INTERNATIONAL ASSOCIATION OF FIRE FIGHTERS

EVIDENCE-BASED FIRE GROUND OPERATIONS

March 2026

VENTILATION

VENTILATION OVERVIEW

- Close coordination between ventilation and suppression provides ***MOST*** benefit!
- Even closely timed suppression and ventilation actions can lead to potential fire growth in room of origin.
- Ventilation not just local to fire and operating crews – must include remote locations as well - less likely to see improvement unless ***forced*** with local vents.

VENTILATION DURING THE ATTACK

Horizontal

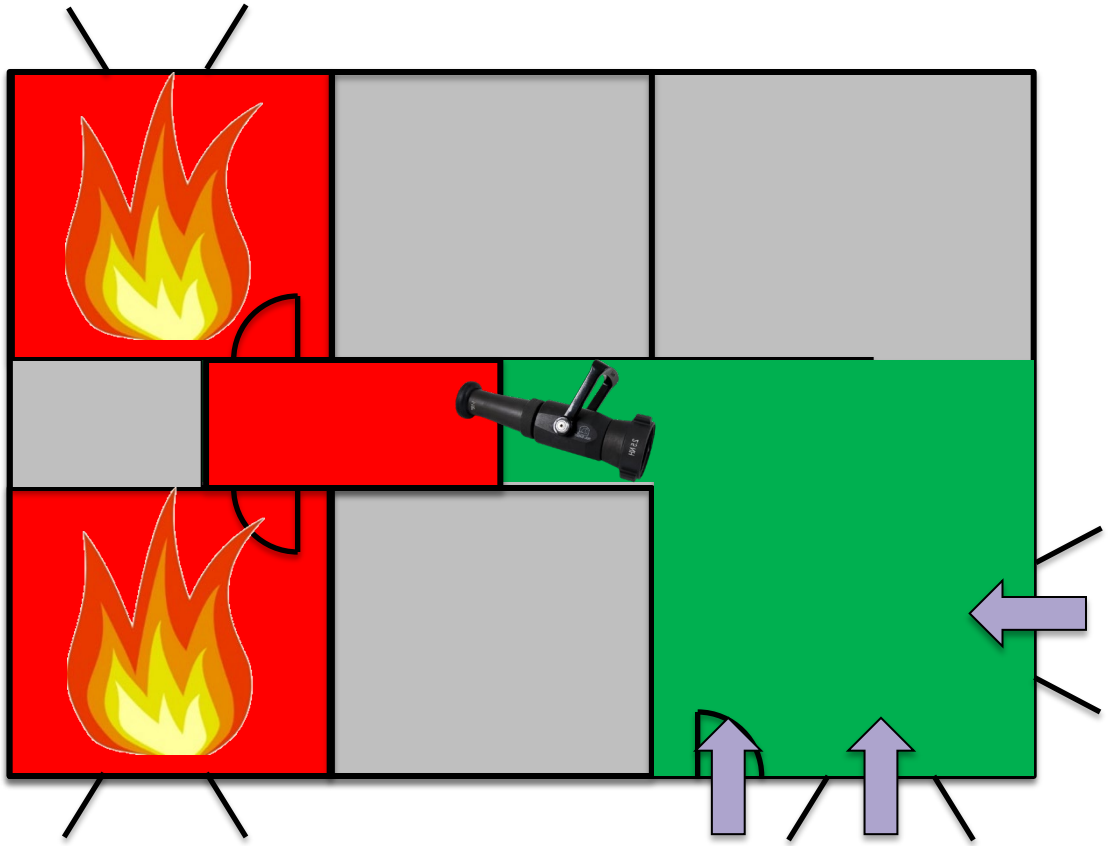
Door Control

Vertical

Positive Pressure - Stairwells

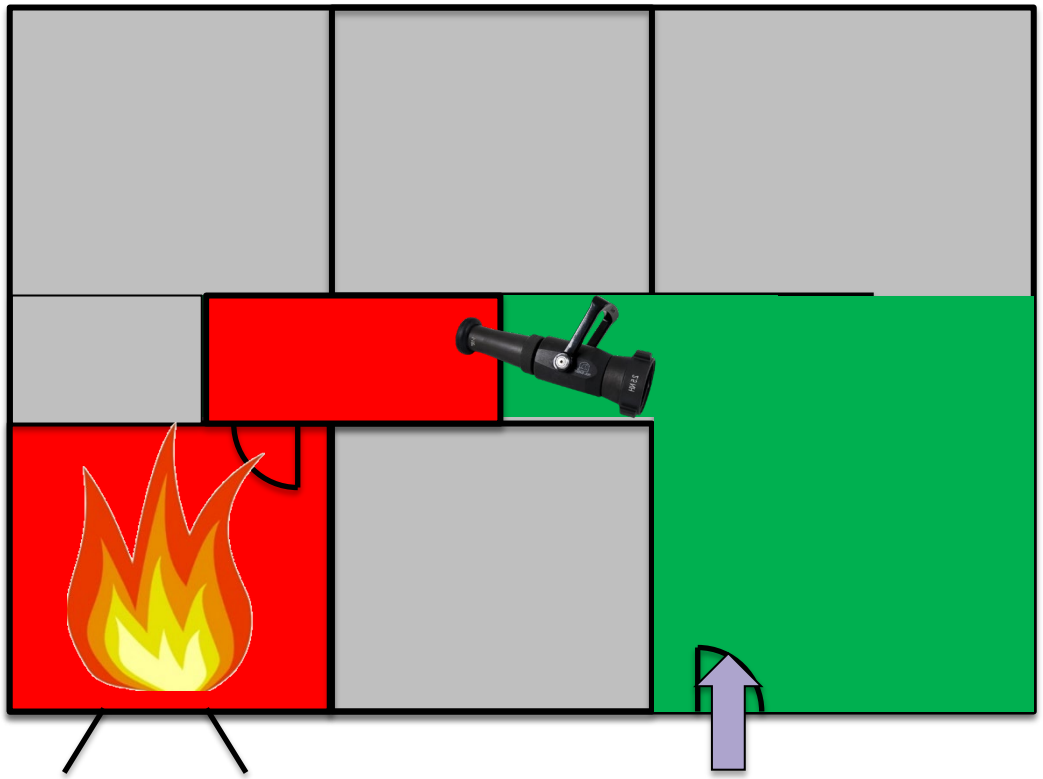
Differences Depending on Structure Type

HORIZONTAL VENTILATION DURING THE ATTACK



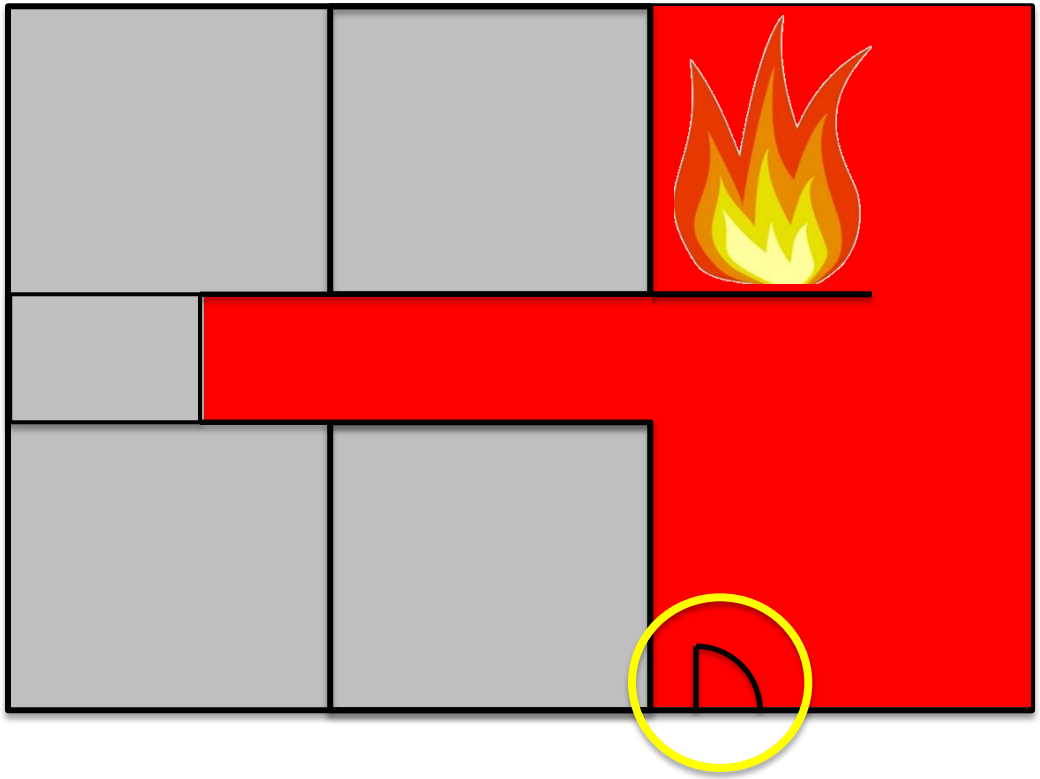
Vent **Behind** At Onset of Suppression

HORIZONTAL VENTILATION DURING THE ATTACK



Vent **Ahead** At Onset of Suppression

DOOR CONTROL DURING THE ATTACK



Close The Door Behind You

KITCHEN IGNITIONS WITH FIXED INITIAL VENTILATION

Experiment 15: Early Door Control


Experiment 16: Late Door Control


Experiment 18: No Door Control


Exp 15: Early Door Control


Exp 16: Late Door Control

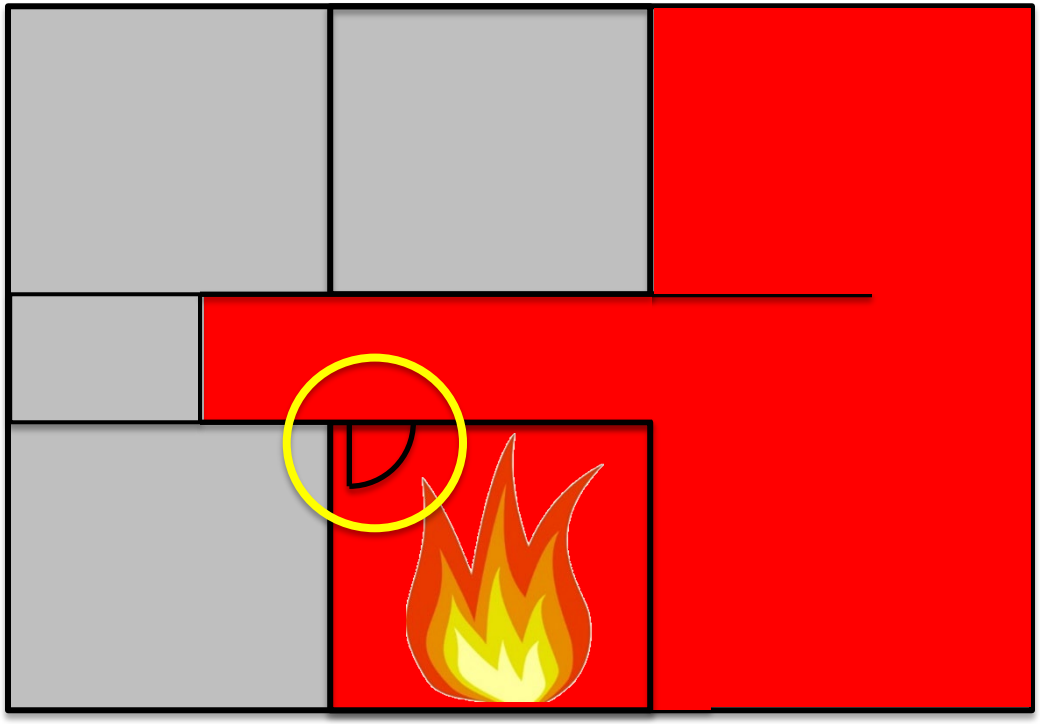

Exp 18: No Door Control


Exp 15: Early Door Control


Exp 16: Late Door Control


Exp 18: No Door Control

DOOR CONTROL DURING THE ATTACK

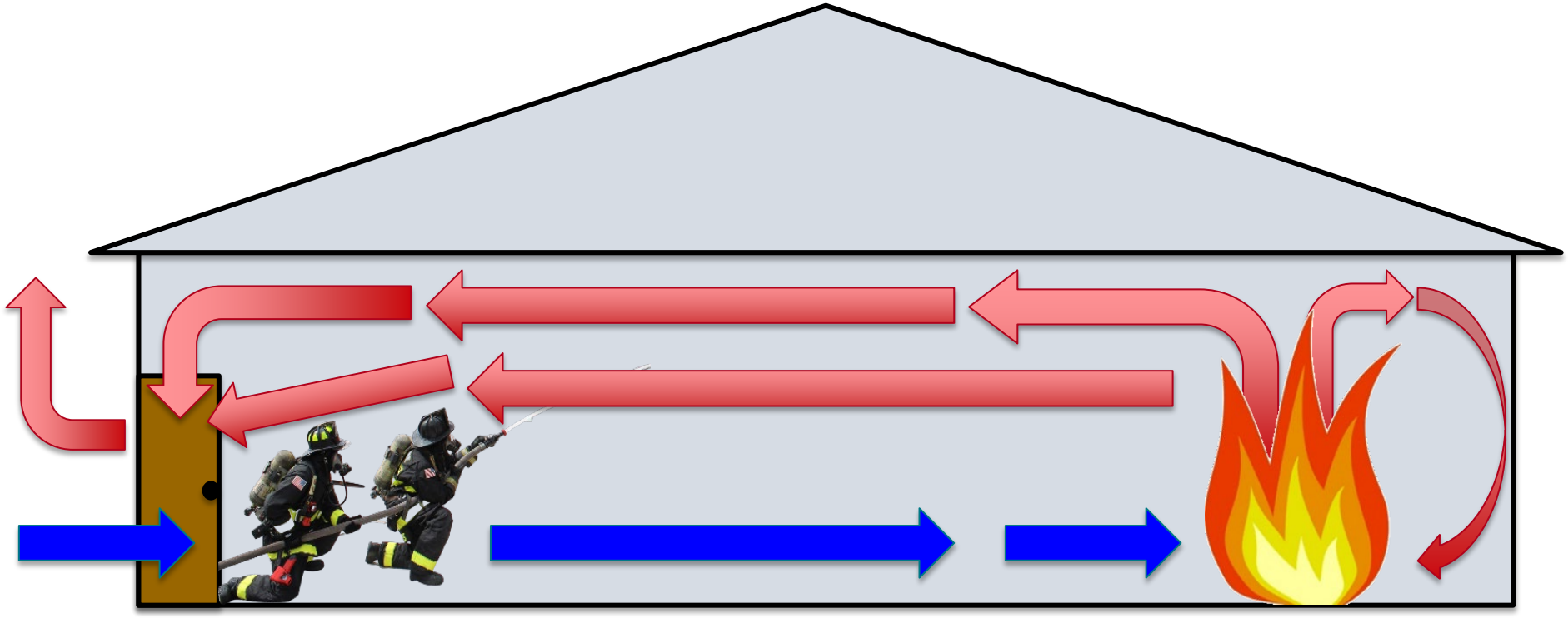


Isolate The Fire Room From The Rest of The Structure

DOOR CONTROL WITH HYDRAULIC VENTILATION MULTI-FAMILY DWELLINGS

Protect The Means of Egress

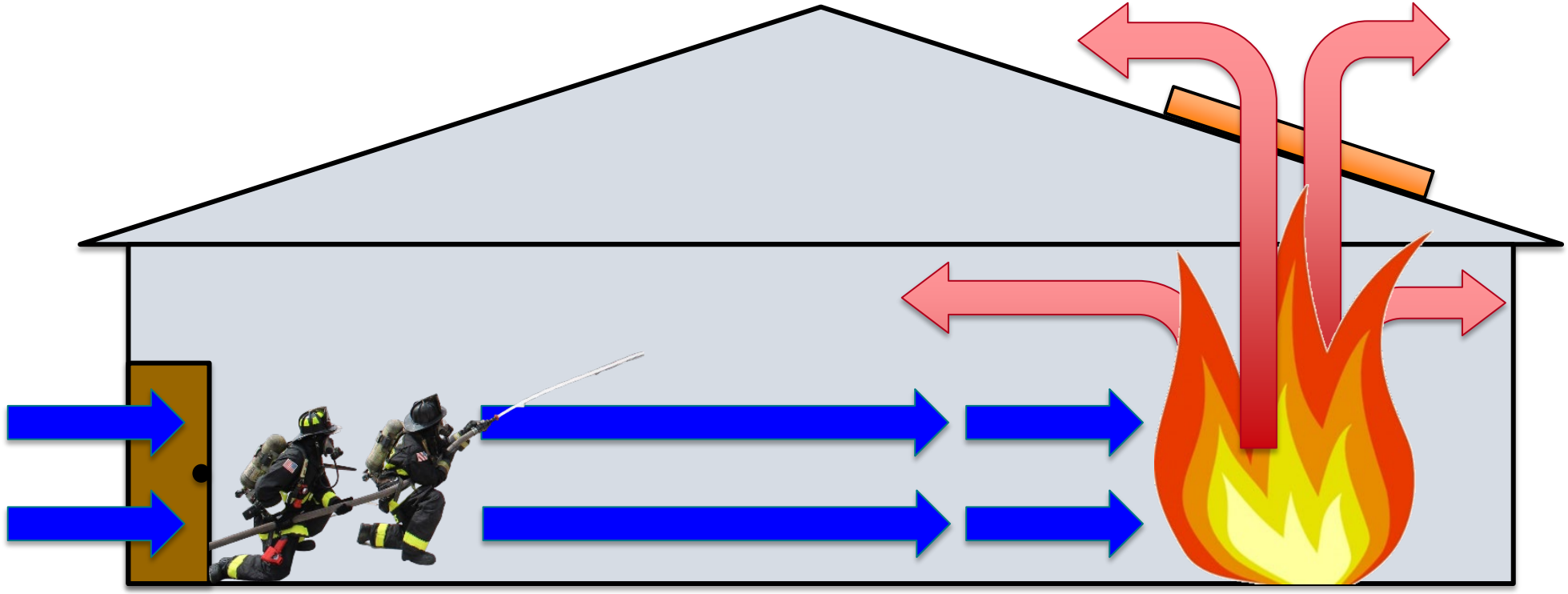
PLACEMENT OF VERTICAL VENT HOLE



Pre-Vertical Vent:

- Bi-directional flow at the front door and in the flow path to the fire
- Heat may prevent engine advance if proper mapping not possible

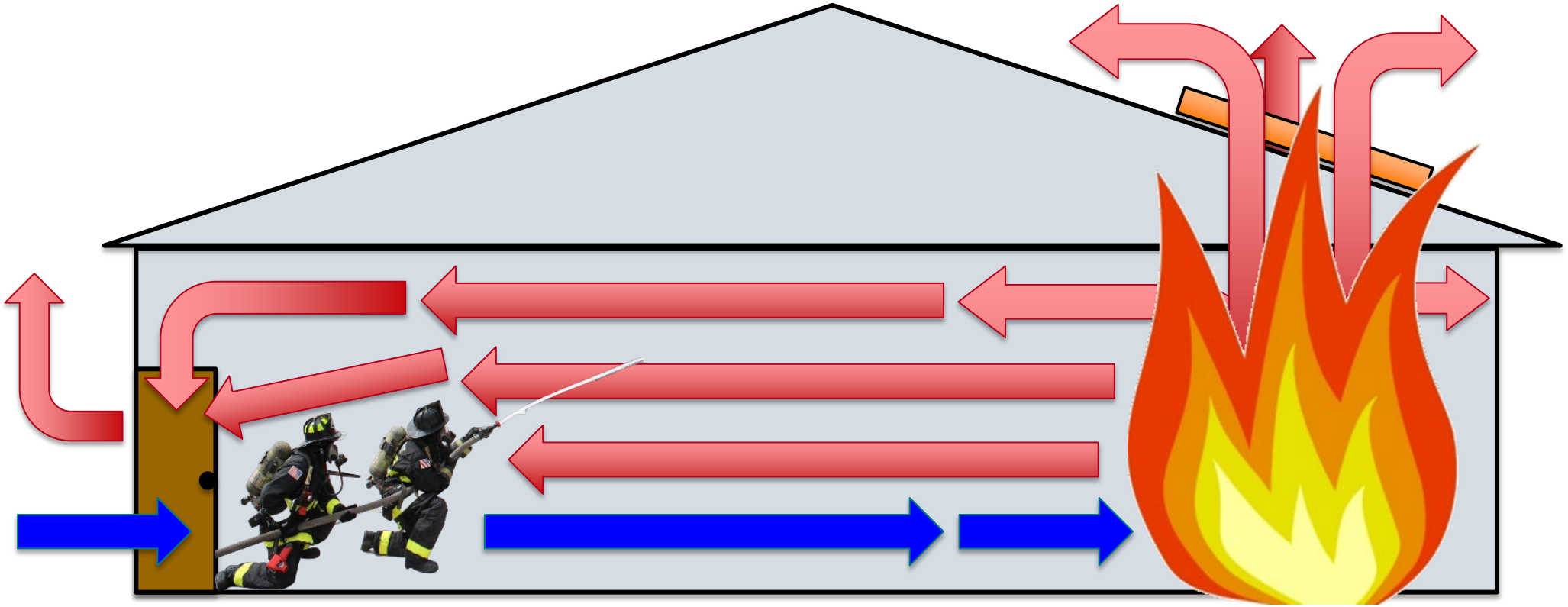
PLACEMENT OF VERTICAL VENT HOLE



Temporarily Post Vertical Vent:

- Bi-directional flow at the front door can become mostly intake
- Temporary lift may allow engine to advance for proper mapping
- Improvement limited to flow path (not remote spaces)

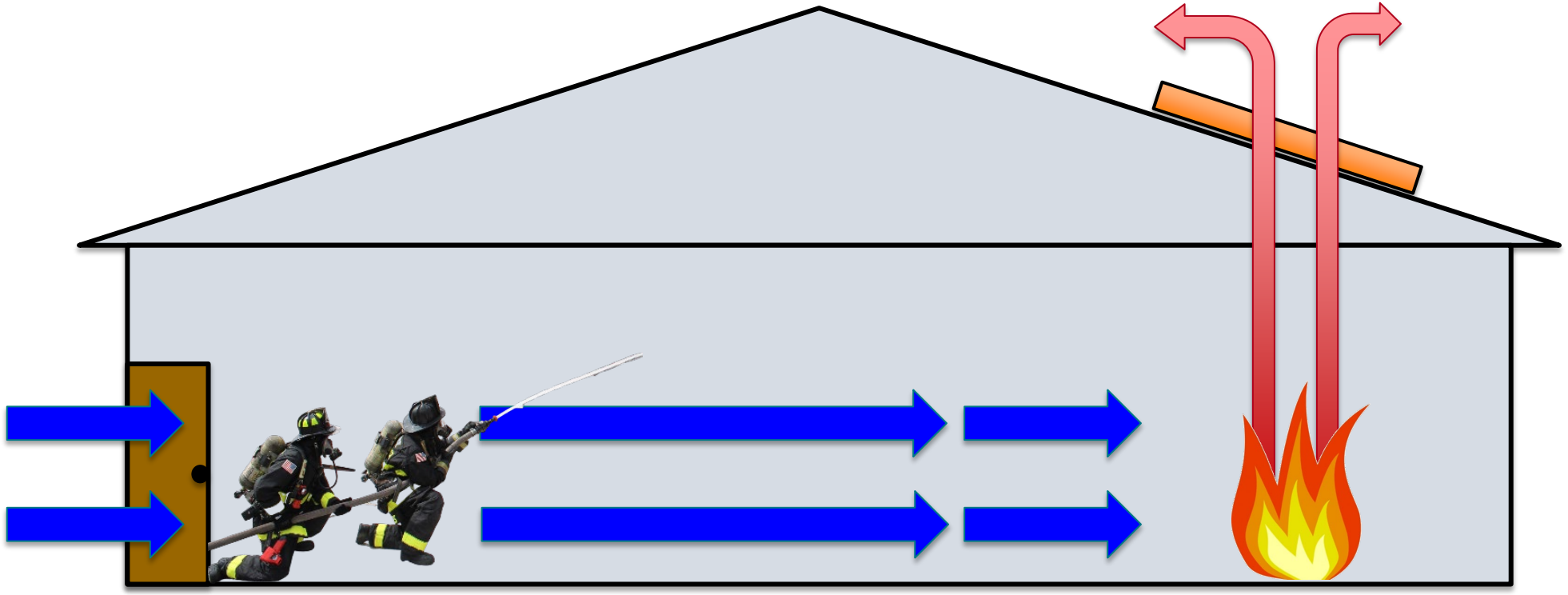
PLACEMENT OF VERTICAL VENT HOLE



Post Vertical Vent:

- Without effective suppression, flow path may return to bi-directional
- Fire will grow and move in flow path to FF location

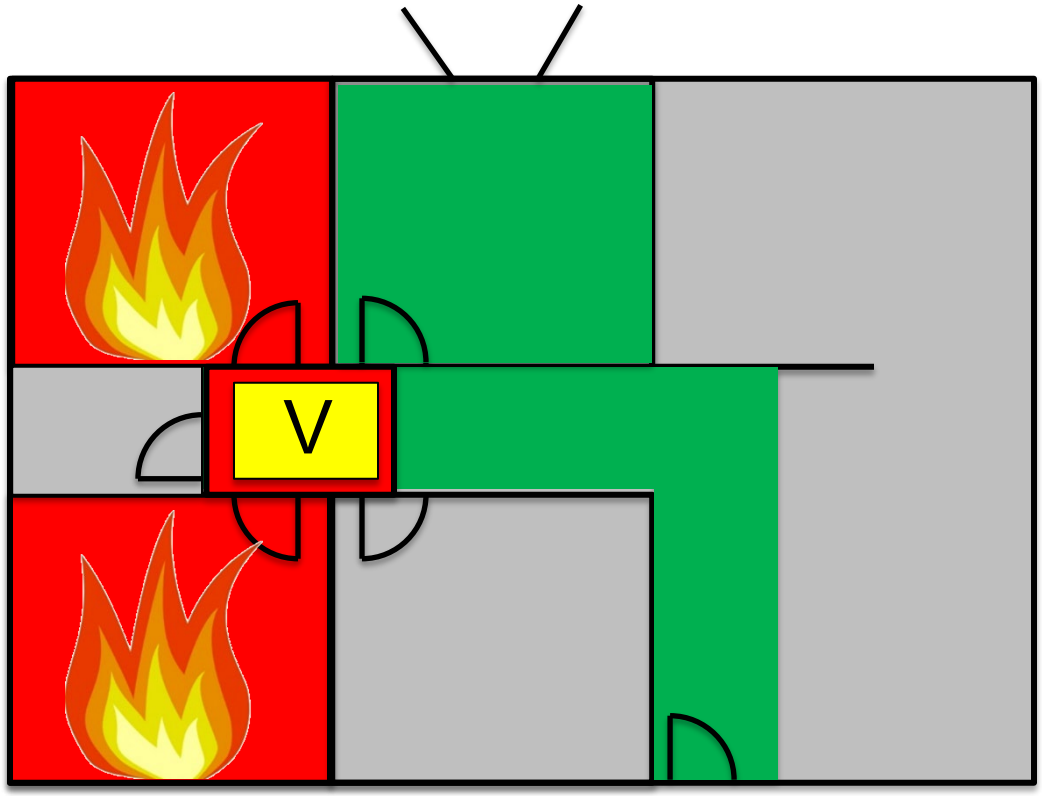
PLACEMENT OF VERTICAL VENT HOLE



Post Vertical Vent:

- With effective suppression, flow path remains fresh air intake
- Vertical vent exhausts fire gases until they are no longer buoyant

VERTICAL VENTILATION DURING THE ATTACK



Must Be Coordinated With Horizontal

- Close coordination between top-side ventilation and attack crew entry & suppression provided most benefit
- Improvement most noted in the inlet portion of the flow path (coincides with street experience of “assisting the engine company with the push” – visible LIFT)
- Increase in time between top side vent and start of EFFECTIVE suppression decreases benefit

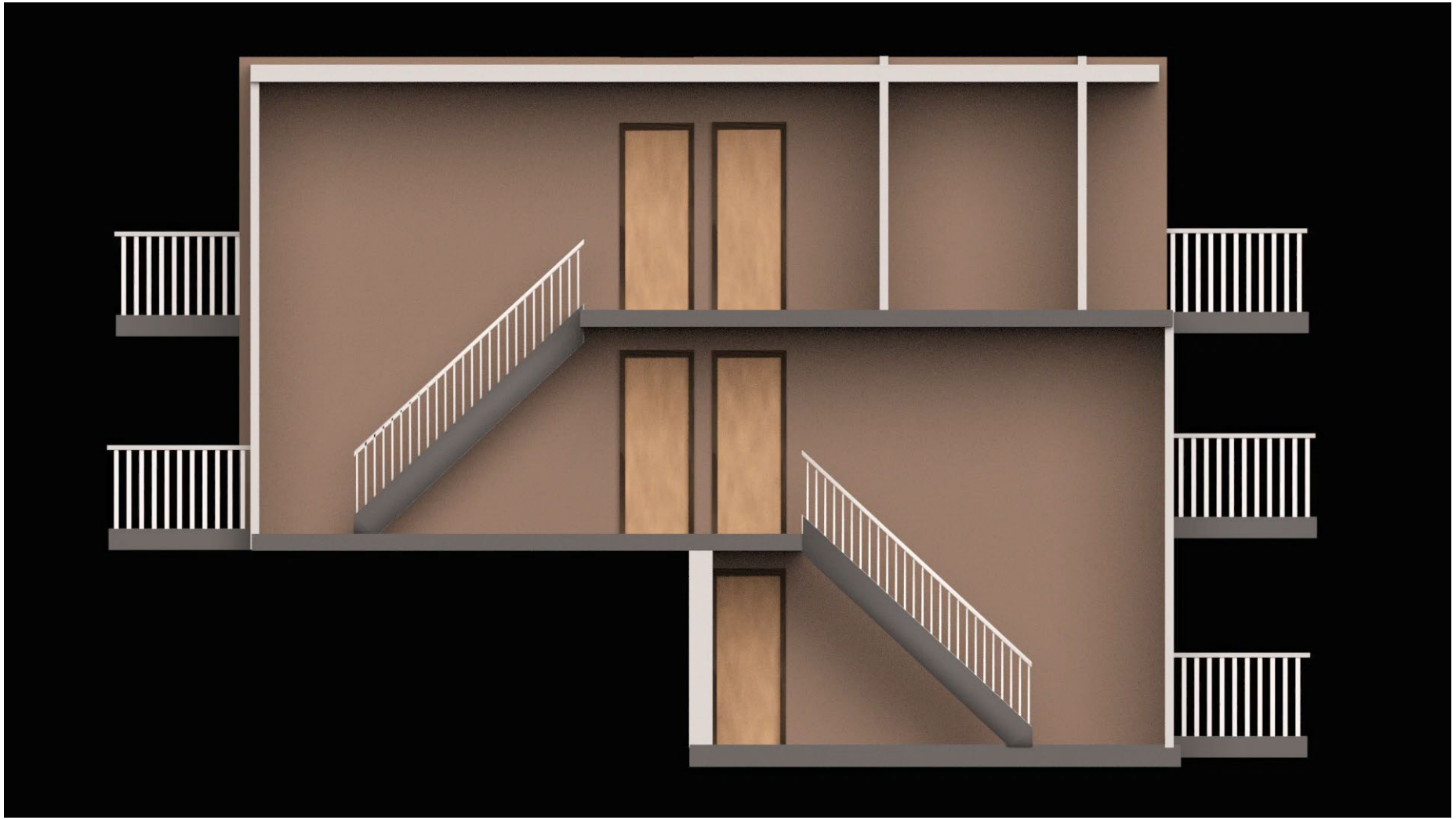
POSITIVE PRESSURE VENTILATION DURING THE ATTACK MULTI-FAMILY DWELLINGS

- Similar to “pressurizing the stairwell” in a high-rise
- Fan timing critical – earlier the better if stairwell is clean
- Beware of fresh air/oxygen making to any area with a vent present

POSITIVE PRESSURE VENTILATION POST KNOCK-DOWN

Delayed Timing Mixes Stairwell – Worse Before Better

FIRE BEHAVIOR IN THE STAIRWELL: LOWER-LEVEL APARTMENT



EXPERIMENT 1A: NO VENTILATION

- Bedroom Fire, Lower-Level
- Initial Ventilation
  - Windows Closed
  - Apartment Door Closed
  - Breezeway Door Closed
- Delayed FD Intervention
- A “Can Job”

EXPERIMENT 1A: NO VENTILATION

EXPERIMENT 1A: NO VENTILATION

EXPERIMENT 1B: OPEN APARTMENT DOOR

- Bedroom Fire, Lower-Level
- Initial Ventilation
  - Windows Closed
  - Apartment Door OPEN
  - Breezeway Door Closed
- Delayed FD intervention
- Flow & Move into fire apartment

EXPERIMENT 1B: OPEN APARTMENT DOOR

EXPERIMENT 1B: OPEN APARTMENT DOOR

EXPERIMENT 5: INTERIOR SPREAD

- Living Room Fire, Terrace Level
- Initial Ventilation
  - Living Room Slider OPEN
  - Apartment Door Open
  - Second Floor Apartment Door Open (Apt F, Apt H)
  - Breezeway Door Closed
- Apt H gets closed on visible smoke
- Apt F slider gets opened as room darkens down
- Engine entry Flow & Move
  - Advance halted until exterior water applied
  - Flow & Move downstairs into fire apartment

EXPERIMENT 5: INTERIOR SPREAD

EXPERIMENT 5: INTERIOR SPREAD

Pre-Vent on 2nd Floor

Post-Vent on 2nd Floor

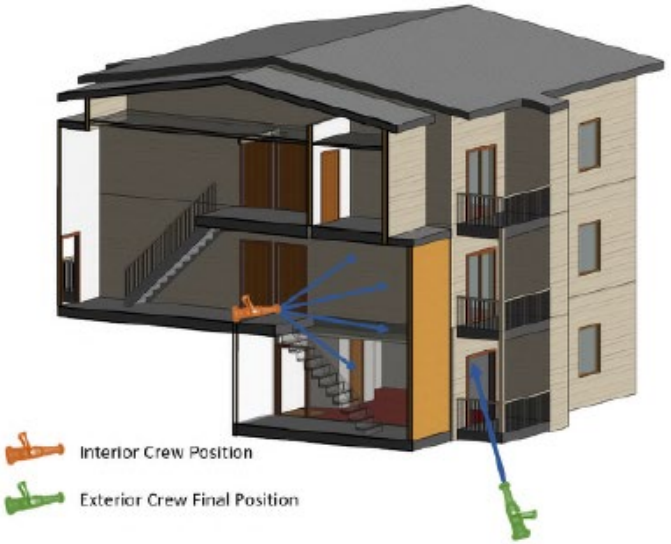
EXPERIMENT 5: INTERIOR SPREAD

EXPERIMENT 5: SIMULTANEOUS STREAMS

(a) Side C View of Exterior Crew Initial Position

(b) Crew Locations During Initial Applications

(a) Side C View of Exterior Crew Final Position



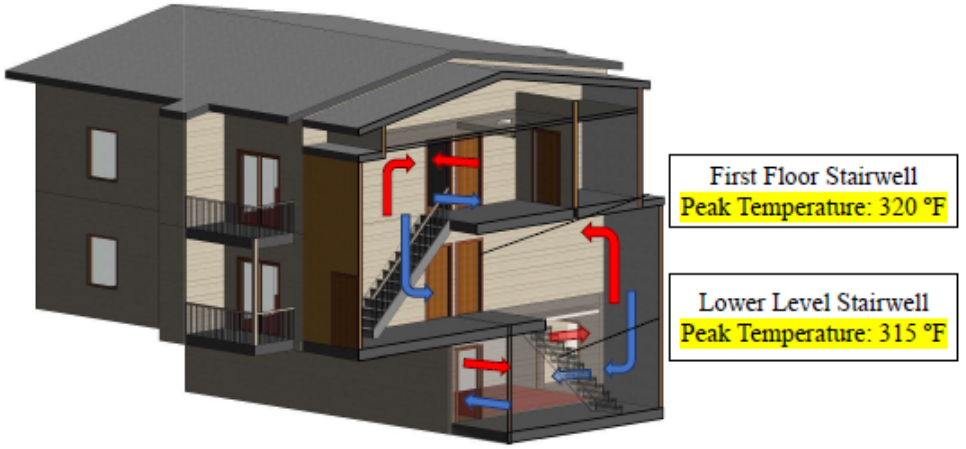
(b) Crew Locations During Final Applications

EXPERIMENT 5: INTERIOR SPREAD

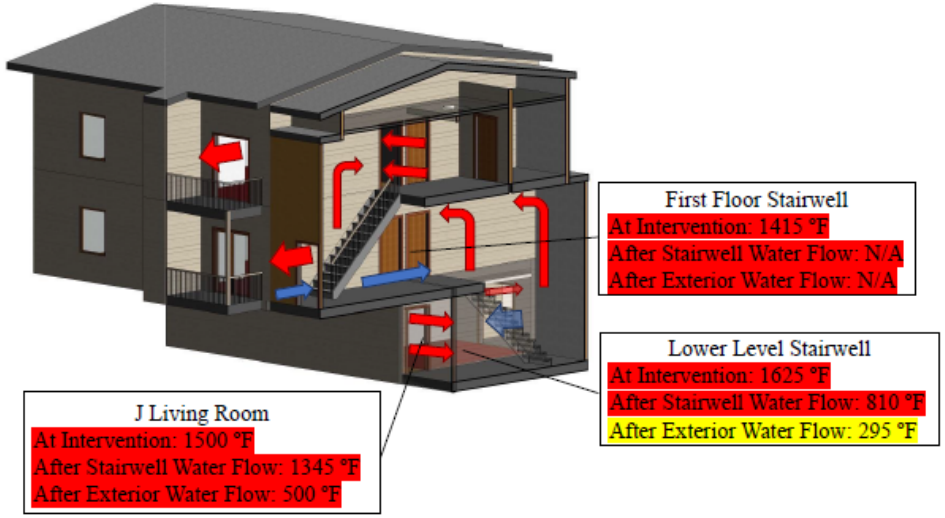
FLOW PATH AWARENESS

Exp. 1B – No Exterior Openings

Exp. 5 – Bidirectional @ Slider



Exp. 5 – Unidirectional Through Breezeway



EXPERIMENT 6: EXTERIOR SPREAD

- Living Room Fire, Terrace Level
- Initial Ventilation
  - Living Room Slider OPEN
  - Apartment Door Closed
  - Second Floor (Apt G) Living Room Slider Open
  - Breezeway Door closed
- Truck takes kitchen window in fire apartment
- Exterior spread all three floors into attic
- Exterior water sequence
  - Water applied into fire apartment through living room slider
  - Water applied upwards from balcony to balcony and eave line

EXPERIMENT 6: EXPOSURE APARTMENT

EXPERIMENT 6: EXTERIOR SPREAD

THERMAL IMAGER LIMITATIONS

"HERE'S WHAT'S MOST IMPORTANT ABOUT THIS FOR YOU..."

- ***Fire Service Thermal Imagers (TI) are inaccurate and unreliable thermometers***, 'spot temp' and / or temperature bar should not be used pre-fire control

- TIs are not X-ray machines, it cannot see through objects, ***TIs only "see" absorbed / radiated / emitted / transmitted IR from material's surface***

- ***TIs may give an indication of a heat condition*** below / above a FF and valuable in size-up, ***but a TI will give no indication of existing structural integrity/stability or reliable predicative indicators of structural collapse***

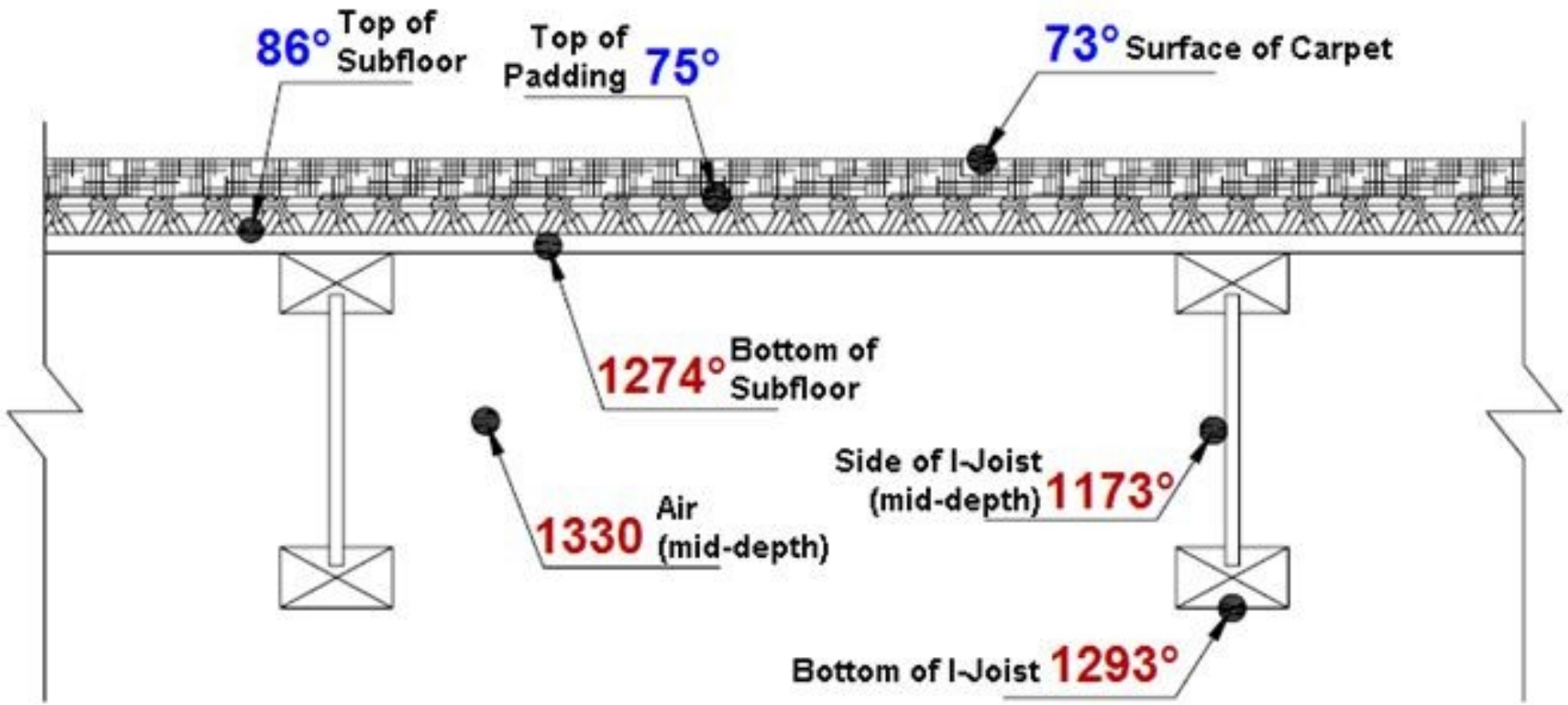
WHY FIRE SERVICE THERMAL IMAGERS (TI) ARE INACCURATE AND UNRELIABLE THERMOMETERS?

- Because I said so….
- Emissivity of the Object
  - Material Type / Roughness / Wavelength / Temperature / Viewing Angle / Surface Geometry
- **Distance-to-Spot Ratio / Field of View**
- Atmospheric Attenuation – "Lessening Effect"
  - Reduction w/ increased distance from source
  - Humidity / Water, Particulate, Gases (CO2)
- **State of Matter**
  - **Solid = Yes**
  - **Liquid = Can and Maybe**
  - **Gas = No (Air, Smoke, Flame) 'Heavy Particulate'**
- **Reflected Energy – "Bouncing Heat"**
  - **Mirror, polished metal surfaces**
- **Key elements for more 'accurate' apparent temperature**
  - **Solid Matter, Dark Finish, Rough Surface, and Close to Operator**

STRUCTURAL COLLAPSE FIRE TESTS: SINGLE STORY WOOD FRAME STRUCTURES - 2004
STRUCTURAL STABILITY OF ENGINEERED LUMBER UNDER FIRE CONDITIONS – 2008

Key Findings: Collapse Times and Limitations of TI

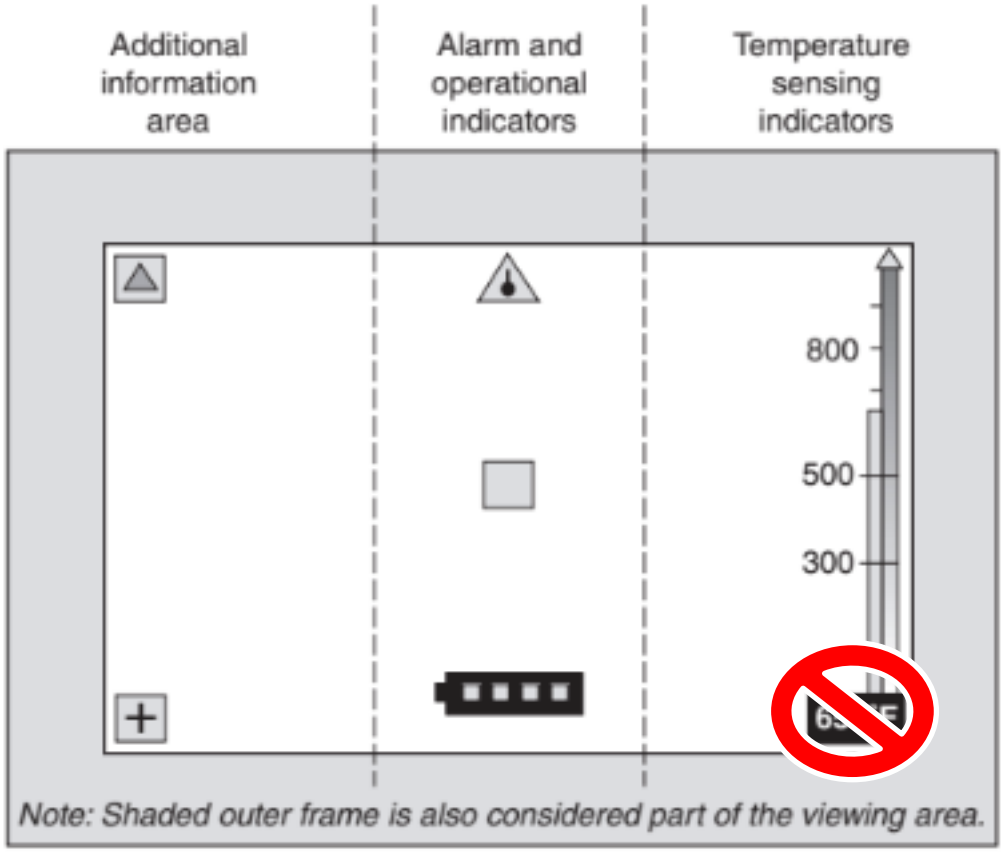
TEMPERATURES AT FLOOR SURFACE THAT THE TI CAN "SEE" VS. THE TEMPERATURES BELOW THE FLOOR

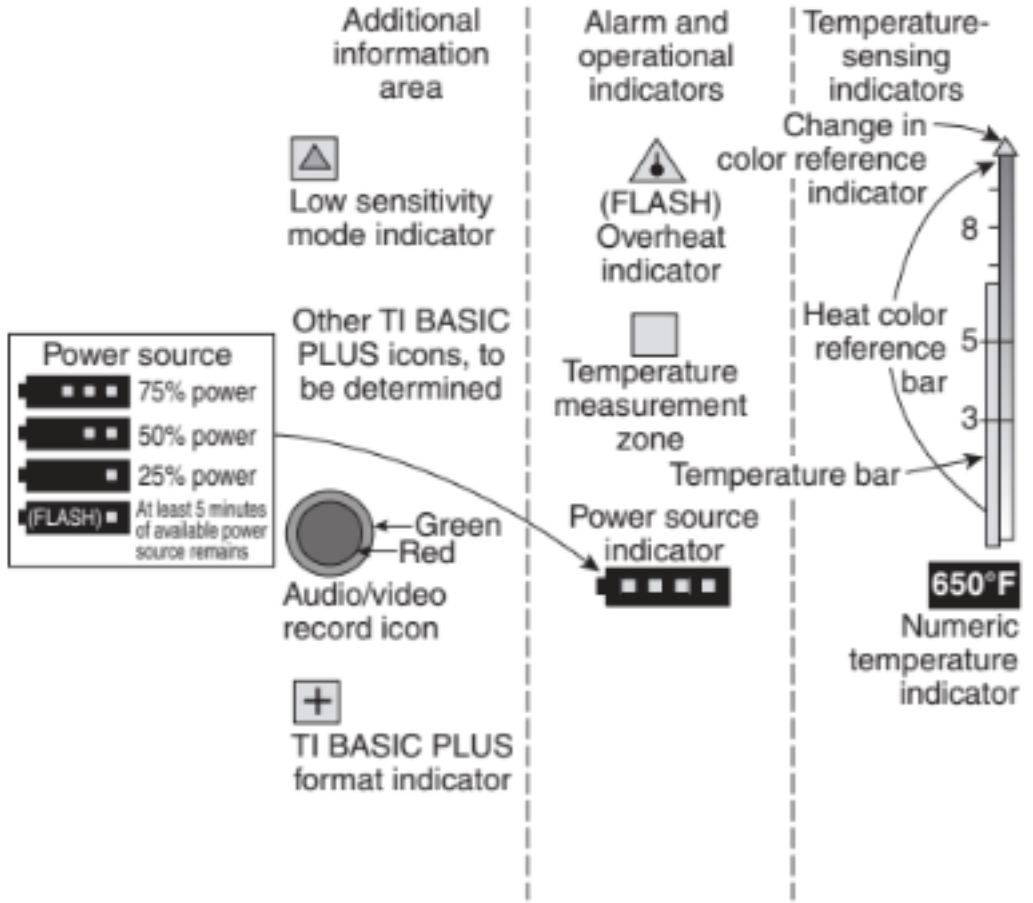


NFPA STANDARDS FOR TICS REFERENCES

- *New - NFPA 1930 - Standard on Fire and Emergency Service Use of Thermal Imagers, Two-Way Portable RF Voice Communication Devices, Ground Ladders, Rescue Tools, Fire Hose, and Fire Hose Appliances*
  - *Old - NFPA 1801 – Standard on Thermal Imagers for the Fire Service (2021 ed.)*
    - ***Grayscale, White Hot / Black Cold, Yellow, Orange, Red***
    - *TIC BASIC \TIC BASIC PLUS – Additional Features*
    - *Design and Performance Criteria*
- *NFPA 1408 – Standard for Training Fire Service Personnel in the Operation, Care, Use, and Maintenance of Thermal Imagers (2020 ed.) [Proposed NFPA 1400]*
  - *Ch 6 – TI Training Program Components*
- *NFPA 1700 – A Guide to Structural Firefighting (2021 ed.)*
- *NFPA 1010 – Professional Qualifications for the Firefighter*

NFPA 1801 – DISPLAY





NFPA 1700 – 9.6.6:

If available and appropriate, a TI is a valuable tool and should be used during the initial 360 to assist in determining fire location and extension.

HOUSTON FD – FLIR FACTS

K33

- IR Res. – 280 x 180 (50,400 pixels) pitch 25 micron
- Refresh Rate – 60 Hz
- NETD - < 40 mK @ 86 deg F
- FOV – 51 x 38, f #: 1.25, 9mm focal length
- Focal Plane Array – 7.5 – 13.5 micron
- Display – 320 x 240 / 4” LCD
- Object Temp. Range: (-4 – 302F) (32 – 1202F)
  - 2% of pixels > one second
- Image Mode
  - TI Basic fire-fighting mode
- FSX Digital Image Enhancement (FLIR)

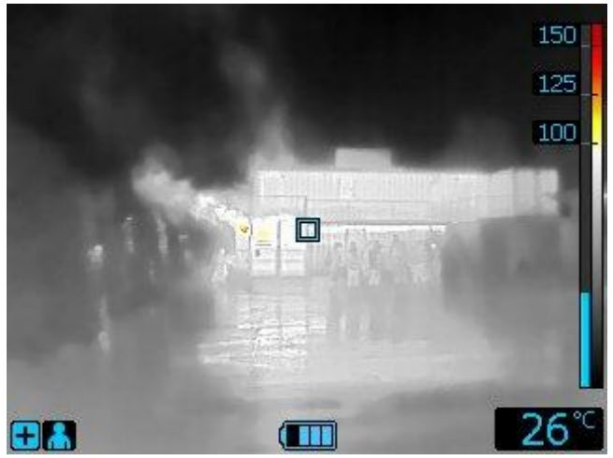
Colorization

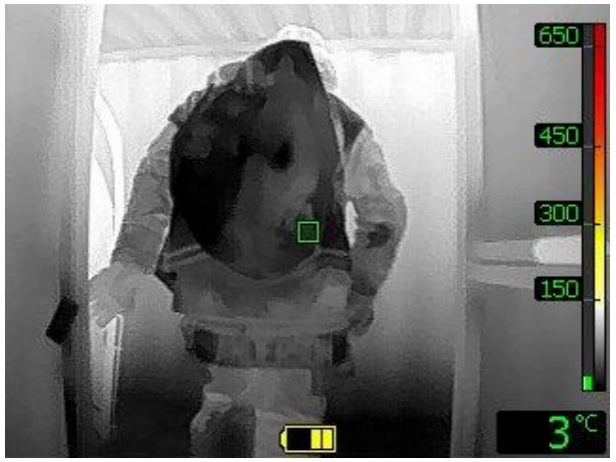
- Yellow: 300 – 500 F
- Orange: 600 – 800 F
- Red: 800 – 1200 F

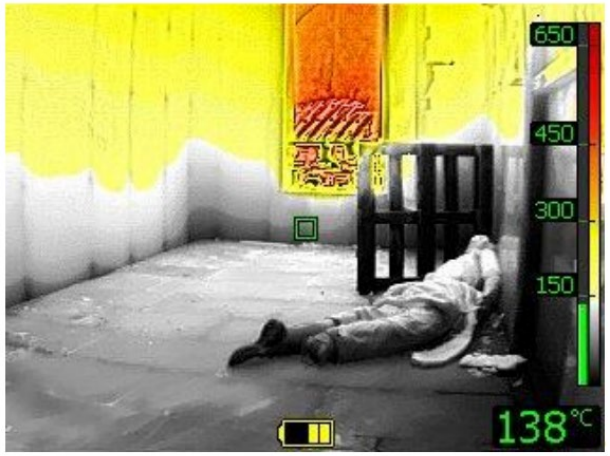
Green Icons vs. Blue Icons

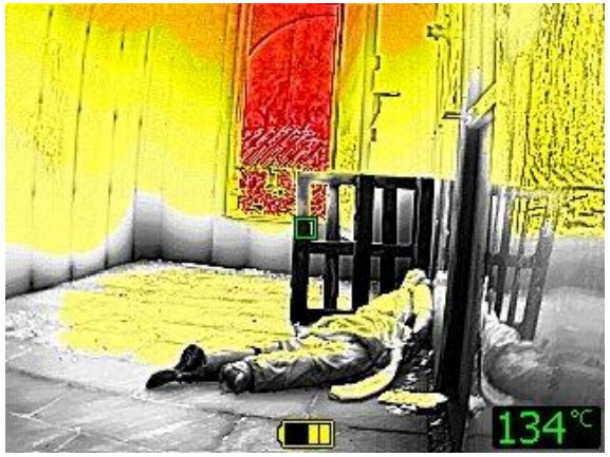
- Green Icons - Camera switches between the high-sensitivity range and the low-sensitivity range automatically when objects with a temp. above 302 F enter the field of view
- Blue Icons - indicate the temperature range is locked into the high sensitivity range (-4 to 302 F)

FLIR ENHANCED IMAGE – 2024 FIRMWARE UPDATE

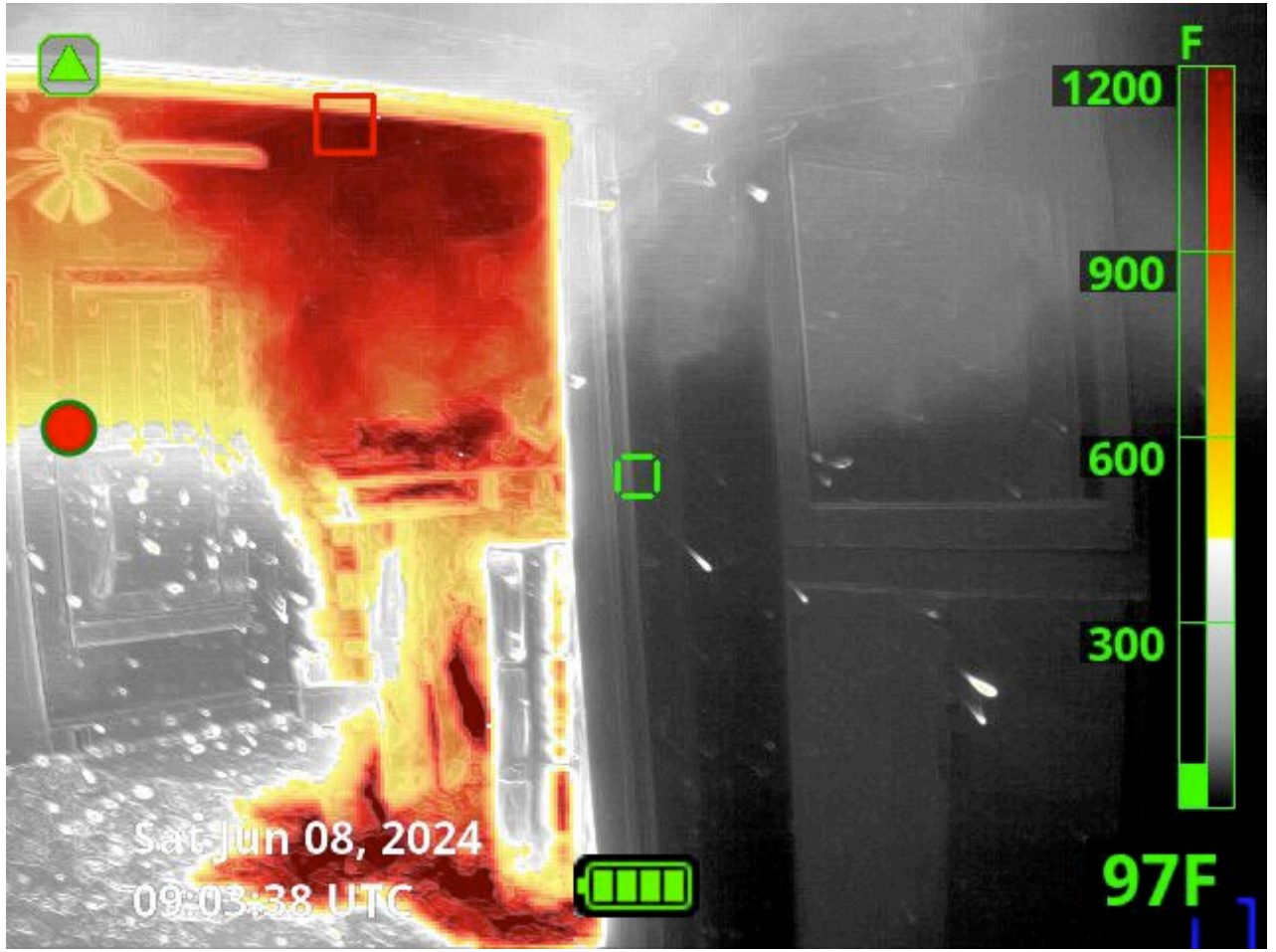








Placeholder – Compare TI video (staged footage) to TI video provided of Real Incidents

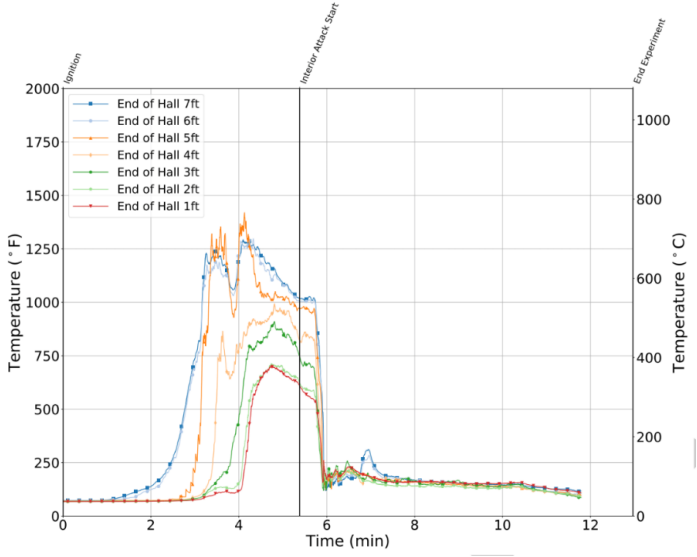


INTERIOR VISIBILITY: JUST INSIDE FRONT DOOR

A THERMAL IMAGER IS NOT AN X-RAY DEVICE


F
1200
900
600
300
2010-06-30 08:40

THERMAL IMAGERS BEWARE: UNDERSTANDING THE LIMITATIONS

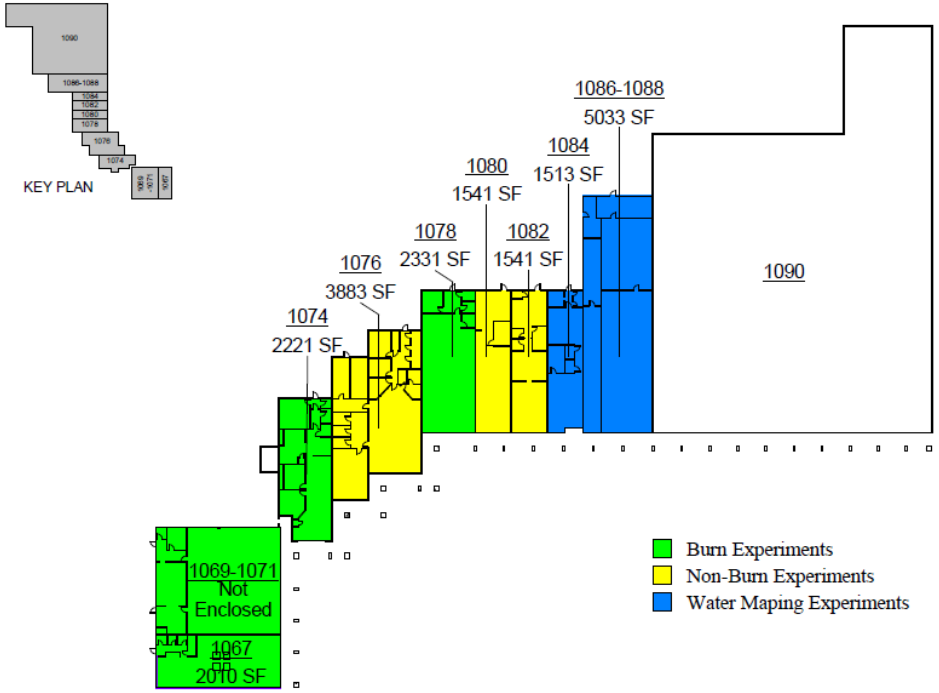


COMMERCIAL

WHAT ARE THE VARIABLES?

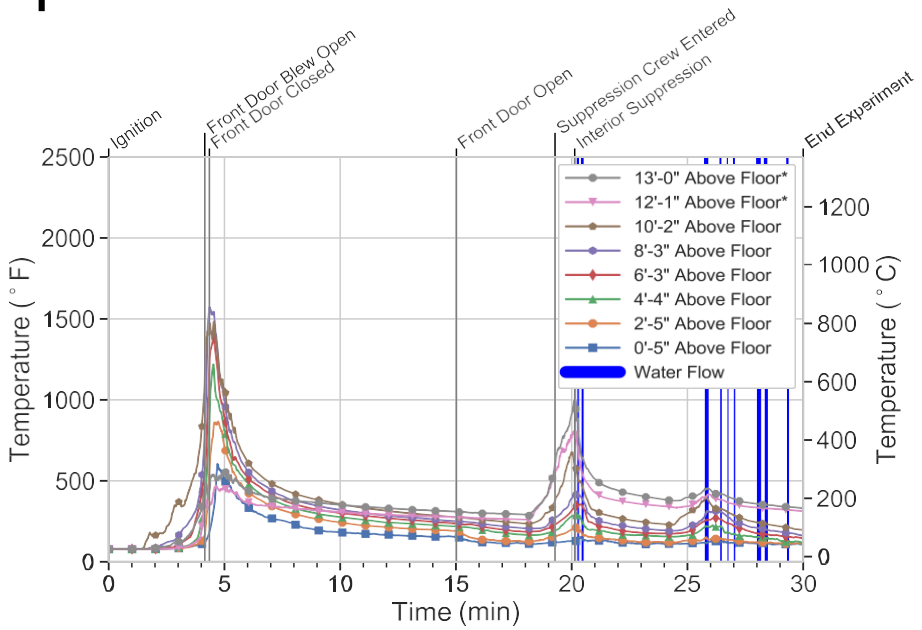
Exp.	Ventilation Type	Openings	Total Horizontal Area (ft^2)	Total Vertical Area (ft^2)
1	No Ventilation	No Open Doors or Windows	N/A	N/A
2	Horizontal	Front Door and Windows (Sequential)	106	N/A
3	Horizontal	Front Door and Windows (Simultaneous)	98	N/A
4	Horizontal	Front Door and Windows (Simultaneous)	98	N/A
5	Vertical	Front Door and Roof Vent	N/A	32
6	Vertical and Horizontal	Front Door and Roof Vents	19	64
7	Vertical and Horizontal	Front Door, Front Windows, and Roof Vents	82	64

STRUCTURE OVERVIEW



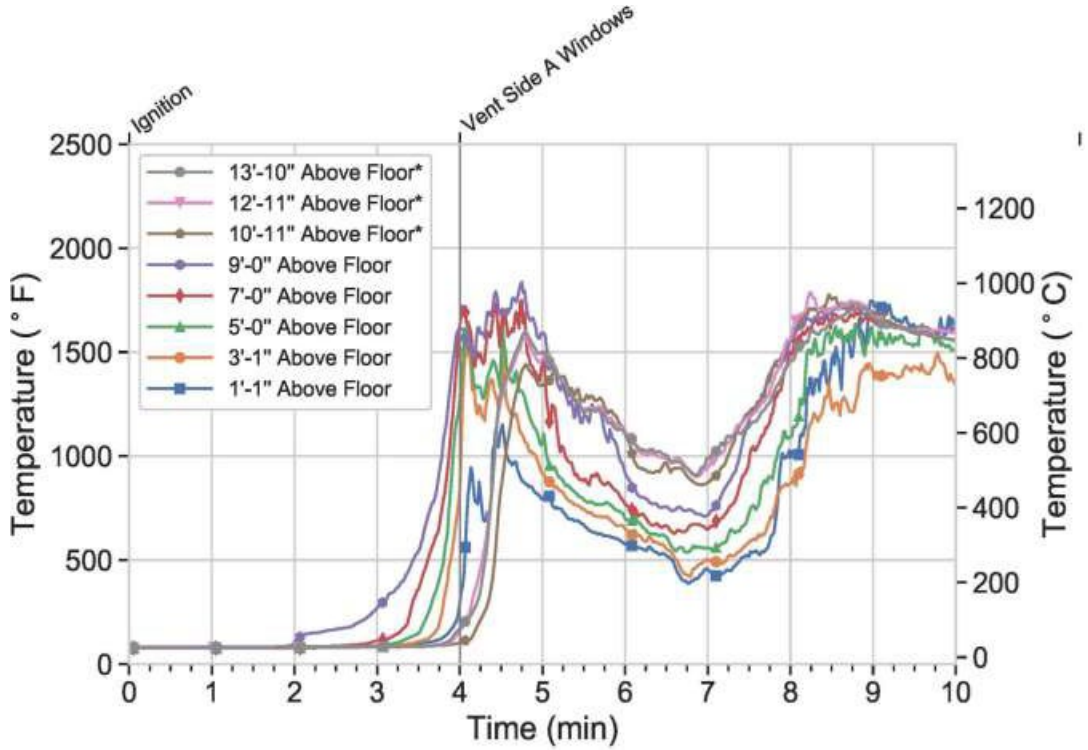
TIMELINE OF COORDINATION: KEEPING IT VENTILATION LIMITED

- Much of the fuel remained due to limited vent which limited HRR
- Opening the door at 15 minutes provided additional oxygen and temperatures increased

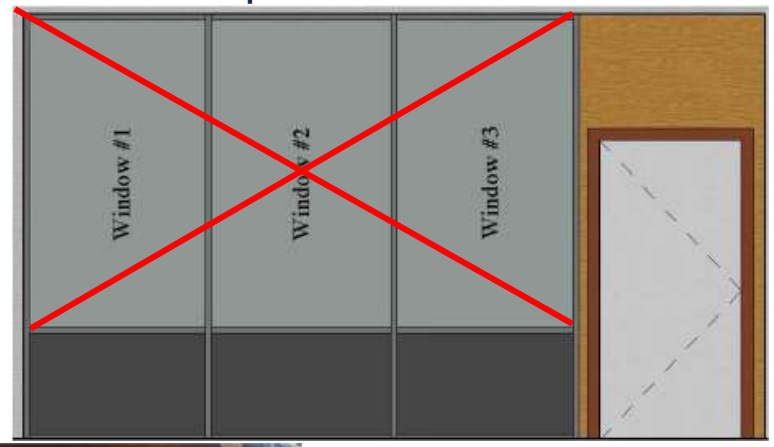


Experiment 1 – AB Quadrant

TIMELINE OF COORDINATION: UNCOORDINATED HORIZONTAL VENTILATION



Simultaneous Horizontal Ventilation
Experiment 3: 96ft^2



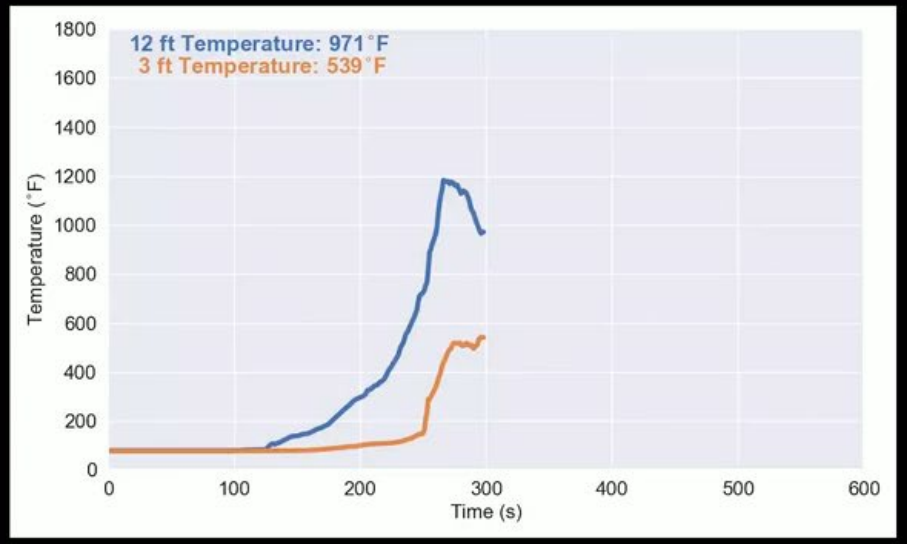
50s After Vent

TIMELINE OF COORDINATION

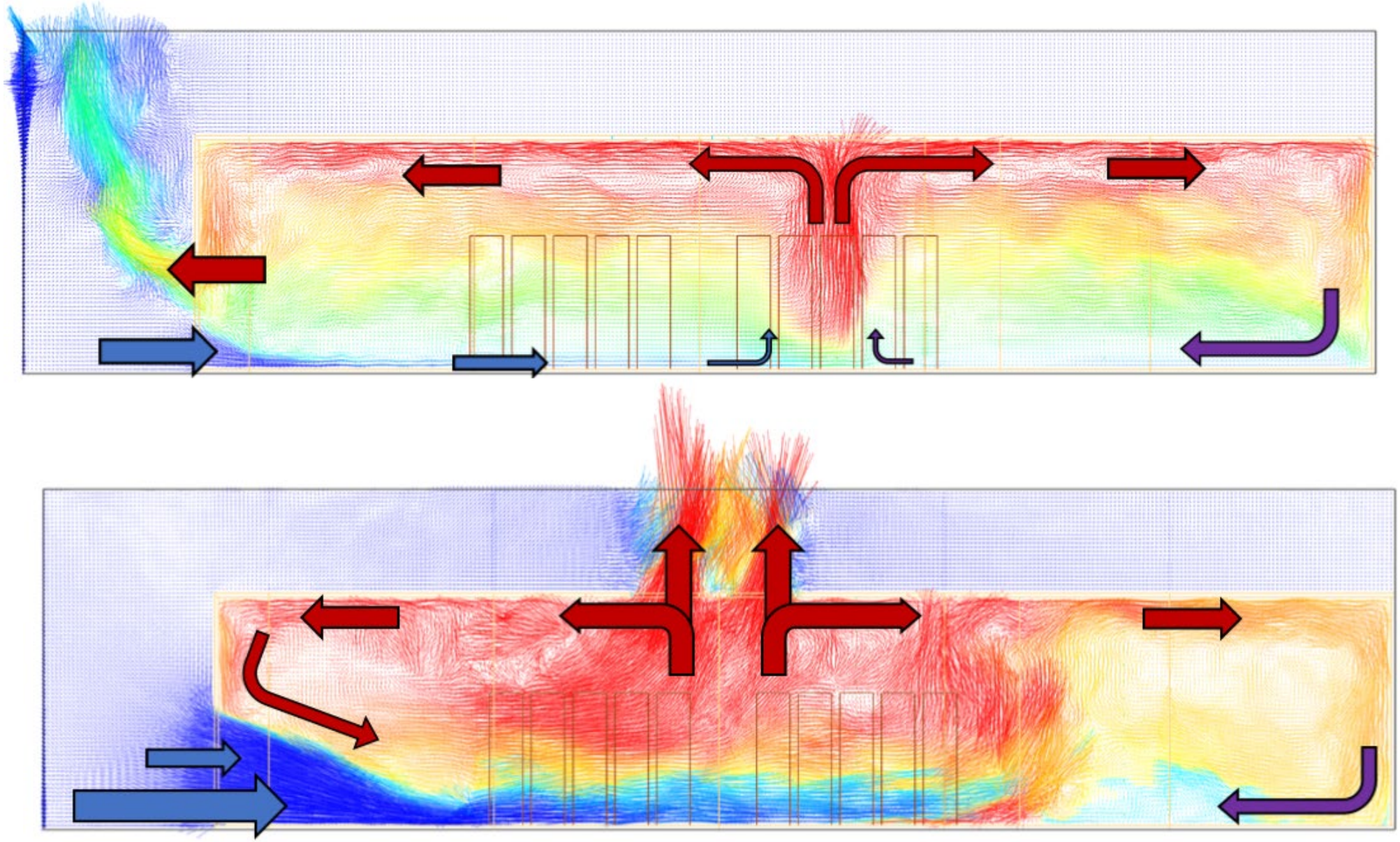
Uncoordinated Fire Attack

Total Vertical Ventilation: 0 ft²

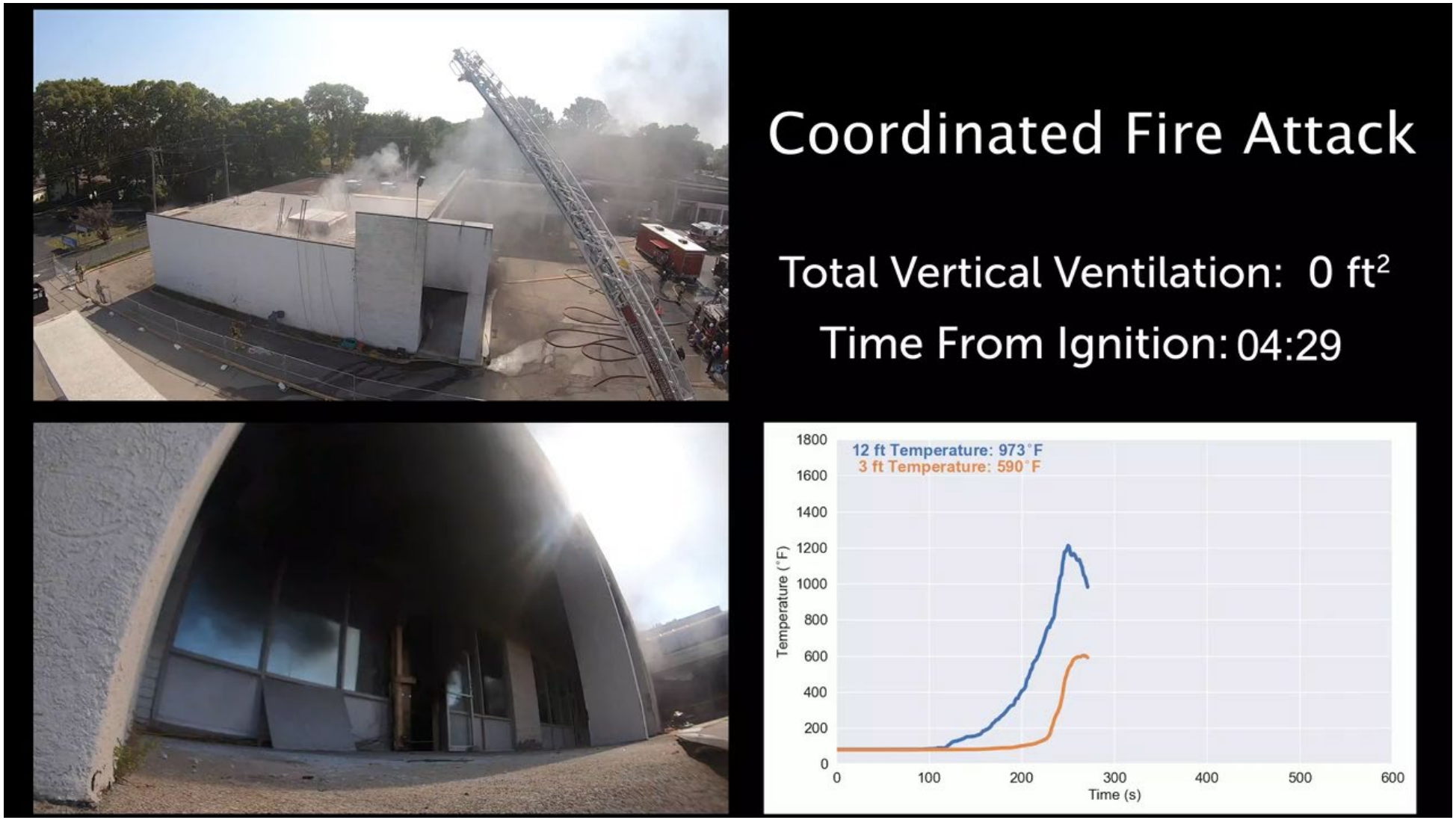
Time From Ignition: 05:00



CHANGE OF FLOW DIRECTION AT FRONT DOOR



TIMELINE OF COORDINATION



INITIAL SIZE-UP AND FIRE GROWTH

- Pressure build up resulted in unidirectional exhaust
- Extended over 75ft from doorway, approximately 45s

Start (0 s)

10 s

20 s

30 s

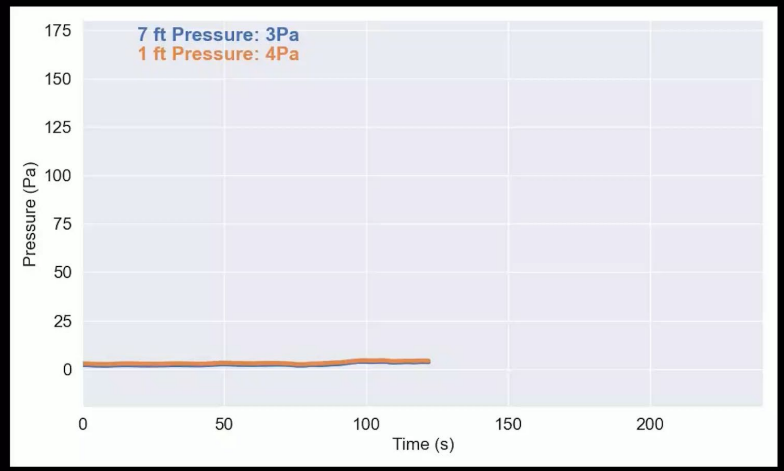
40 s

45 s

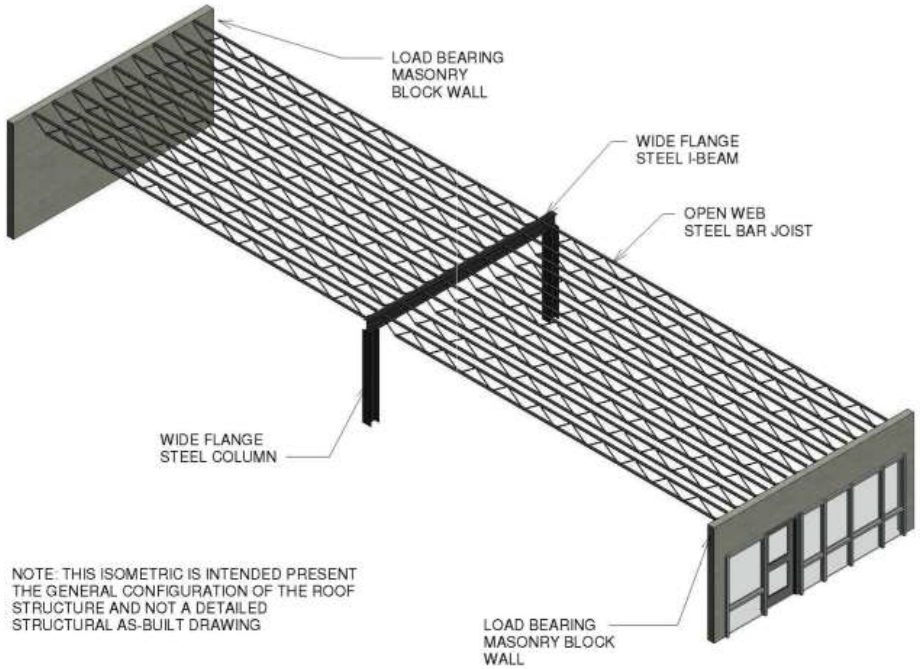
INITIAL SIZE-UP AND FIRE GROWTH

EXPLORATORY ANALYSIS OF THE IMPACT OF VENTILATION ON STRIP MALL FIRES
EXPERIMENT 4

Time From Ignition: 02:02



ROOF COLLAPSE



ROOF COLLAPSE – AFTER KNOCKDOWN

Roof collapse occurred over 30 minutes into the experiment during final mop-up operations.

AFTER THE FIRE

AFTER THE FIRE – CONTAMINATION REDUCTION

- PPE – Soapy brush and rinse removes 85% of dirt
- Use cleansing wipes on scene for neck, face, hands
- Take a shower ASAP after exposure

AFTER THE FIRE – HOT WASH

QUESTIONS?