Gain knowledge, cause learning will keep you alive!
Credit

* National Institute of Standards and Technology (NIST)
* Underwriters Laboratories (UL)
* The UL Firefighter Safety Research Institute (FSRI) Fire Safety Academy
* Blue Card Training Program
* *The “relentless pursuit of knowledge”* by Firefighters
The system we use must match the work we perform:

- **Atmosphere**
  - IDLH
- **PPE Rating**
  - 35 +
- **Resp. Protection**
  - SCBA
- **Op Period**
  - 12-14 minutes
- **Op Area**
  - Hot Zone/HZ

Training that matches the expectations and needs at the Tactical Task & Strategic Levels
**Standard Outcomes:**

**Major Goal - Always match:**

- **Standard Conditions**
- **To:** **Standard Actions**
- **For a:** **Standard Outcome**
What is fire?

Fire is a gas phase, exothermic chemical reaction that produces light and emits heat.

The individual elements of the fire triangle will not promote fire growth and flame development without an uninhibited chemical reaction.
Smoke is Fuel

Smoke is the product of incomplete combustion.

Smoke is an aggregate of particulates, aerosols, and gases.

Smoke will ignite at the right temperature with the right amount of oxygen.
Fuels Burn Differently

Wood

Polystyrene
The addition of oxygen facilitates combustion and increases heat.
**Heat Release Rate vs. Temperature Candles**

One Candle

![Image of one candle with flame](image1)

- Flame Temperature Is Constant
- HRR = 80 W

Ten Candles

![Image of ten candles with flames](image2)

- HRR = 800 W

*Similar items burn at the same temperature. HRR varies greatly*
Heat Release Rates of Common Items

- Match: 80 W
- Trash Can (small): 32 kW
- Upholstered Chair: 1.8 MW
- Upholstered Sofa: 2.5 MW
- Queen Size Bed: 4.3 MW
- Christmas Tree: 5.2 MW
Heat Release Rates
Three things directly impact a fuel’s heat release rate:

- Fuel density
- Fuel arrangement
- Ventilation Profile (air supply)
Fuel Density Impacts Heat Release Rate
Fuel Density Impacts Heat Release Rate

Old Growth Dimensional Lumber

New Growth Dimensional Lumber

How does density impact construction materials?
Fuel Arrangement Impacts Heat Release Rate
Ventilation Impacts Heat Release Rate

With the door open...
Temps are >1,000°F.
Fire Dynamics

Fire dynamics is the field of study that encompasses how fire starts, spreads, develops, and is extinguished.

Fire dynamics is an understanding of how chemistry, fire science, material science, and the engineering disciplines of fluid mechanics and heat transfer interact to influence fire behavior.
Heat Transfer – Radiation

Transfer of heat by way of electromagnetic energy.
Heat Transfer – Convection

Transfer of heat by circulation within a medium.

Protection from Convection?

Neutral Plane
Heat Transfer – Conduction

Protection from Conduction?

Conduction

Transfer of heat through direct contact.
Heat flux is the measure of the rate of heat transferred to a surface expressed in kW/m$^2$.

Firefighter turnout gear is designed to withstand a heat flux of 84 kW/m$^2$ for 17.5 seconds.
Heat Flux & SCBA Face Piece

Weakest Link

- Softens at $\approx 250 \, ^\circ F$
- Separates $\approx$ at $300 \, ^\circ F$
- Melts at $\approx 450 \, ^\circ F$

NIST Testing

- 15 kW/m² Radiant Heat Flux
- No flame impingement
- Failure under 5 minutes
111° F – Human skin feels pain
162° F – 3rd degree burn – skin destroyed
212° F – Water boils / trachea damaged
284° F – SCBA glass transition
446° F – Polycarbonate melts
484° F – Cotton fibers chars
572° F – Turnout gear chars
1112° F – Post flashover temp

5 kW/m² Pain to skin within seconds
20 kW/m² Considered the onset of flashover
MODERN
FIRE DYNAMICS
Houses are getting larger
1973 = 1,600 sq. ft.
2008 = 2,500 sq. ft.

Lot sizes are getting smaller
1976 = 10,100 sq. ft.
2008 = 8,800 sq. ft.

Floor plans incorporate more open concepts
Home are more energy efficient
Alternative energy sources and . . .
Fuel Loads Have Changed

**LEGACY HOME**
8-10,000 BTU / # of natural fuels

**MODERN HOME**
18 – 20,000 BTU / # of synthetic fuels

*Fuel loads have doubled in size and contain more hydrocarbons!*
Legacy Fire vs. Modern Fire

Modern home fires reach flashover 8X faster than legacy fires.

Significant reduction in discretionary time (Decision Making)
Our New Reality

Rate of firefighter deaths due to traumatic injuries is increasing

Late 1970s = 1.8 deaths per 100,000 working fires
Late 2000s = 3.0 deaths per 100,000 working fires

Increase of 67%

The annual number of structure fires is decreasing

Decrease of 53%

The number of Line-of-Duty-Deaths remains constant

≈ 100 LODDs per year
Addressing the New Reality

The challenge facing the American Fire Service is one of balance.

Training and education bring balance to the equation and improves Recognition Prime Decision Making
Fuel Controlled Fire
Ventilation Controlled Fire
The majority of today’s fires are ventilation limited.
The majority of today’s fires are ventilation limited.
Opening a Door

Opening a door or a window is A VENTILATION TACTIC.

Creates a flow path.

Provides more oxygen to the fire.

Controlling the door after forcing entry limits the oxygen supply and slows the fire progression until a coordinated fire attack is ready.
Door Control

Not just for suppression

Temporary Action
Door Control

![Graph showing temperature changes over time with labels 'Door Open' and 'Door Controlled']
No Door Control

Engine company on location

Opens the front door

Remove glass from window

Position hoseline for fire attack

Improve Situational Awareness:
Watch conditions change with induction of more oxygen?
Ventilation & Fire Behavior

The fire service is well trained in the art of cutting holes and forcing entry. The impact these actions have on modern fire dynamics is often misunderstood.

Vertical Ventilation

Forcible Entry
Exterior Water Application
The **NUMBER 1 Priority** of any offensive situation is: put water on the fire as quickly and as safely as possible. **Put the fire out!**
Putting water on the fire (quickly):

- Makes it safer/better for the occupant(s)
- Makes it safer/better for the buildings structural elements
- Makes it safer/better for the firefighters
“As safely as possible” - is defined as: The further away from the fire you are in order to control/extinguish it, the safer you are.

This applies to interior operations as well!
Goals of Attack Positioning:

- Quickest water
- Same level as the fire,
- Weather/wind at your back,
- Don’t position between the fire and its travel path,
- Ability to isolate entry crews from flow path.

Don’t let the closest door dictate attack position.
Quickest Water May Be From Exterior Position

Reduces Heat Release Rate

Reduces surface temperatures and slows pyrolysis

Displaces flames from fuel surfaces

Steam production absorbs energy

Does NOT replace the need for an aggressive interior attack!
As water converts to steam, hot gases are cooled and contract.

Still (relatively)
Straight Stream
Steep Angle
Do Not Block Vent
Flow Path Control and Isolation

When you open a door or window, you are connecting the pathway from the compartment of the structure (high pressure due to fire) with the lower pressure on the exterior of the compartment.
Door control must be provided for entry crews whenever necessary
Get Water on the fire ASAP
During Interior Attack
Additional Resources

National Fire Research Laboratory
https://www.nist.gov/el/fire-research-division-73300/national-fire-research-laboratory-73306/videos

UL Firefighter Safety Research