Riadenie dymu/ Smoke Management

Smoke as a Part of Fire Literacy

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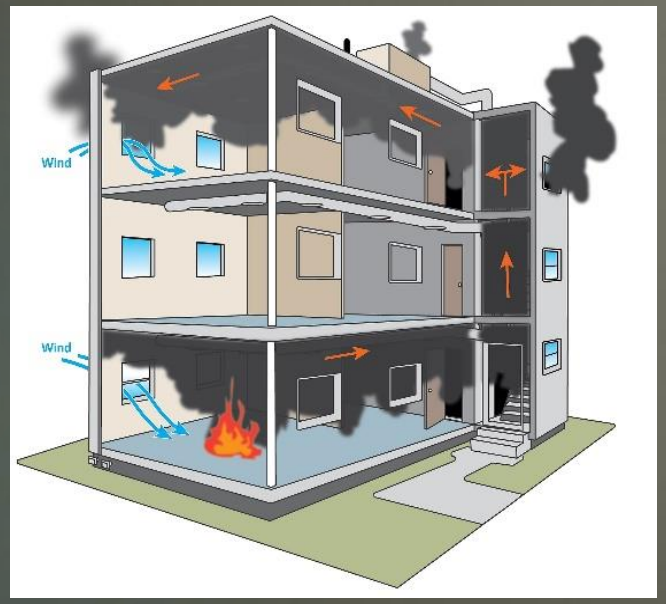
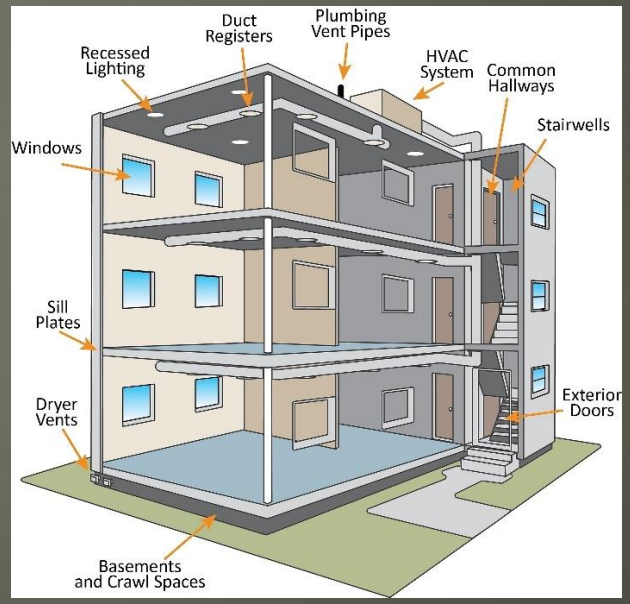
VP = BE + SAHF

- Fire Dynamics Size-Up Model
- Ventilation Profile = Building + Environment + Smoke, Air, Heat, Flame



Ventilation Profile – Fire Conditions and



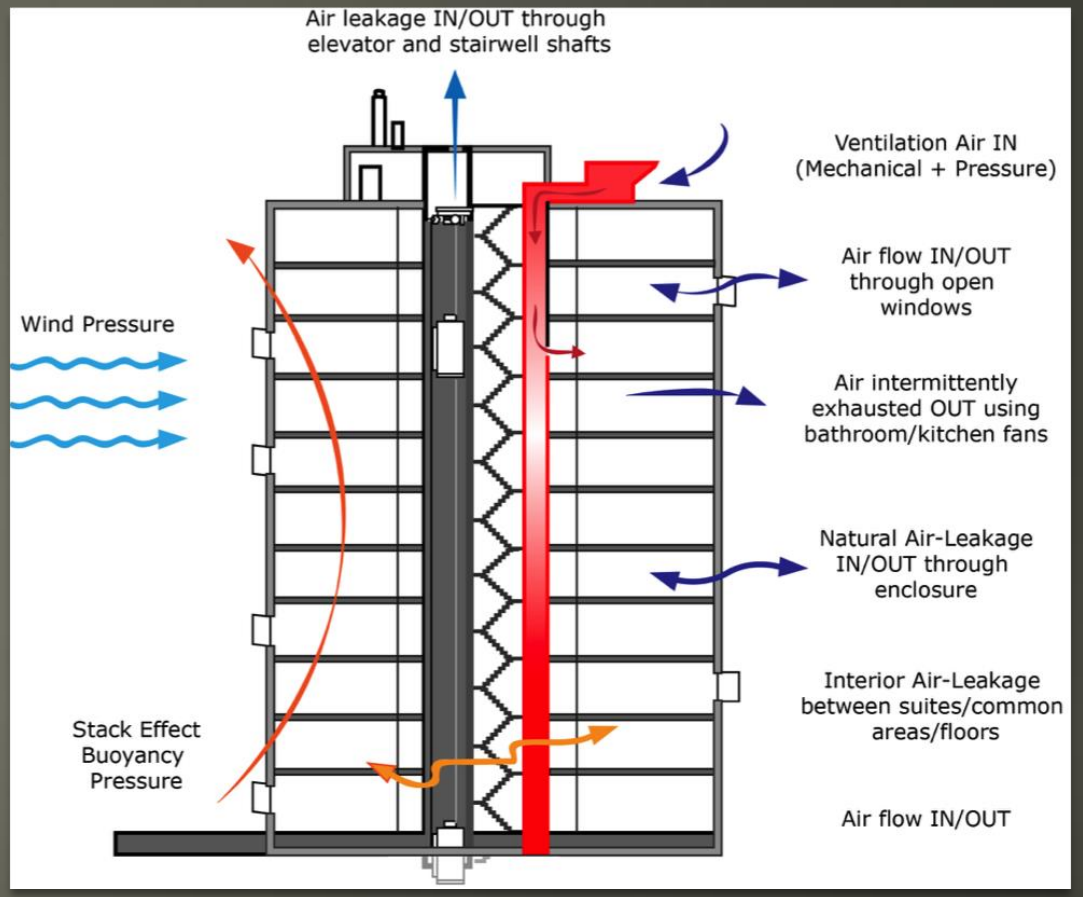
no Fire Conditions

VP = BE + SAHF

- Provides a common language for fire behavior assessment
- Links fire dynamics theory to operational decision-making
- Used as a real-time size-up and training model

Ventilation Profile

- = the appearance of all ventilation openings in the entire building
- Shows air intake paths and exhaust paths of smoke, heat, and flame
- Critical for predicting fire development and flow paths

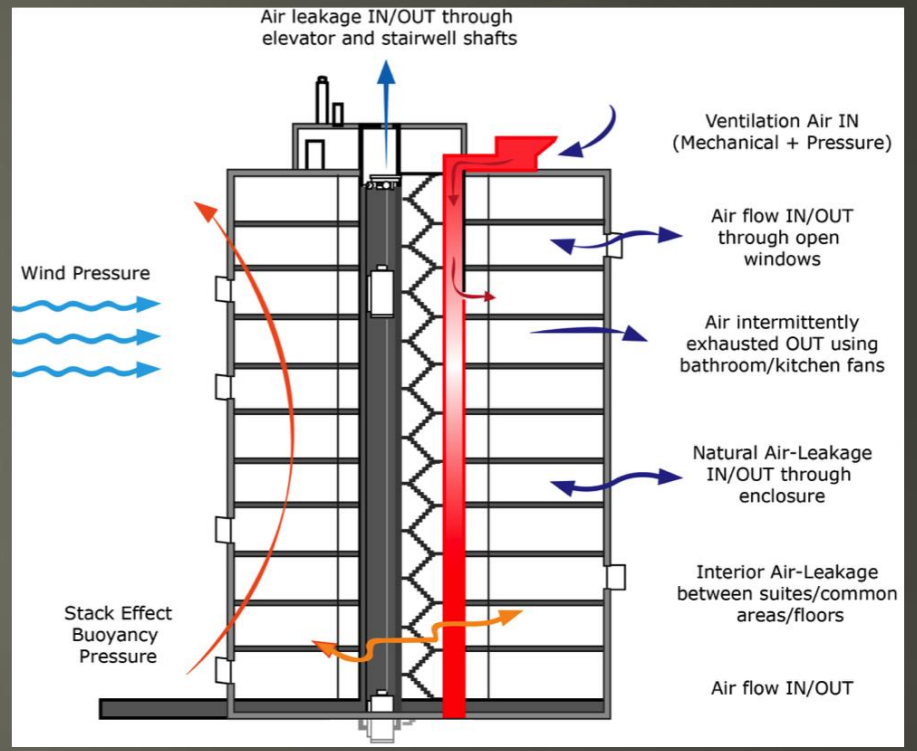


Planned Ventilation Openings

- Doors, windows, stairwells, shafts, HVAC systems
- Designed airflow can significantly change fire behavior once fire occurs
- Reference: Fig. 1–2

Unplanned Ventilation Openings

- Leakage in the building envelope
- Fire-damaged or failed construction elements
- Uncontrolled openings increase risk of RFD



Ventilation profile - high-rise under normal conditions

Flow Path – Definition

- The route air travels toward the fire and smoke/flames travel away
- Driven by pressure, buoyancy, and wind
- Fire grows faster when flow paths are uncontrolled

Building Factors (BE)

- Construction type
- Compartmentation
- Fuels
- Protective features

Principles of Construction

- Loads are transferred through compression, tension, and shear
- Fire weakens structural members and connections
- Collapse potential must always be evaluated

Types of Construction (NFPA)

- Type I – Fire Resistive
- Type II – Non-Combustible
- Type III – Ordinary
- Type IV – Heavy Timber
- Type V – Wood Frame

Performance-Based Design (PBD)

- Uses engineered components and calculations ("math")
- Lightweight structural elements
- High strength under normal conditions, rapid failure under fire
- Reference: Fig. 4–5

Mass vs. Math

- Legacy buildings relied on large dimensional lumber (mass)
- Modern buildings rely on optimized engineered components (math)
- Fire causes early deformation and collapse in PBD structures
- Reference: Fig. 4–5

Connections in Modern Construction

- Traditional structures: few connections per element
- Modern structures: many metal connectors and plates
- Connection failure often precedes collapse
- Reference: Fig. 6–7

Compression vs. Tension

- Traditional buildings: loads transferred mainly by compression
- Modern PBD buildings: loads transferred by tension
- Tension failures occur suddenly and without warning

Energy Conservation and Fire Behavior

- Modern buildings are tightly sealed for energy efficiency
- Fires often become ventilation-controlled
- Opening doors or windows can trigger RFD

Compartmentation – Definition

- Division of a building into fire-resisting compartments
- Limits fire spread and heat transfer
- Reduced compartmentation increases fire growth rate

Finishes and Thermal Properties

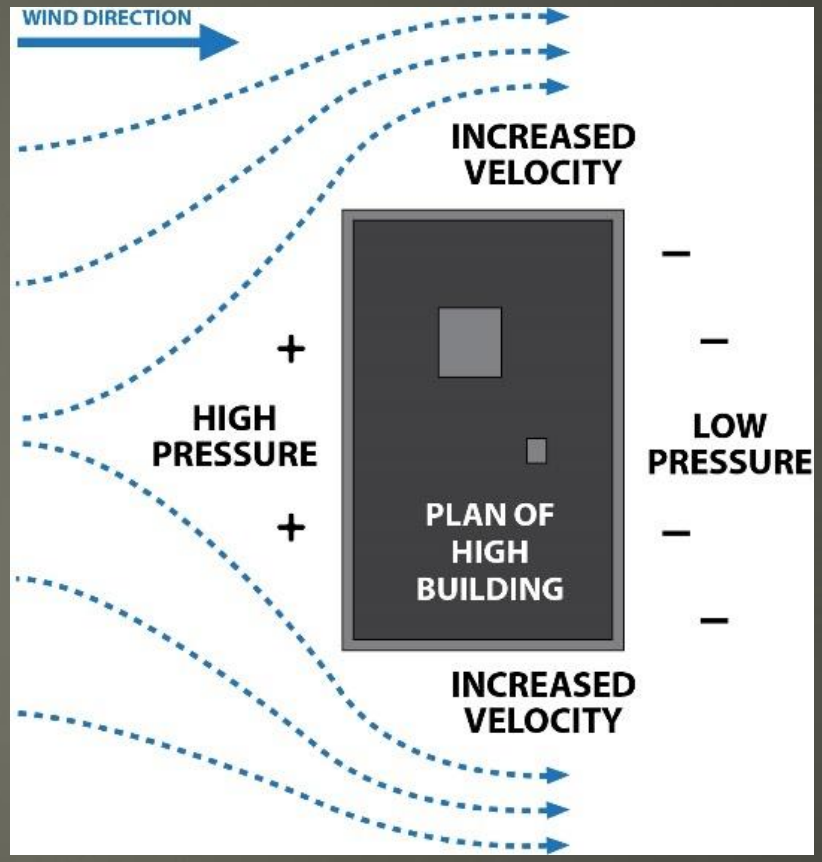
- Thermally thick materials absorb and store heat
- Thermally thin materials transfer heat rapidly
- Combustible finishes increase fuel load

Compartment Size

- Ceiling height and floor area affect fire growth
- Modern open layouts allow faster fire development
- Higher temperatures before ventilation limitation

Environmental Factors

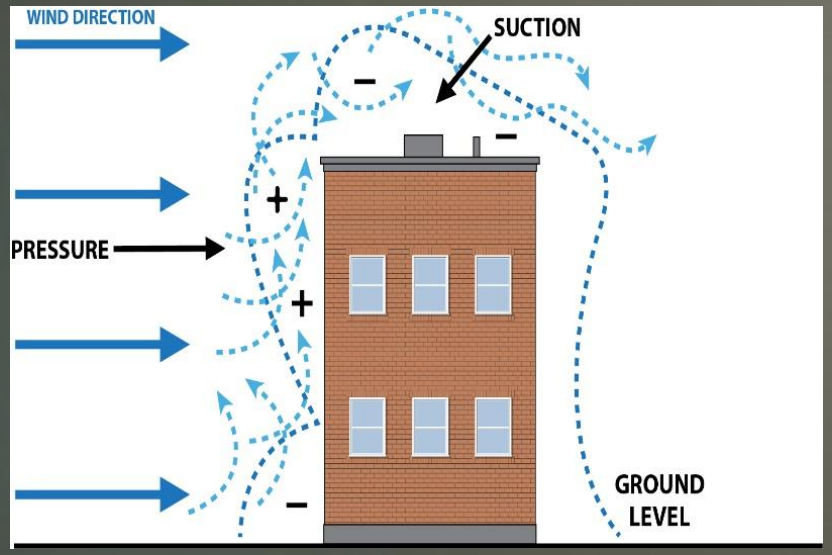
- Wind
- Temperature
- Humidity
- Topography



Wind effects on a building - plan view

Wind Effects on Fire

- Creates pressure differences across a structure
- Dominates smoke and air movement
- Can create wind-driven fires

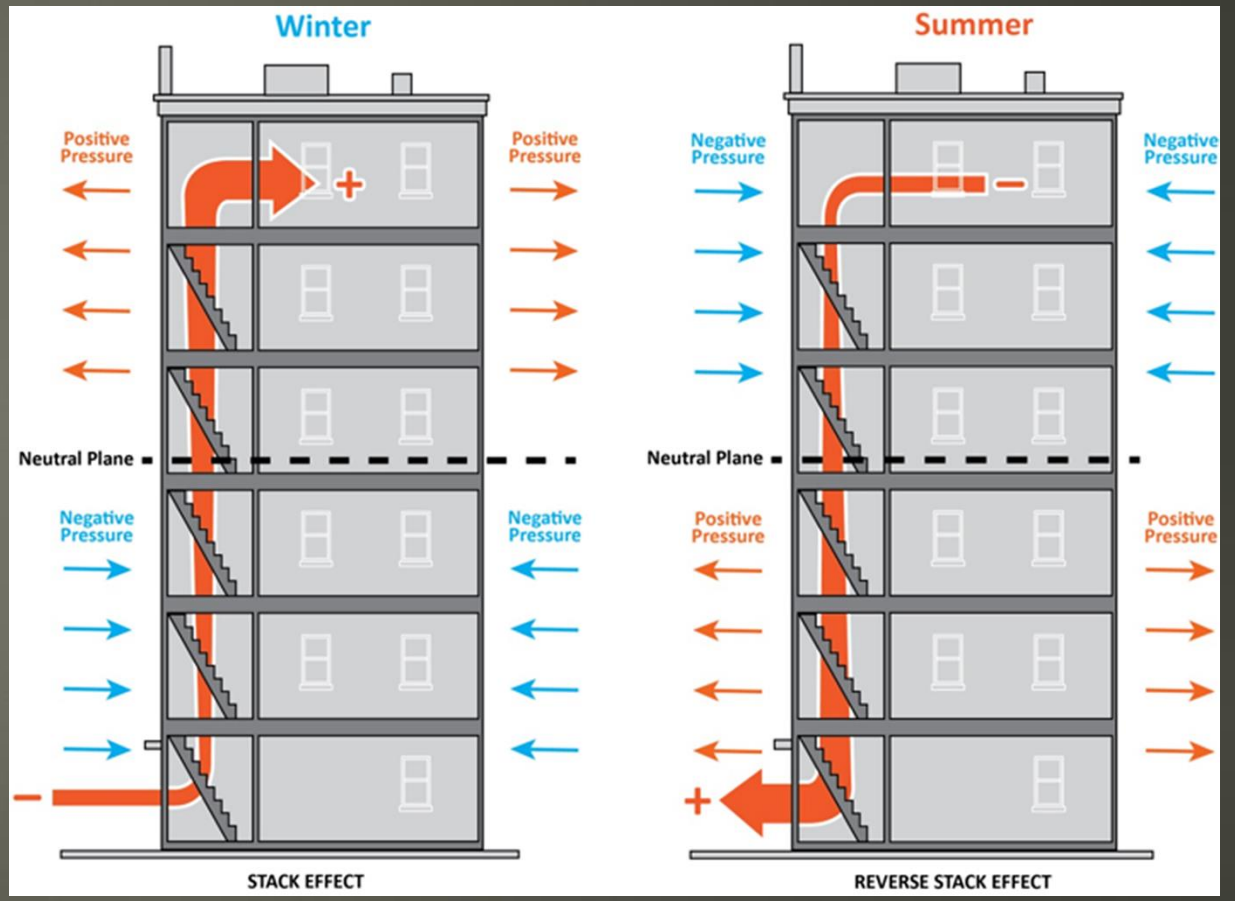


Wind effects on a building – elevation

Roof delamination from wind effects

Stack Effect

- Vertical air movement caused by temperature differences
- Common in stairwells and high-rise buildings
- Significantly affects smoke spread



Stack effect in tall buildings - seasonal variations

SAHF Indicators – Overview

- Smoke
- Air
- Heat
- Flame

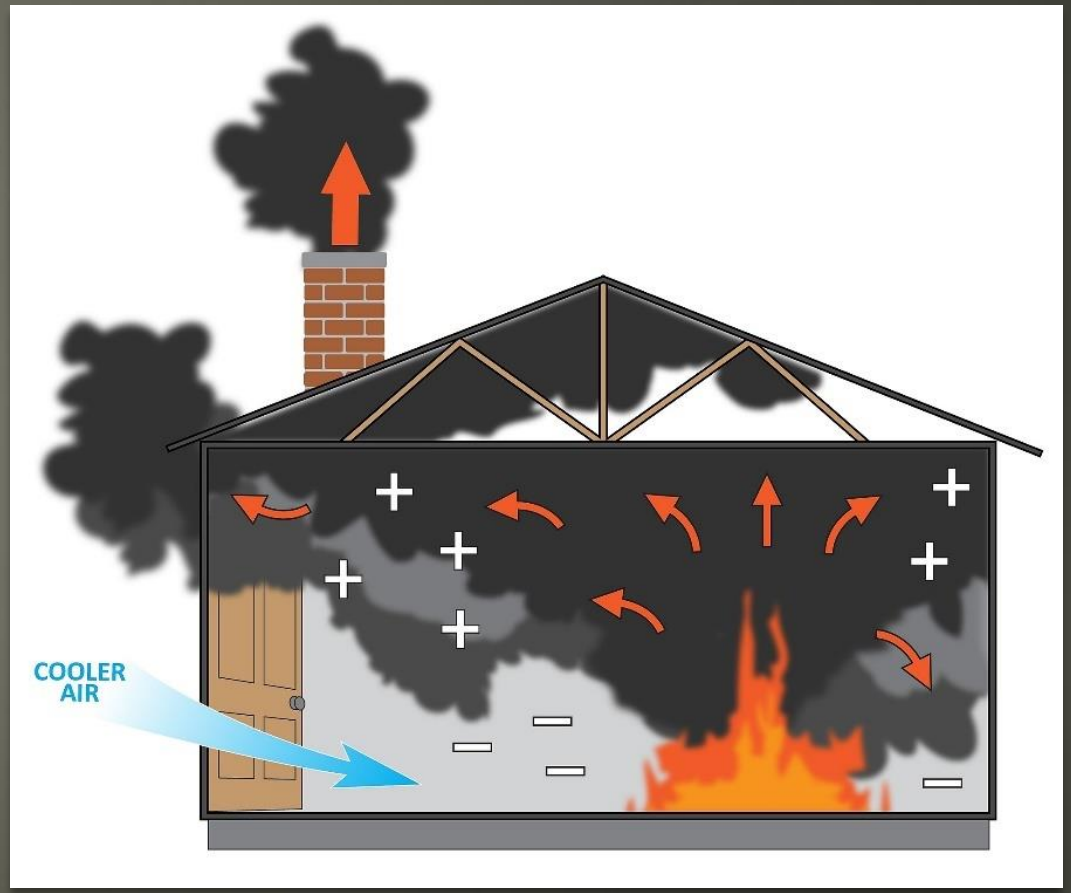
- All indicators must be evaluated together

Smoke – Definition

- Mixture of solid particles, liquid aerosols, and gases
- Contains toxic and flammable components
- Represents unburned fuel mixed with air

Smoke – Buoyancy

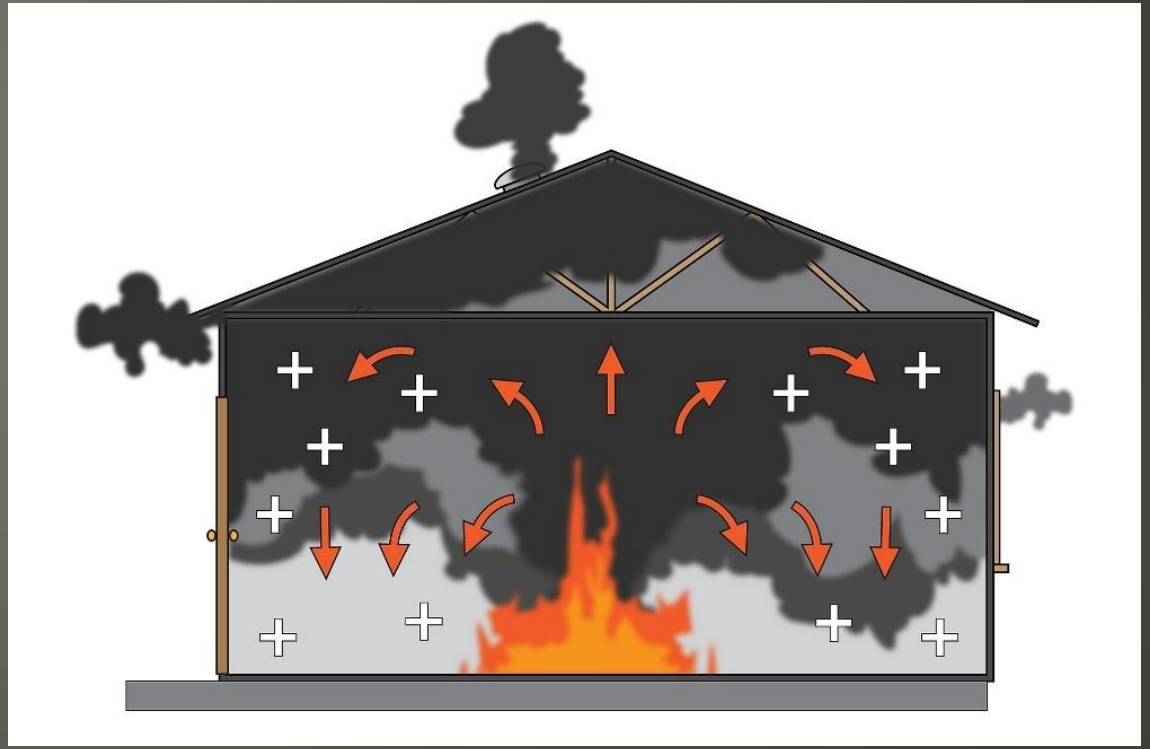
- Hot smoke is less dense and rises
- Drives vertical fire spread
- Effect decreases as smoke cools



Buoyancy of smoke

Smoke – Expansion

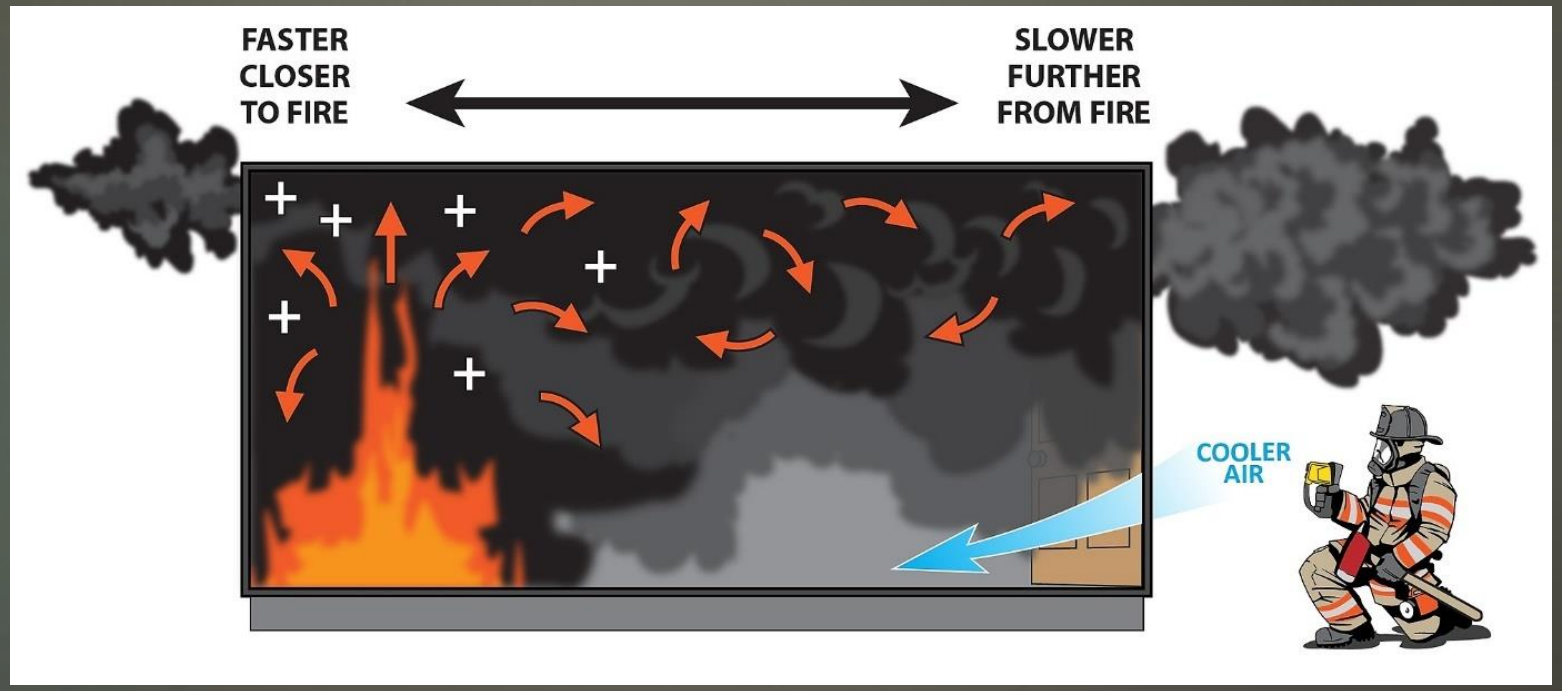
- Heating causes gases to expand
- In confined spaces, pressure increases
- Smoke is forced into uninvolved areas



Expansion of smoke

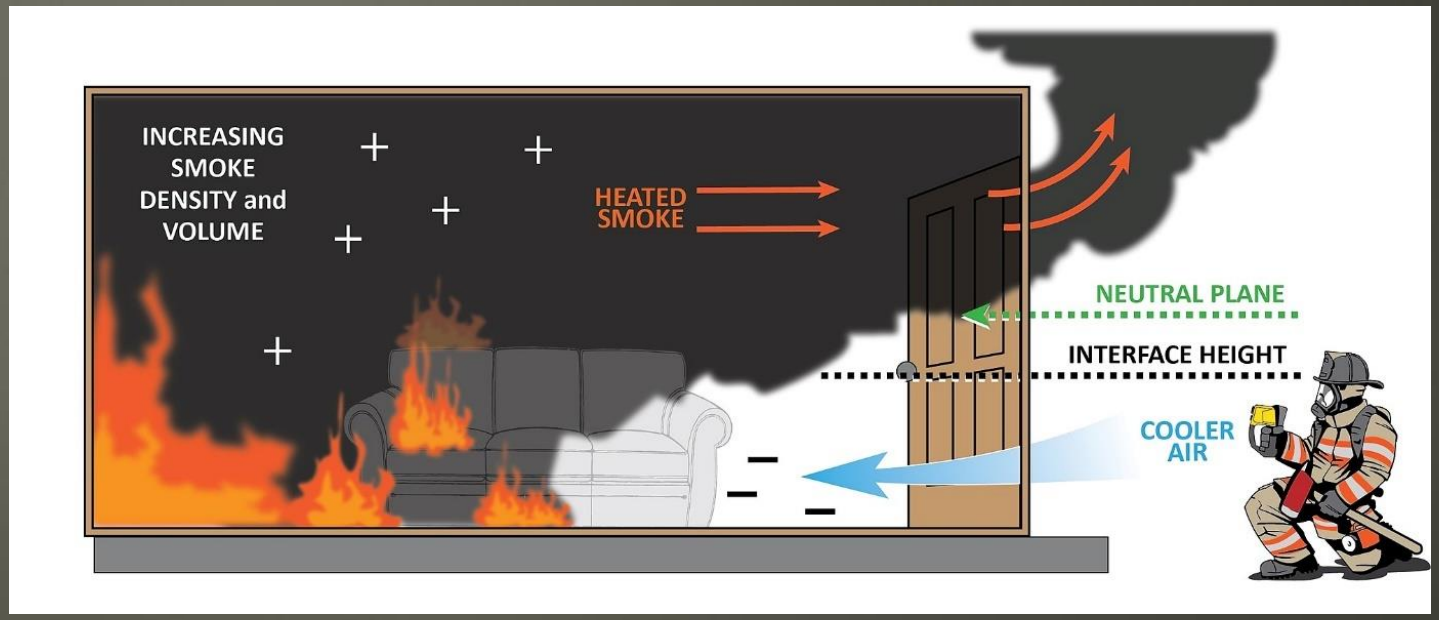
Smoke – Volume and Velocity

- Large volume may indicate fire size or confinement
- High velocity indicates high internal pressure



Interface Height and Neutral Plane

- Interface: boundary between hot smoke and cool air inside
- Neutral plane: pressure balance at openings
- Lowering layers indicate worsening conditions



Smoke Colour – Interpretation

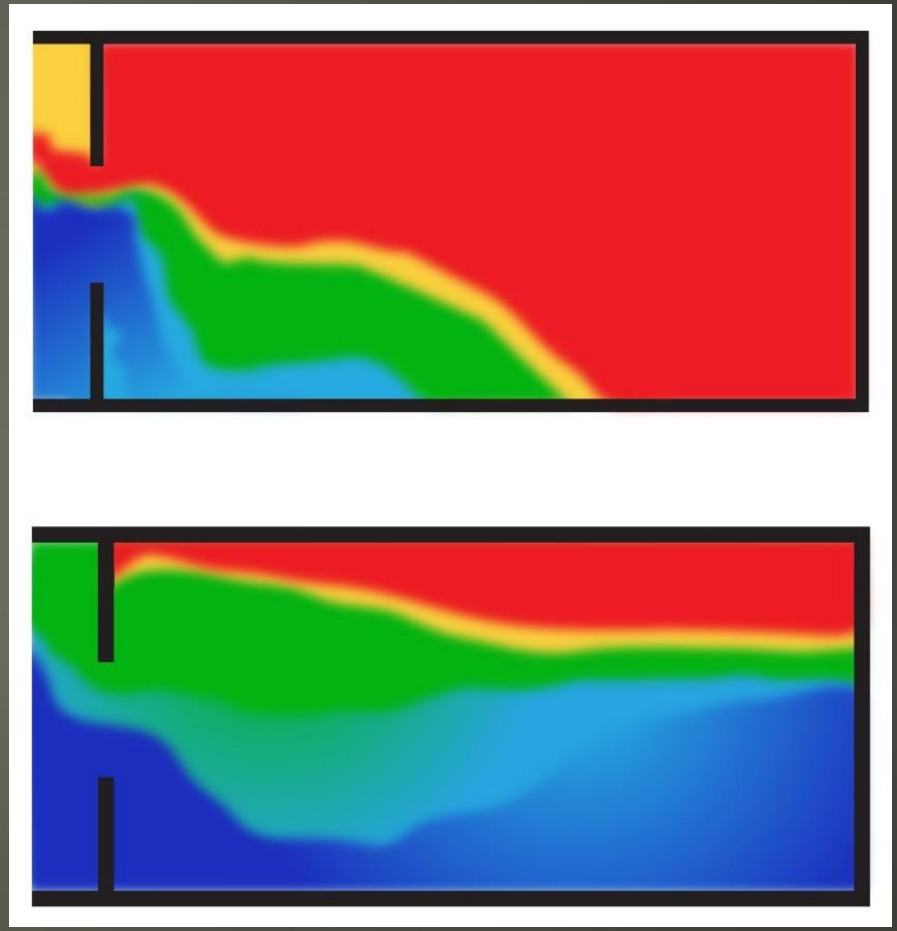
- Black: fuel-rich, ventilation-limited
- Brown: wood pyrolysis
- Grey: mixed combustion
- White: high-energy unburned gases

Air Indicator

- Invisible but critical to fire growth
- Observed through smoke movement
- Doors and windows supply oxygen to the fire

Gravity Current

- Cool air flows in low, hot smoke flows out high
- Creates pre-mixed combustible zones
- Major factor in RFD



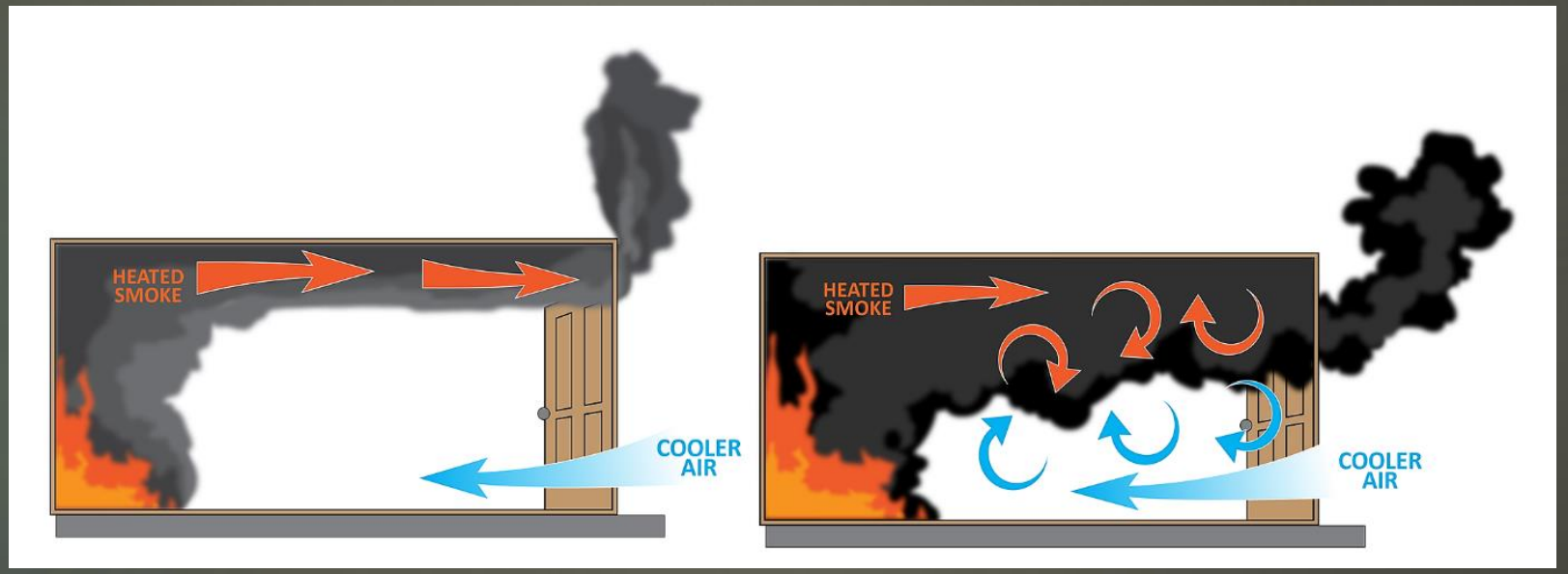
Burning Regimes

- Fuel-controlled: adequate oxygen
- Ventilation-controlled: oxygen-limited
- Ventilation-controlled fires are more dangerous

Ventilation controlled vs. fuel-controlled fire

Flow Path Management

- Control doors and windows
- Coordinate ventilation with fire attack
- Reduces fire growth and improves safety



Laminar smoke movement

Turbulent smoke movement

Conclusion

- VP = BE + SAHF improves situational awareness
- Supports safer and more effective fireground decisions

- Key Safety Principle
  - Never assess one indicator in isolation
  - Always evaluate the full ventilation profile

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