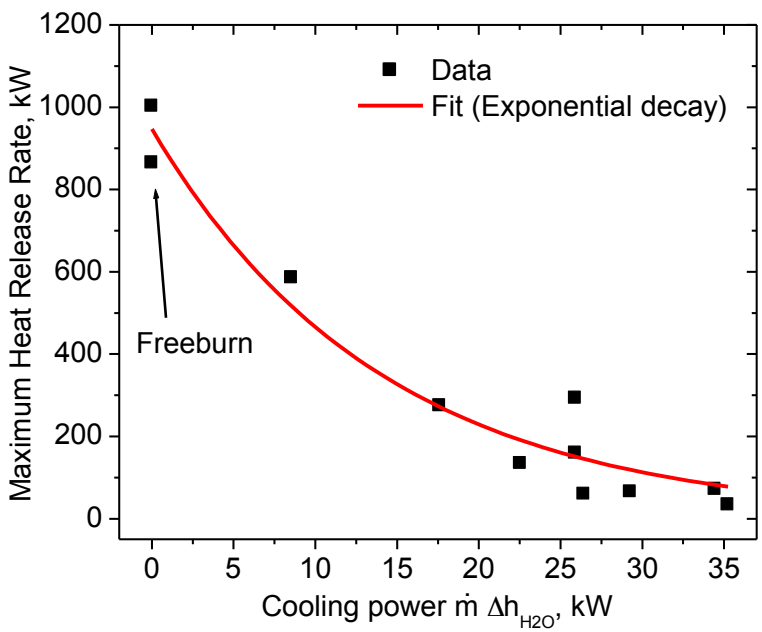
Experimental Study: Single-Wall Suppression



Experimental Study: Parallel Panel Suppression

Experimental Study: Parallel Panel Suppression

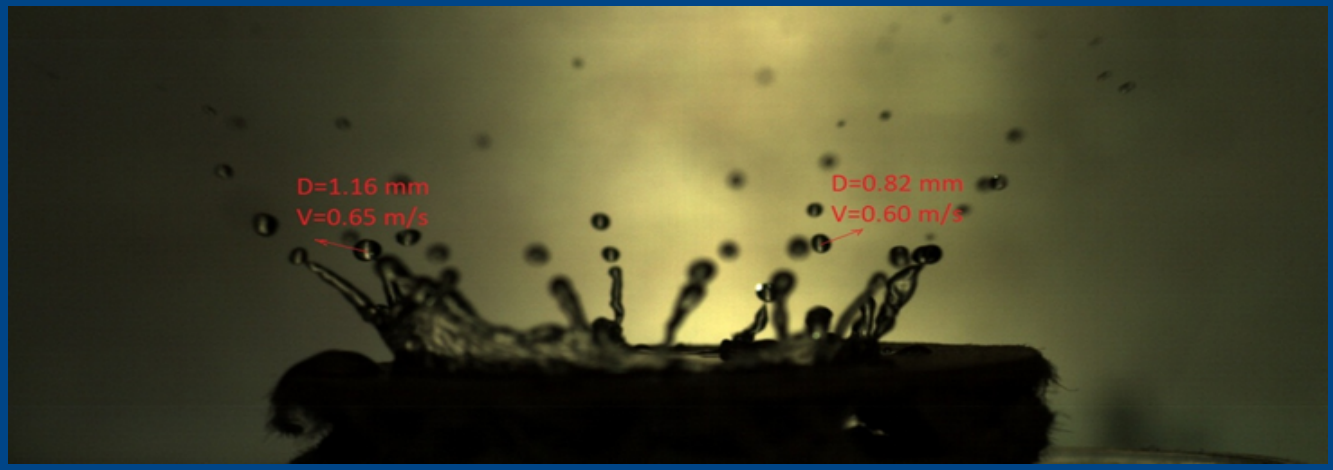


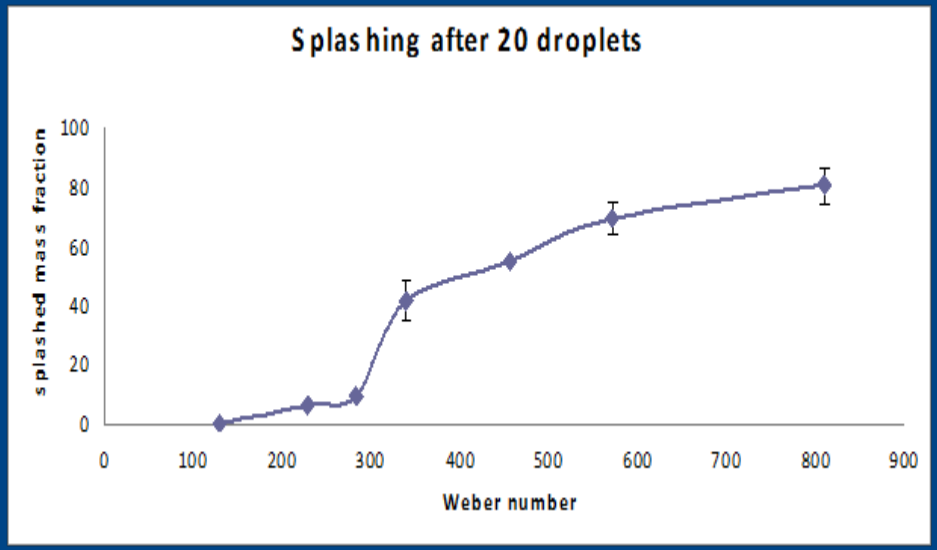


Summary

- Advancing sprinkler technology requires development of new research tool - FireFOAM
- Combined approach of testing and modeling
- On track for basic suppression model
  - Experimental studies of physics
  - Modeling framework: 3D, transient, parallel code coupling three phases

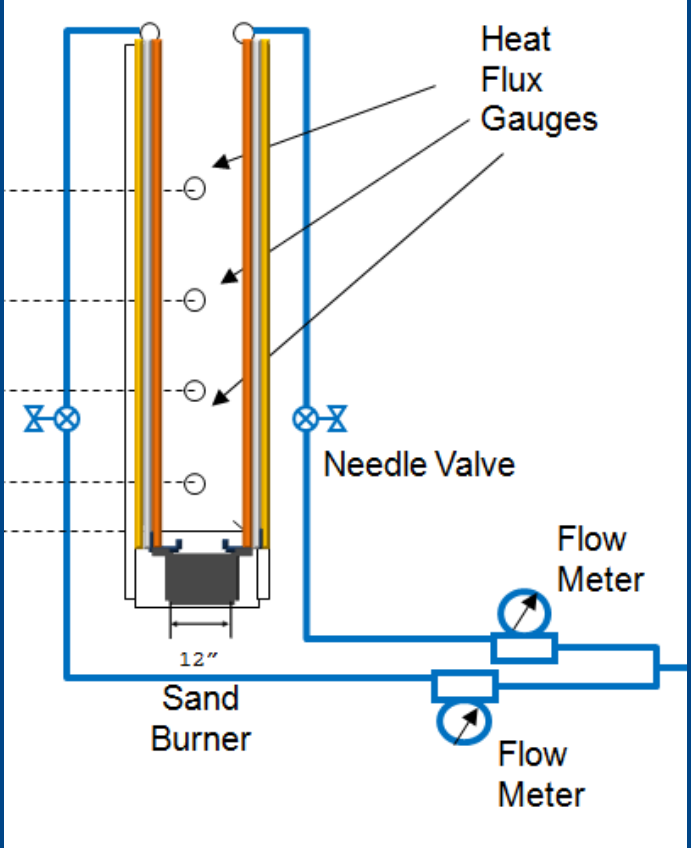
Ongoing Study: water splashing on cardboard

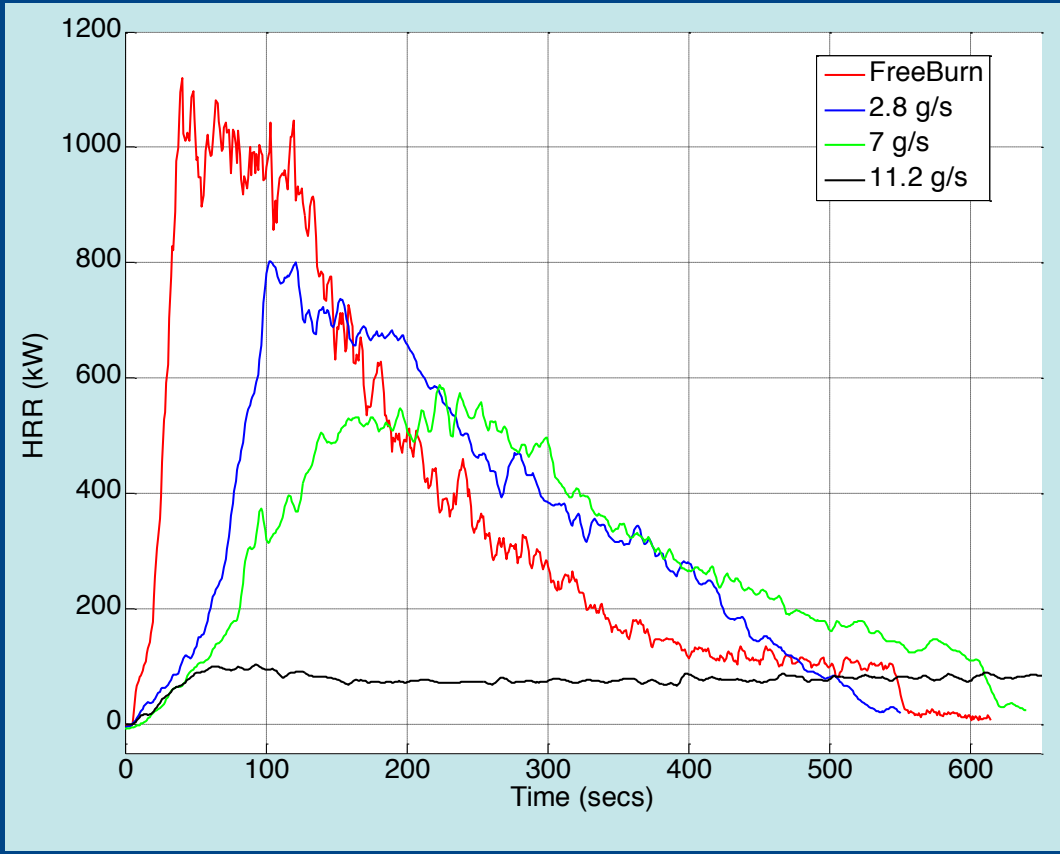




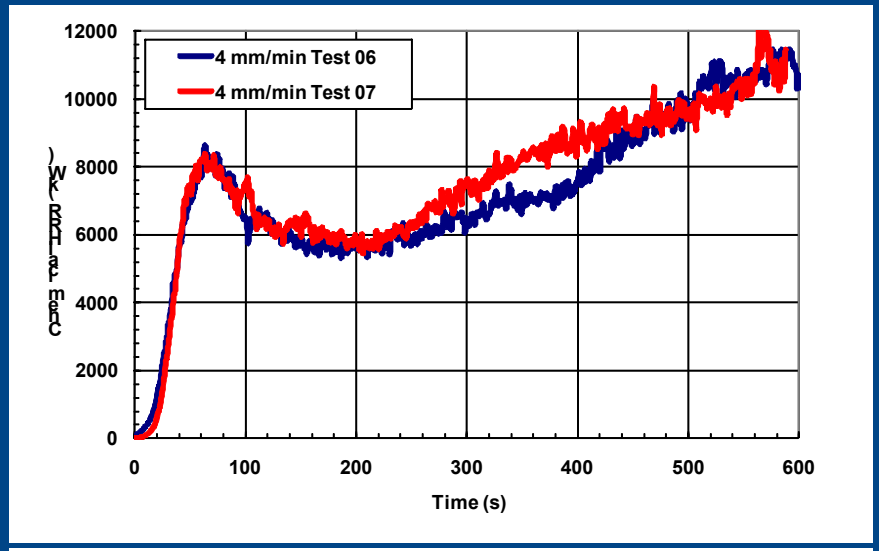
Ongoing Study: radiation-controlled, single-wall tests

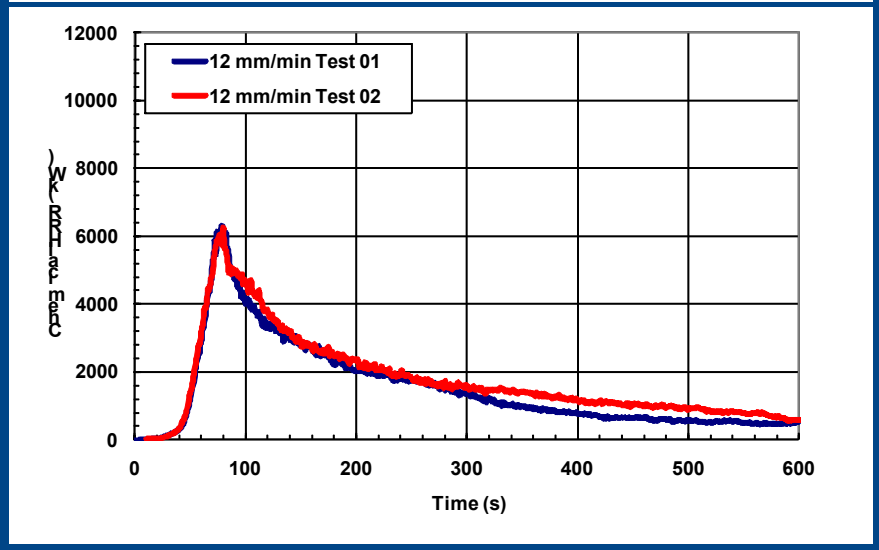
Ongoing Study: parallel panel suppression



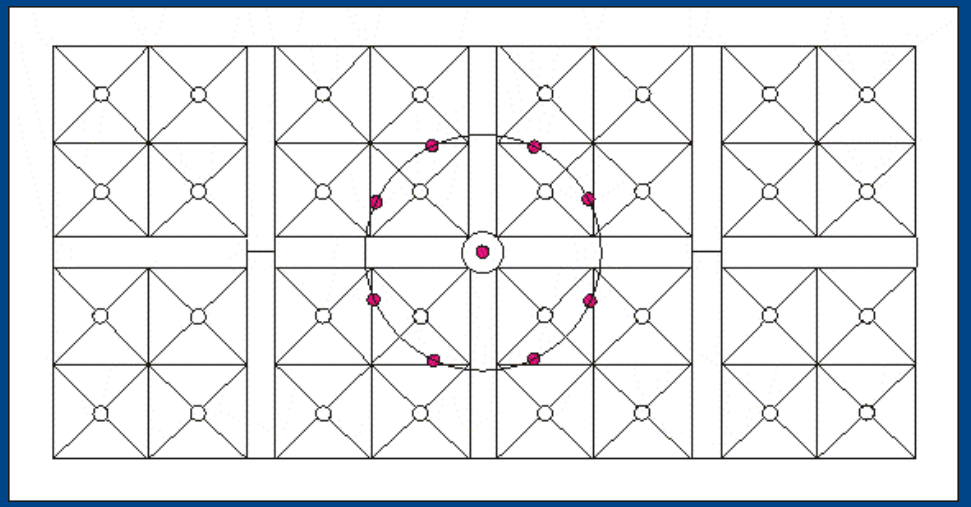


Ongoing Study: suppression w/ uniform water flux



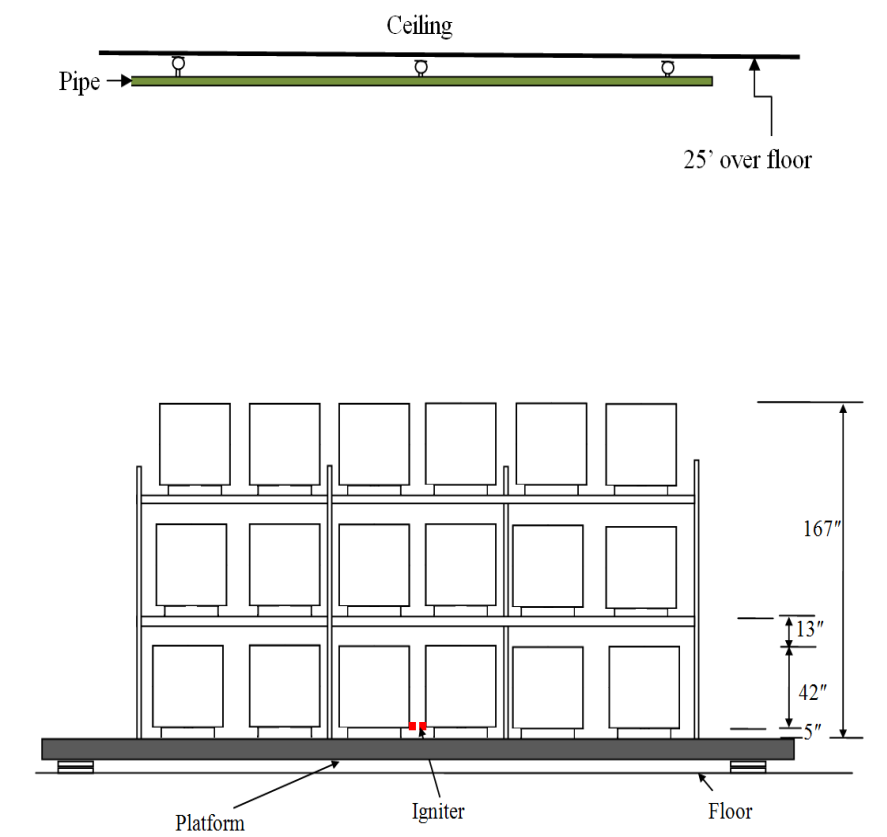


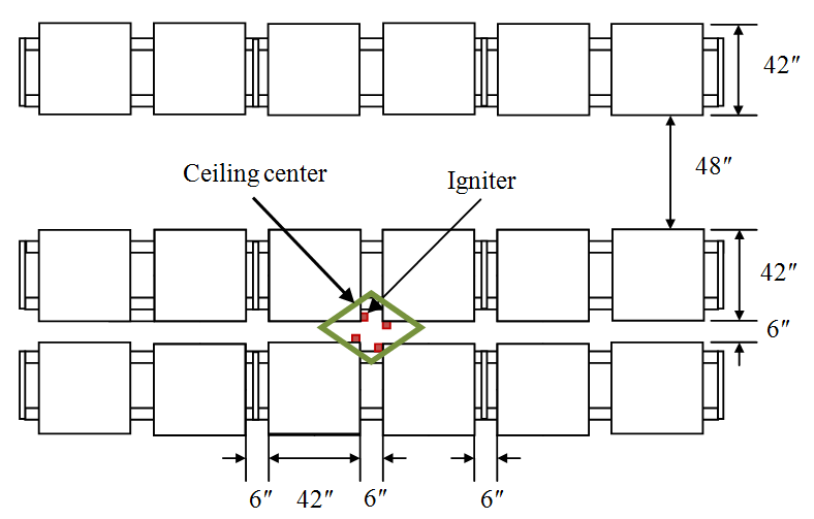
Ongoing Study: Actual delivered density (ADD)

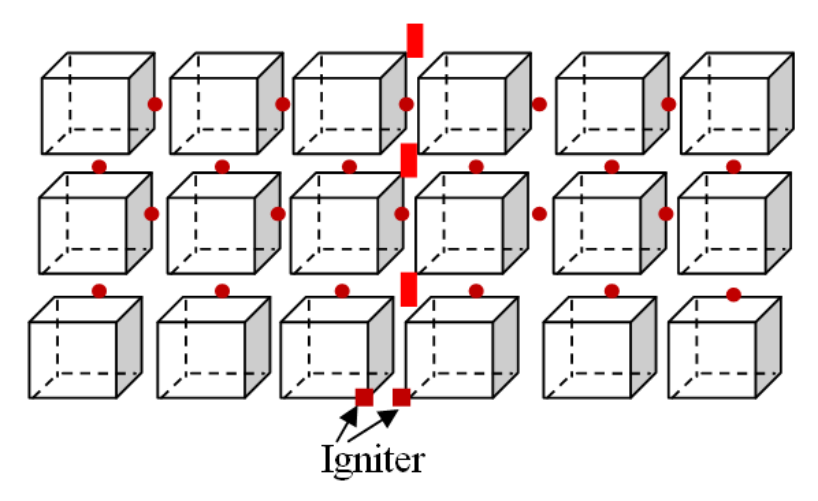


Z (ft-in.)	ΔT (°C)		U_g (m/s)	
	Target	Actual	Target	Actual
8-5	837	1035	12.4	12.2
15-5	466	572	11.0	12.0
22-5	251	283	9.8	9.7
29-5	160	163	8.9	8.6

Future Work: full-scale sprinkler tests of idealized Class 2

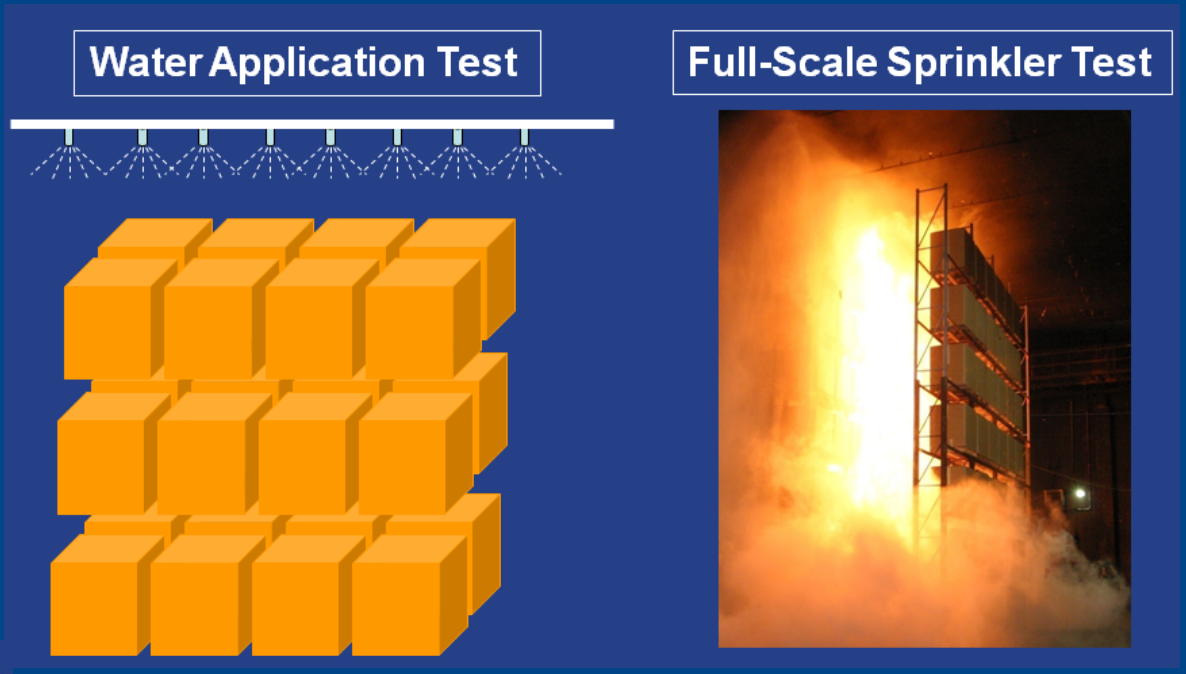






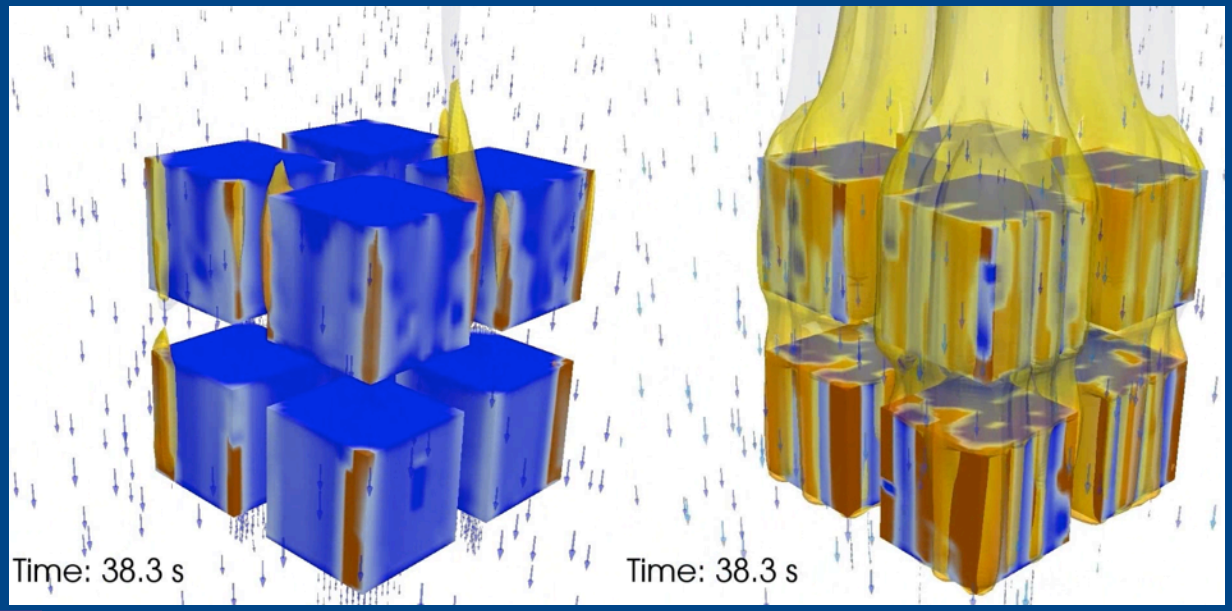
Future Work: experimental studies

- Cold flow: splashing, rivulet & corner flow, flow on charred surfaces
- Radiation-controlled evaporation and suppression
- Validation: parallel panel, WAA, ADD and sprinkler tests



Future Work: FireFOAM model development

- Continue model validation for separate effects
- Validate models using fire tests
  - Water application tests;
  - Full-scale sprinkler tests



Acknowledgement

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- FM Global Research Campus Staff

Thank you.

Questions?