

# Fire Service Ventilation – Understanding Fire Dynamics is Key to Effective Ventilation

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# Overview of UL Firefighter Research

2006 - Structural Stability of Engineered Lumber under Fire Conditions

2007 - Firefighter Exposure to Smoke Particulates

**2008 - Impact of Horizontal Ventilation**

2009 - Firefighter Safety and Photovoltaic Systems

2009 - Basement Fires (NIST ARRA)

**2010 - Impact of Vertical Ventilation**

2010 - Governors Island Testing with FDNY and NIST

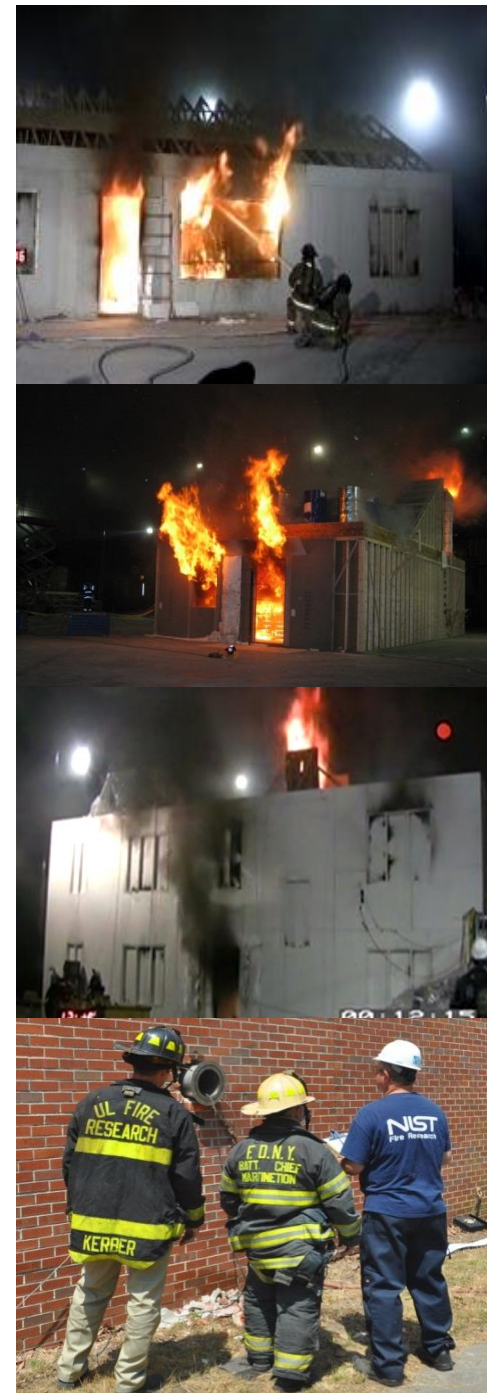
2011 - Exterior Fire Spread and Attics Fires

**2012 - Study of Positive Pressure Ventilation in Homes**

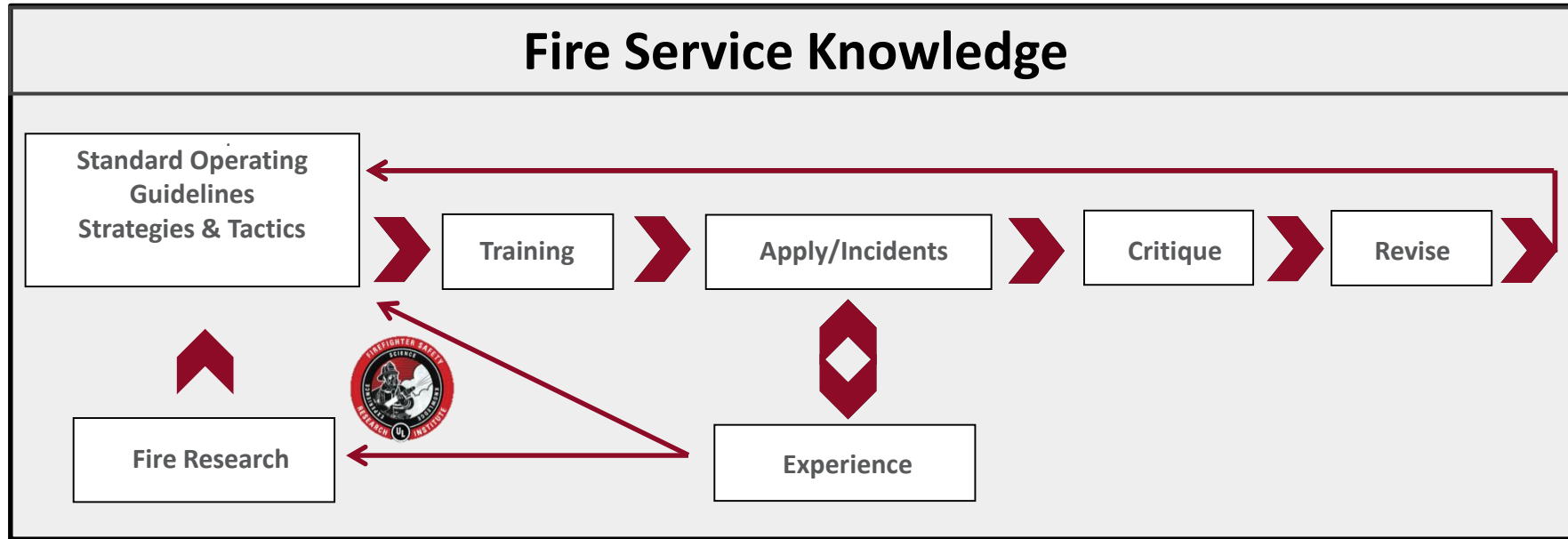
2013 - Impact of Fire Attack Utilizing Interior and Exterior Streams

2013 - Cardiovascular and Carcinogenic Risks of Modern Firefighting (IFSI)

2014 - Study of the Fire Service Training Environment: Safety, Fidelity, and Exposure



# Consistent Theme



To move forward, knowledge of fire dynamics has to be the foundation of the firefighting system, experience and fire research need to work together to improve strategies and tactics.

Technology needs to support this system with the understanding that no amount of technology can replace knowledge (Turnout gear, SCBA, predictive tools, suppression tools, magic widgets...)

Without dissemination of research results it is useless, (Dissemination is a constant process with no magic bullet)

# UL Firefighter Safety Research Institute DHS Ventilation Grants

2008 - Impact of Ventilation on Fire Behavior in Legacy and Contemporary Construction

2010 - Study of the Effectiveness of Fire Service Vertical Ventilation and Suppression Tactics in Single Family Homes.

2012 - Study of the Effectiveness of Fire Service Positive Pressure Ventilation During Fire Attack in Single Family Homes Incorporating Modern Construction Practices



# Reasons for Ventilation

## Essentials of Firefighting

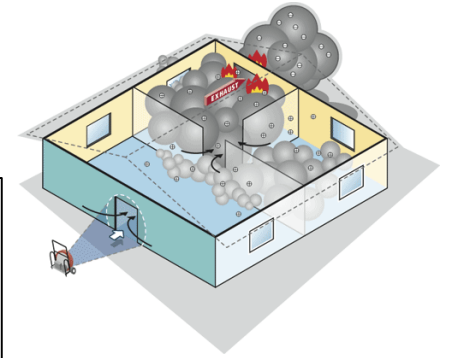
- Reduce Interior Heat Levels
- Decreasing Rate of Fire Spread
- Reducing Potential Extreme Fire Behavior
- Improving Interior Visibility
- Improving Firefighter Efficiency
- Improving Potential Victim Survivability
- Reducing Smoke Damage and Property Damage

## Officers Handbook of Tactics

- To Allow attack teams to enter and operate within the structure (Venting for fire)
- To provide fresh air for breathing (Venting for Life)
- To improve visibility while searching (Venting for Life)

## Positive Pressure Attack for Ventilation and Firefighting

- Assists with survival and rescue of trapped victims
- Protects firefighters
- Aids firefighter entry
- Rapid advance to the seat of the fire.
- Decreases fire spread
- Decreases property damage



## 2008 - Impact of Ventilation on Fire Behavior in Legacy and Contemporary Construction



# DHS – 2008 Horizontal Ventilation

## Legacy vs. Contemporary Burns

- 2 Room Scale Burns
- 2 Full Scale Burns



## Heat Release Rate Burns

- 3 Room Scale Burns



## Full Scale Fire Experiments

- 7 Single Story
- 8 Two Story

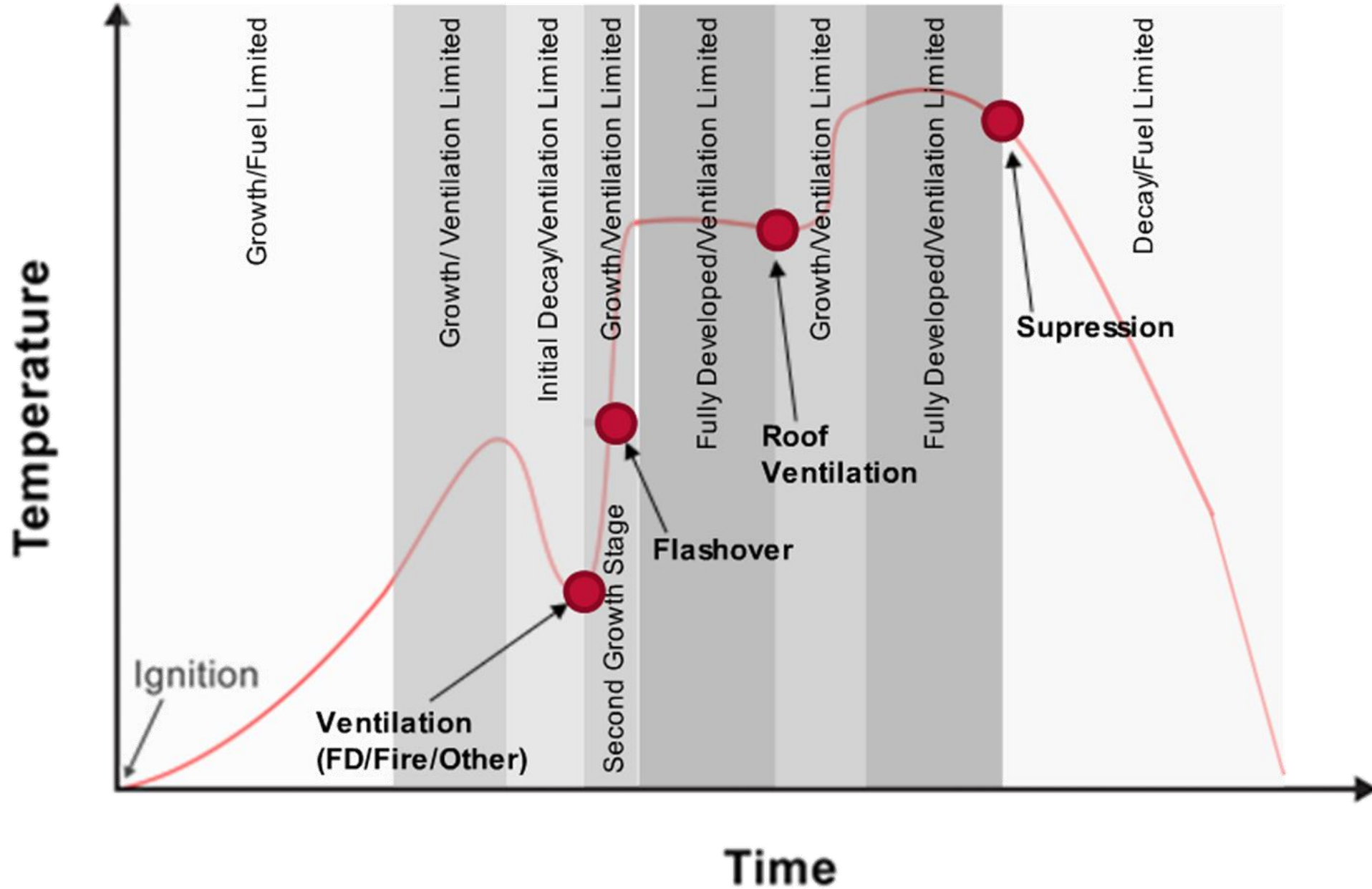


# Stages of Fire Growth





# Ventilation Limited Curve





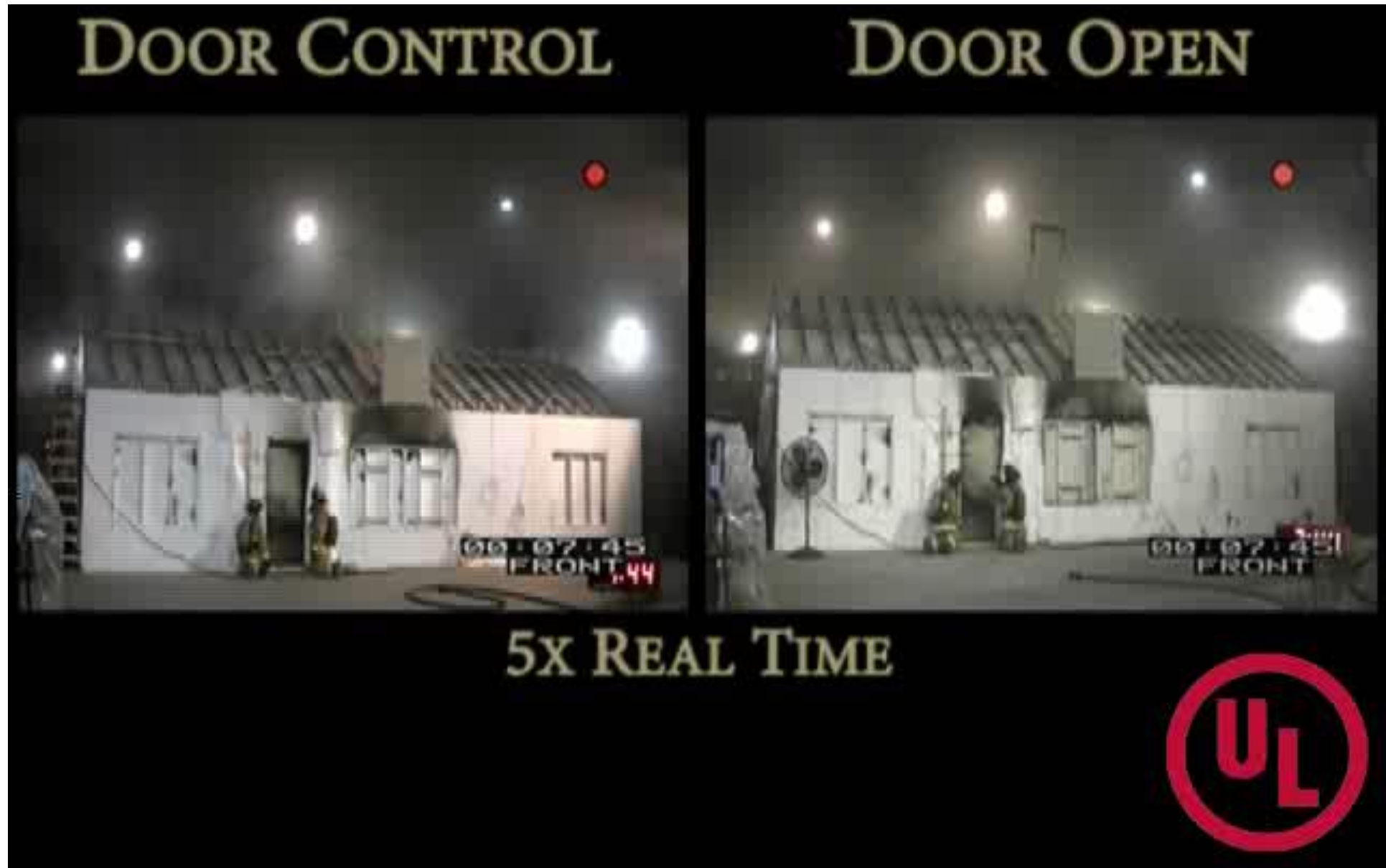
**Forcing the Front Door  
Needs to be Thought of  
as Ventilation**

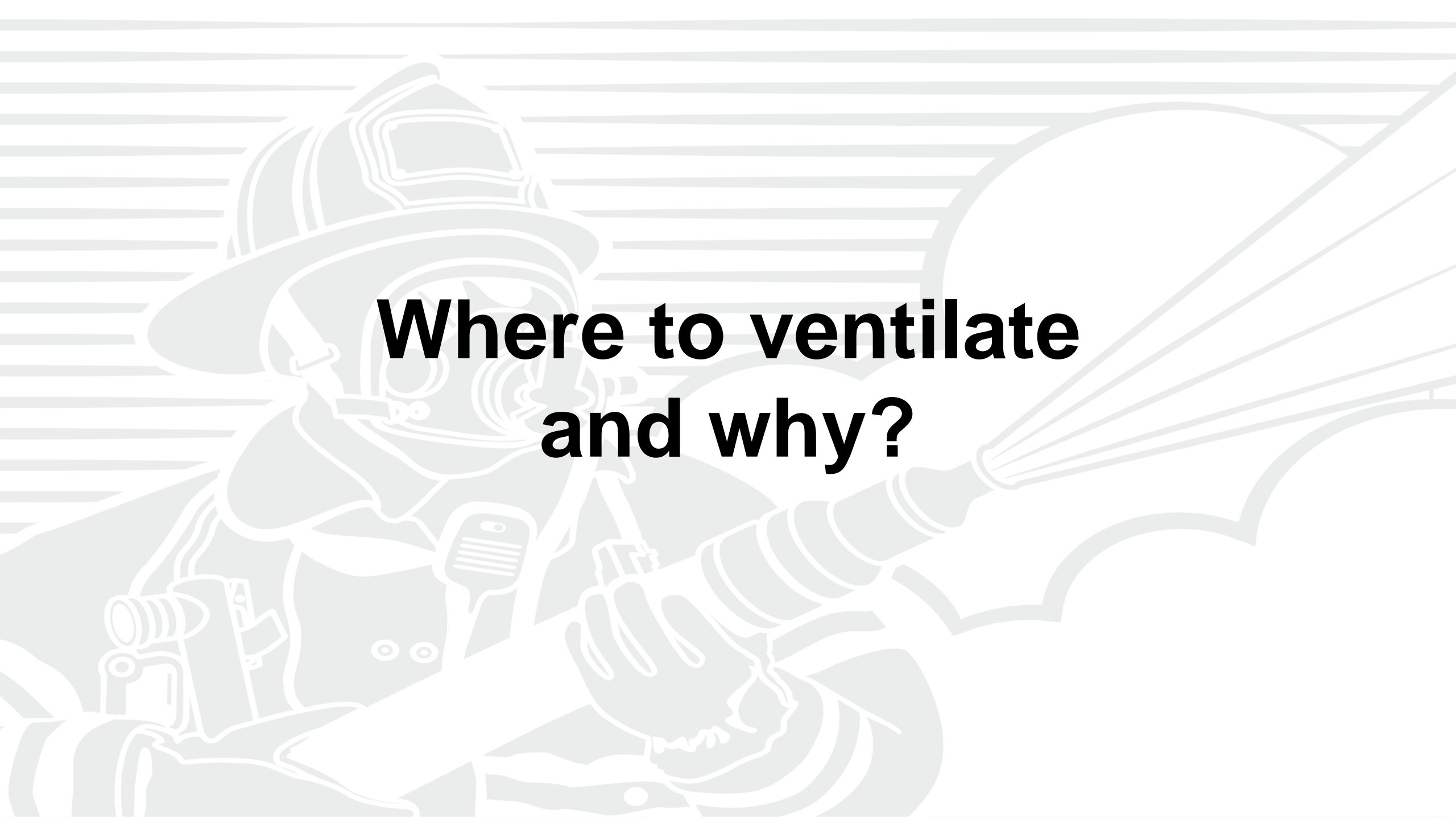


# Control the Front Door



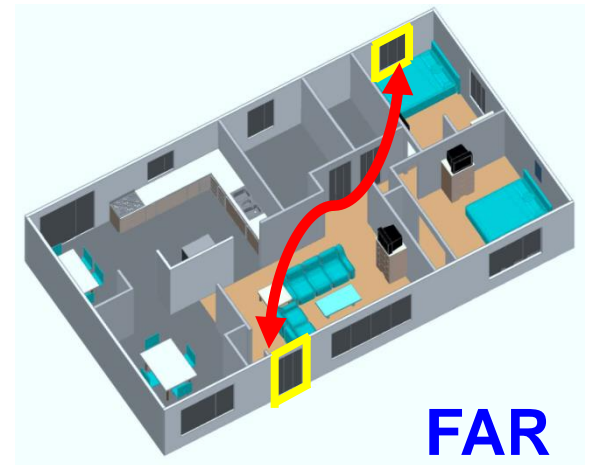
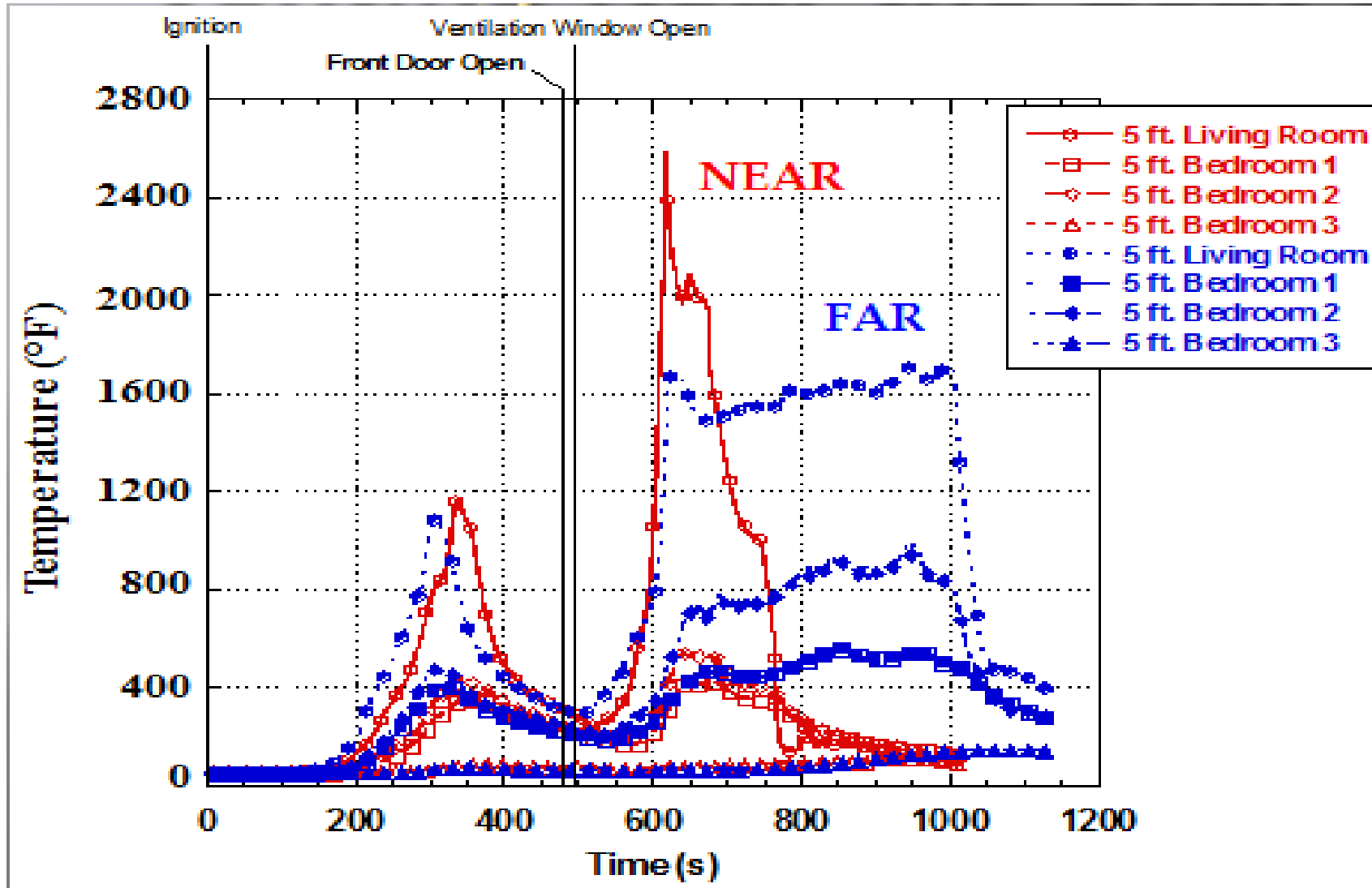
# Control the Front Door



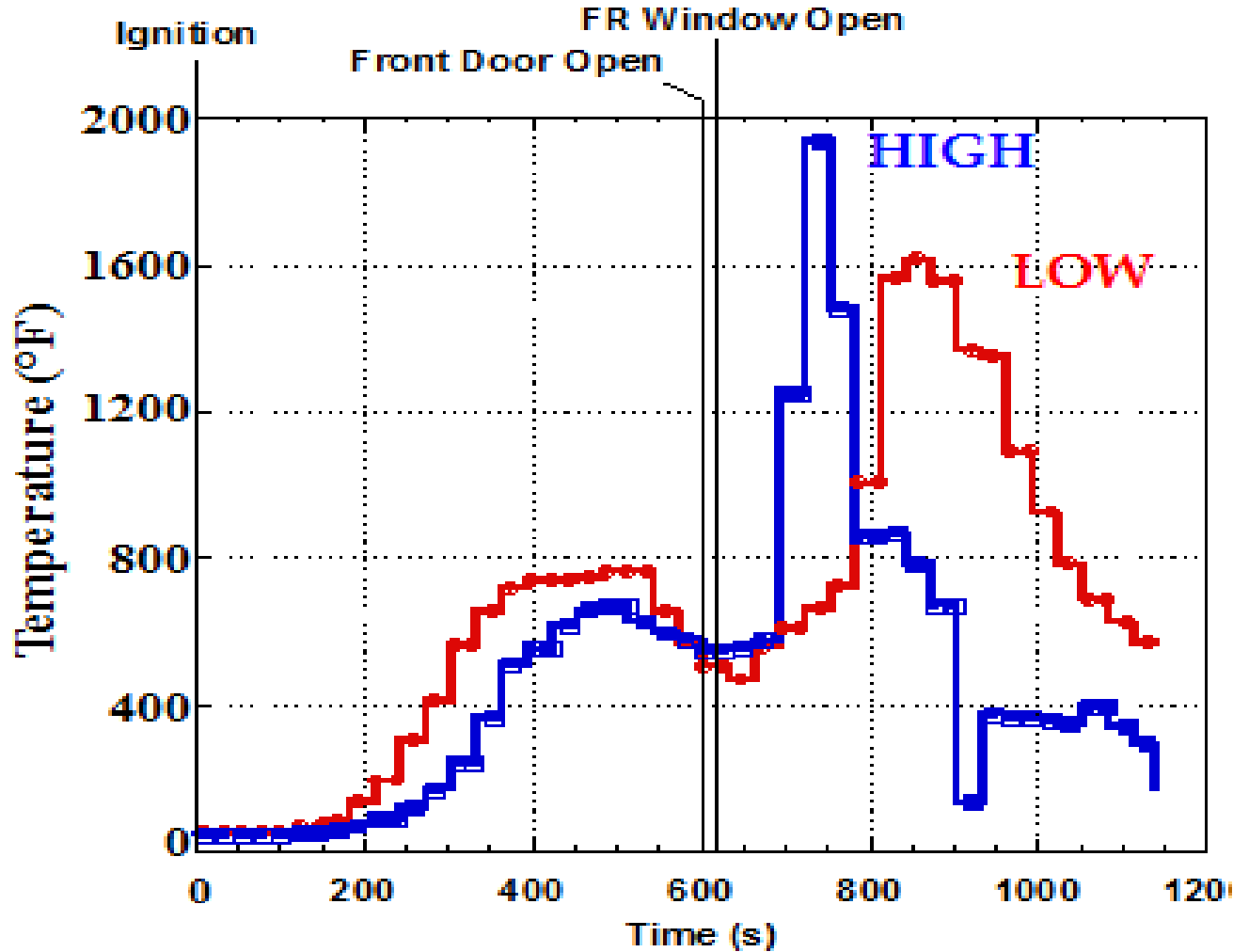


# **Where to ventilate and why?**

# Venting Near the Seat of the Fire



# Venting Low vs. High



Vent High Window


- 600°F to 1700 °F in 120 sec

Vent Low Window

- 600°F to 1500°C in 250 sec

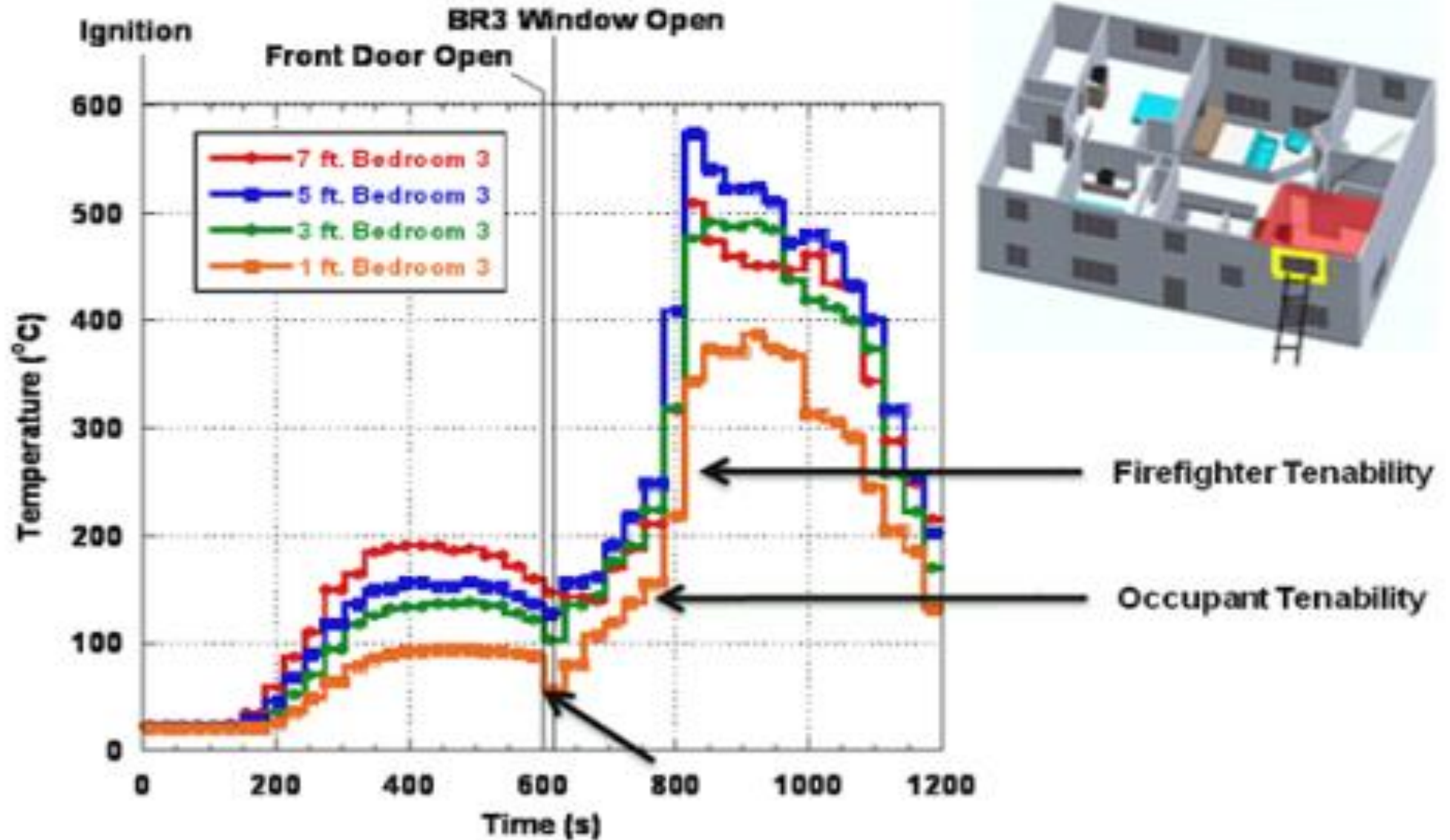






**Vent  
Enter  
Isolate  
Search**

# VES or VEIS (Vent Enter Isolate Search)



# Questions

DHS – 2012 “Study of the Effectiveness of Fire Service Positive Pressure Ventilation During Fire Attack in Single Family Homes Incorporating Modern Construction Practices”

**[www.ulfirefightersafety.com/training](http://www.ulfirefightersafety.com/training)**

- 400 Page Scientific Report
- 50 Page Fire Service Summary Report



**2010 - Study of the Effectiveness of Fire Service Vertical Ventilation and Suppression Tactics in Single Family Homes.**



# DHS – 2010 Vertical Ventilation

## Heat Release Rate Burns

- 3 Room Scale Burns



## Full Scale Fire Experiments

- 9 Single Story
- 7 Two Story



# UL Vertical Ventilation Experiments

5x Real Time

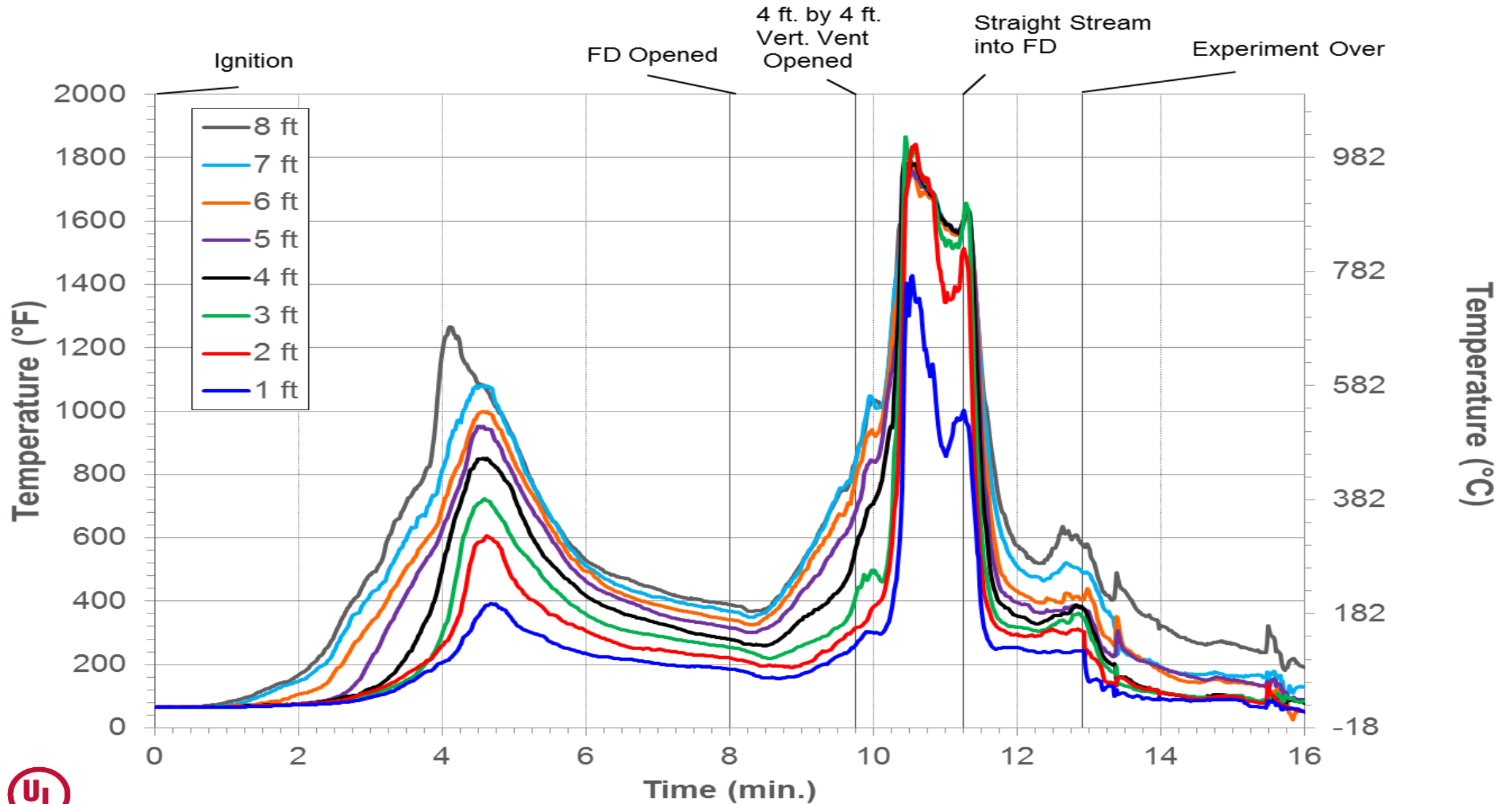


4 ft. by 4ft. Vent Hole

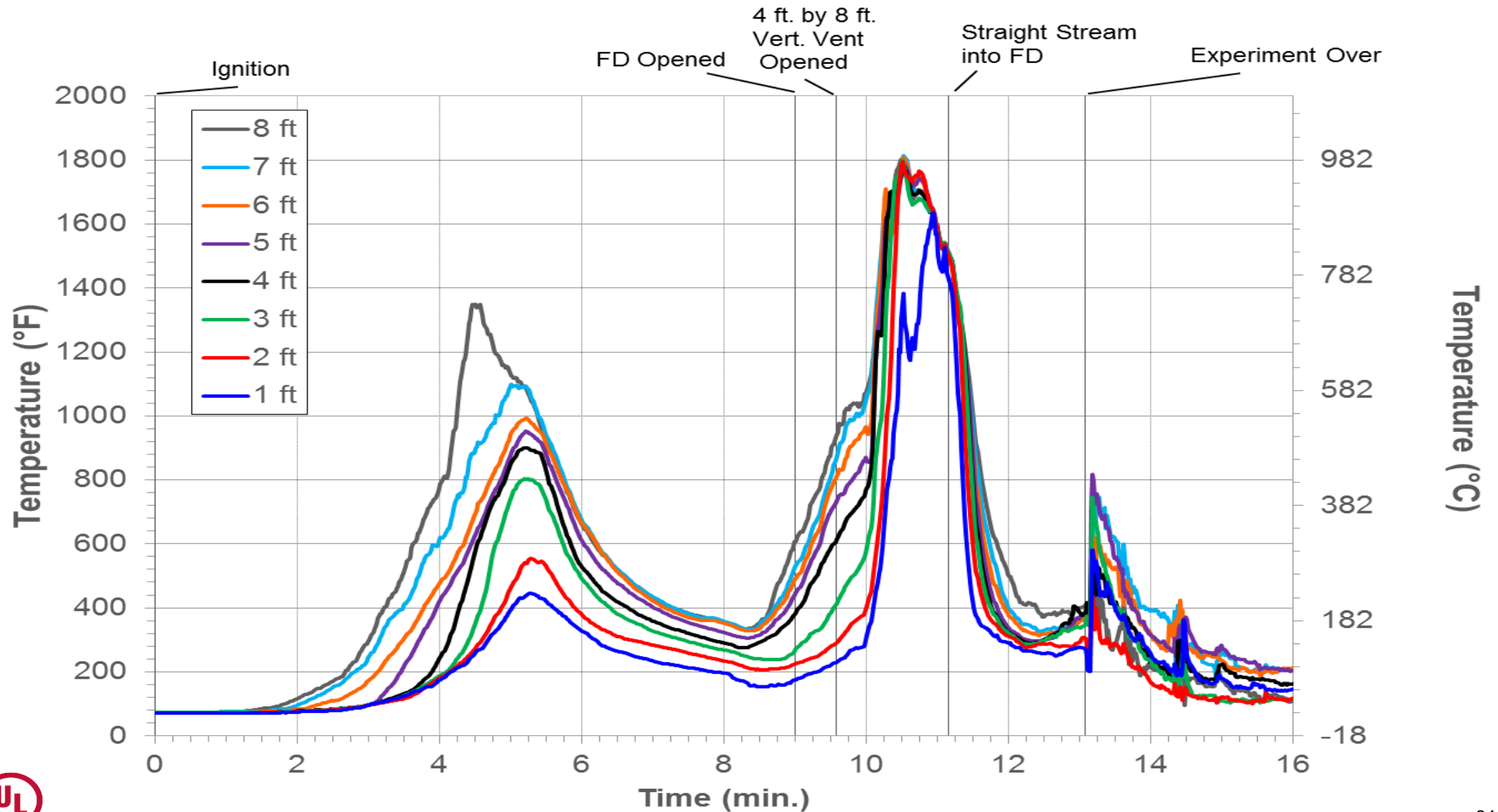
4 ft. by 8 ft. Vent Hole



# 4 ft by 4 ft – Living Room Temperatures

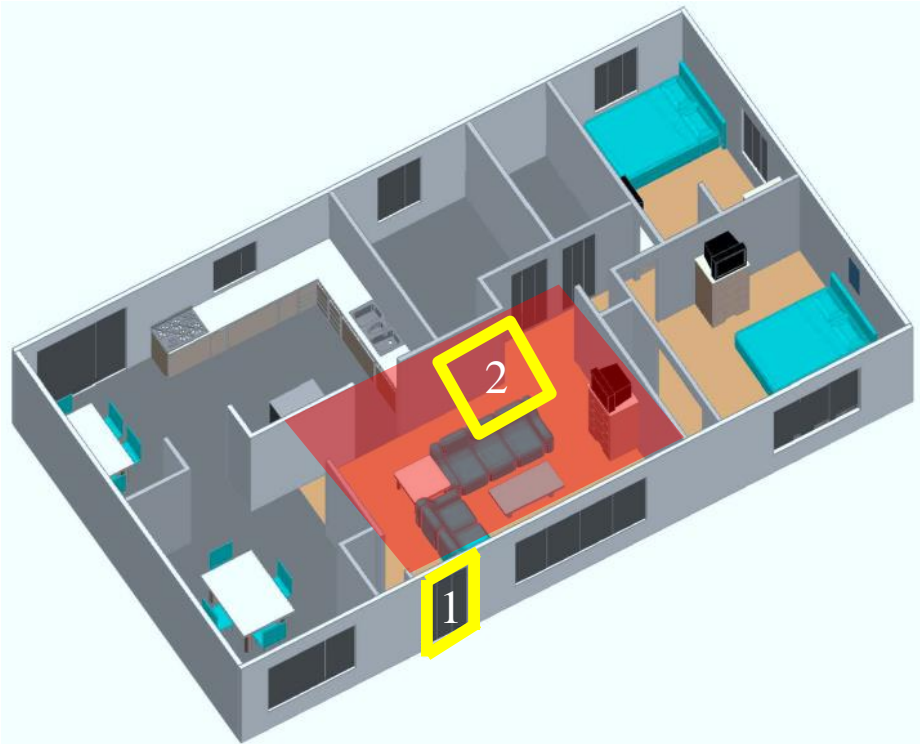


# 4 ft by 8 ft – Living Room Temperatures

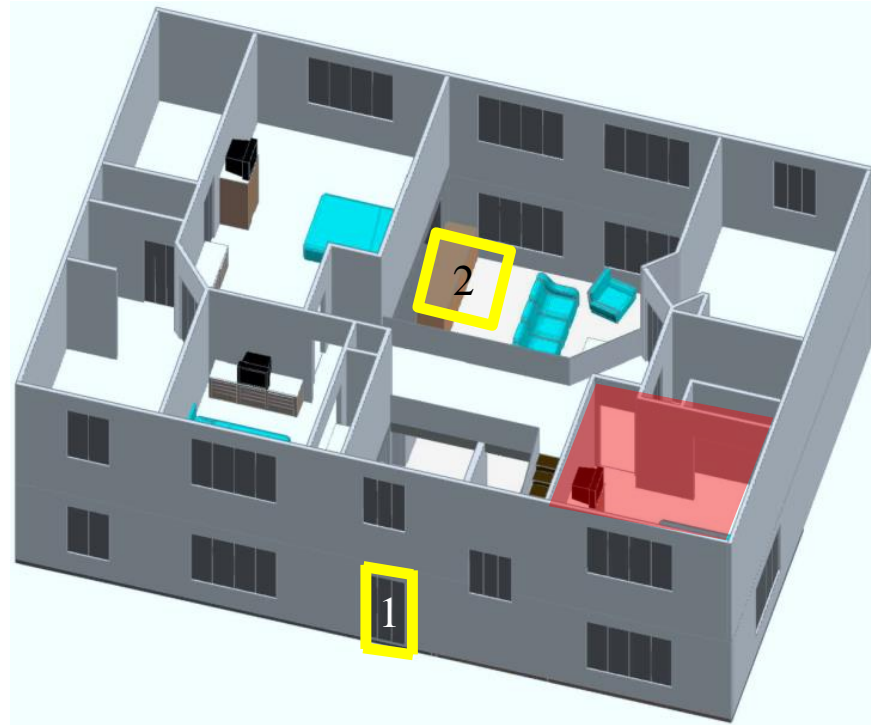
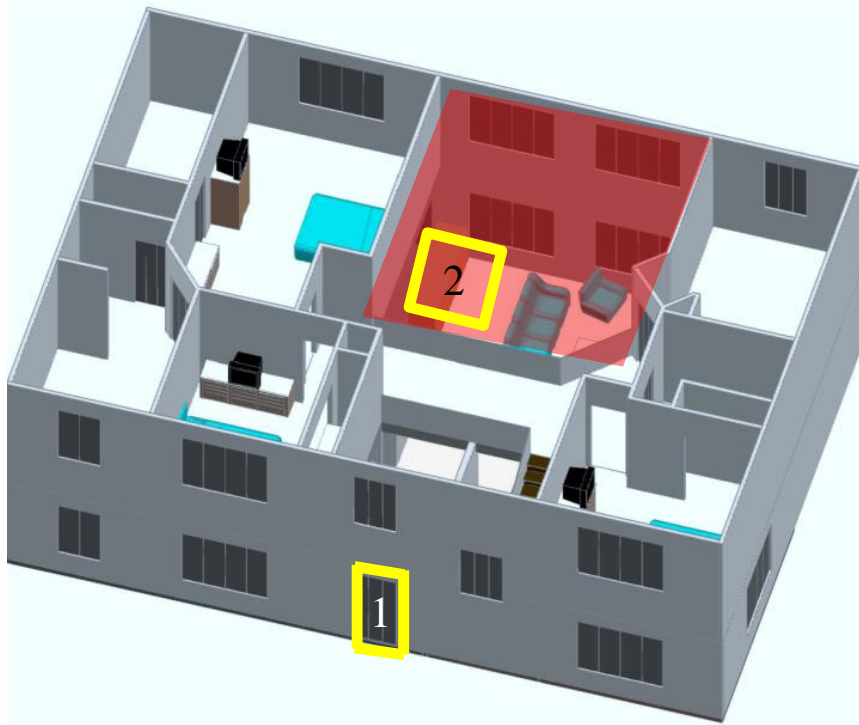




# It's All About Flow Paths and Timing Especially With Vertical Ventilation



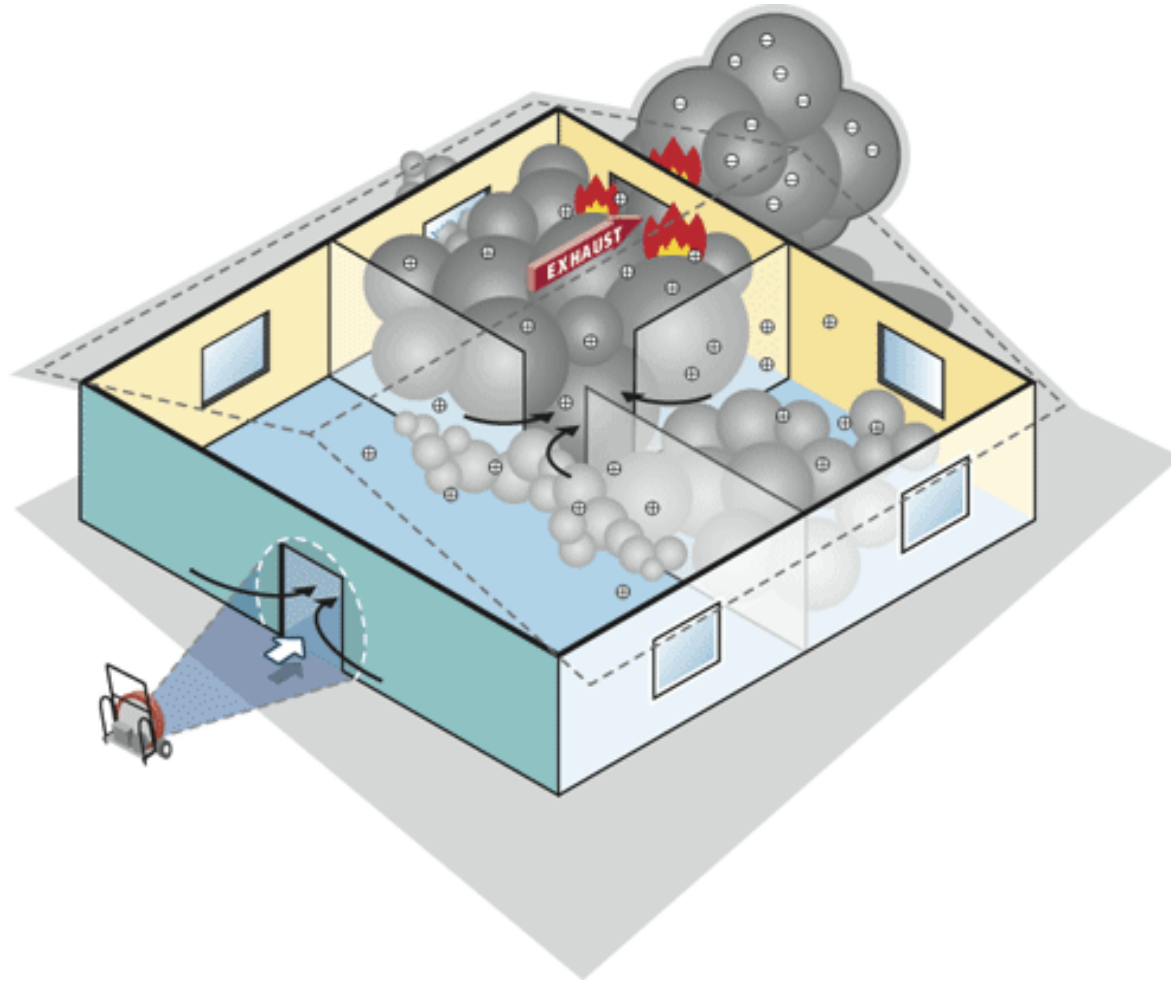
# Vertical Ventilation – Far and Near



**2012 - Study of the Effectiveness of Fire Service Positive Pressure Ventilation During Fire Attack in Single Family Homes Incorporating Modern Construction Practices**



# Intent of Positive Pressure Attack



Use high powered ventilation fans to change the flow of gasses in a structure fire.

PPV – Use of fans after fire is controlled to return interior of structure to ambient conditions.

PPA – Use of fans prior to fire control in an attempt to influence the flow paths created by fire department access.

# DHS – 2012 Positive Pressure Attack

- 30 Cold Flow Experiments
  - Single Story & Two Story
- 25 Fire Experiments
  - 15 Single Story
  - 10 Two Story
- Over 500 Visitors during the experiments

## Yields:

- 72hrs of video (Post Processed)
- Over 2 Million Data Points
- 750 Graphs



# Experimental Procedure – Cold Flow

Blind Selection from Panel Members based on flow results.

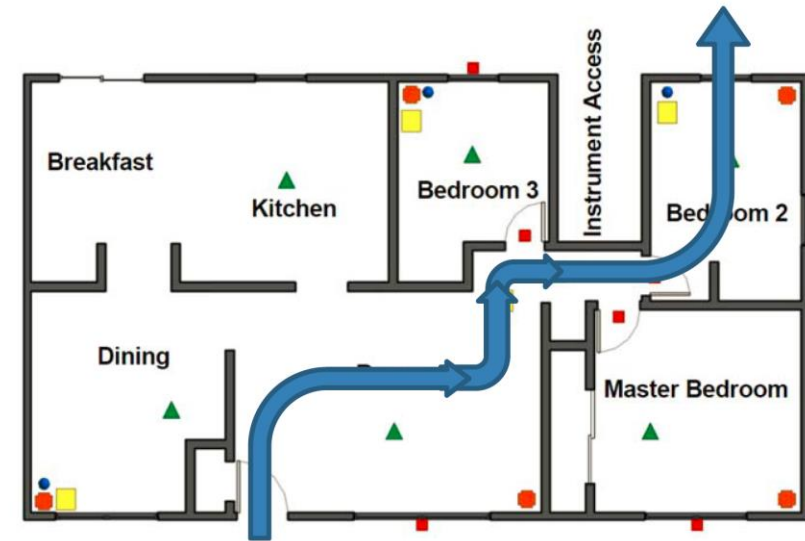
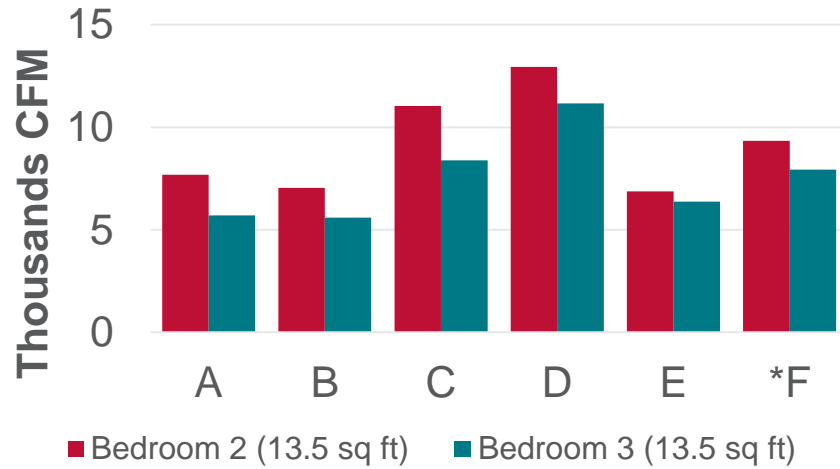


Any manufacturer was invited to send fans for blind selection

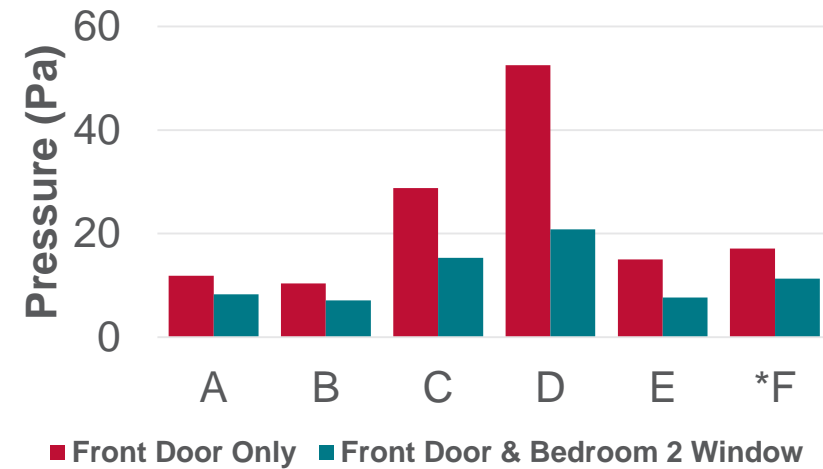
- Five Manufacturers Participated
- 12 Total fans (1 Gas and 1 Electric)

# Cold Flow Analysis – Single Story

Single Story Fan Testing



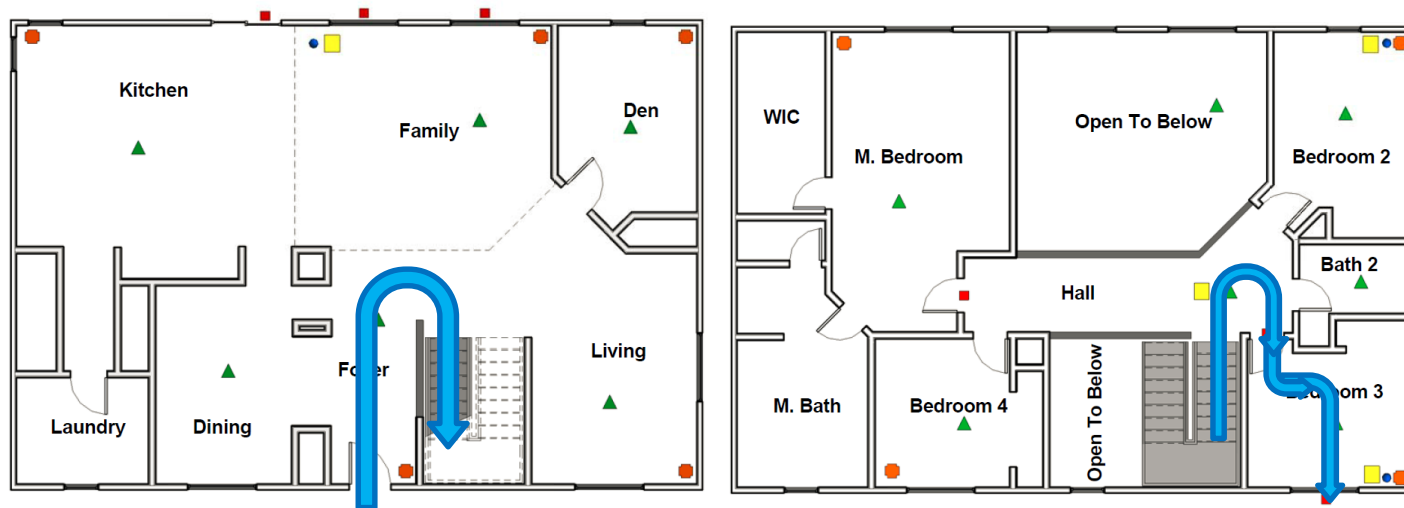
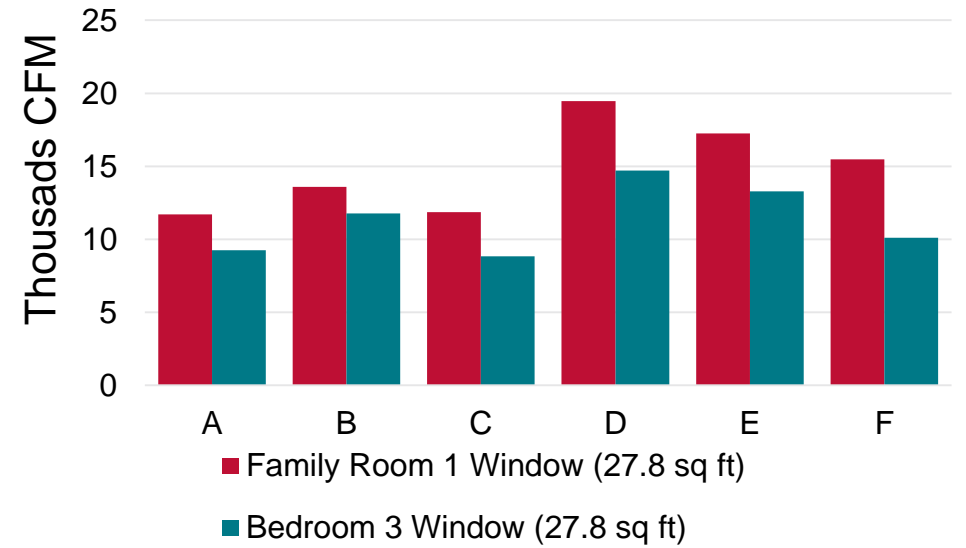
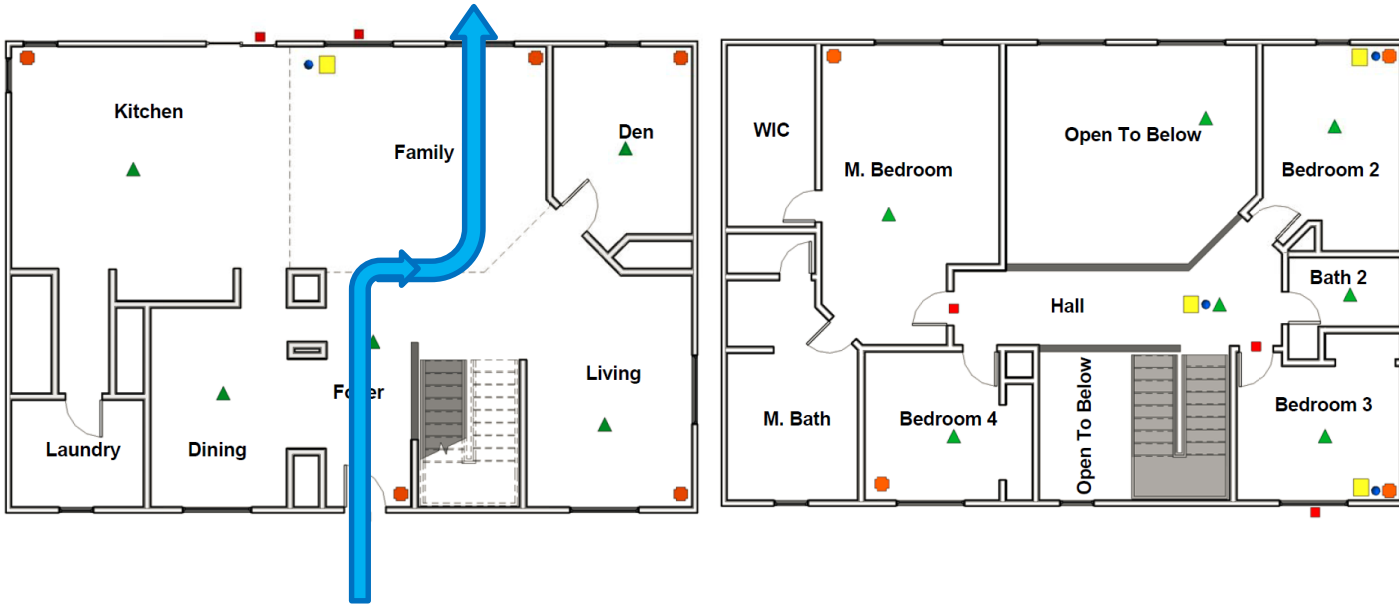
Single Story Fan Testing



\* Selected fan

# Fan Selection – Two Story

Two Story Fan Testing

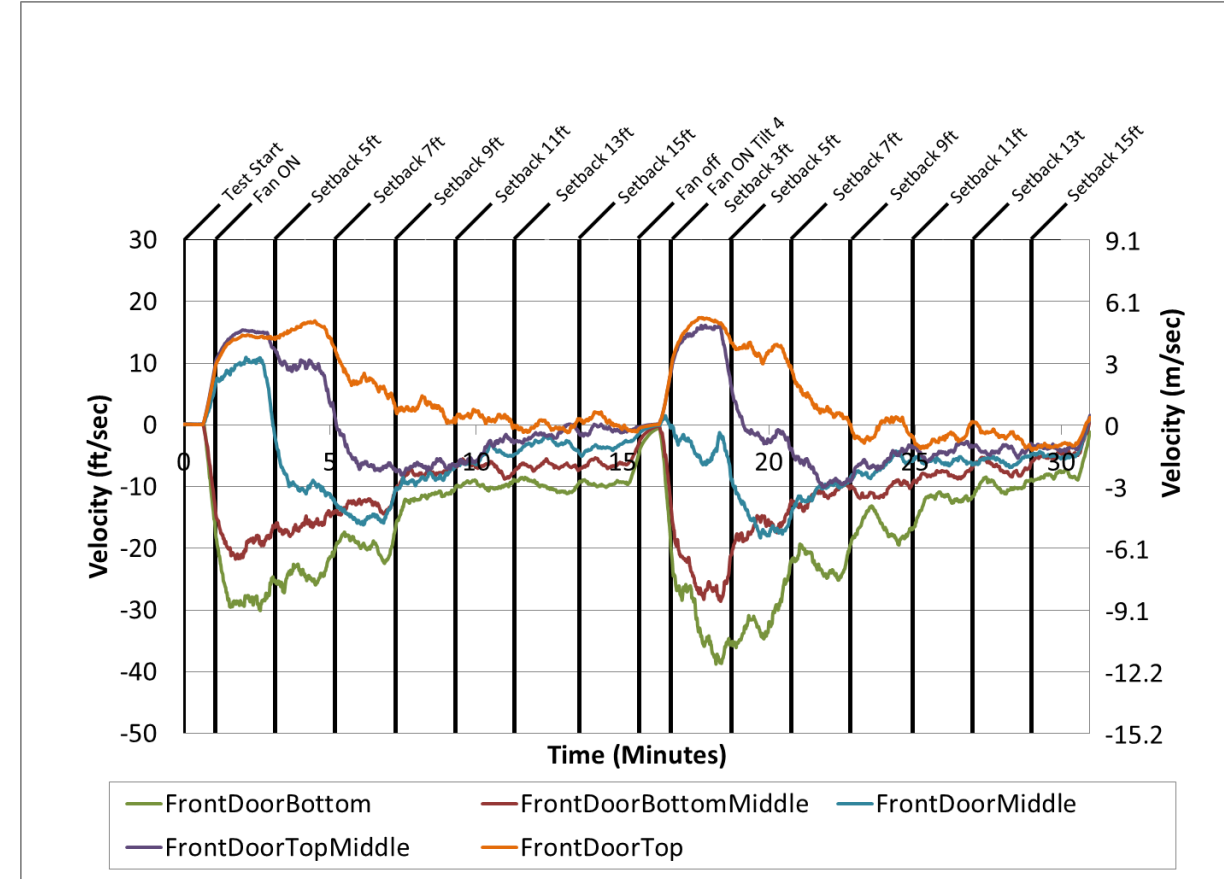
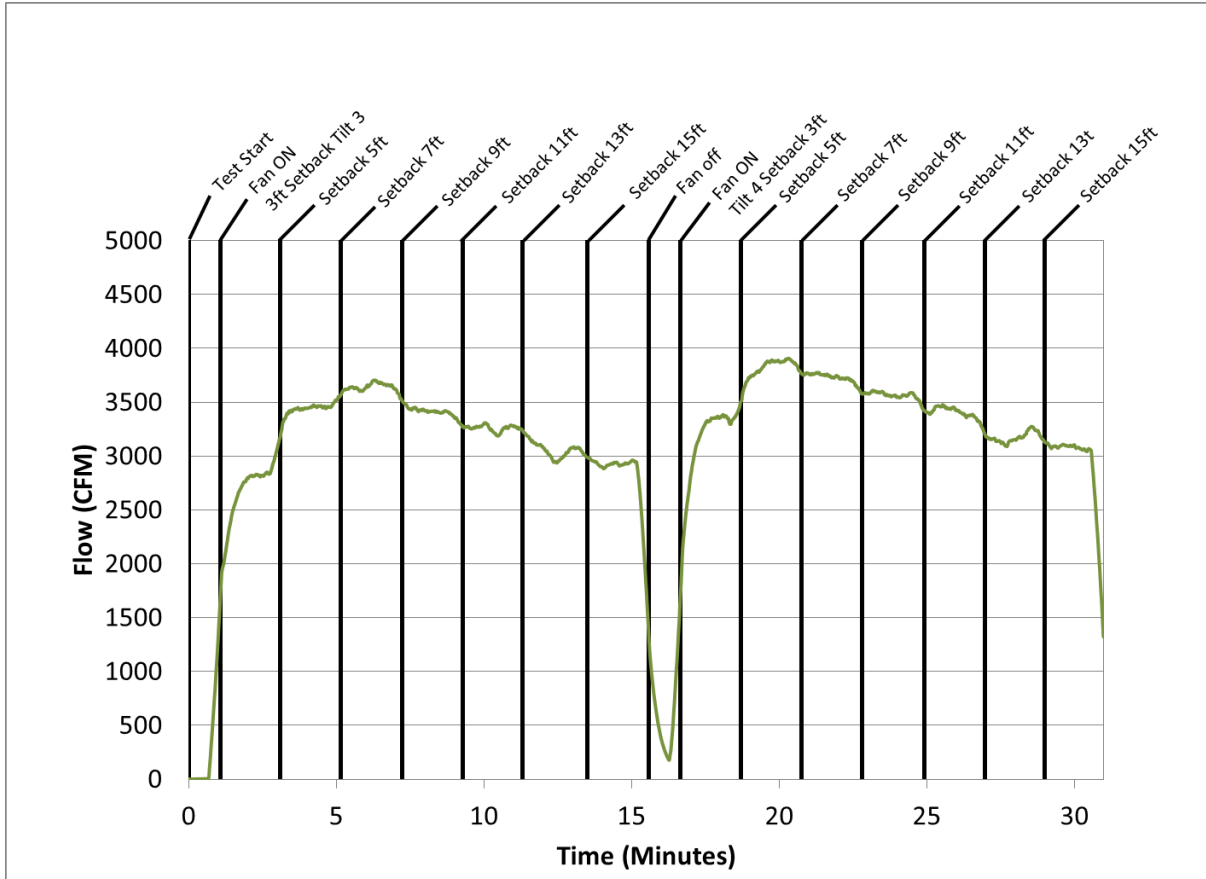


\* Selected fan

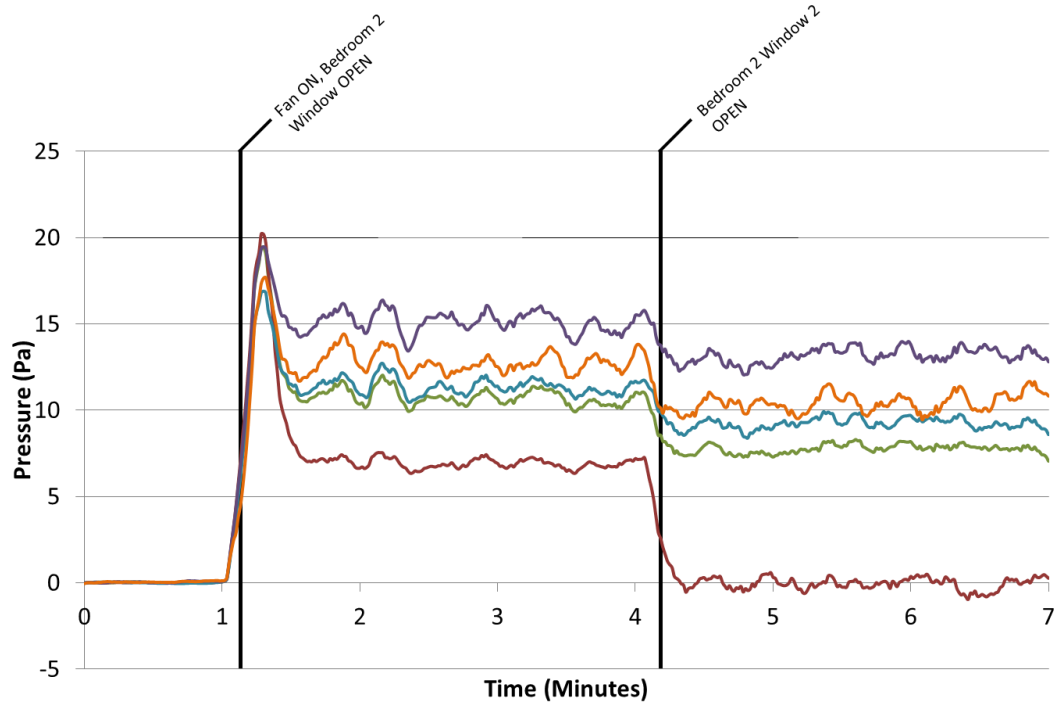


# Fan Positioning and Flow

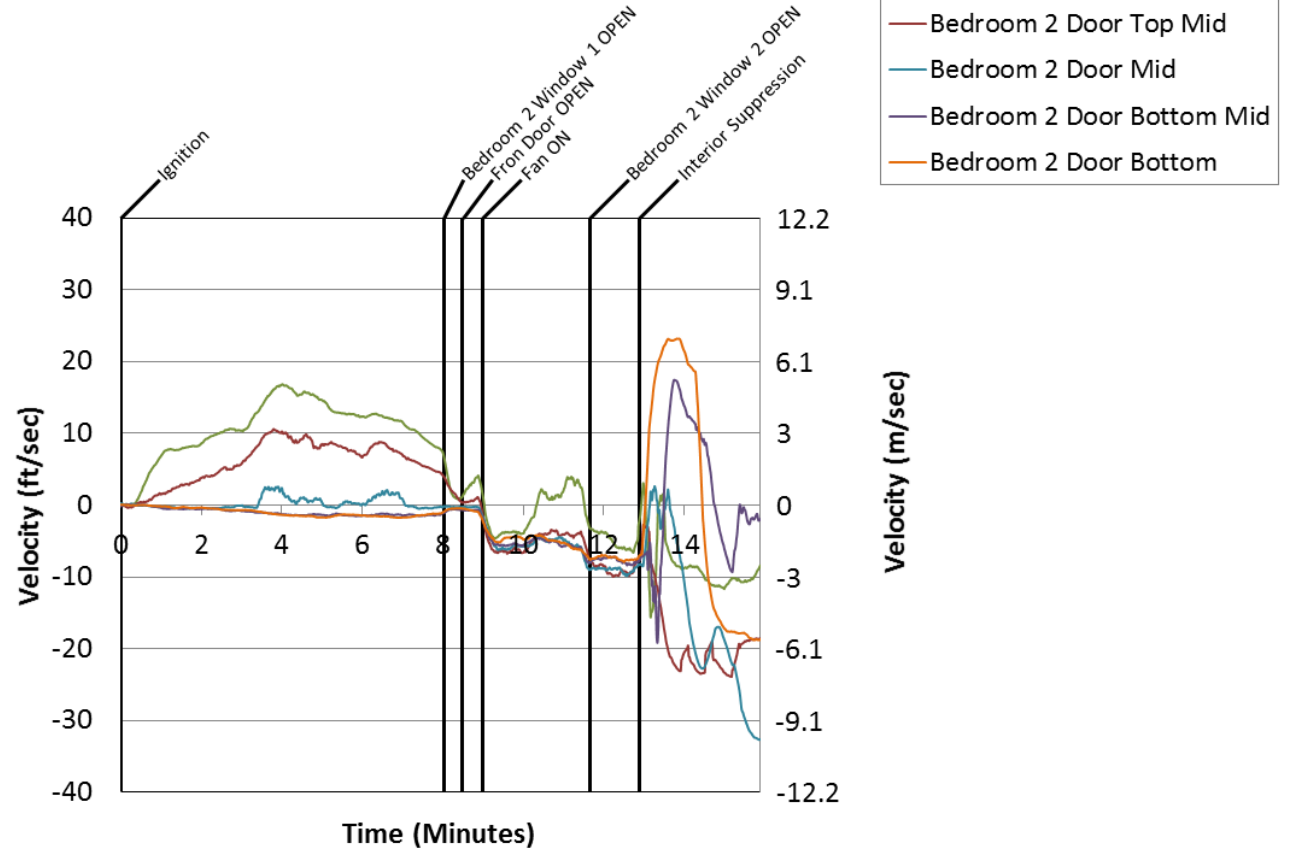
Positioning the fan a greater distance from the door does not necessarily produce less flow.



# Understanding inlet to outlet ratio



— M. Bed Press. Mid.      — Bedroom 2 Press. Mid.      — Bedroom 3 Press. Mid.  
— Dining Press. Mid.      — Living Room Press. Mid.

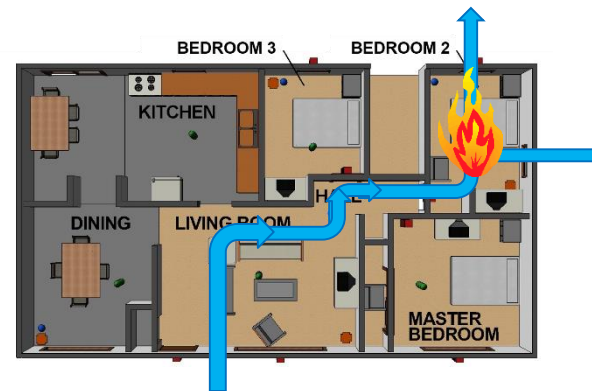


Velocity (m/sec)

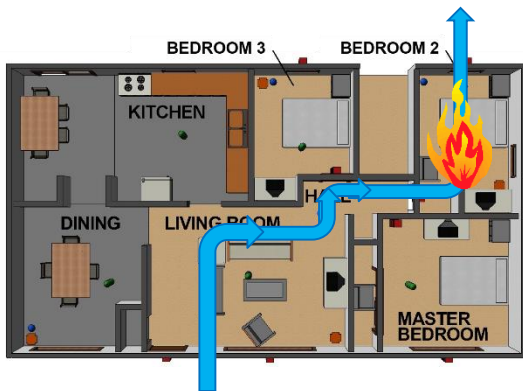
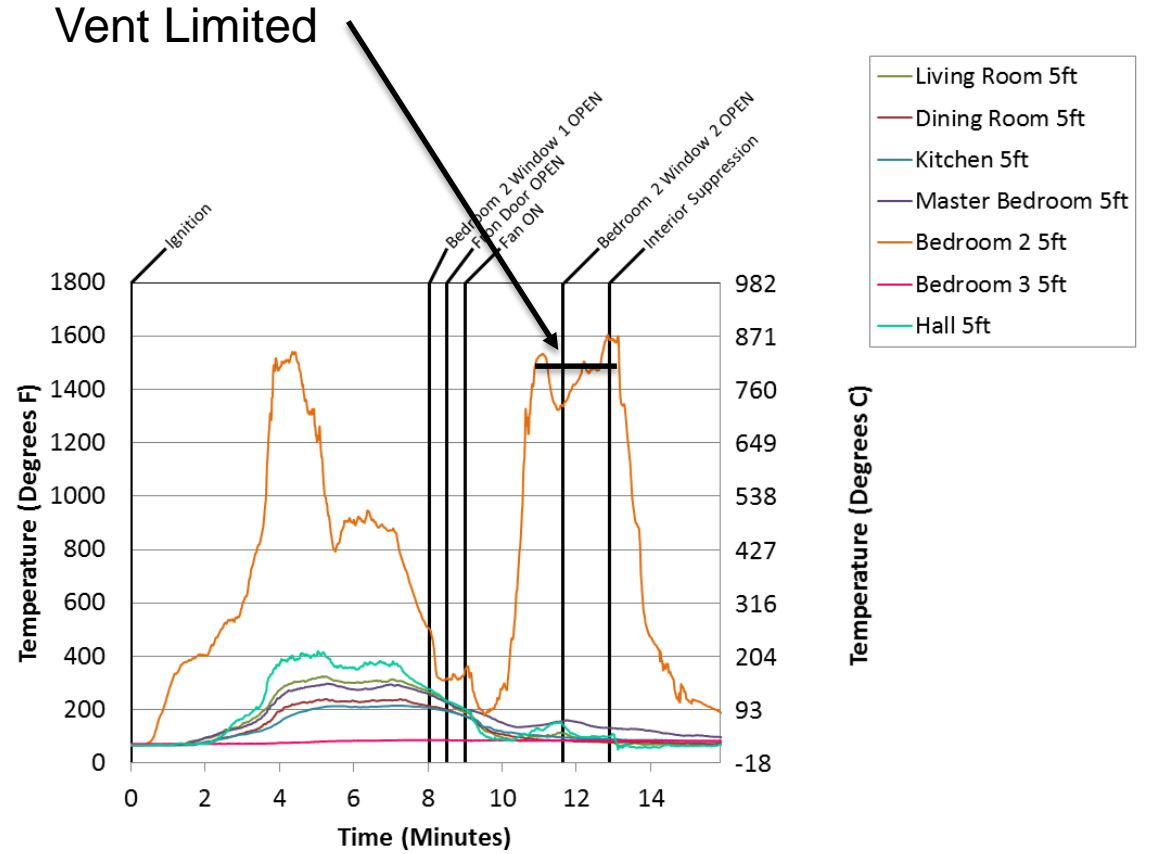
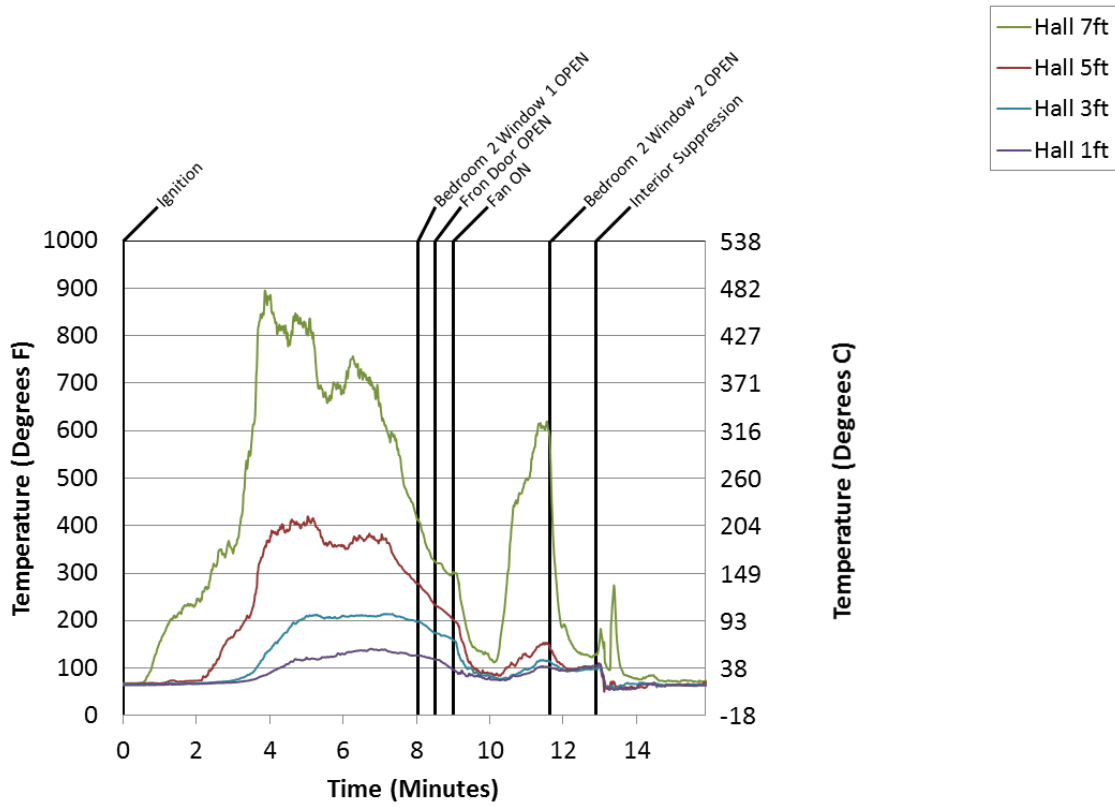
— Bedroom 2 Door Top  
— Bedroom 2 Door Top Mid  
— Bedroom 2 Door Mid  
— Bedroom 2 Door Bottom Mid  
— Bedroom 2 Door Bottom



VS.



# Understanding inlet to outlet ratio

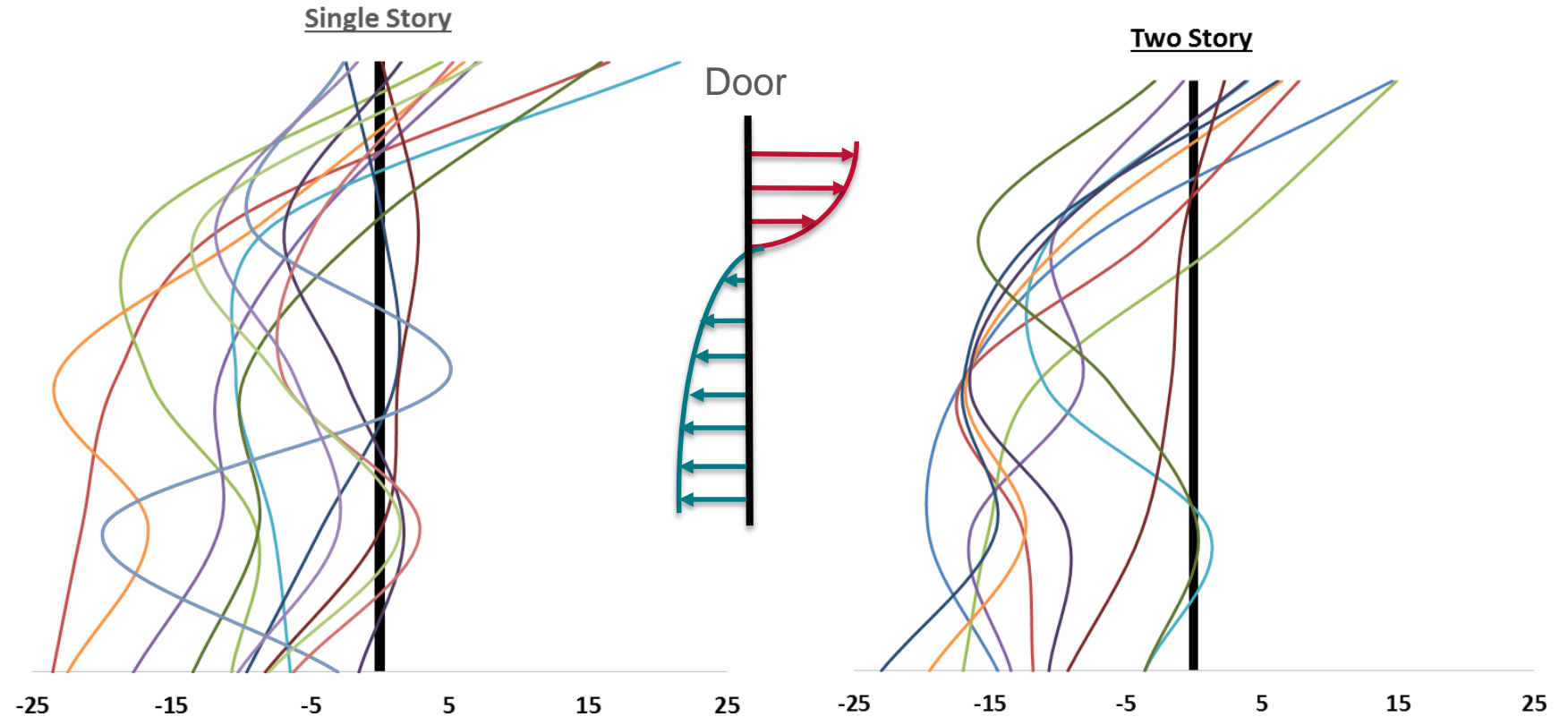


VS.



# Reading the Front Door

Unidirectional Flow can not be achieved at the front door. Flow at the top of the inlet does not mean ineffective PPA, changing smoke conditions in the structure indicate PPA effectiveness



# Ongoing assessment of the inlet and outlet is essential:

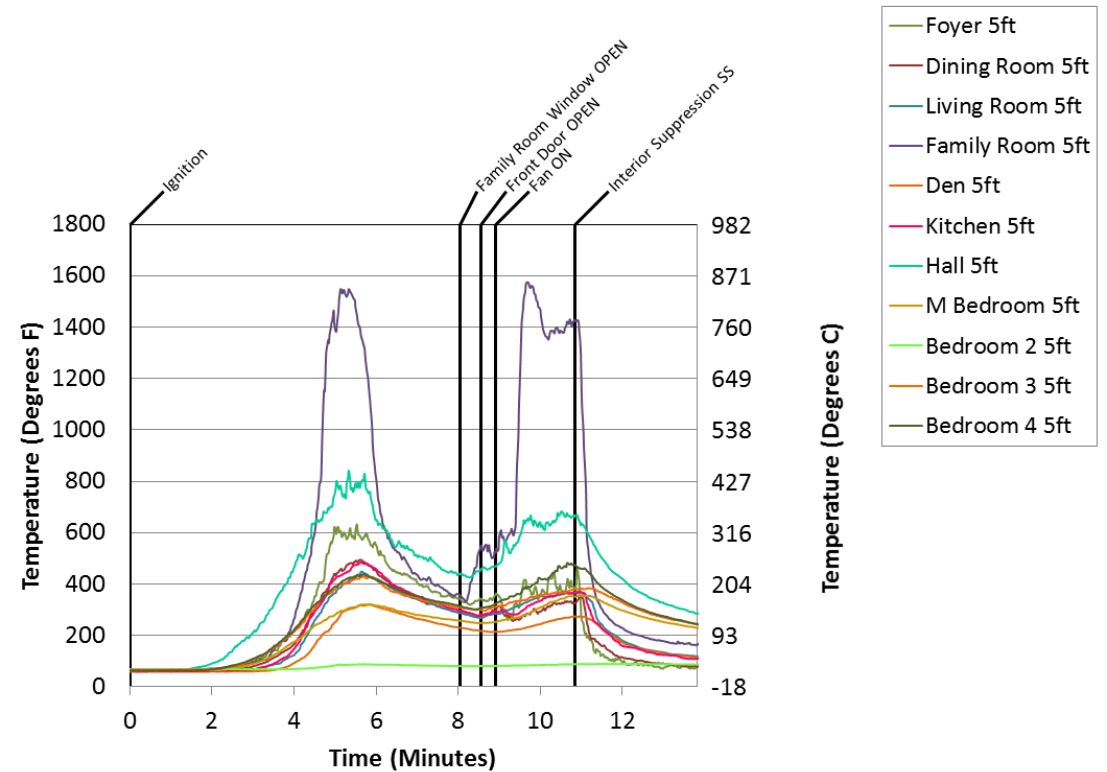
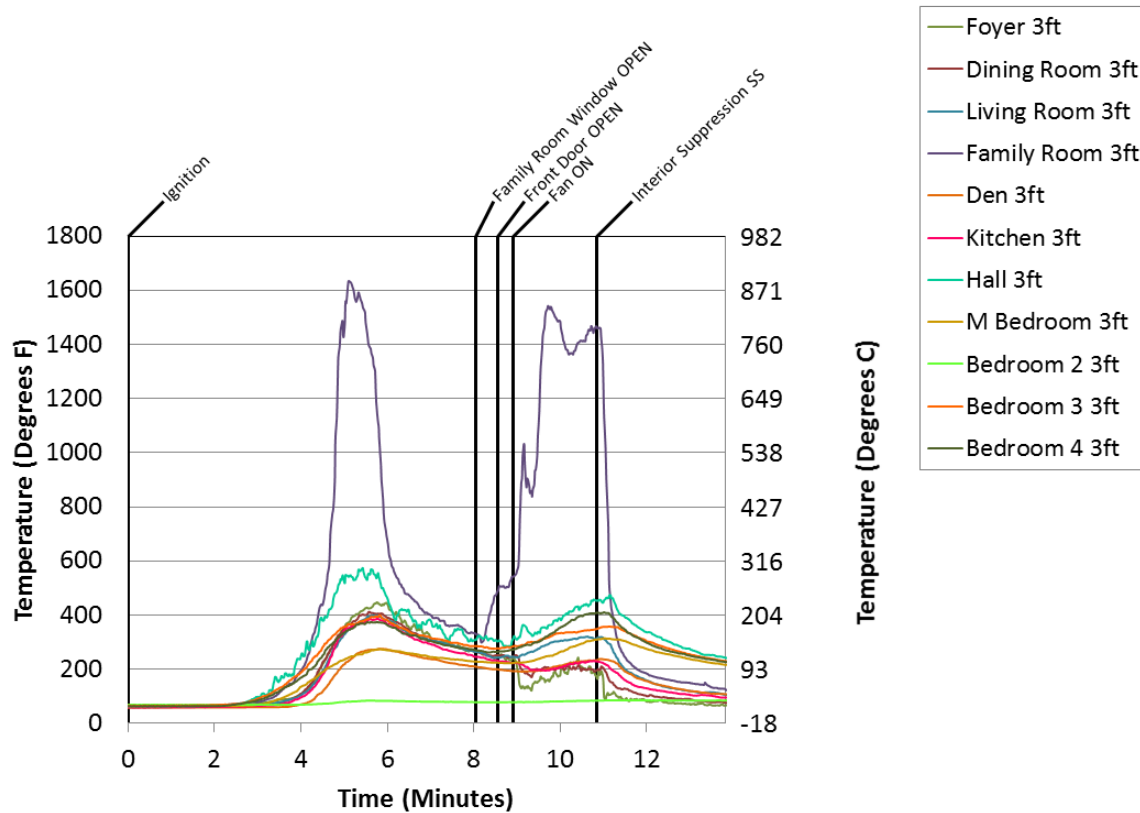
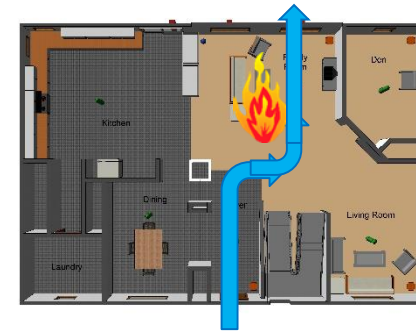
Exhaust can tell you as much as the inlet.



# Tactical Consideration # 7 –

17

PPA may not be effective for open concept floor plans where the fire is in the open area.



# What do we know so far?

How Much did we cover?

- 3 of 25 Experiments
- 5 of 750 Graphs
- 2.5 min of 72hrs of video

## What did we learn?

- **Flows inside structures are complex**
- **Fans create additional flows that may adversely effect conditions inside.**
- **Unidirectional flow does not exist with PPA**
- **Understanding the flow created is essential to a positive outcome.**



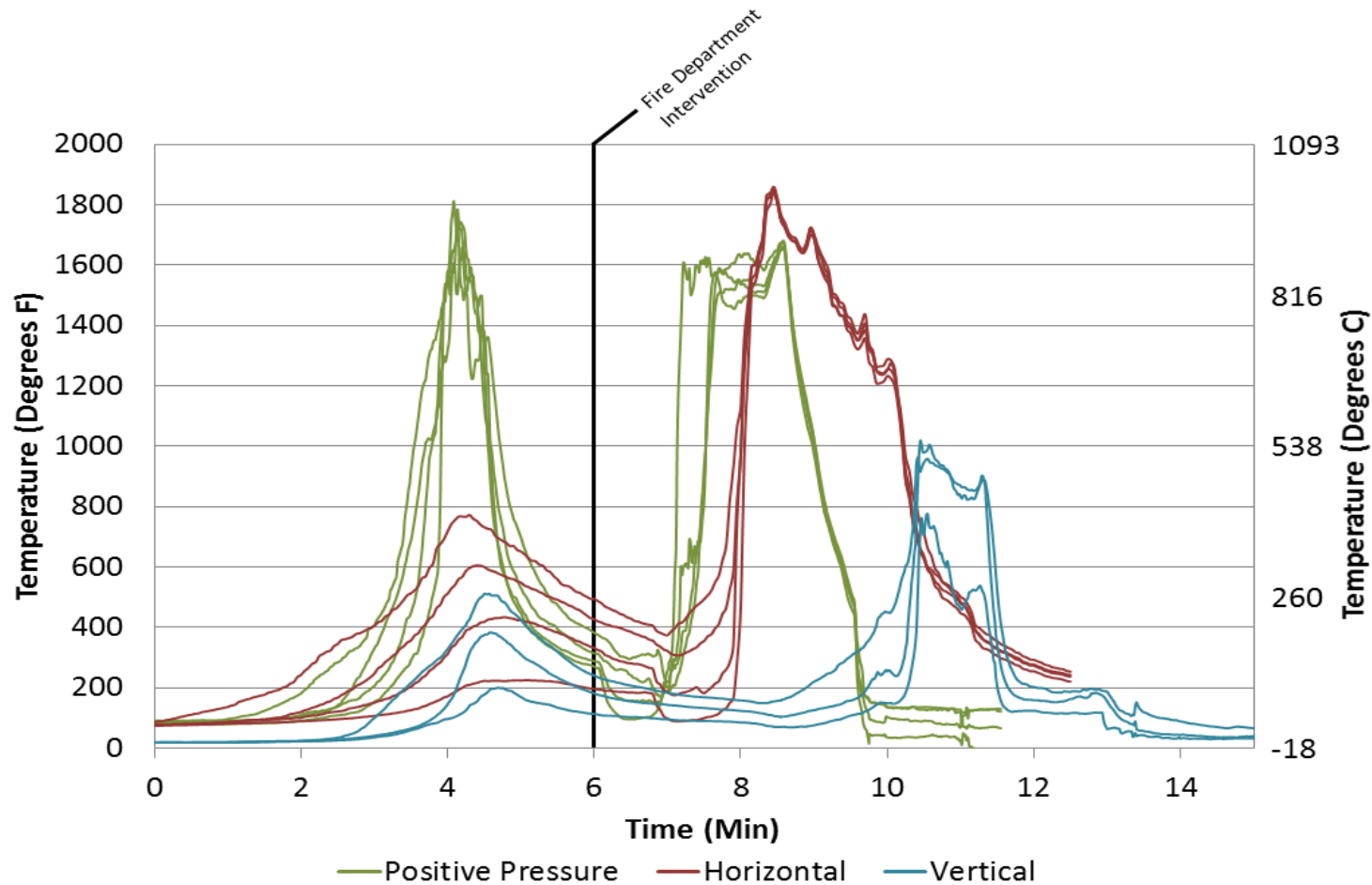
# Putting it all together – Tactical Choices in Ventilation





# The Fire Dynamics of Ventilation

Positive Pressure, Horizontal and Vertical Ventilation are tactical choices. No one tactic will work in every scenario.

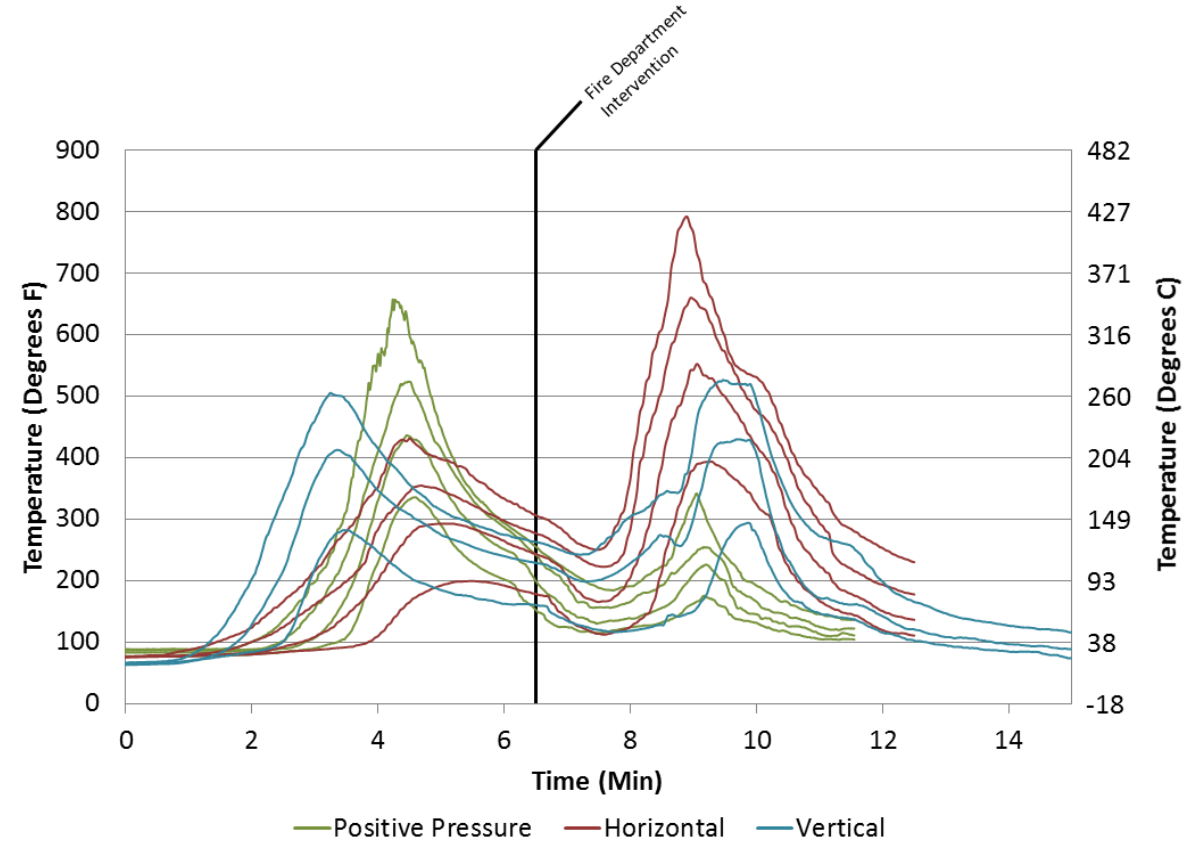
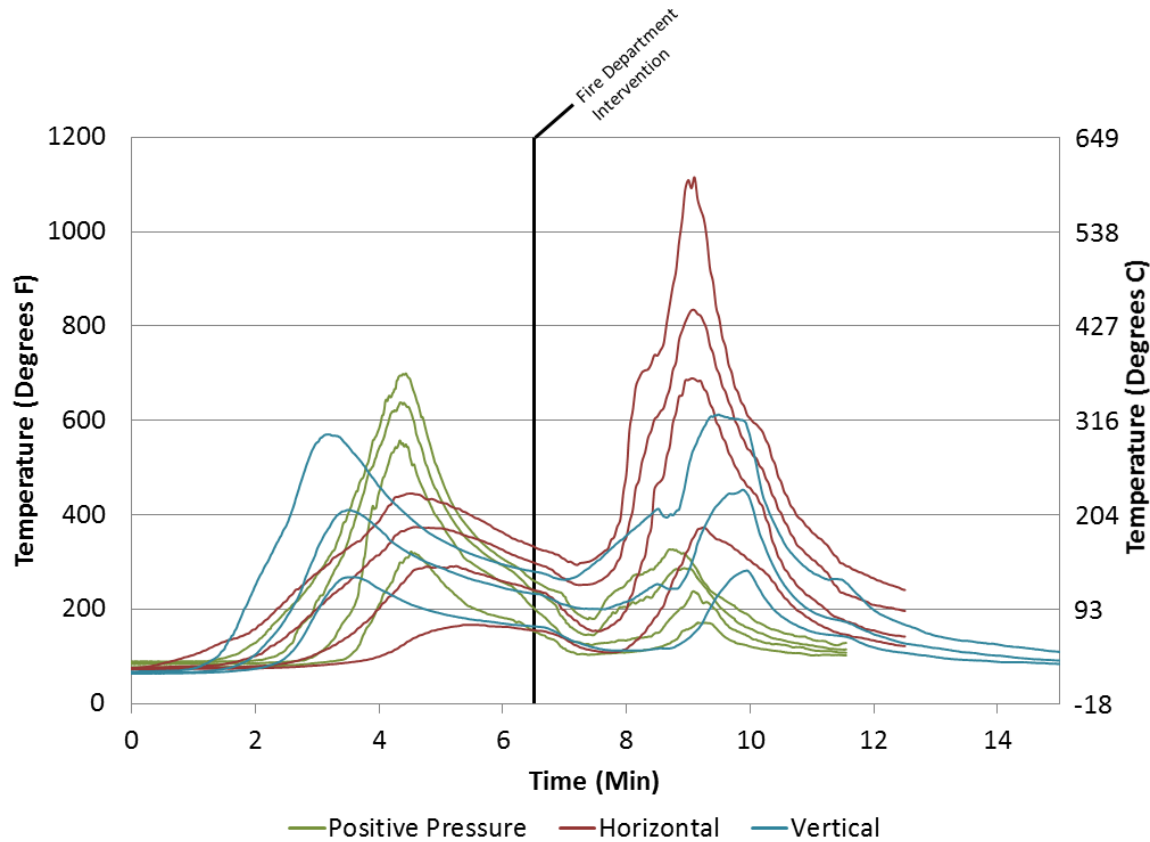


Living Room



# The Fire Dynamics of Ventilation

Positive Pressure, Horizontal and Vertical Ventilation are tactical choices. No one tactic will work in every scenario.

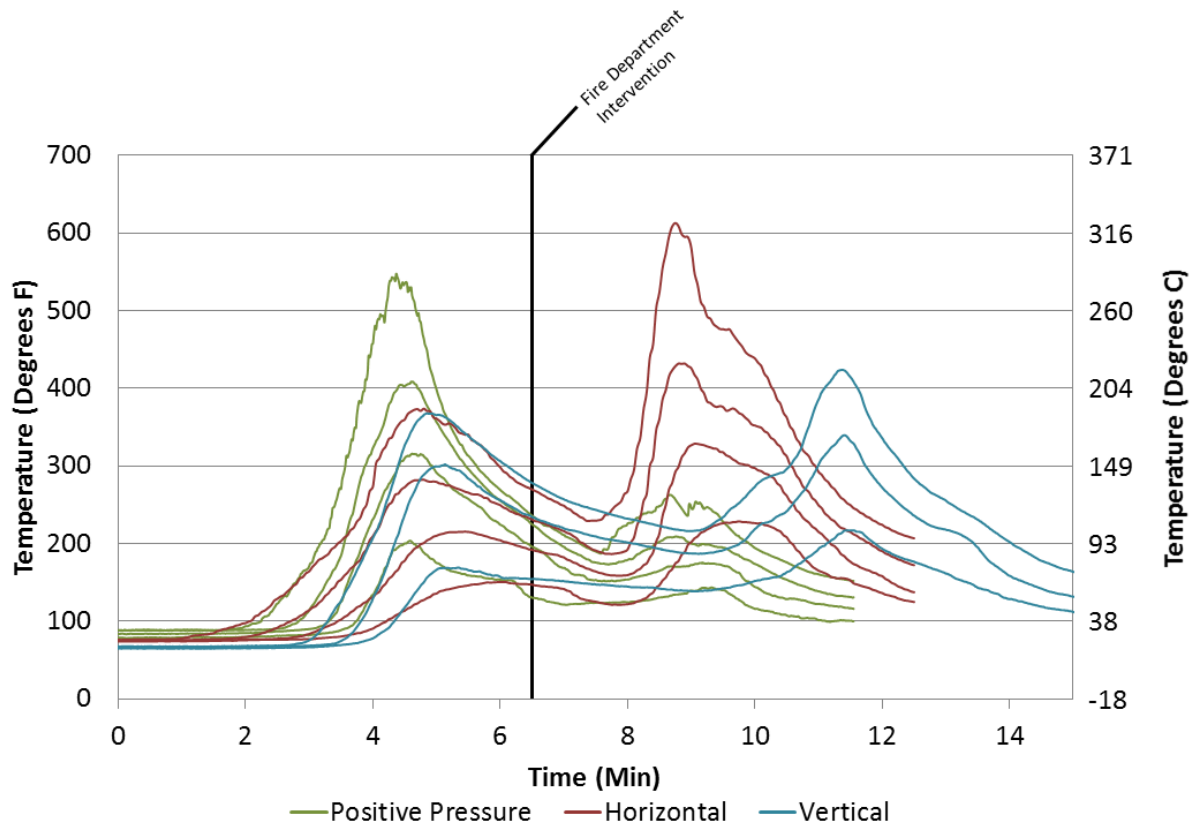


Dinning Room

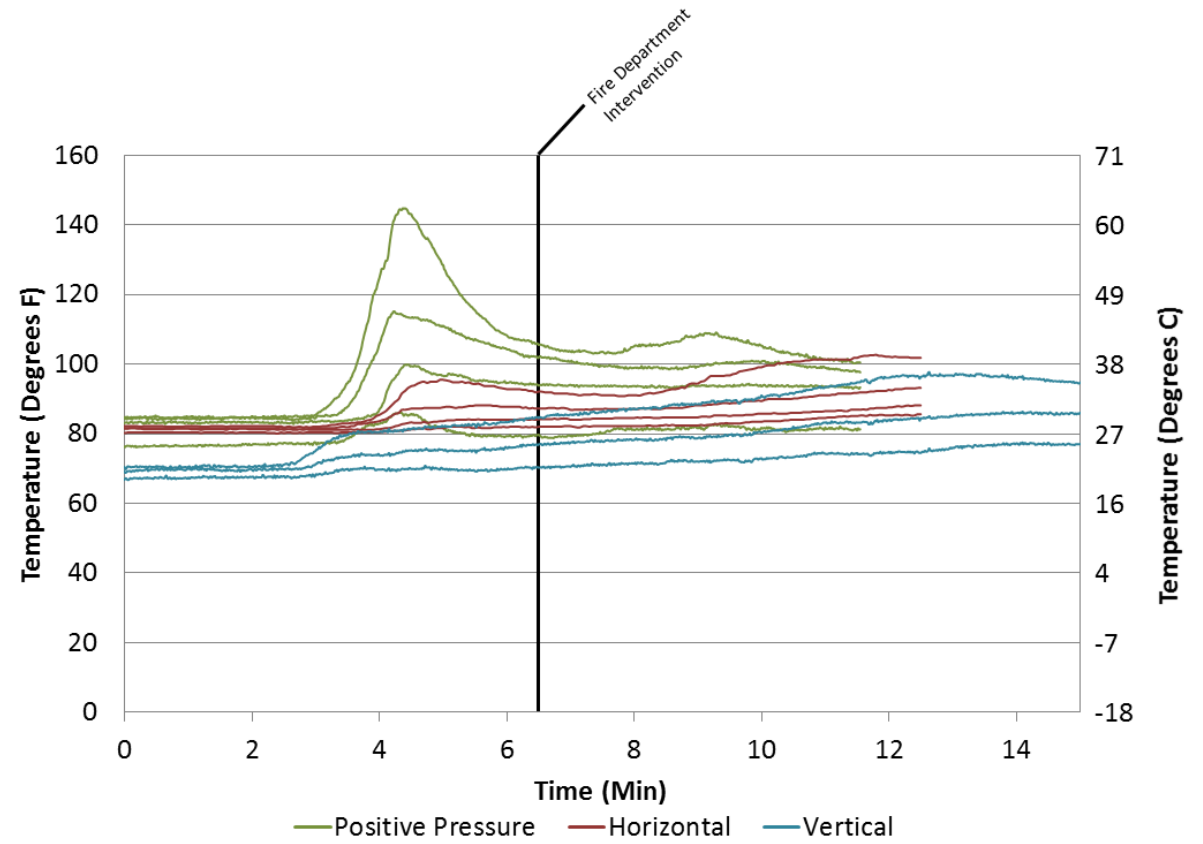
Kitchen

# The Fire Dynamics of Ventilation

Positive Pressure, Horizontal and Vertical Ventilation are tactical choices. No one tactic will work in every scenario.



Bedroom 1



Bedroom 3



# Free Online Fire Service Training

[www.ULfirefightersafety.com](http://www.ULfirefightersafety.com)



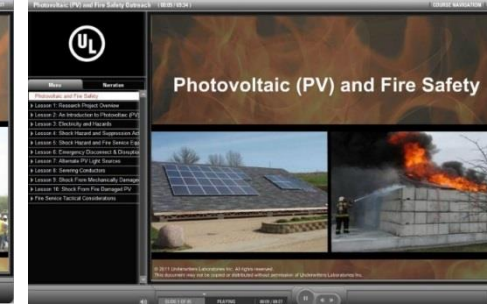
Lightweight Collapse



Horizontal Ventilation



Basement Fires



PV Firefighter Safety



Vertical Ventilation & Suppression  
(40,000+)



Effective Tactics with FDNY and NIST  
(36,000+)



Attic & Exterior Fires  
(27,000+)



# Get Involved



Recent Project Updates  
Follow UL FSRI's full-scale experiments that help firefighters understand and anticipate new and dangerous situations.  
[View All Projects](#) →



Eave Fire Experiments Completed

August 31, 2013 - No Comments (0/0)

In July, a series of 3 large scale experiments were conducted that examined exterior fire spread into the eaves and how and the speed at which exterior fires transitioned to [...]



Apply to be a part of the UL FSRI PPV Study's Technical Panel

August 30, 2013 - No Comments (0/0)

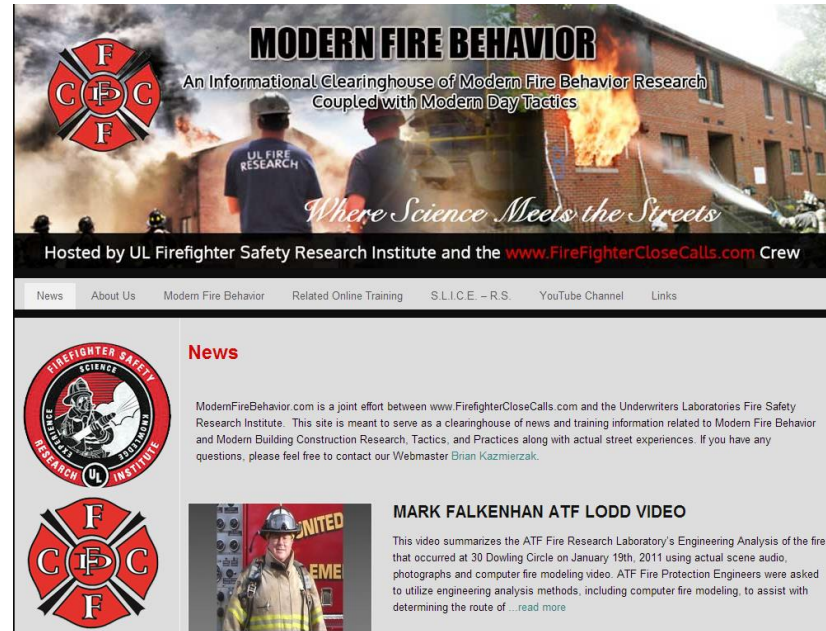
Since we announced the funding of the PPV study we have received an overwhelming amount of support and inquiries to be a part of the project. Our funding is limited [...]



UL Firefighter Safety Research Institute Launches Vertical Ventilation and Suppression Online Training

August 29, 2013 - 13 Comments (0/0)

UL FSRI is proud to announce the release of "Effectiveness of Fire Service Vertical Ventilation and Suppression Tactics in Single Family Homes" - an online course that serves as a [...]



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[Modernfirebehavior.com](http://Modernfirebehavior.com)

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# QUESTIONS and DISCUSSION

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