



INTERNATIONAL ASSOCIATION OF FIRE FIGHTERS

EVIDENCE-BASED FIRE GROUND OPERATIONS

March 2026

WHY WE'RE HERE

FSRI'S STRATEGIC PRIORITY AREAS

Firefighter Health & Safety



Advancing fire safety knowledge to decrease death and injury among the fire service and the communities they serve.

Battery Fire Safety



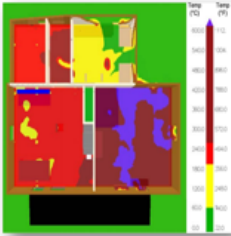
Quantifying and mitigating the hazards posed to occupants and first responders by LiB-powered devices and storage.

Wildland-Urban Interface



Evaluating the threats posed to wildland urban interface communities and the built environment by large-scale fires.

Fire Modeling, Materials & Fire Dynamics



Understanding fire behavior of materials, structures and systems to improve the accuracy of fire models and decrease risk.

Education & Training



Improving firefighter safety and decision-making by equipping the fire service with free training, tools, and resources based on the latest fire safety science.

Public Safety



Building on our research discoveries, FSRI's public safety programs empower communities to mitigate fire safety risks and improve public safety.

Data Science & NERIS



The National Emergency Response Information System (NERIS) is the leading resource for information and advanced analysis on fire-related issues in the US.

Firefighter Health & Safety

History & Scope

Structural Stability of Engineered Lumber

Firefighter Exposure to Smoke Particulates

Firefighter Safety Research Institute (2013)

Impact of Horizontal Ventilation

Firefighter Safety and Photovoltaic Systems

Basement Fires

Impact of Vertical Ventilation

Governors Island Testing with FDNY & NIST

Attic Fires

Positive Pressure Ventilation in Homes

Fire Attack Study, Interior and Exterior Tactics

Fire Service Training Environment

Coordinated Fire Attack

Fire Safety Research Institute (2021)

Size Up and Search & Rescue

Fire Dynamics Boot Camps

Near Miss Investigations

Training Fire Exposures

Firefighting Tactics Multi-Story Residential Structures



Firefighter Health & Safety Research

History & Scope

- Firefighting Strategies & Tactics
- Firefighter Personal Protective Equipment
- Firefighter Exposure (Thermal & Carcinogenic)
- Victim Exposure (Toxic & Thermal)
- Near-Misses, Line of Duty Injuries/Deaths (LODI/D)
- Public Safety Intersection (Fire Service)
- Fire Safety Academy (FSA)
- Codes, Standards, Textbooks, Instructor Materials



THE FIREFIGHTING MINDSET

THE FIREFIGHTING MINDSET

- Culture and Tradition are IMPORTANT
 - Don't forget where we have come from and WHY
- Fire service strategies typically based on experience and tradition
 - Should be supported by data
- Fire fighters can hold experience as truth and all encompassing

Experience \neq Knowledge

Knowledge \neq Understanding

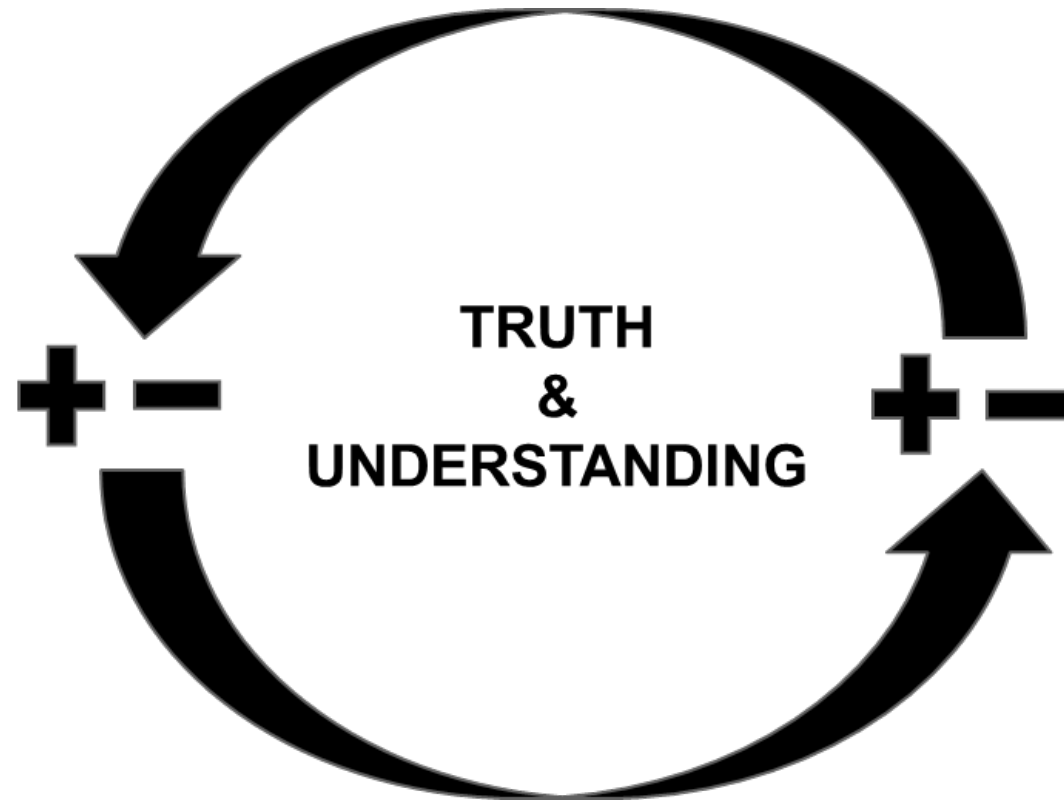
Knowledge + Experience = Understanding



THE FIREFIGHTER MINDSET



Knowledge



Experience

We All Have Biases!

Confirmation

Cognitive

Success



Fire Dynamics

Building Stock

Response Model

Pre-Incident Bias

Your Experience on the Fire Ground



What is your VANTAGE POINT??

Arrival Order

Combinations of Tactics & Timing

Your Location

Suppression Or Ventilation

SETTING THE STAGE

THE RESIDENTIAL ENVIRONMENT - STRUCTURES

- Multiple Construction Types
- Wide Range of Square Footages
- Access Challenges
- Exposure Concerns



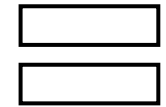
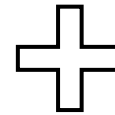
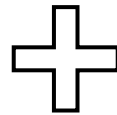
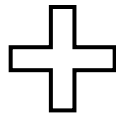
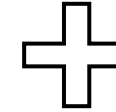
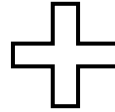
THE RESIDENTIAL ENVIRONMENT - STRUCTURES

What We Have Going For Us:

- Mostly Flat Surfaces
- Manageable Compartment Volumes (Ceiling Heights!)
- Consistency of Interior Finishes
- Consistency of Interior Furnishings



THE HAZARDS – HOW IT'S CHANGED

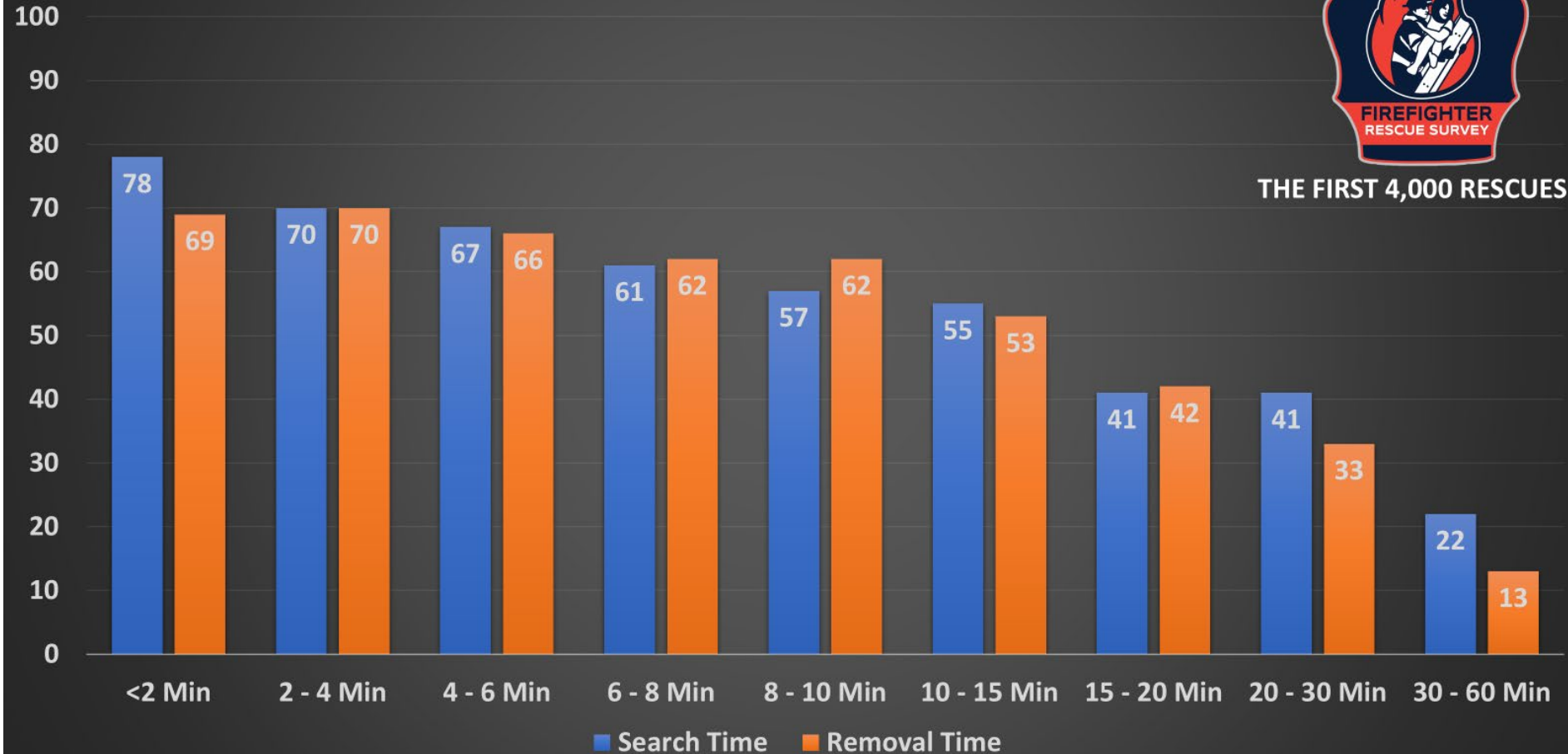


Faster fire propagation
Shorter time to flashover
Rapid changes in fire dynamics

Shorter escape times
Shorter time to collapse
Increased exposure problems
New & unknown hazards

THE HAZARDS – VICTIM POTENTIAL IS INCREASING

Time v Survival Percentage



Faster Fire Growth

=

Shorter Escape Times

=

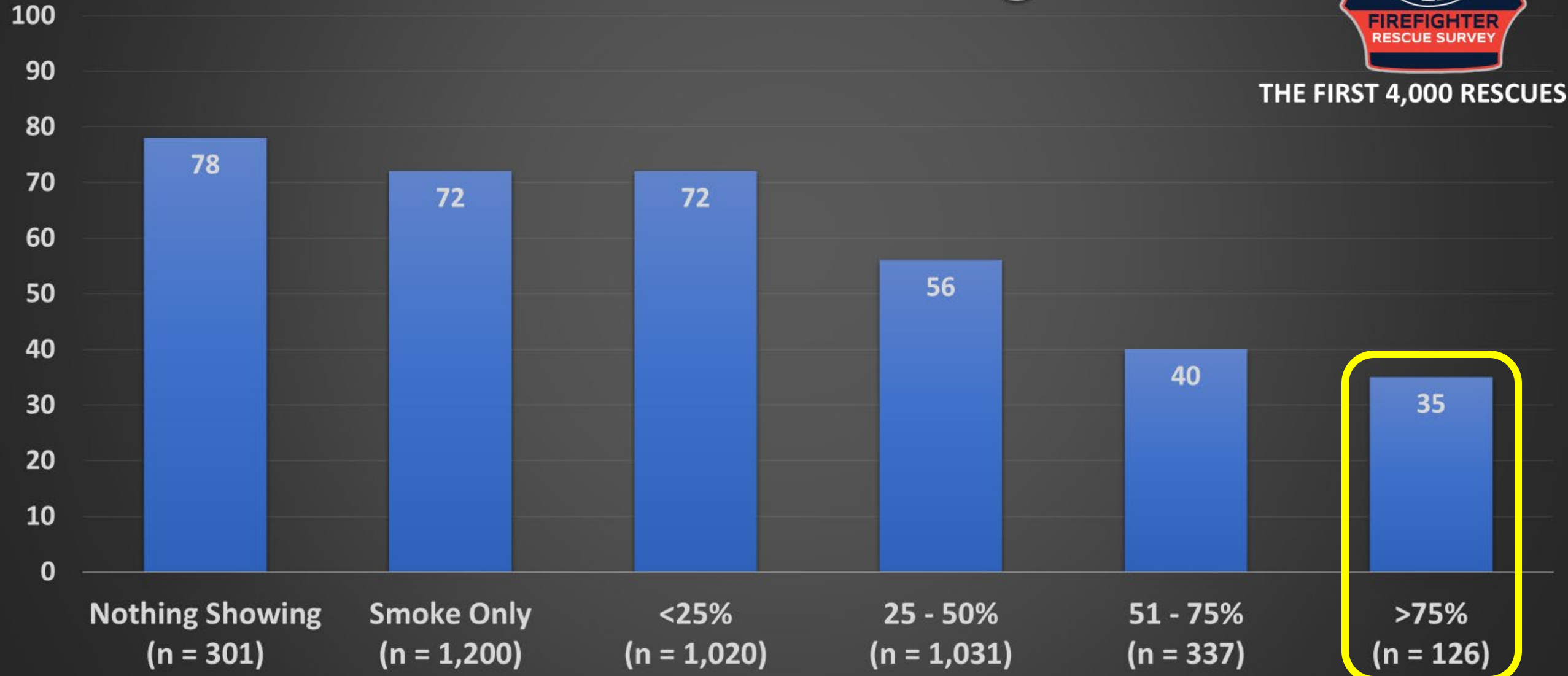
Faster Time to Incapacitation

Both *SEARCH* and *REMOVAL* times matter!

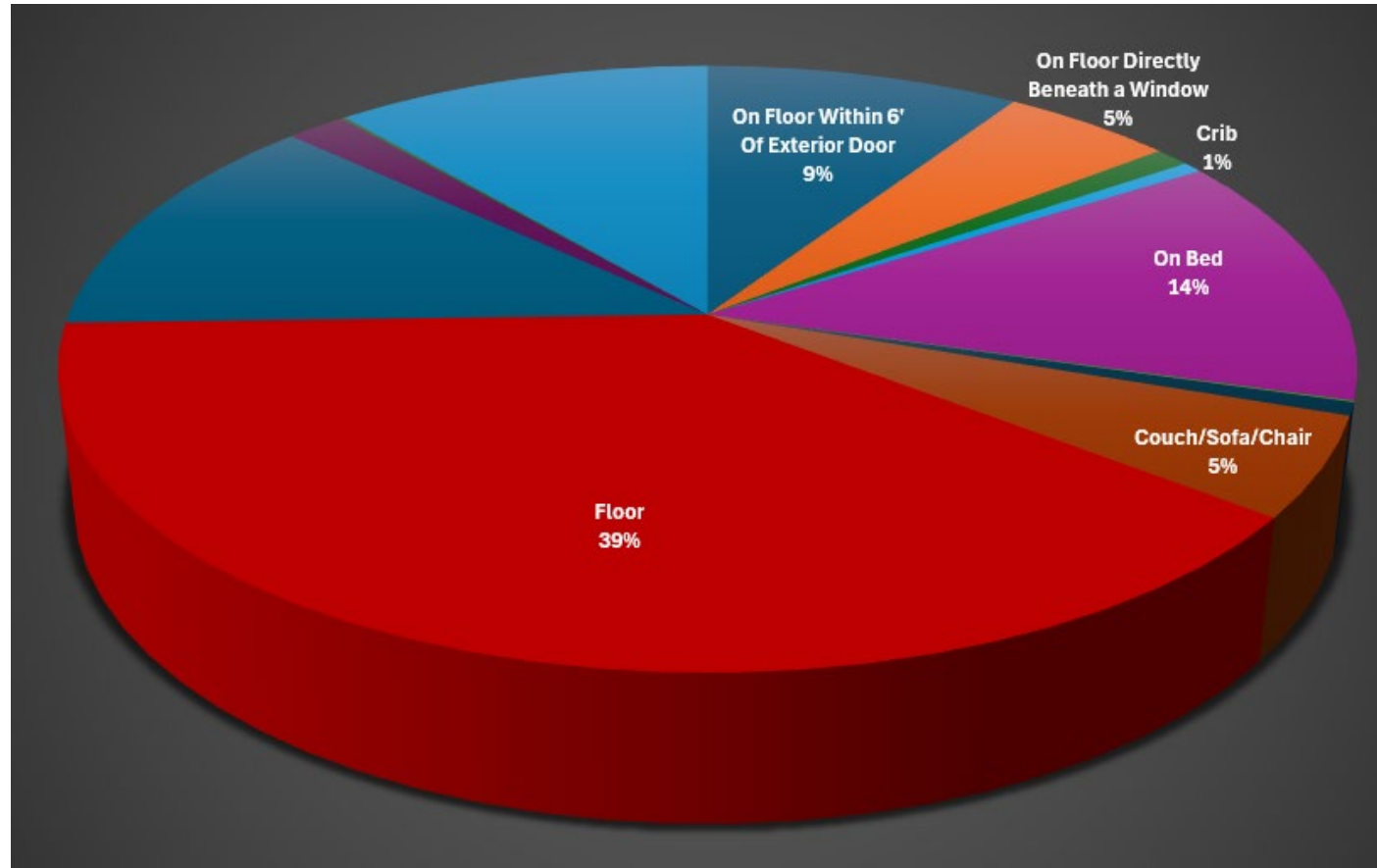
Exterior Conditions Upon Arrival v Survival Percentage



THE FIRST 4,000 RESCUES



WHERE ARE THE VICTIMS FOUND?



1st Most Common: On Floor (57%)
2nd Most Common: On Bed/Couch (20%)



THE HAZARDS – FOR THE PUBLIC

Fractional Effective Dose Calculation → LD50

- Lethality for approximately 50% of the population
- Incapacitation for approximately 89% of the population

FED Thresholds: 1.0 for thermal, 3.0 for toxic

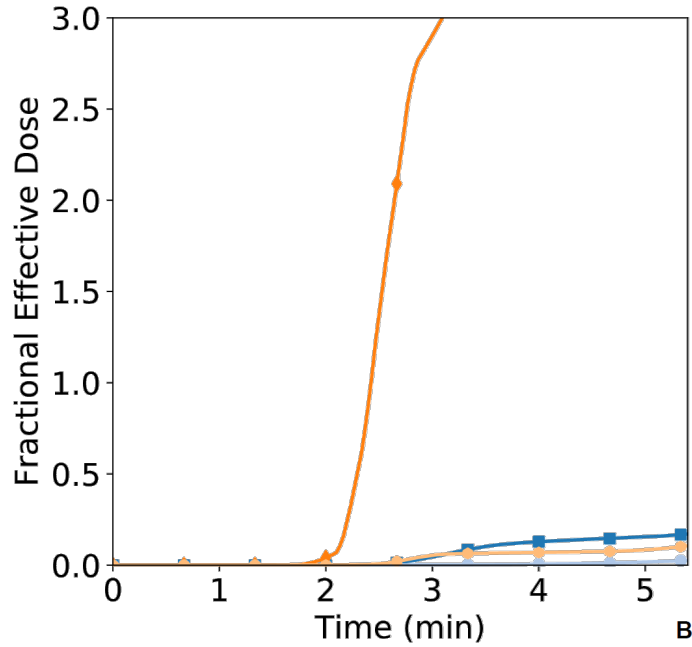
Worst case scenario

Two rooms of fire with fire showing A/C Sides

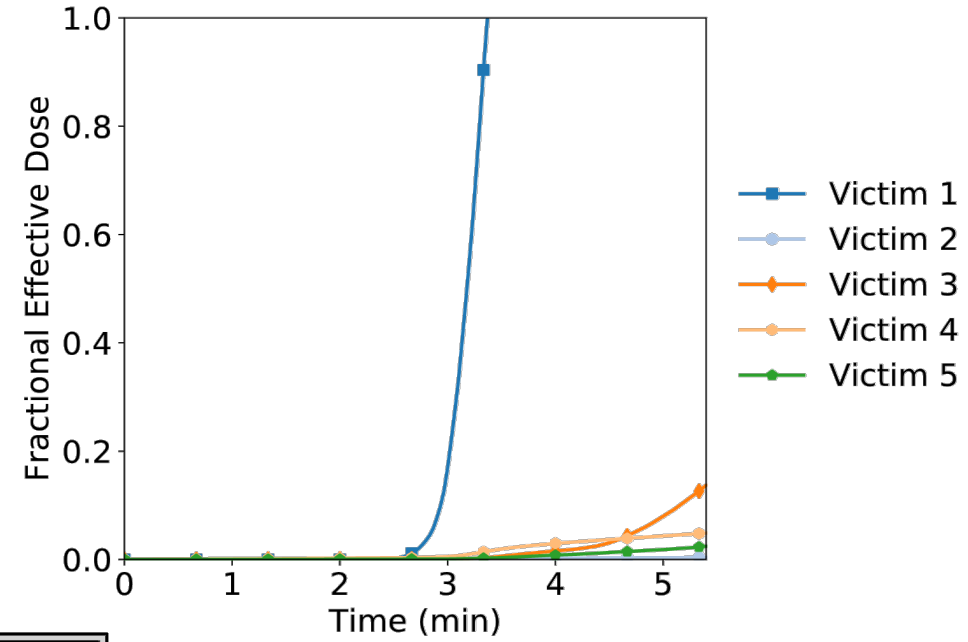
Evaluation at time of FD arrival



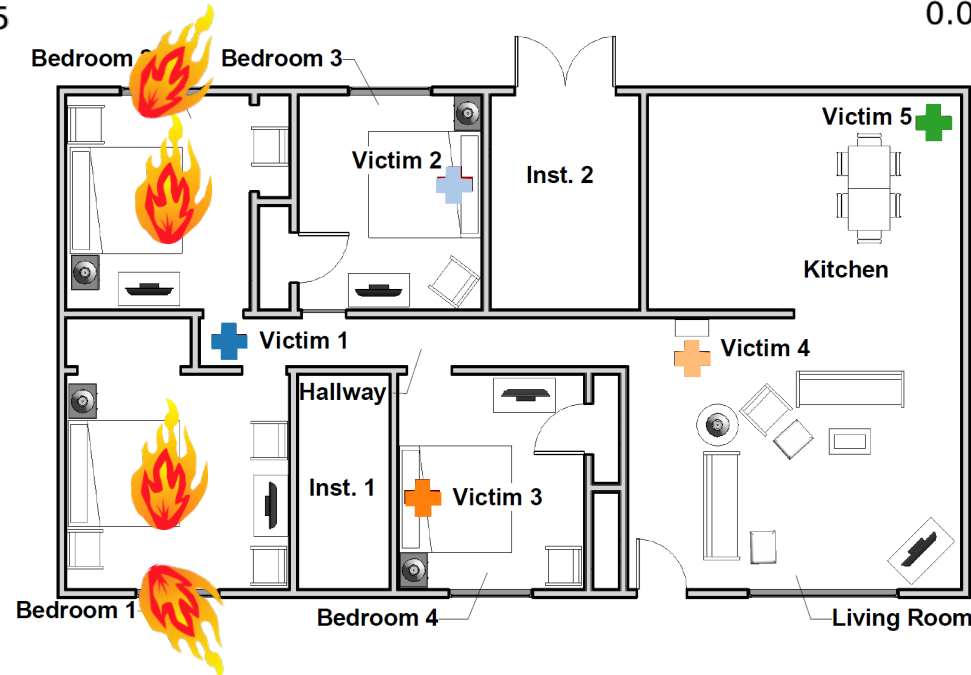
THE HAZARDS – FOR THE PUBLIC



Gas Concentration



Total Energy Flux



THE HAZARDS – FOR THE PUBLIC

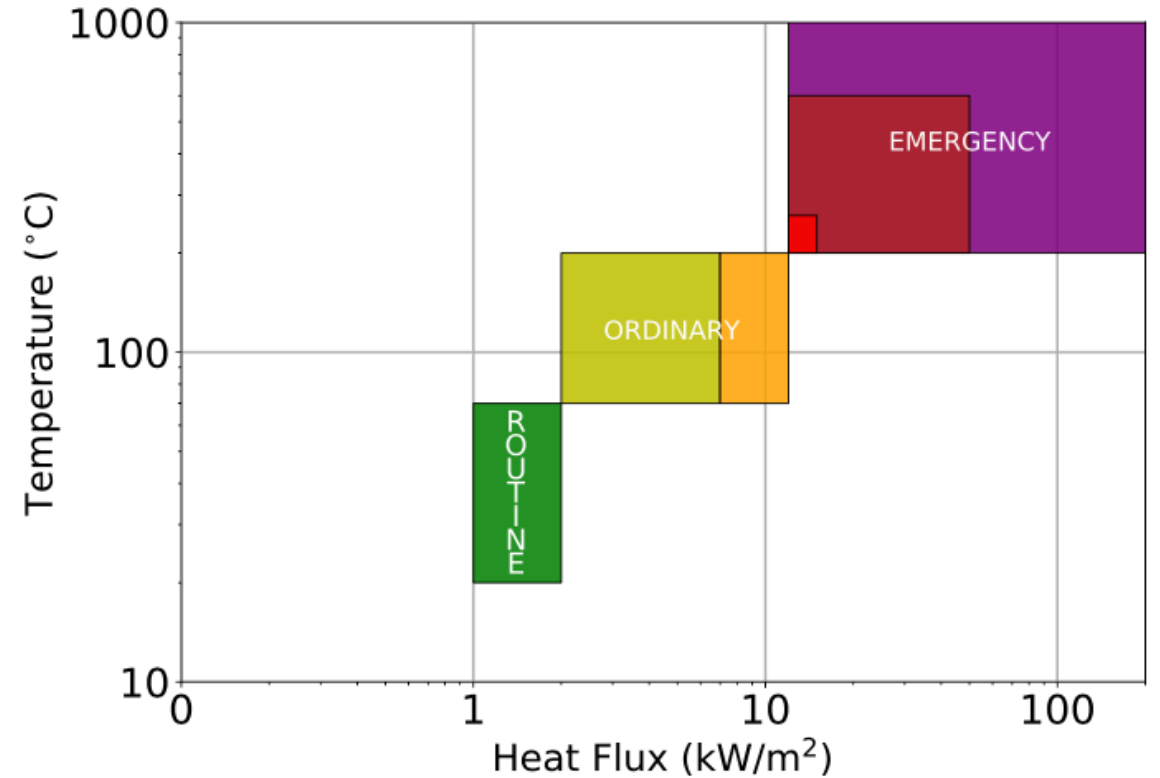
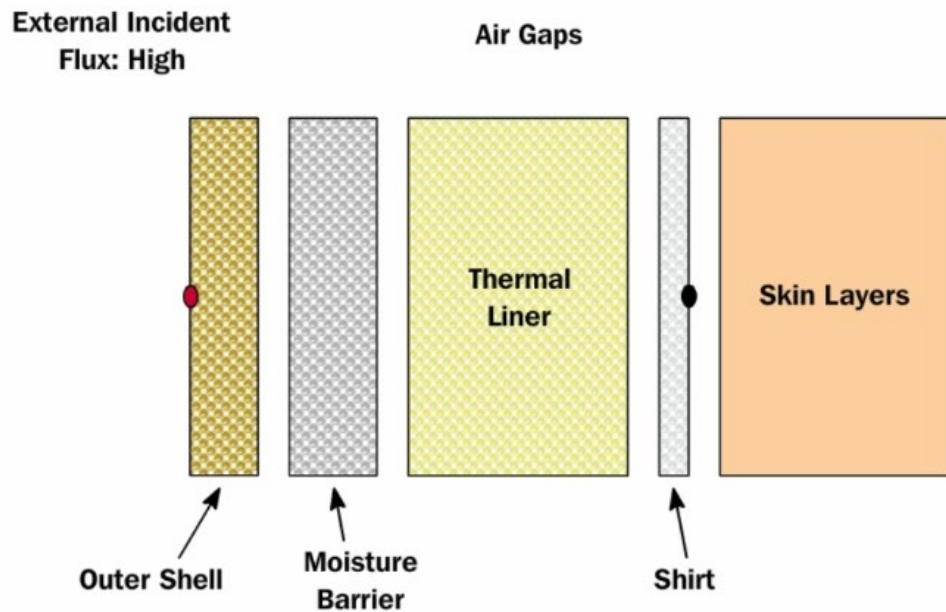
- Survivability is Dependent on Occupant **Proximity** and **Elevation**
- Exposure to Toxic Gases is Dose and Time Dependent
- Overall Exposure is Cumulative (Toxic & Thermal)
- Visually determining survivability from the exterior is difficult

Our tactical choices matter and we must search the building!



THE HAZARDS – FOR US

- Better PPE/SCBA Lead to False Safety Factor
- Lack of Understanding PPE Limitations



Operating Class	Temperature Range [°C]	Heat Flux Range [kW/m ²]
Routine	20 – 72	1 – 2
Ordinary I	72 – 200	2 – 7
Ordinary II	72 – 200	7 – 12
Emergency I	200 – 260	12 – 15
Emergency II	260 – 600	15 – 50
Emergency III	> 600	> 50

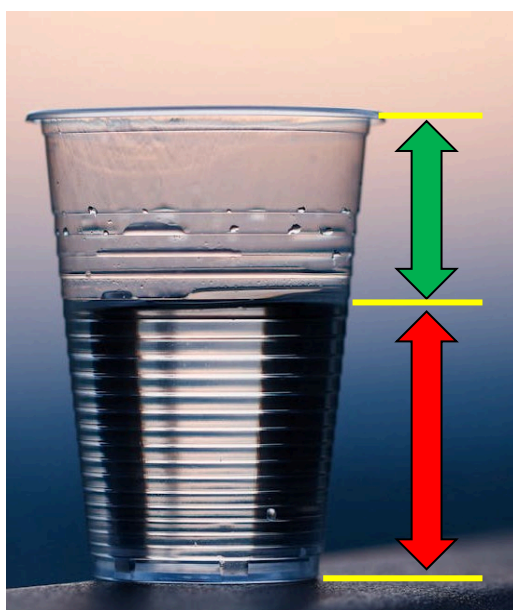
THE HAZARDS – FOR US

'BAG IT' Acronym

Where Have You Been?

Where Are You At?

Where Do You Need To Go?



THE HAZARDS – OUTSIDE IN FIRES



Side 'A' – Missing Cues

Side 'C' – Full Picture



THE HAZARDS – NEW TECHNOLOGY





Intentional E-Scooter Overcharge: Living Room

Overcharge Time:
01:38:26

Living Room Low



Entry



Living Room High



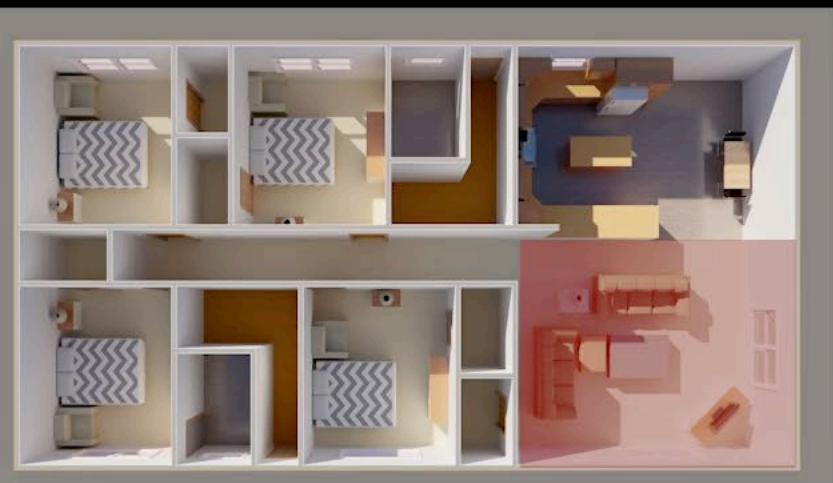
Hallway



Living Room Infrared



Living Room Windows



Living Room

THE HAZARDS – FLOOR CONSTRUCTION



THE HAZARDS – FLOOR CONSTRUCTION



THE HAZARDS – FLOOR CONSTRUCTION



COMPARTMENT FIRE BEHAVIOR

WHAT IS A FIRE?



A fire is an exothermic chemical reaction (rapid oxidation – gas phase) that emits heat and light of varying intensities

FIRE DYNAMICS



- How fires start, develop, and spread
- More detailed: it is study of how chemistry, fire science, material science, and the engineering disciplines of fluid mechanics and heat transfer interact to influence fire behavior.



TEMPERATURE

A measure of the molecular activity of a material compared to a reference point.

Temperature °C (°F)

37 °C (98.6 °F)

44 °C (111 °F)

48 °C (118 °F)

55 °C (131 °F)

62 °C (140 °F)

72 °C (162 °F)

100 °C (212 °F)

140 °C (284 °F)

230 °C (446 °F)

250 °C (482 °F)

>300 °C (>572 °F)

>600 °C (>1112 °F)

Response

Normal human oral/body temperature

Human skin begins to feel pain

Human skin receives a first degree burn injury

Human skin receives a second degree burn injury

A phase where burned human tissue becomes numb

Human skin is instantly destroyed

Water boils and produces steam

Glass transition temperature of polycarbonate

Melting temperature of polycarbonate

Charring of natural cotton begins

Charring of modern protective clothing fabrics begins

Temperatures inside a post-flashover room fire



HEAT RELEASE RATE

The speed at which thermal energy is produced by combustion. I.E., the amount of heat energy released per unit time (fire's power)



The heat release rate of an object or room is important to understanding how the energy released from that item would change the thermal conditions in a room or how it might ignite other nearby fuels via heat transfer.



SMOKE

The airborne solid and liquid particulates and gases evolved when a material undergoes pyrolysis or combustion, together with the quantity of air that is entrained.

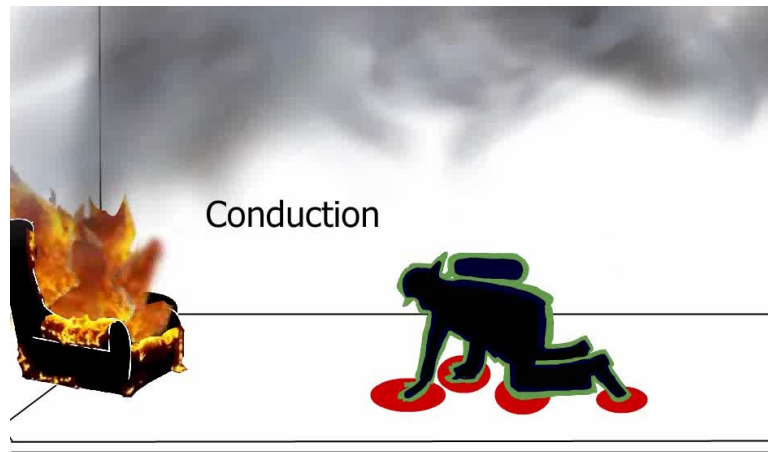
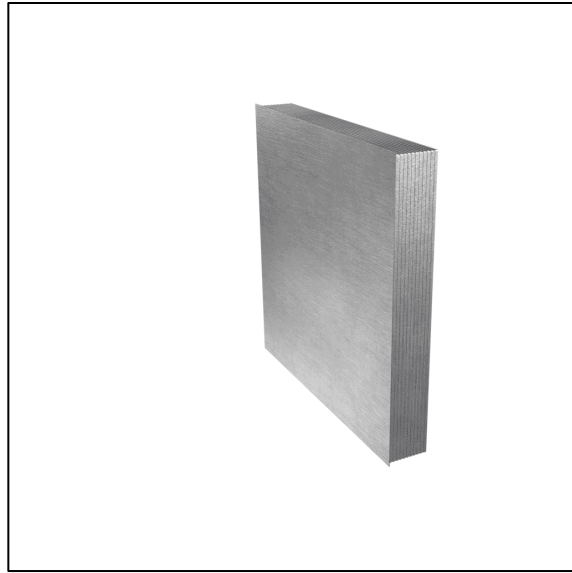
Remember, in that smoke is unburned fuel gas. In other words, **smoke = fuel!**

HEAT TRANSFER

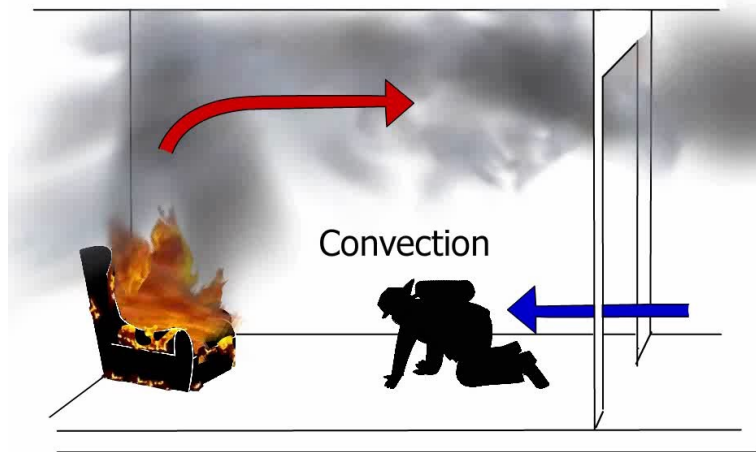
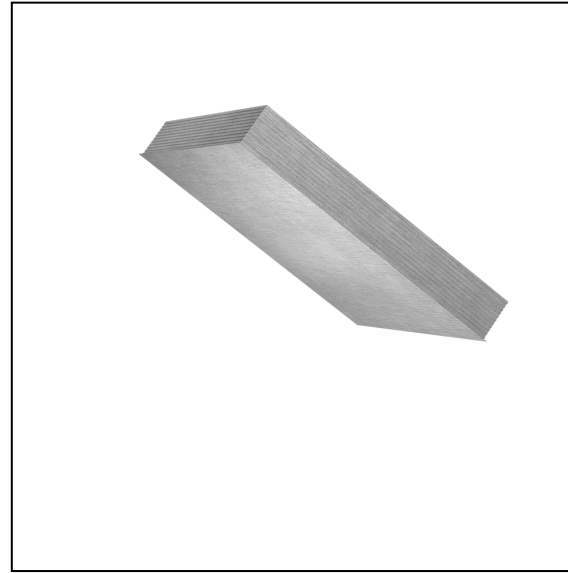
- Major factor in the ignition, growth, spread, decay, and extinction of a fire.
- Heat energy transferred to an object increases the object's temperature.
- Heat energy transferred from an object decreases the object's temperature.
- Heat is always transferred from the hotter object to the colder object.



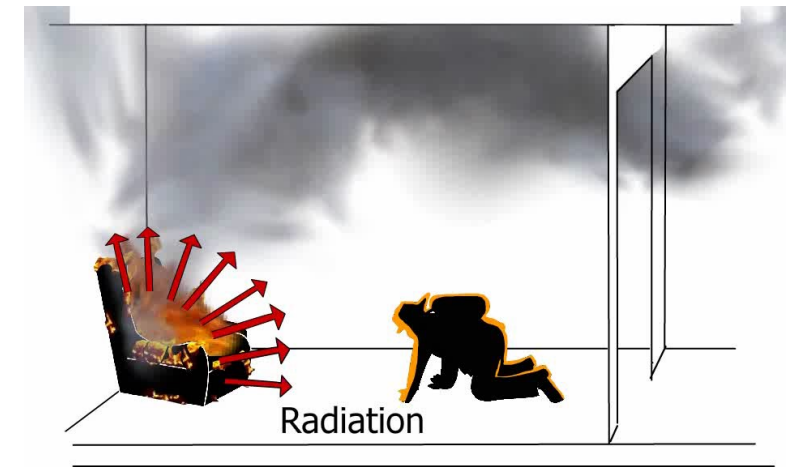
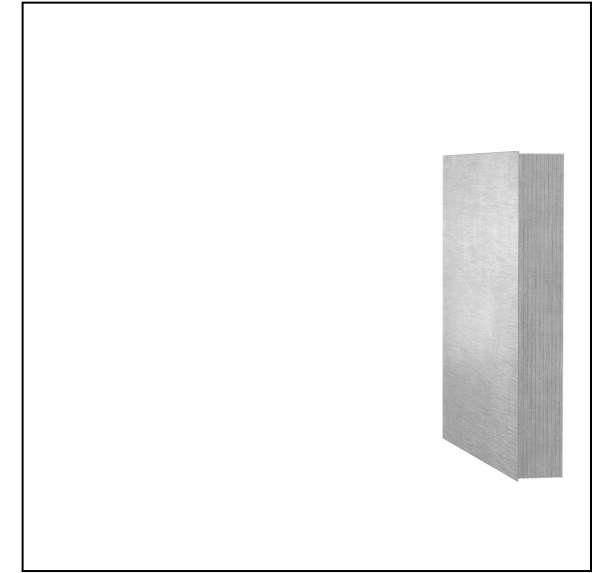
CONDUCTION



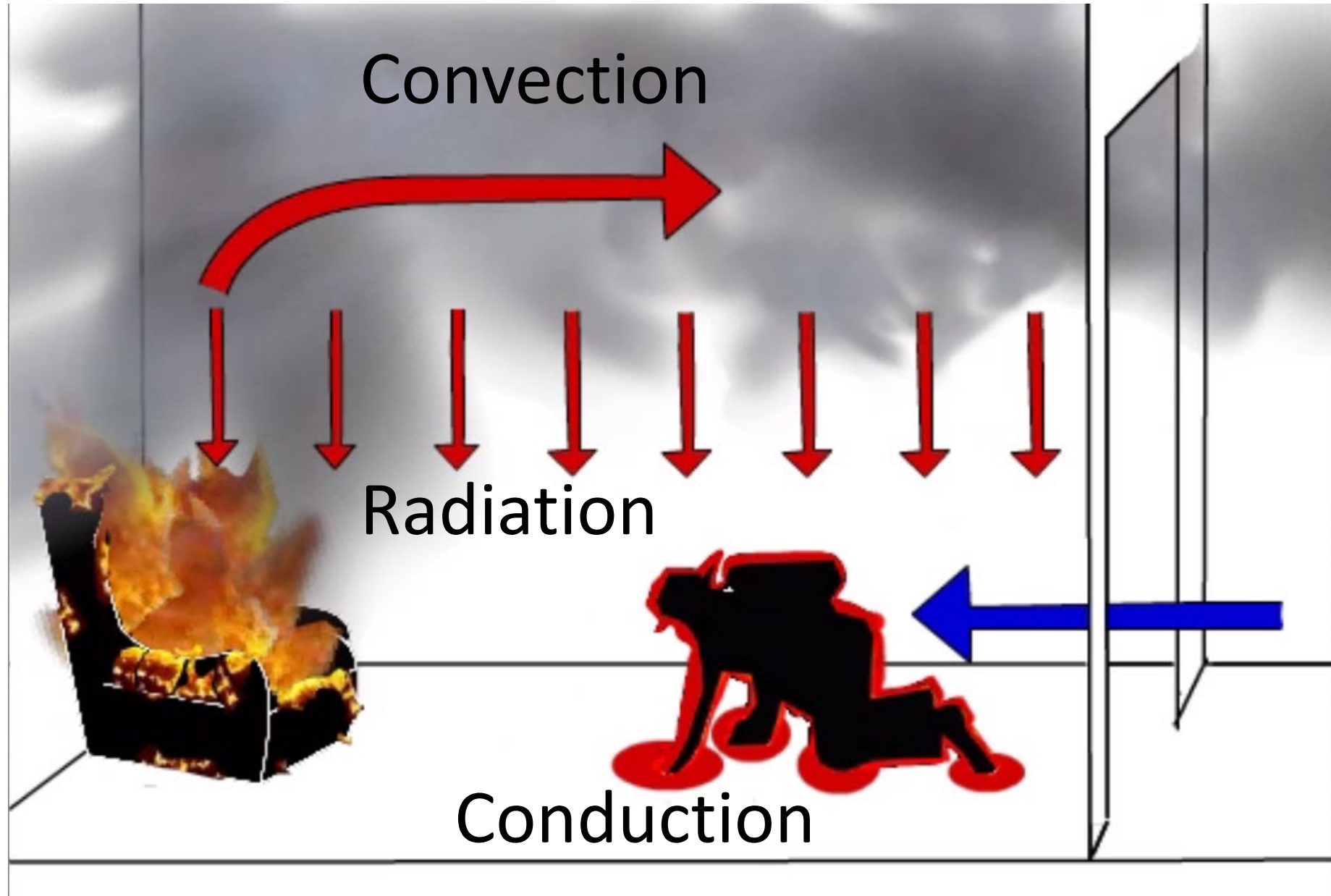
CONVECTION



RADIATION



HEAT TRANSFER MECHANISMS ON THE FIRE GROUND



COMPARTMENT FIRES

Fire growth in a compartment is a function of:

- fuel properties
- fuel quantity
- ventilation (natural or mechanical)
- compartment geometry - volume and ceiling height
- location of fire
- ambient conditions (wind, temperature and humidity)
- time

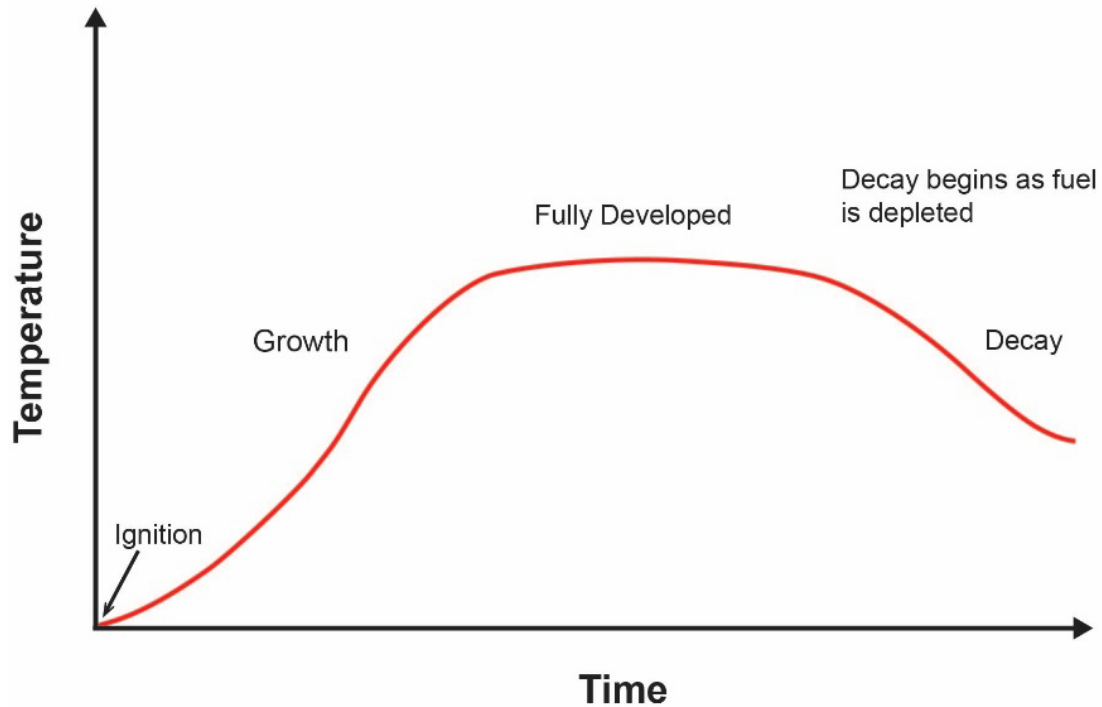


COMPARTMENT FIRES

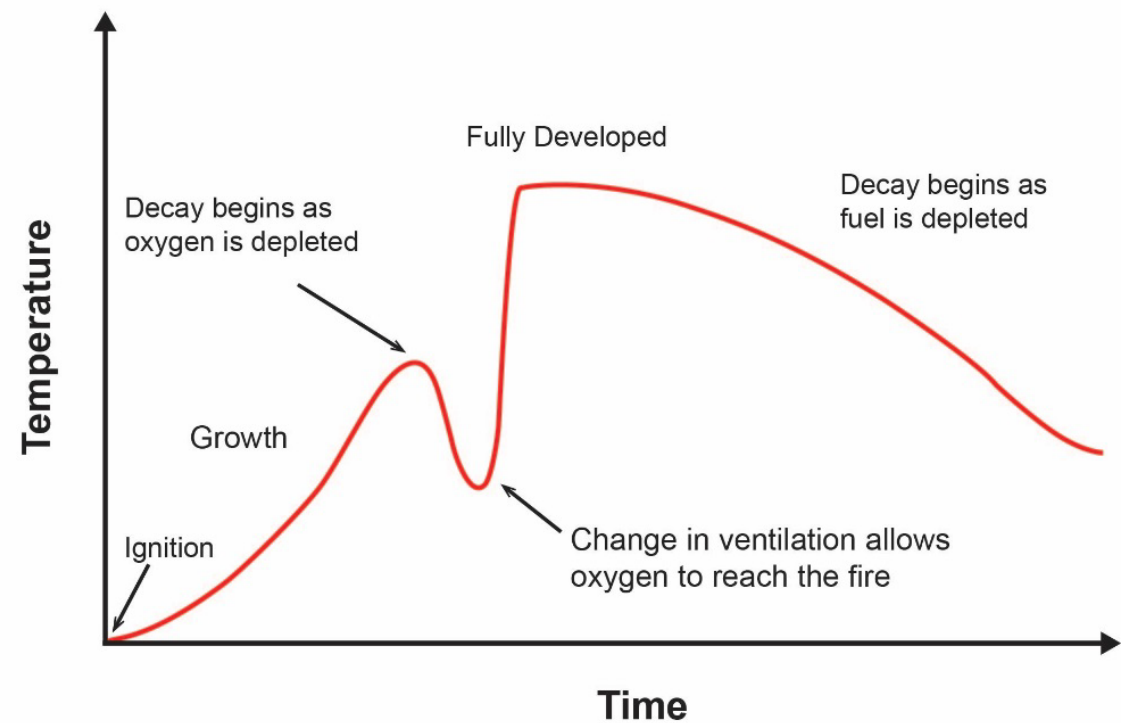


FIRE DYNAMICS IN A STRUCTURE

Ideal Fuel Controlled Model



Ideal Ventilation Controlled Model





Comparison of Home Furnishings



Natural Room



Synthetic Room



 00:00

FLASHOVER

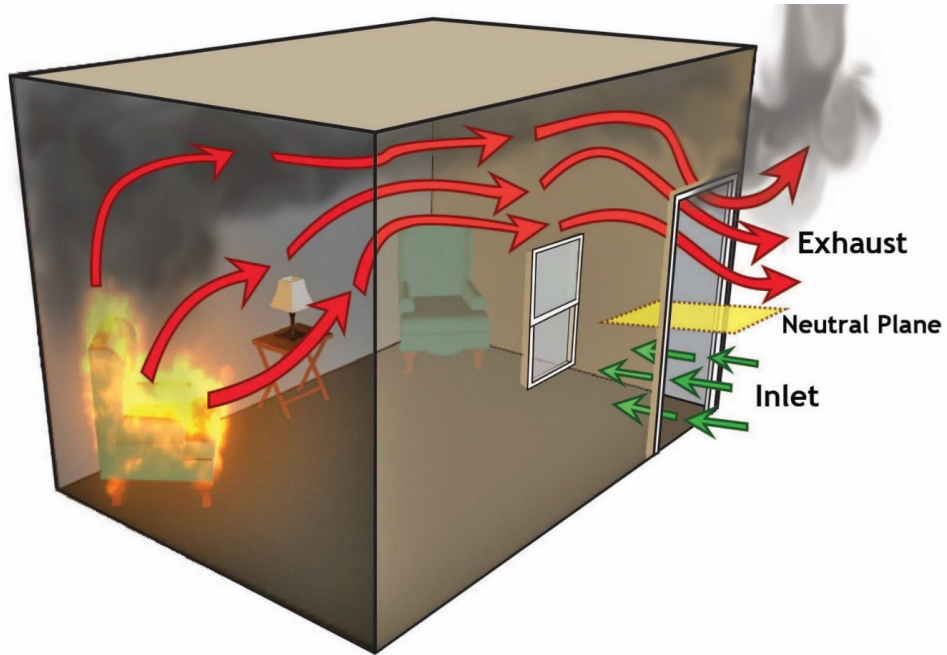
The transition phase in the development of a contained fire in which surfaces exposed to the thermal radiation, from fire gases in excess of 1100° F, reach ignition temperature simultaneously and fire spreads rapidly through the space.



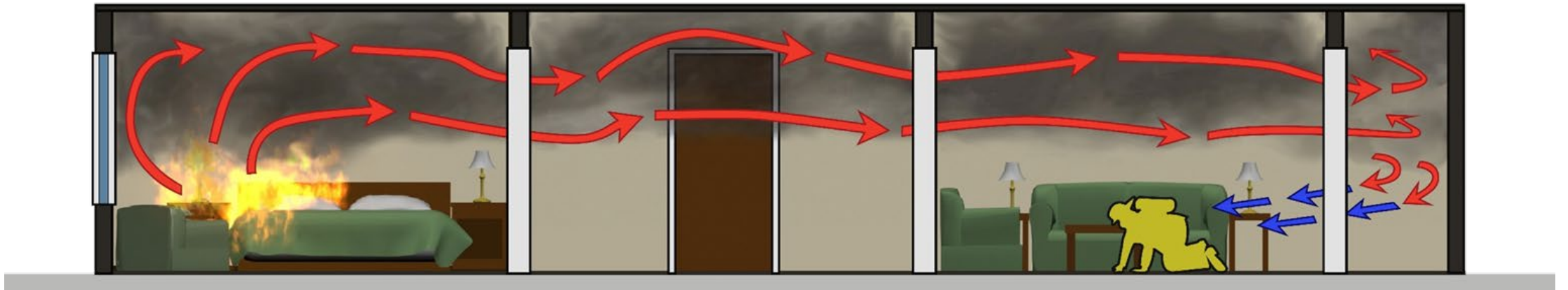
VENTING A VENTILATION-LIMITED FIRE



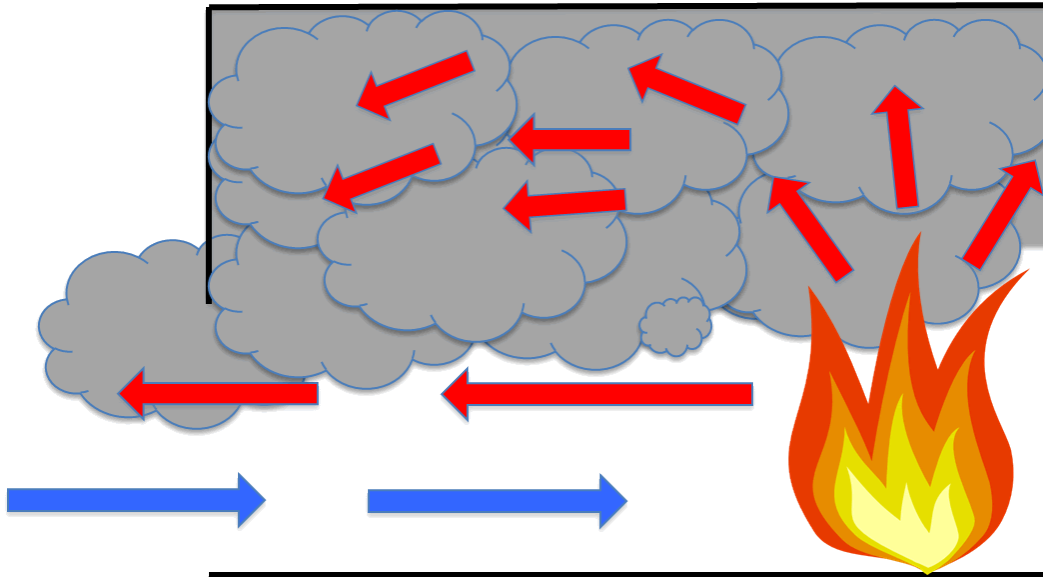
WHAT IS A FLOW PATH?



- The flow path is the volume between an inlet and an outlet that allows the movement of heat and smoke from the higher pressure within the fire area towards the lower pressure areas accessible via doors and window openings.
- A fire receives its oxygen through one or more flow paths.



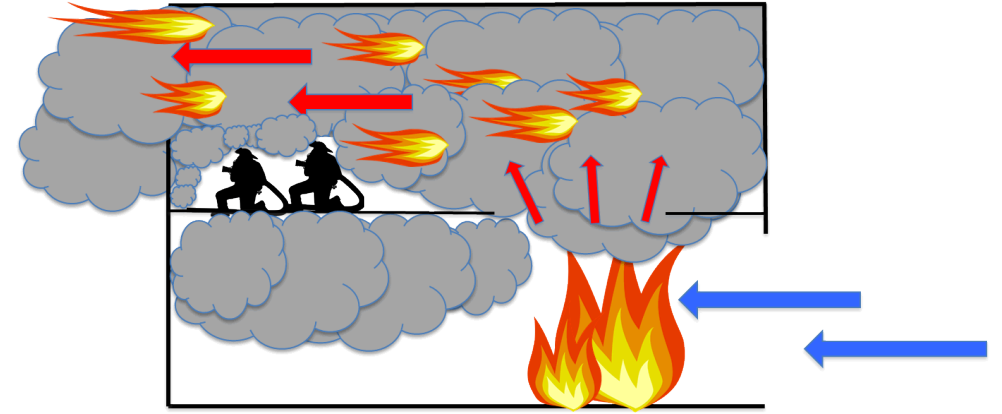
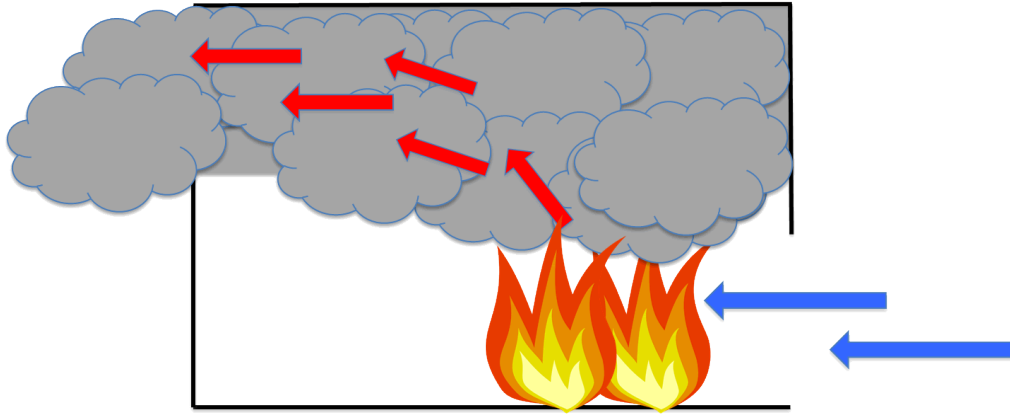
VENTILATION OPENINGS: BI-DIRECTIONAL



- Thermal buoyant (less dense) gases rising and following path of least resistance out of the compartment
- Replacement air (relatively cooler/more dense) coming in that same opening to replace the mass of combustion products leaving the compartment



VENTILATION OPENINGS: UNI-DIRECTIONAL



- Thermal buoyant (less dense) gases rising and following path of least resistance out of the compartment (i.e. higher exhaust outlet)
- Pressure generated by the fire condition
- Wind
- Positive pressure ventilation



NEUTRAL PLANES

The interface at a vent, such as a doorway or a window opening, between the hot gas flowing out of a fire compartment and the cool air flowing into the compartment.



FIRE GROUND SIZE-UP

FIRE GROUND SIZE-UP

The Structure, The Fire & Our Response

Perform a 360 Walk Around Whenever Possible

Communicate Findings

Assume All Structure Fires Are Ventilation Limited

Nothing Showing Means Nothing

Attack Method Comes After Initial Size-Up

Attempt Entry on Lowest Level of Fire Conditions

Keep the Wind At Your Back

It Doesn't Stop At the Threshold!

Continual Evaluation of Tactics and Results



SIZE-UP: MAKE IT MEANINGFUL!



What Are Your Qualitative Descriptors?



SIZE-UP: WHAT DO YOUR VENTS TELL YOU?



Pre-Vent On 2nd Floor



Post-Vent On 2nd Floor



SIZE-UP: STABILITY ON THE FLOOR ABOVE



SIZE UP- LOW INTAKE, HIGH EXHAUST

A-side prior to entry



A-side after entry



SIZE-UP- LOW INTAKE, HIGH EXHAUST

C-Side before entry



C-Side during entry



ASSUME VENTILATION LIMITED



ASSUME VENTILATION LIMITED



ASSUME VENTILATION LIMITED



NOTHING SHOWING MEANS NOTHING



IMPACT OF WIND



Left View: Exterior of fire compartment with 25MPH wind present.

Right View: Thermal imaging of the public hallway. Door to the fire apartment is open.

Video shows window failure (auto-vented by fire) and IMMEDIATE change to untenable conditions in the public hallway.



RECOGNITION OF IMMINENT FLASHOVER





QUESTIONS?