PPA

POSITIVE PRESSURE ATTACK

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Content

CLASROOM (8h)

- Basics and technical background
- Risks and safety measures
- FAQ
- Tactics

LIVE BURNS (16h)

- Doll house demo
- Flashover container demo (2 burns)
- PPA vs Confined Space Techniques drills (4 burns)
- Venting for fire (5 burns on single story – 5 burns on high rise)
- Venting for life (5 burns on single story – 5 burns on high rise)
- Venting for position (4 burns)
- Multiple company final exercise

BASICS
TECHNICAL BACKGROUND

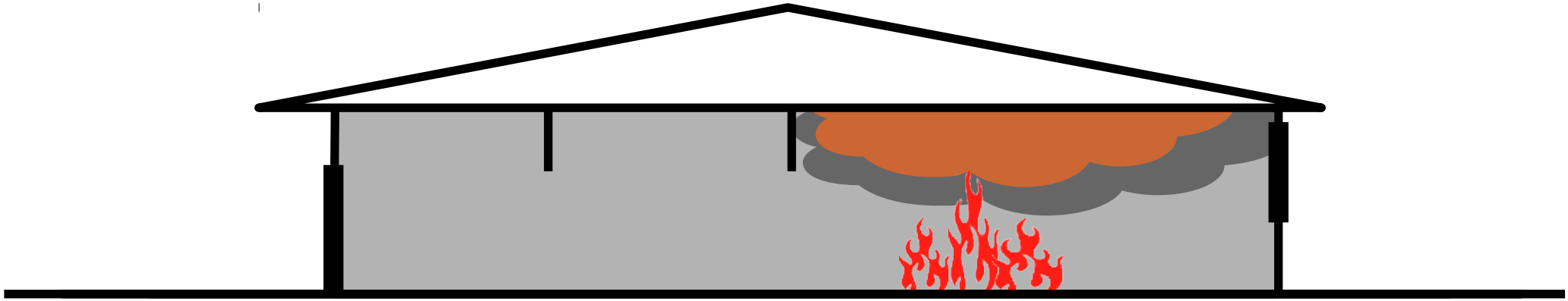
What is a PPA?

A Positive Pressure Attack (PPA) is a coordinated attack for fire control and/or victim rescue involving mechanical positive pressure ventilation for smoke removal before fire knockdown.

What is a PPA?

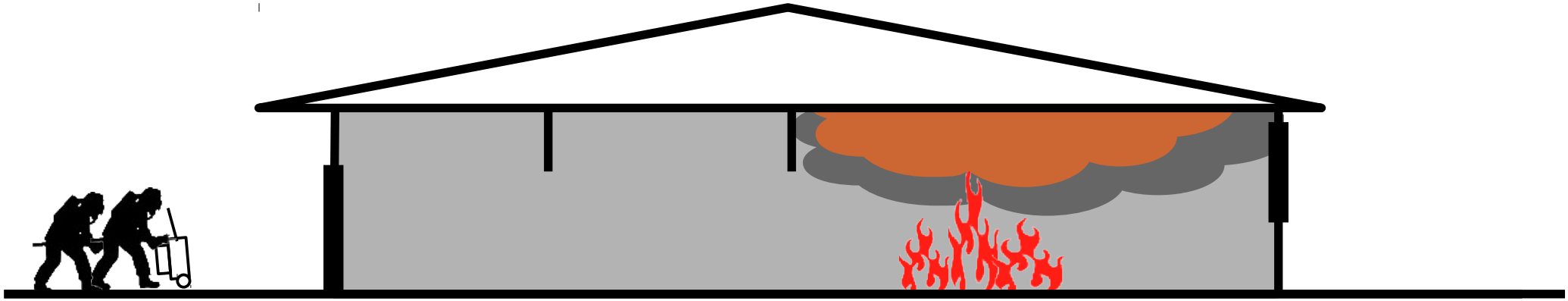
A Positive Pressure Attack (PPA) is a **coordinated** attack for **fire control** and/or **victim rescue** involving mechanical **positive pressure ventilation** for smoke removal **before fire knockdown.**

General PPA evolution



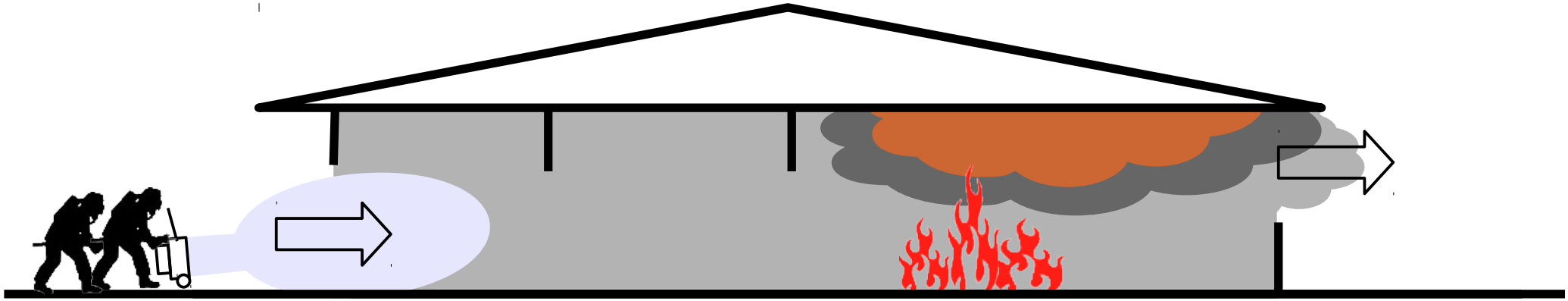
360º Size-up
Check for interior conditions

General PPA evolution



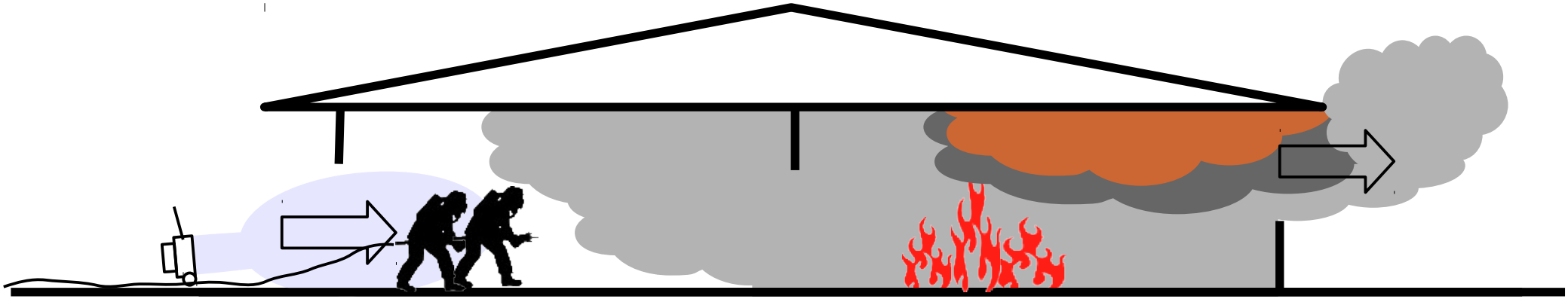
Fan setup
Water line ready to advance

General PPA evolution



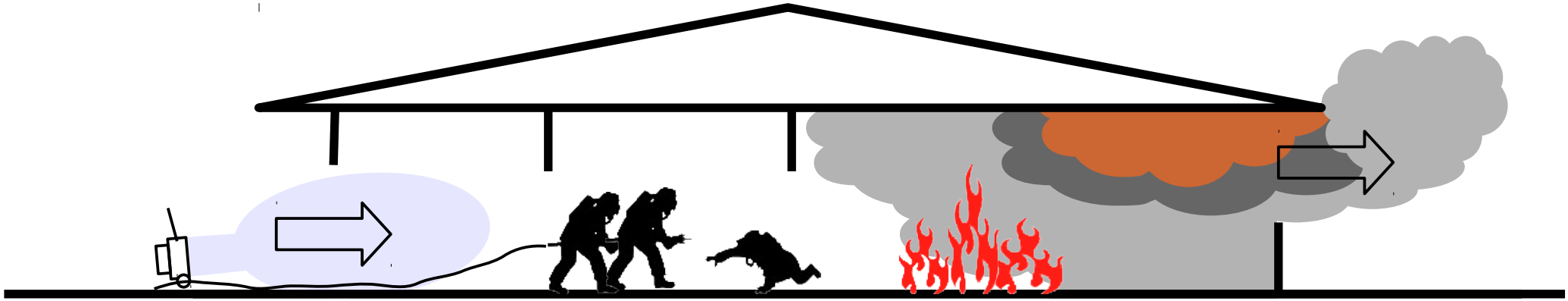
Open exhaust
Fan at full power
Open inlet
WTF - "Windows the fan"

General PPA evolution



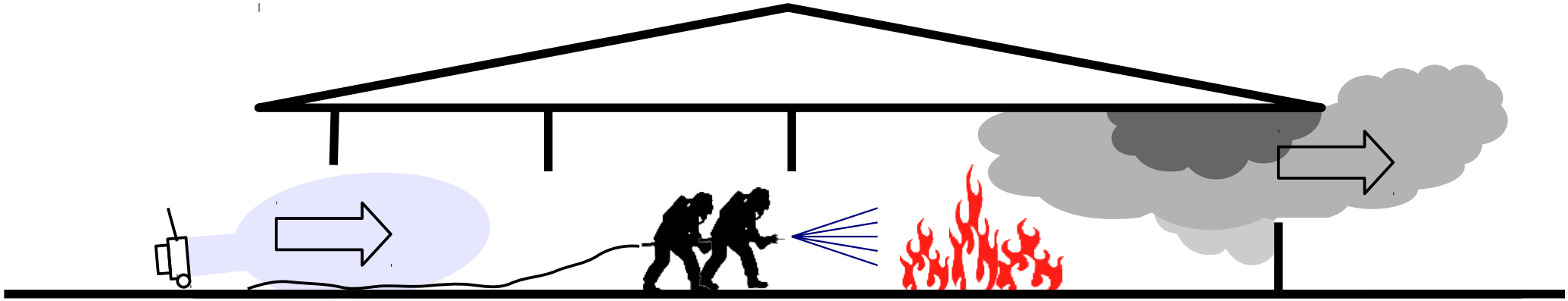
Safety wait for improved interior conditions
Rapid interior advance

General PPA evolution



Victim location
Rescue

General PPA evolution



Fire control and extinguish

Historic reference

1926 Chief Higgins invents a device to clear out smoke (Grand Rapids, MI)

1954 First documents on the “reverse” use of smoke extractors for fire attack (LAFD)

1980 Chief Cliff Allmon pioneers PPA (Kern County, CA)

1987 Modern blower development using hot air balloonists experience

1990 Important development of PPA lead by Salt Lake City FD, LAFD, Austin FD, among others

2003 NIST studies on ventilation allow a better knowledge and a deeper understanding of PPA

Higgins Invents Device to Clear Smoke-Filled Blazing Buildings

The latest apparatus for firemen now is ready for use in the city of its origin, Grand Rapids.

This device, designed by Fred P. Higgins, assistant fire marshal, and constructed in the department shop, is a smoke remover mounted on an old steamer chassis and made to enter and where the flames spread because we can't get inside the building," explained Higgins. "With this machine I believe we can clear out a smoke-filled house within half a minute. The smoke sucker will pay for itself in one fair-sized fire and undoubtedly will save lives."

Don't mistake this for a PPA

...though it also comes from the USA

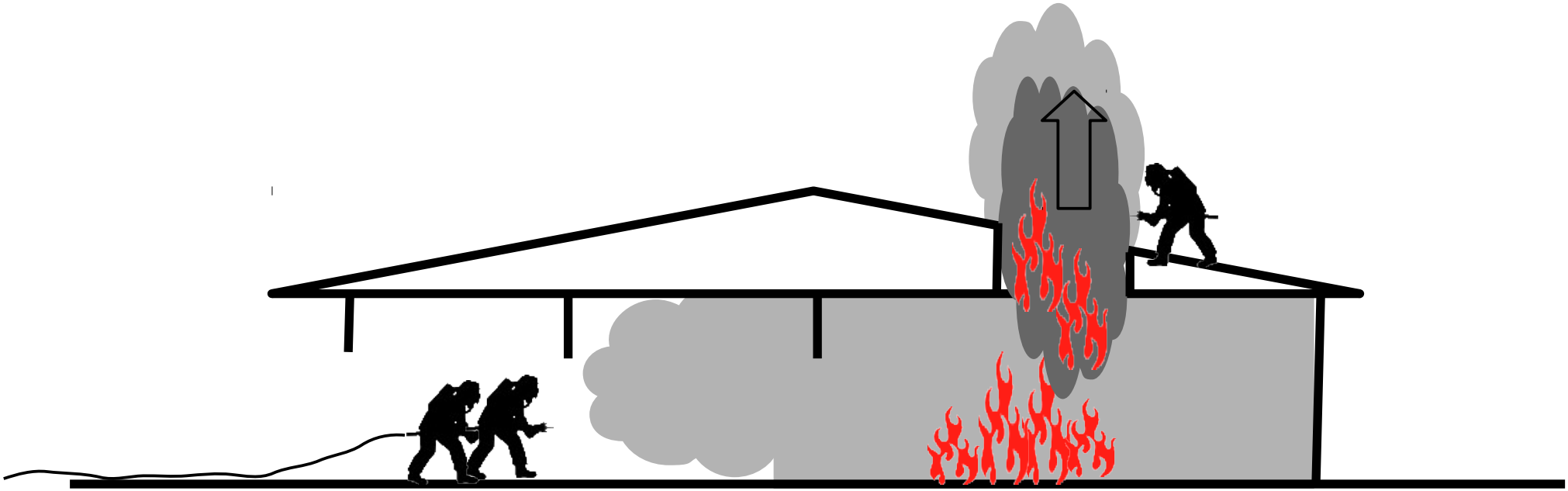
Video: LAFD Vertical Ventilation (LA Fire @Youtube)
http://www.youtube.com/watch?v=FQFny1l4V-U

Don't mistake this for a PPA

Video: LAFD Vertical Ventilation (LA Fire @Youtube)
http://www.youtube.com/watch?v=FQFny1l4V-U

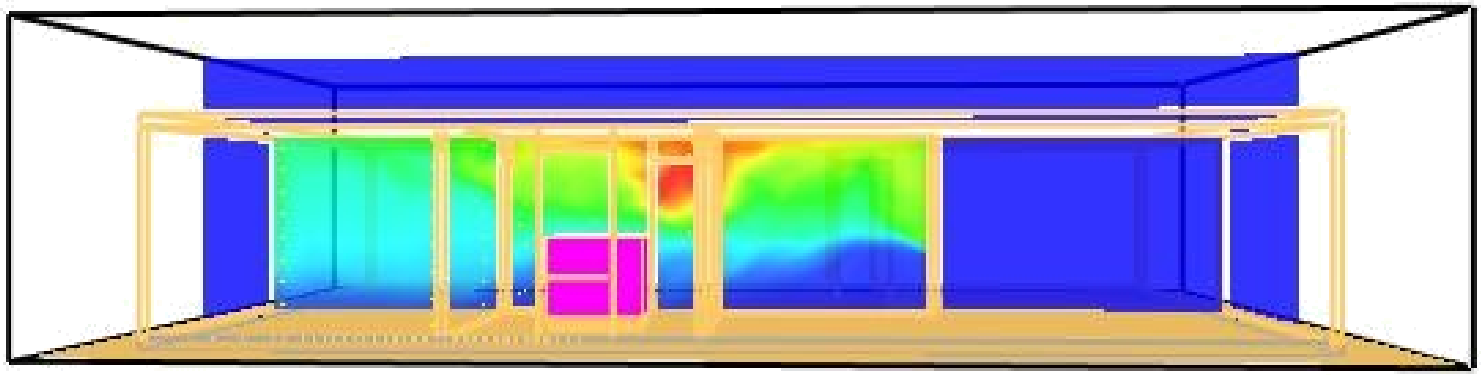
Vertical Roof Ventilation

- Traditional fire attack technique in the USA, rarely used in Europe.
- Smoke is removed through hole on roof.
- Involves risky roof and ladder operations.



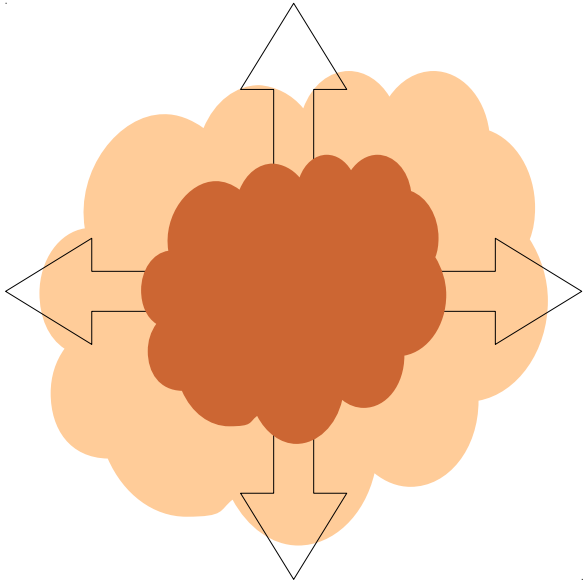
Fire behavior

- **Thermodynamics and Fluid Dynamics rule fire development and behavior.**
- Computer assisted tools allow fire simulation (e.g. Fire Dynamics Simulator - NIST) using Navier-Stokes and Thermodynamics Equations.



Fluid Dynamics (keeping it simple)

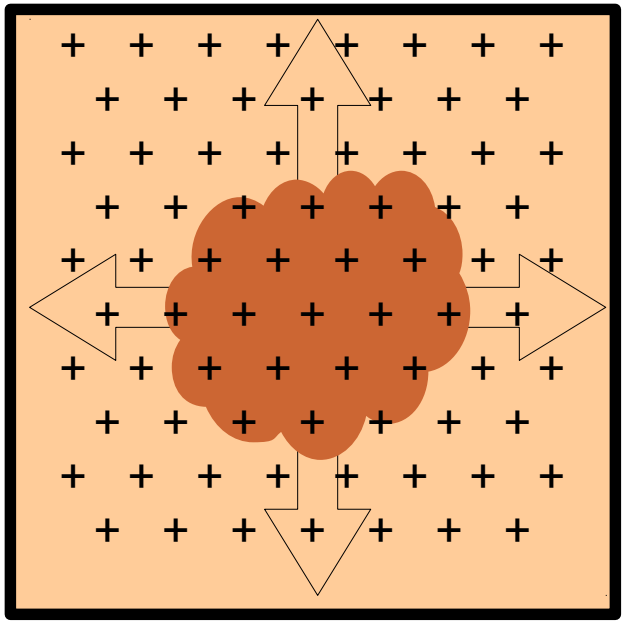
GAS HEATS



→ EXPANDS

Fluid Dynamics (keeping it simple)

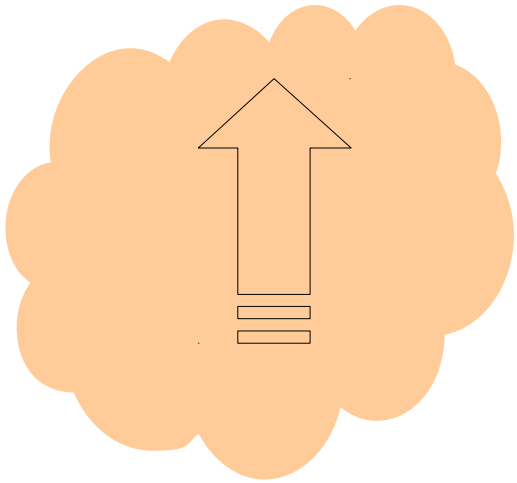
GAS HEATS
WITHIN CONFINED SPACE



→ PRESSURE RISES

Fluid Dynamics (keeping it simple)

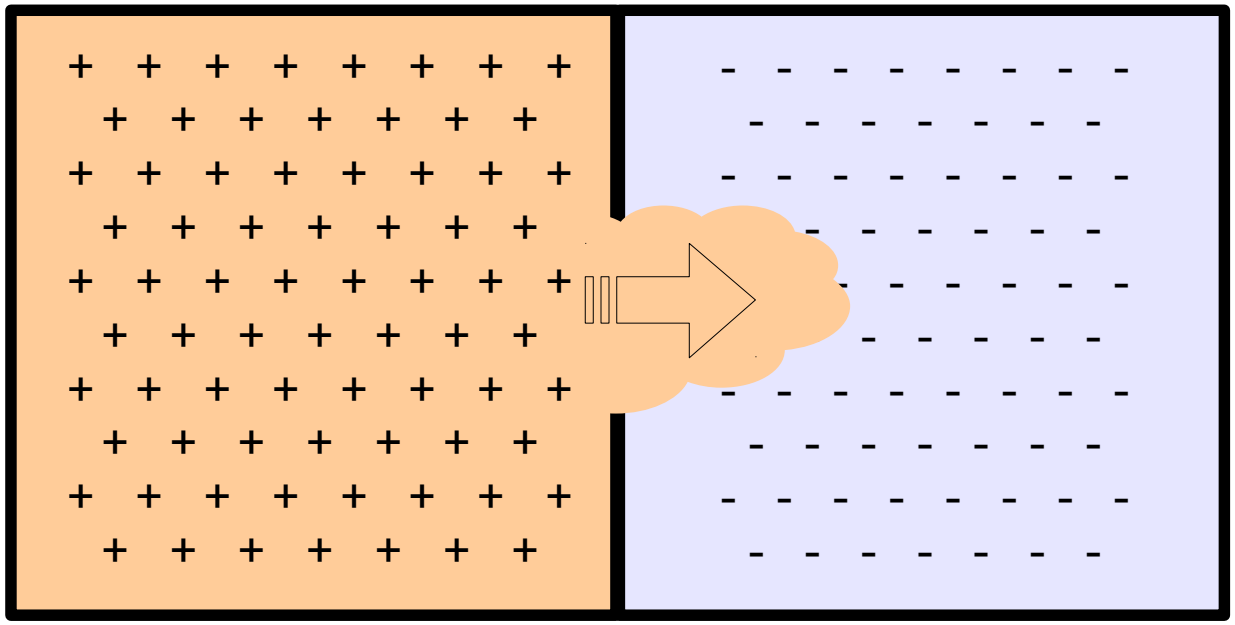
GAS HEATS



FLOWS UPWARDS

Fluid Dynamics (keeping it simple)

PRESSURIZED GAS



FLOWS TO LOWER PRESSURE THE EASIEST WAY (PATH OF LESS RESISTANCE)

Thermoynamics (keeping it simple)

The Ideal Gas Law is a good approximation for gas behavior.

Pressure (P), volume (V) and temperature (T) are linked.

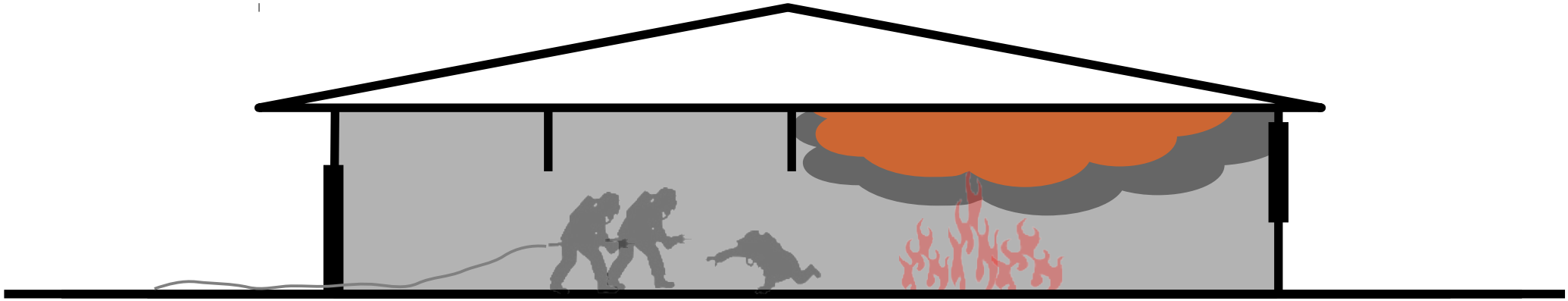
$$P \cdot V = n \cdot R \cdot T$$

Fire is a dynamic situation where multiple factors must be accounted for.

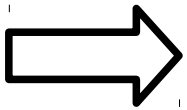
Fuel combustion →	**↑↑↑ T ↑↑↑ V**
Heat in confined space →	**↑↑↑ P**
Mechanical ventilation →	**↑↑↑ P**
Exhaust opening →	**↓↓↓ P**
Air speed →	**↓↓↓ P**

Biggest concern during operations MUST be

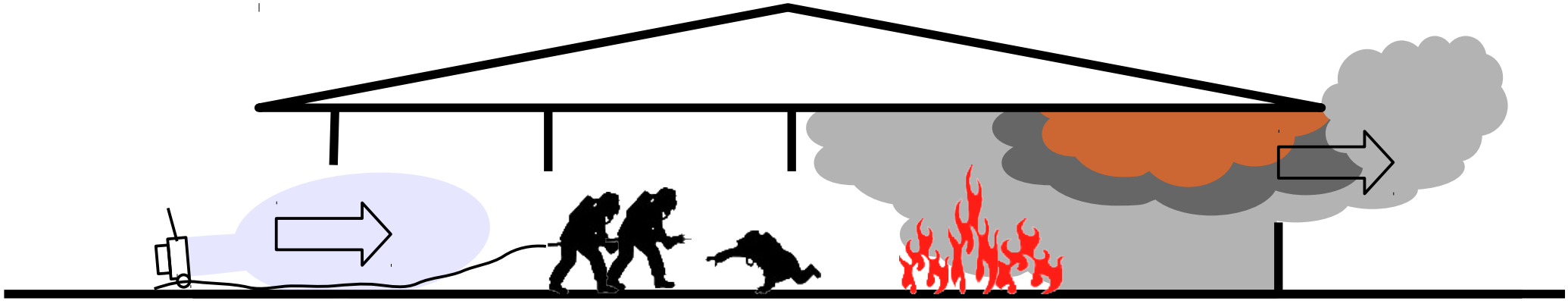
SMOKE



Toxic atmosphere
Fuel rich atmosphere
Low (almost zero) visibility
Heat



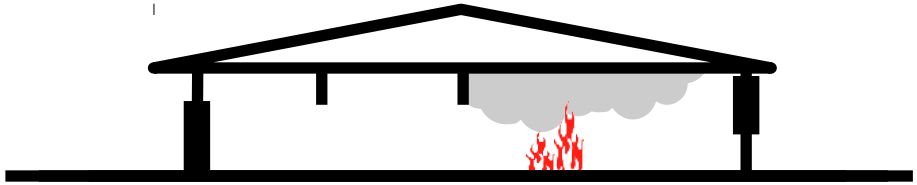
Risk for victims
Risk for firefighters
Property damage



Breathable, clean, not flammable atmosphere
Good visibility
Low temperature

Better victim tenability
Safer conditions for firefighters
Reduced property damage

Which is the situation when first crew arrives at fire scene?



Fire starts

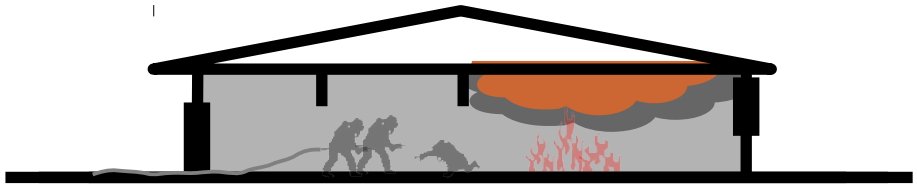
Arrival at fire scene

PPA

Confined Space Extinguish

Vertical Roof Ventilation

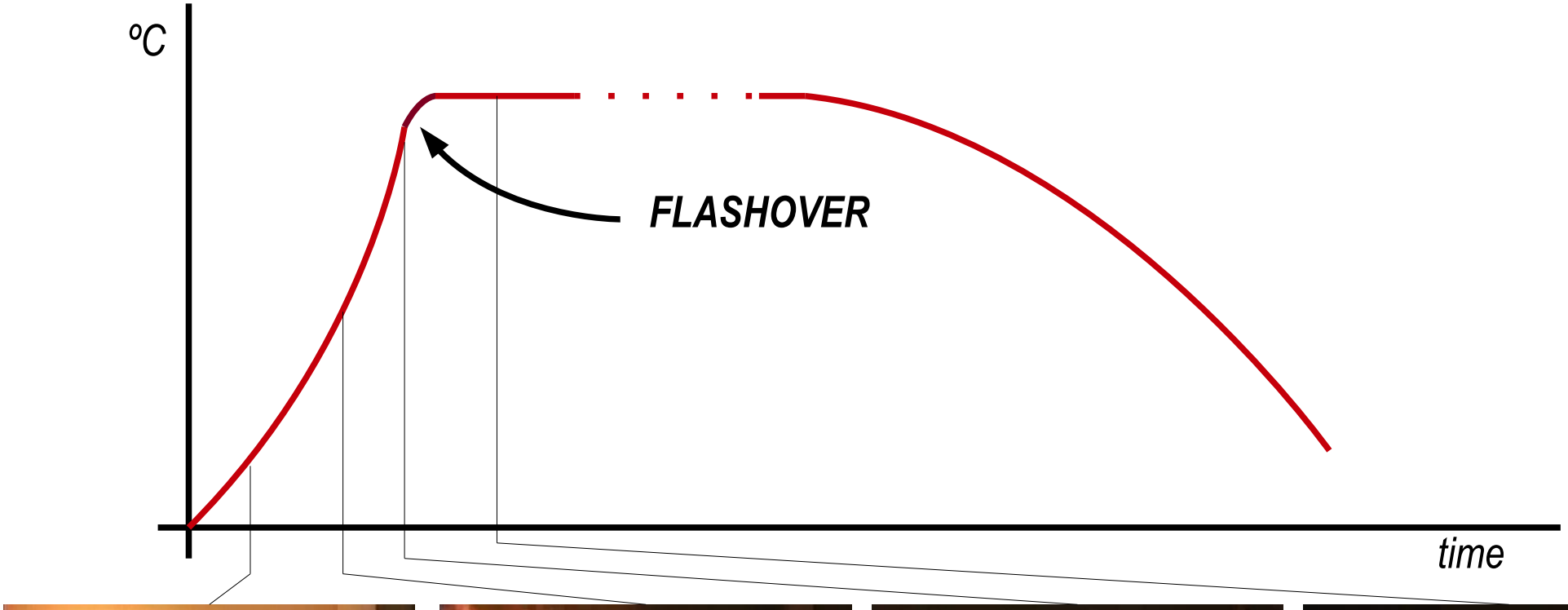
Natural Ventilation



Confined Fire Behavior

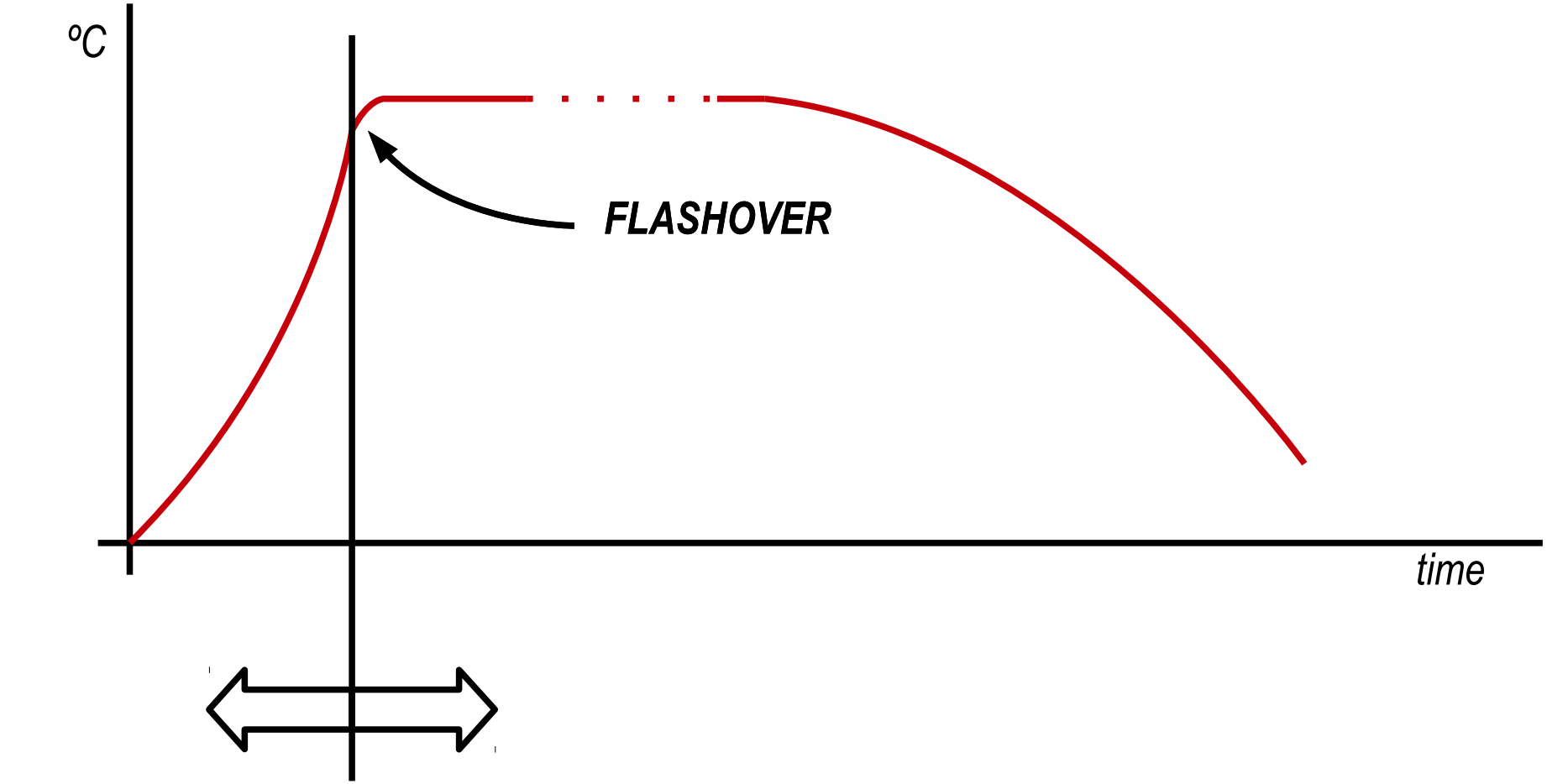
Video: Dry Scotch Pine Tree Fire – NIST
http://www.youtube.com/watch?v=yv5NtpkthVE

Confined Fire Behavior *(temperature vs time)*

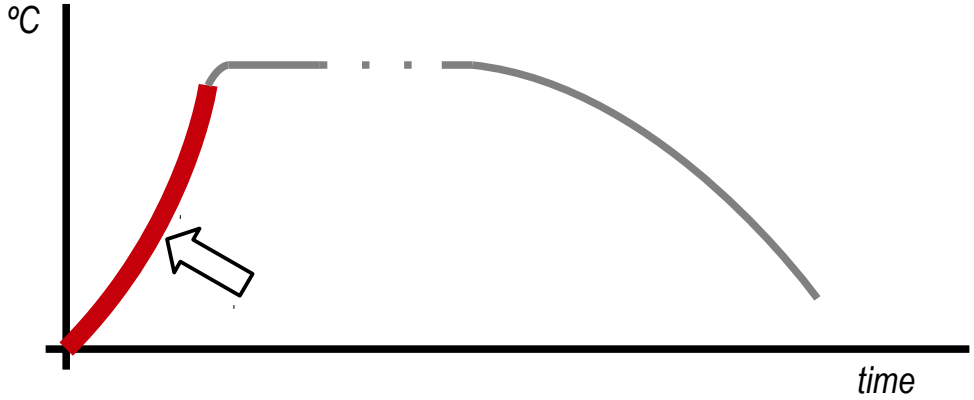


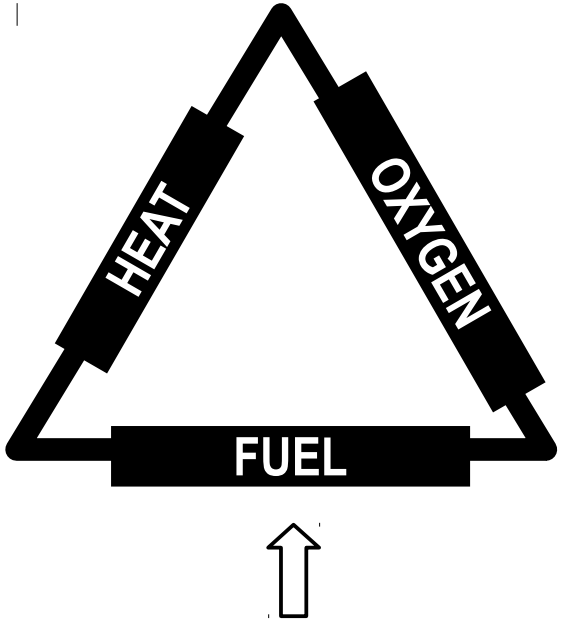
Source: Dry Scotch Pine Tree Fire - NIST

Confined Fire Behavior



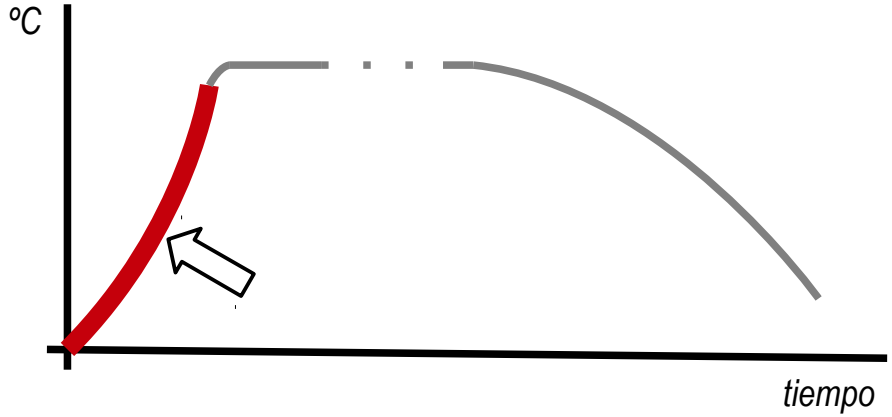
Fuel Controlled Fire





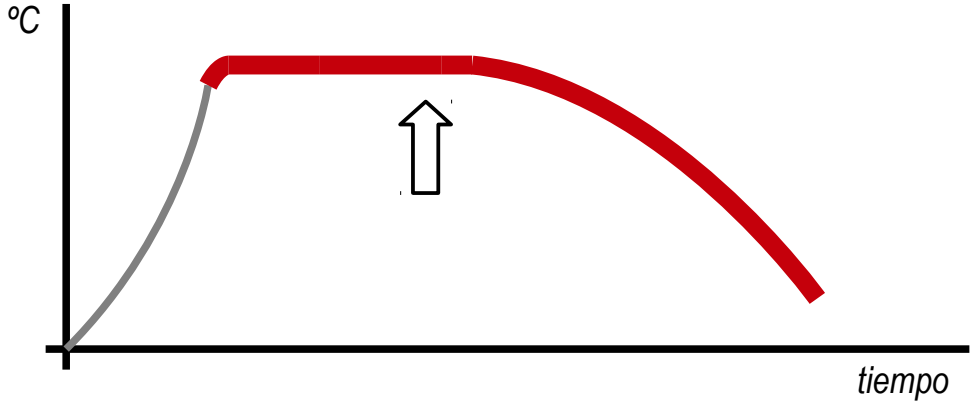
Fuel Controlled Fire

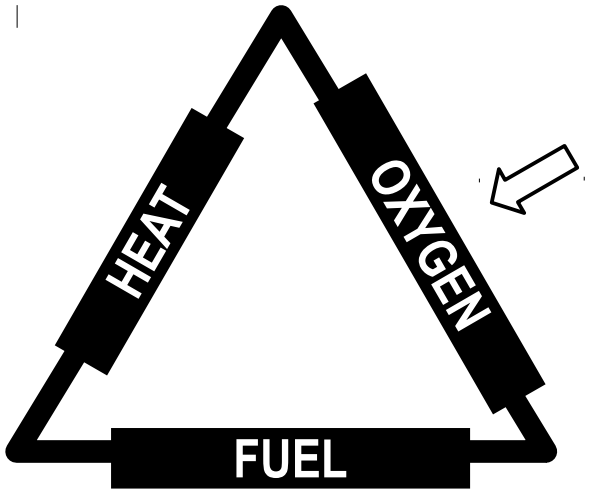
- **Good visibility**
- Breathable layer of air at floor level
- ↓↓↓ toxic gases (CO, HCN)
- Complete combustion
- ↓↓↓ low radiation from hot gas layer
- Seat of fire easily spotted



SAFE CONDITIONS

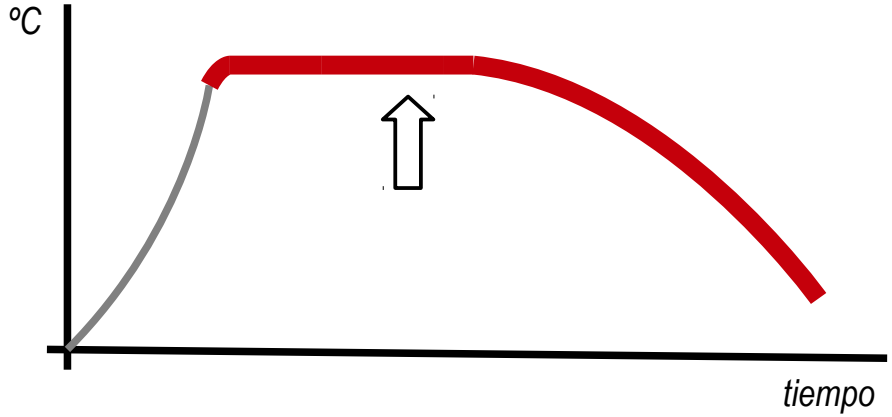
Ventilation Controlled Fire





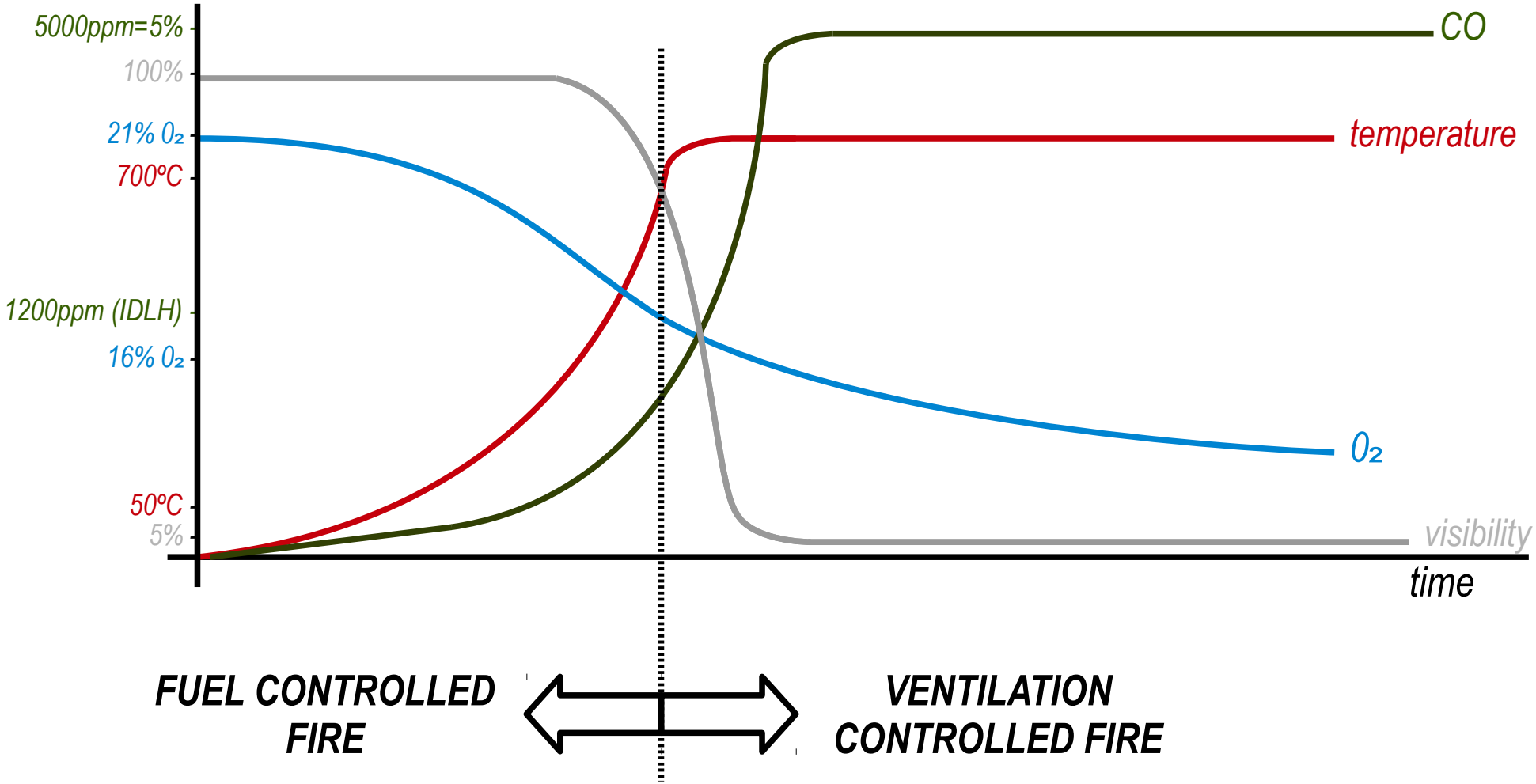
Ventilation Controlled Fire

- **Low visibility (almost none)**
- Non breathable atmosphere
- ↑↑↑ toxic gases (CO, HCN)
- ↑↑↑ high radiation from hot gas layer
- Unable to spot fire seat
- ↑↑↑ incomplete combustion products
- Backdraft risk

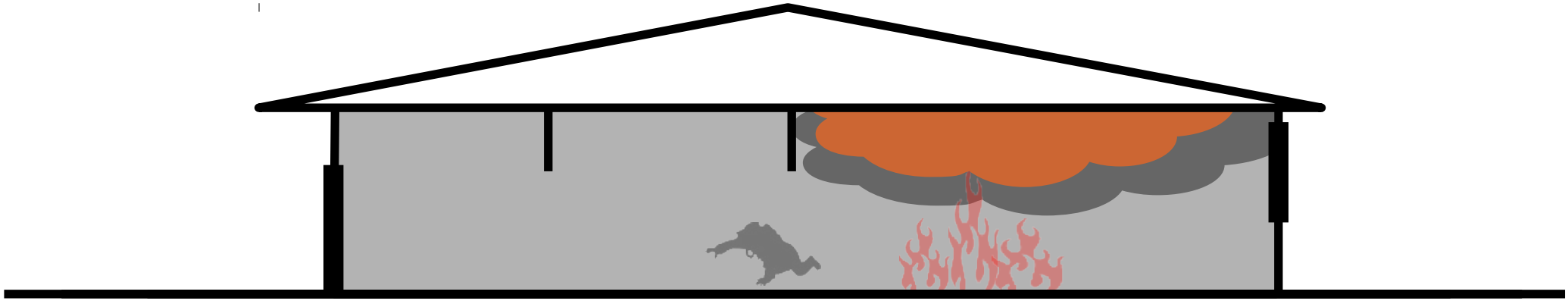


DANGEROUS CONDITIONS

Confined Fire Behavior

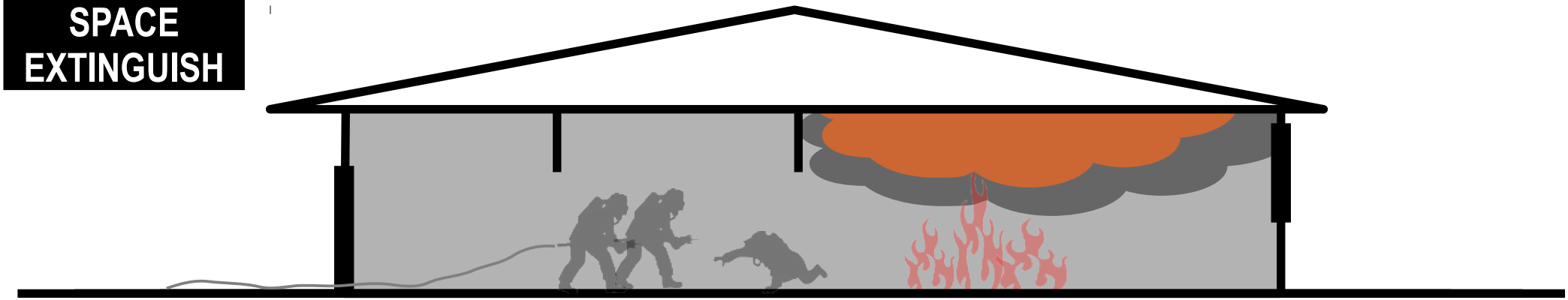


Fire scene at arrival...

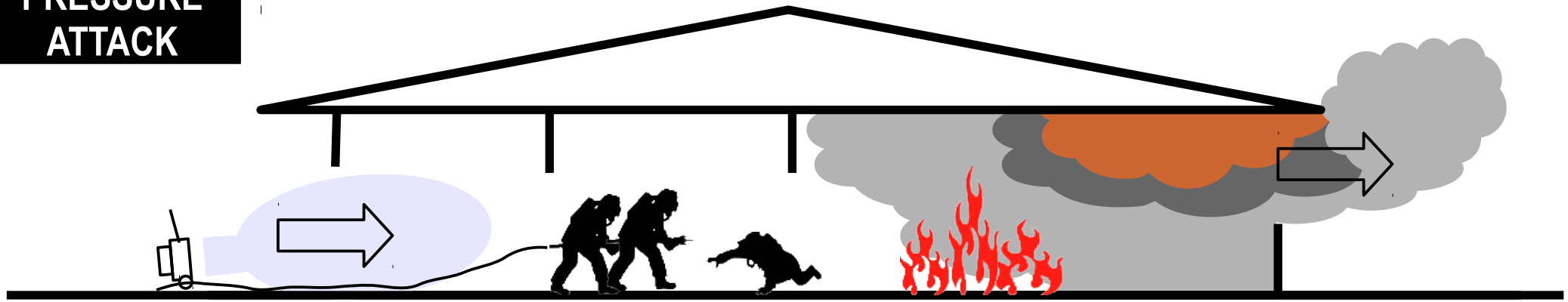


...two ways to go

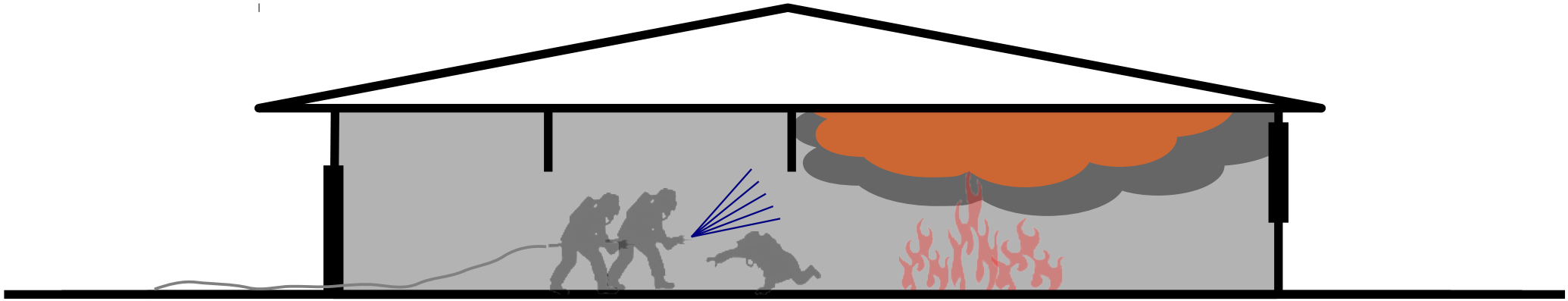
CONFINED SPACE EXTINGUISH

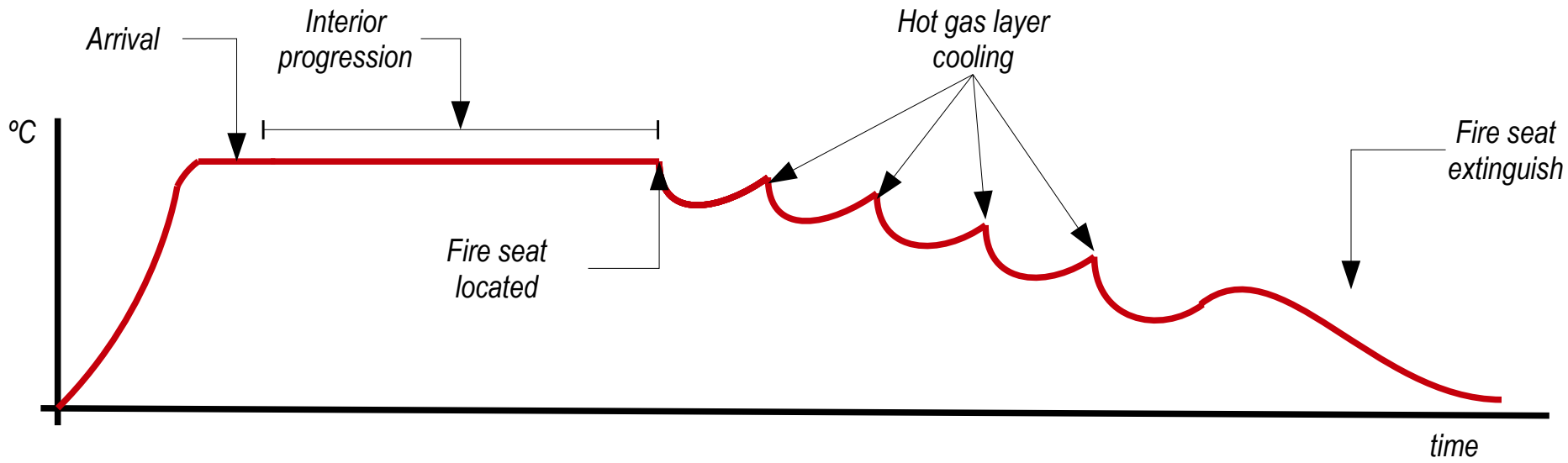


POSITIVE PRESSURE ATTACK

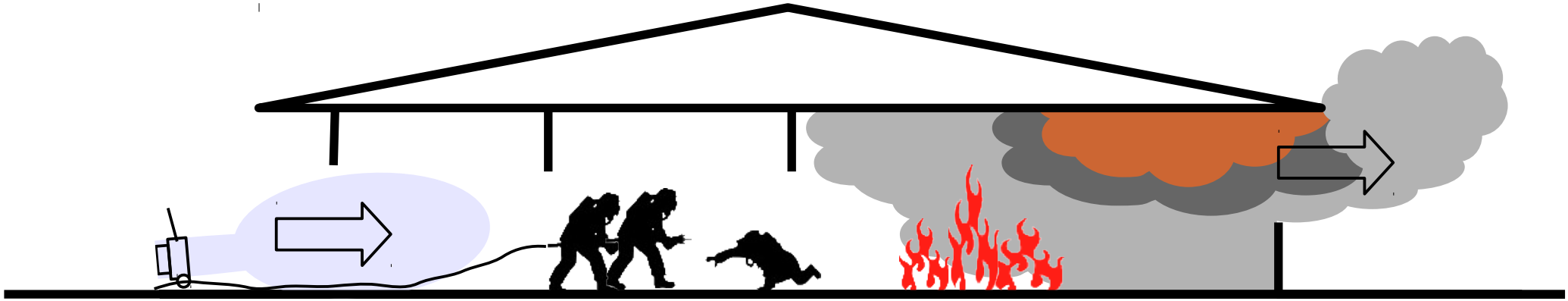


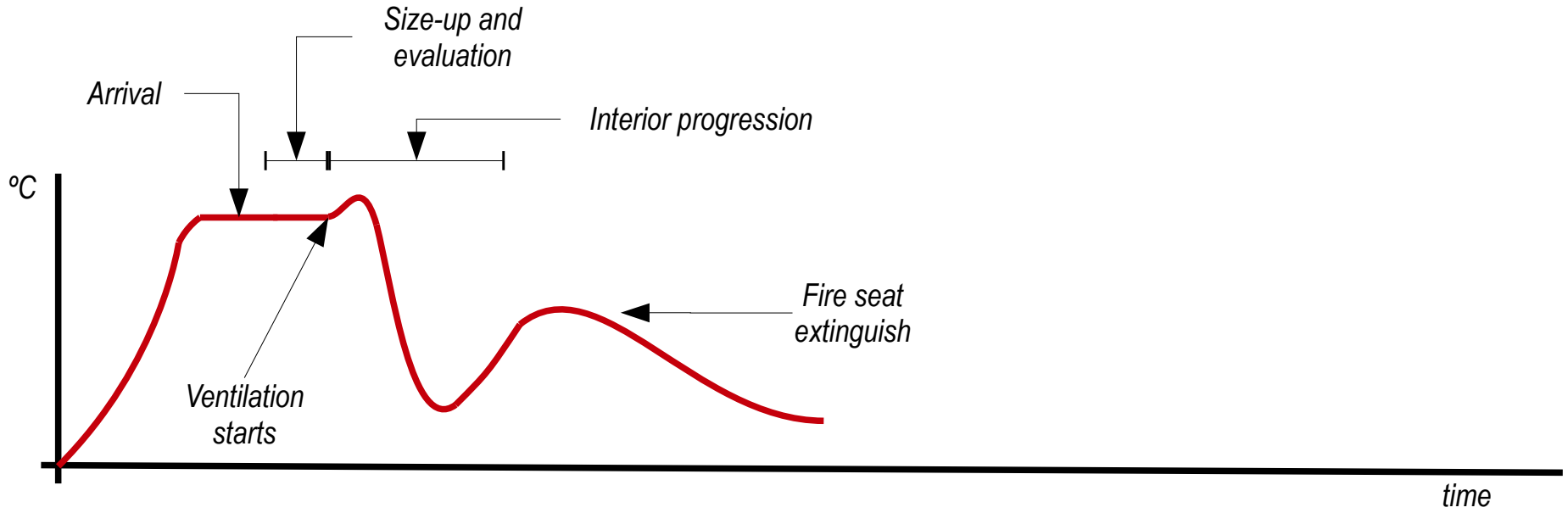
Confined Space Extinguish



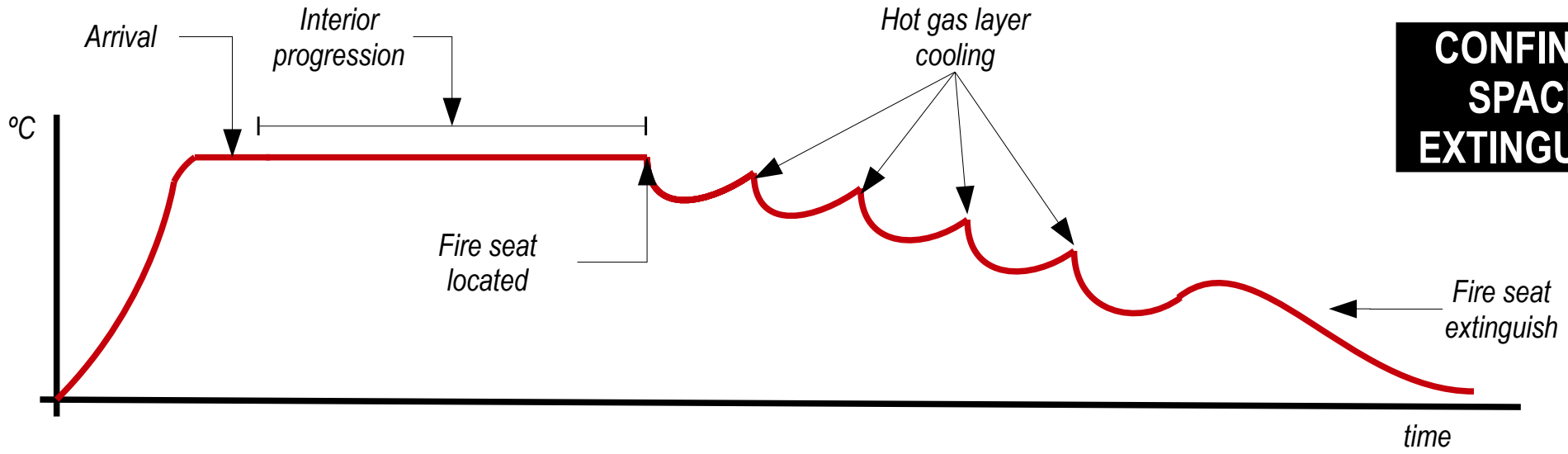


Positive Pressure Attack

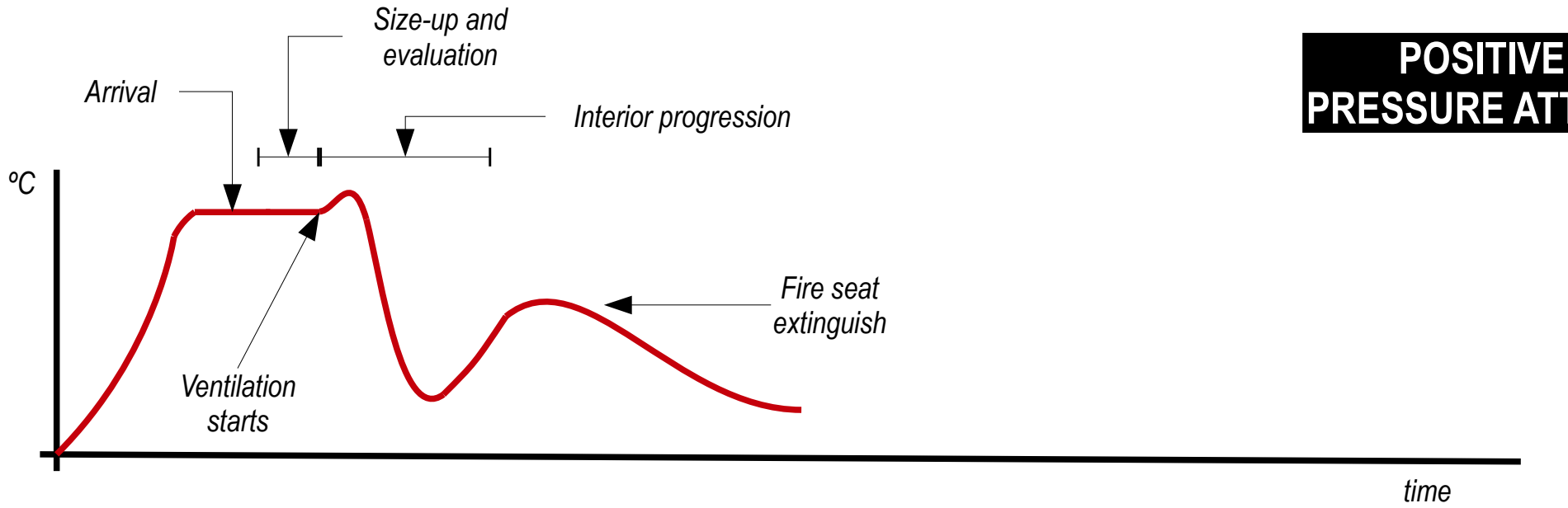




Time matters!



CONFINED SPACE EXTINGUISH

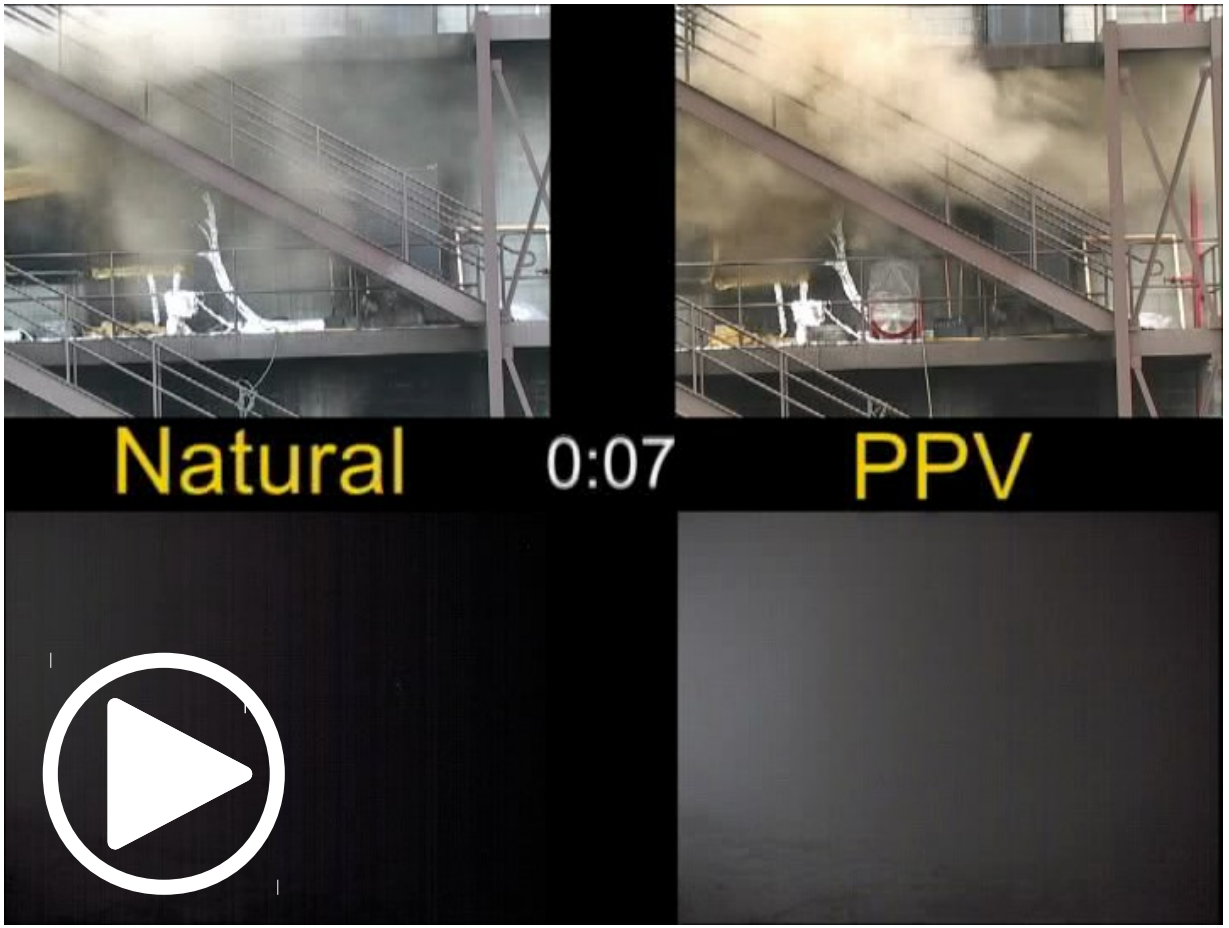


POSITIVE PRESSURE ATTACK

PPA rapidly improves interior conditions

Video: Austin Fire Department
http://www.youtube.com/watch?v=Wnk3H-T-dMY

PPA vs Natural Ventilation



Video: Test PPV vs Natural – Kerber NIST
http://www.youtube.com/watch?v=NfcD2iRq53Y

Generic PPA Evolution

Video: PPA Instructor Academy, Bakersfield (CA) 2013
http://www.youtube.com/watch?v=hHEjXUk3mts

RISKS
SAFETY MEASURES

Risks involving a Confined Space Extinguish

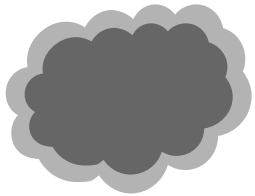
LOW VISIBILITY

FUEL

TOXIC

PROPAGATION

Smoke is fuel



SMOKE

	LEL	UEL	AIT
CO	12%	74%	609ºC
Formaldehyde	7%	73%	740ºC
HCN	6%	41%	538ºC
Benceno	1,2%	7,8%	498ºC

PROPANE

	LEL	UEL	AIT
CO	2,1%	9,6%	540ºC

Would you enter a propane filled room to put out a fire?

Would you enter a propane filled room to put out a fire?

It doesn't seem the best way to go.

However heat of combustion on propane is higher than on smoke.

(C3H8 46MJ/kg - CO 8,4MJ/kg - CH20 17,3MJ/kg)

Smoke is toxic, deadly toxic

Typical gas concentrations found in a confined ventilation controlled fire:

	FIRE		IDLH (*)
HCN	1000ppm	>>	50ppm
CO	5.000ppm	>>	1.200ppm
0_2	15%	~	14%

(*) IDLH Immediately Dangerous to Life or Health, likely to cause death or immediate or delayed permanent adverse health effects or prevent escape from such an environment. (NIOSH)

Smoke spreads fire

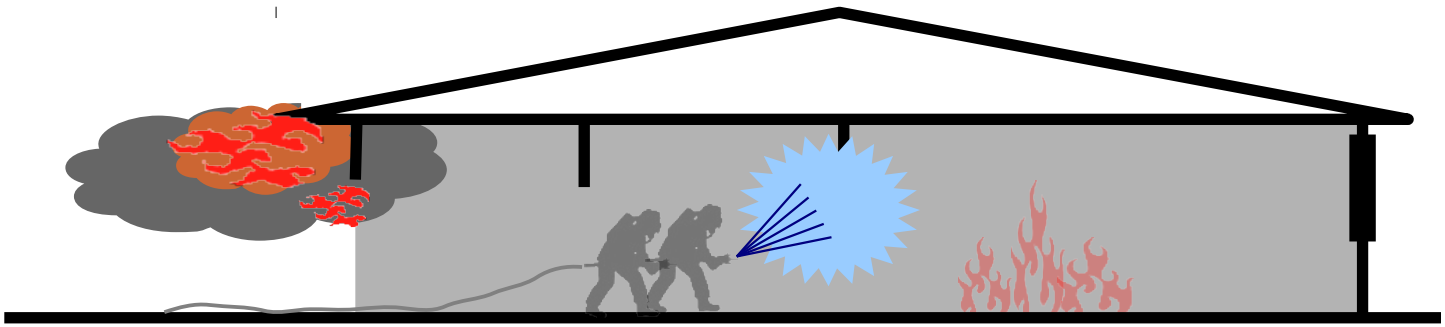
- **Smoke spreads easily providing heat and fuel to unaffected areas.**
- **Nozzling water into a smoke filled structure may push smoke to undesired areas.**

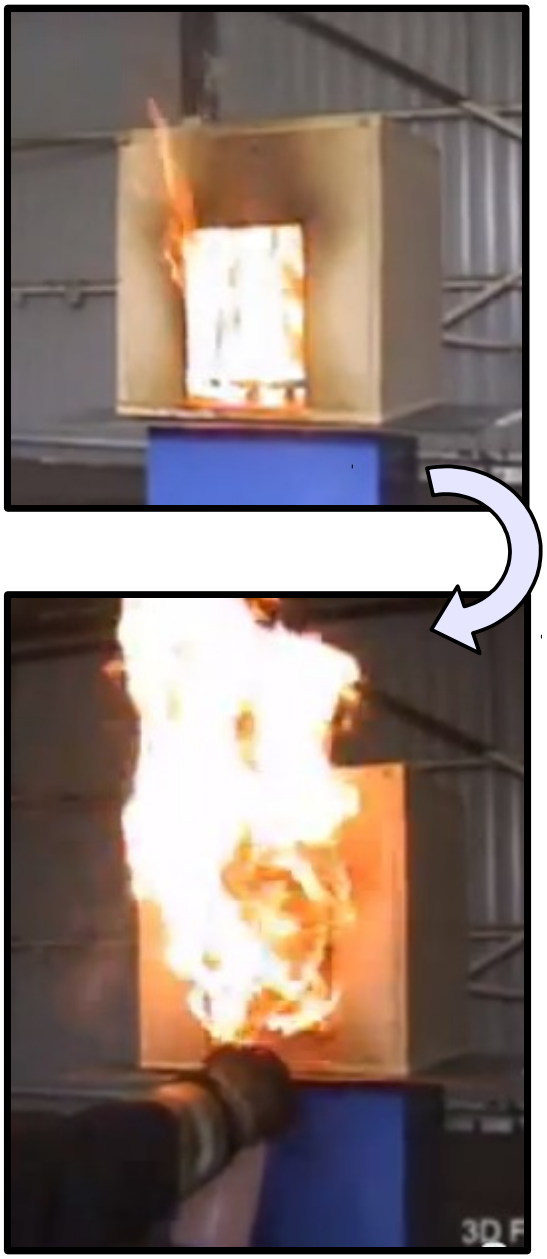
Water expands 1600 times as it goes from liquid to vapor

1 liter water ≈ 1,6 m³ water vapor

1 gallon water ≈ 215 cubic feet water vapor

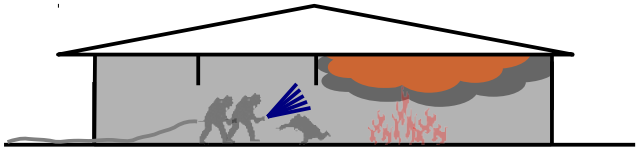
- **Smoke may ignite as it mixes with clean air.**

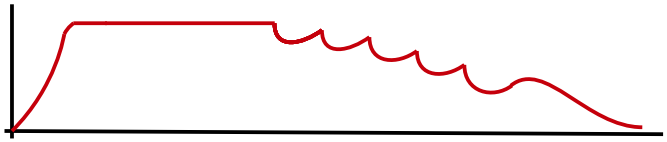




Risks involving a Confined Space Extinguish

- Non tenable conditions for victims
- Non tenable conditions for firefighters without SCBA / bunker gear
- Non breathable atmosphere
- High temperature (water vapor worsens heat transfer)
- Fuel filled atmosphere
- Hot gas layer radiation
- Low visibility, difficulties finding way in and out
- Slow progression, longer times to knockdown
- Water vapor pushes smoke to undesired areas
- Backdraft
- Smoke extends fire to other rooms

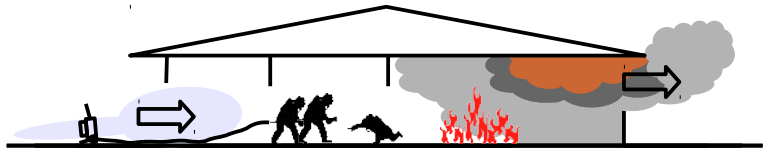


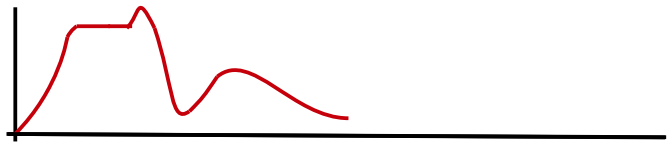


Do we avoid risks involving a Confined Space Extinguish performing a PPA?

Risks involving a Positive Pressure Attack

- ~~Non tenable conditions for victims~~
- ~~Non tenable conditions for firefighters without SCBA / bunker gear~~
- ~~Non breathable atmosphere~~
- ~~High temperature (water vapor worsens heat transfer)~~
- ~~Fuel filled atmosphere~~
- ~~Hot gas layer radiation~~
- ~~Low visibility, difficulties finding way in and out~~
- ~~Slow progression, longer times to knockdown~~
- ~~Water vapor pushes smoke to undesired areas~~
- **Backdraft**
- ~~Smoke extends fire to other rooms~~



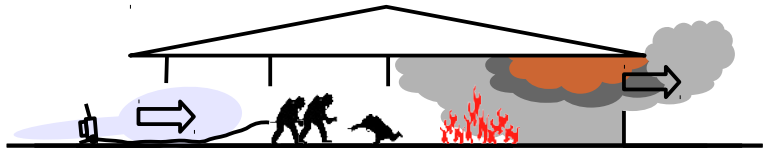


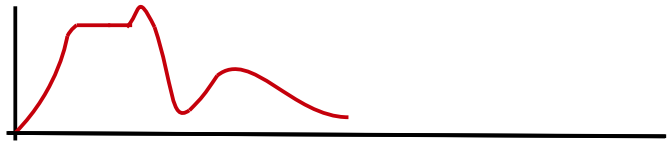
Do we avoid risks involving a Confined Space Extinguish performing a PPA?

We do avoid most of them.
But we also have to consider some other risks.

Risks involving a Positive Pressure Attack

- Backdraft
- Rapid fire progression phenomena
- Fire propagation
- Poor coordination → PPA may go wrong
- Unsufficient training/education
- Victims or firefighters on exhaust
- Class B or dust fuel fires





For every risk, there must be a Safety Measure.

(Safety Measures in blue and marked with )

Backdraft

A deflagration resulting from the sudden introduction of air into a confined space containing oxygen-deficient products of incomplete combustion. (NFPA)

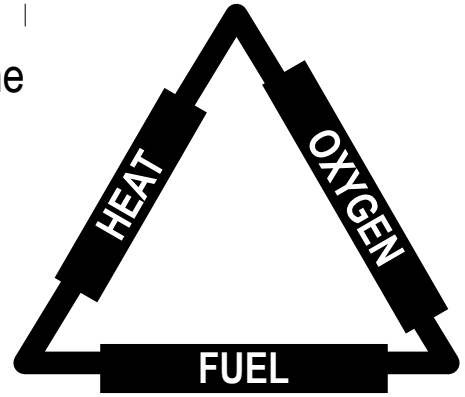
Flashover

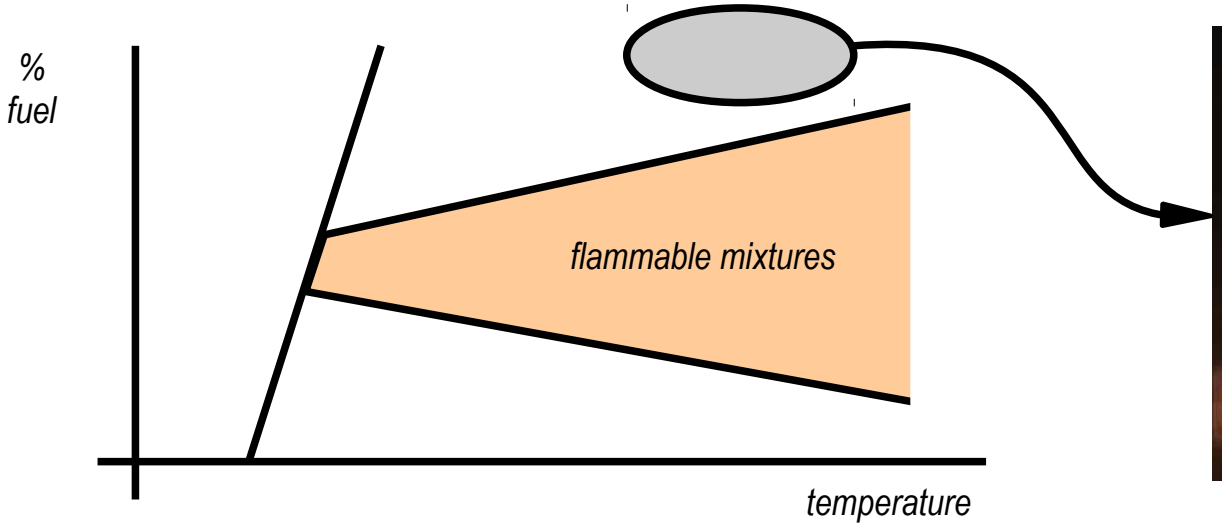
A transition phase in the development of a compartment fire in which surfaces exposed to thermal radiation reach ignition temperature more or less simultaneously and fire spreads rapidly throughout the space, resulting in full room involvement or total involvement of the compartment or enclosed space. (NFPA 921 8)

Backdraft

Smoke is fuel

- A Ventilation Controlled Fire produces incomplete combustion products.
- Radiation from the smoke layer may add additional fuel as solid fuels in the room pyrolize.





Backdraft

- **Misconception – Backdraft is fueled by Carbon Monoxide**

  CO concentration found at confined fire <5% *(DeHaan; Babrauskas; Gottuk)*

  Lowest Explosive Limit (LEL) for CO is 12%

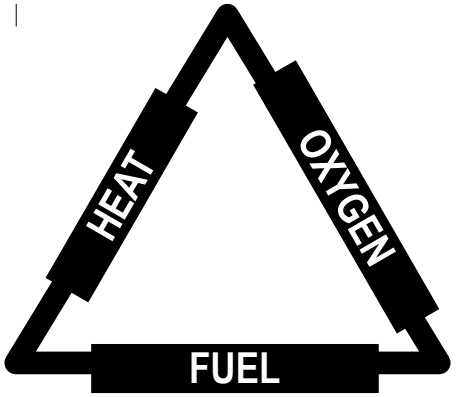
- **Backdraft is fueled by incomplete products of combustion and flammable gases coming from combustion or solid fuel pyrolisis.**

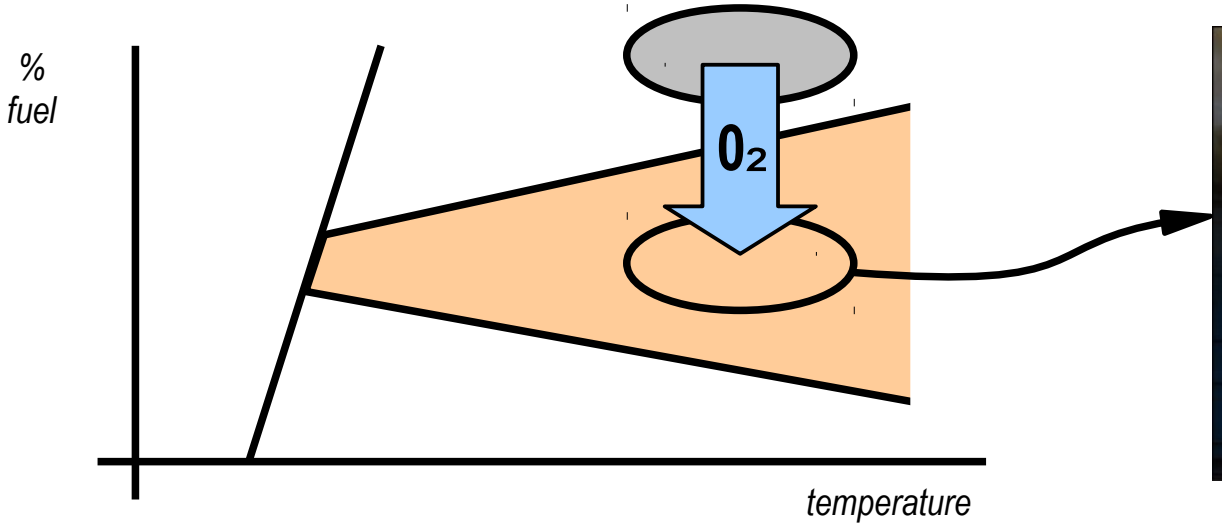
- **Reducing room temperature below CO autoinflammation temperature (609ºC) does not avoid backdraft risk.**

  Consistent with backdrafts occurred in low temperature rooms.

Backdraft

- As smoke mixes up with air, the mixture is driven into its flammability range from an oxygen deficient situation generating a sudden combustion.





Backdraft

Video: Backdraft Harrison, NJ 2013.03.11
http://www.youtube.com/watch?v=bfa5aT_qz70

Video: Full operation Backdraft Harrison, NJ 2013.03.11
http://www.youtube.com/watch?v=jQ8tZFbwjgk

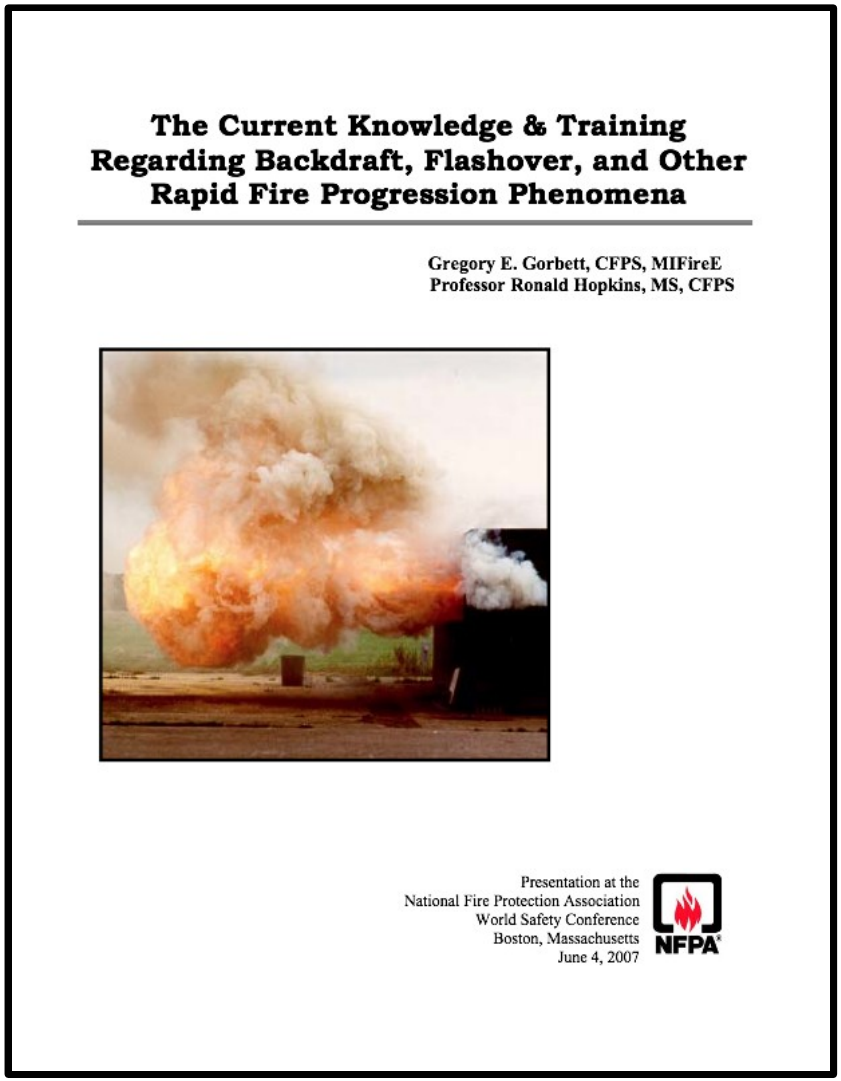
Backdraft, flashover, flameover,...

For further information and misconception solving:

The Current Knowledge & Training Regarding Backdraft, Flashover, and Other Rapid Fire Progression Phenomena

Gregory E. Gorbett, CFPS, MIFireE Professor Ronald Hopkins, MS, CFPS

NFPA 2007



PPA risks/safety measures – Backdraft

Don't use PPA with imminent backdraft signs

- thick yellow smoke
- fire seems to be pulsating and breathing
- hot windows/doors, no flames seen

Video: Fireground Size-Up and How to Read Smoke (DALE G. PEKEL @Youtube)
http://www.youtube.com/watch?v=fHUjG5Zt1tM

PPA risks/safety measures – Backdraft / Flashover

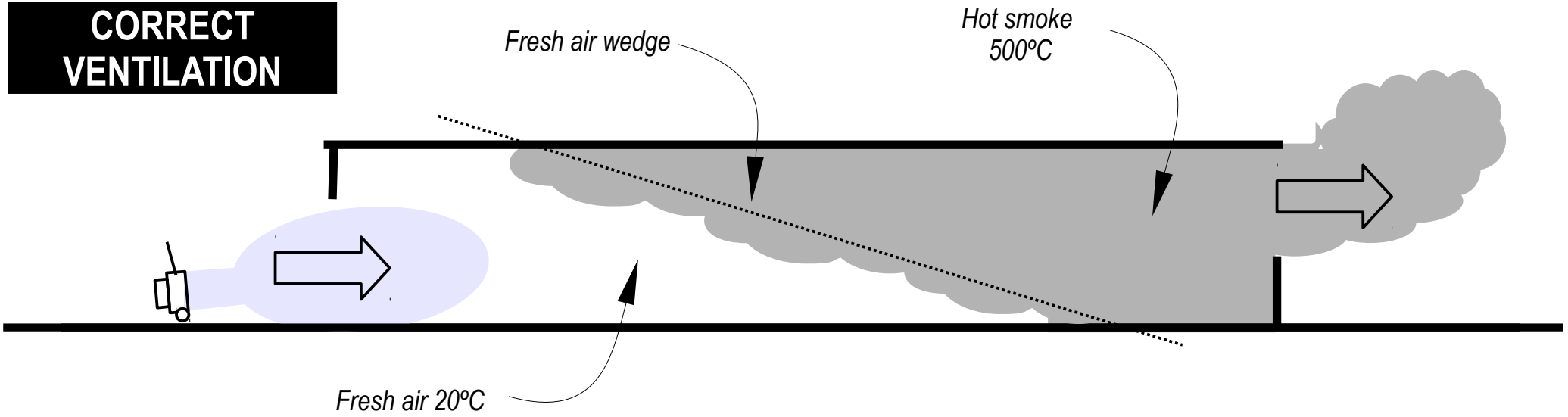
- For backdraft to happen, smoke and air have to mix up to reach a flammable mixture.
- Backdraft risk is reduced if smoke and air don't get to mix up.

How?

Being FAST and AVOIDING TURBULENCE

PPA risks/safety measures – Backdraft / Flashover

CORRECT VENTILATION



- Fast smoke removal generates a fresh air wedge reducing backdraft risk.

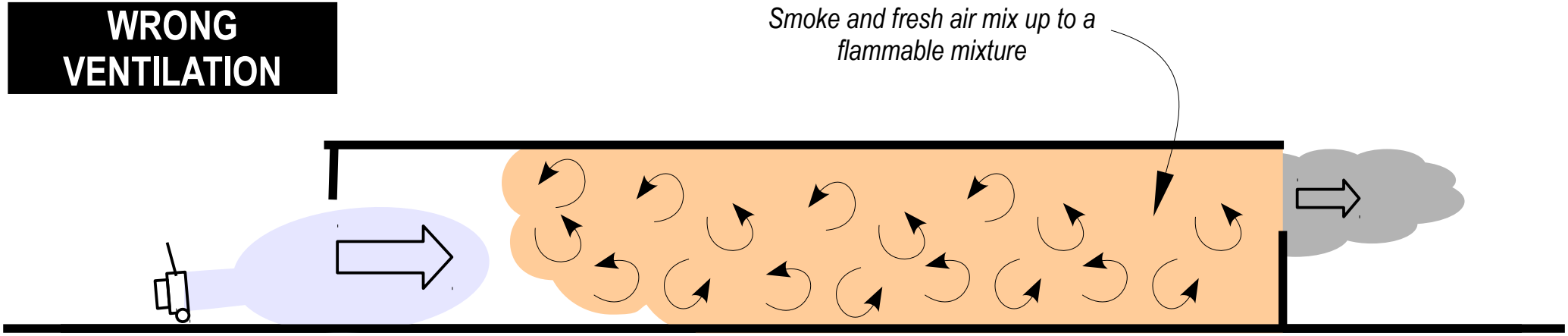
  In a correct (fast) ventilation, fresh air and smoke mix up just at the wedge border.

  → **Don't advance over the fresh air wedge.**

- Along the fresh air wedge combustion may occur though it won't progress (mix is above UEL on smoke side, below LEL on fresh air side)

PPA risks/safety measures – Backdraft / Flashover

WRONG VENTILATION



- Slow smoke removal allows fresh air and smoke to mix up to a flammable mixture.

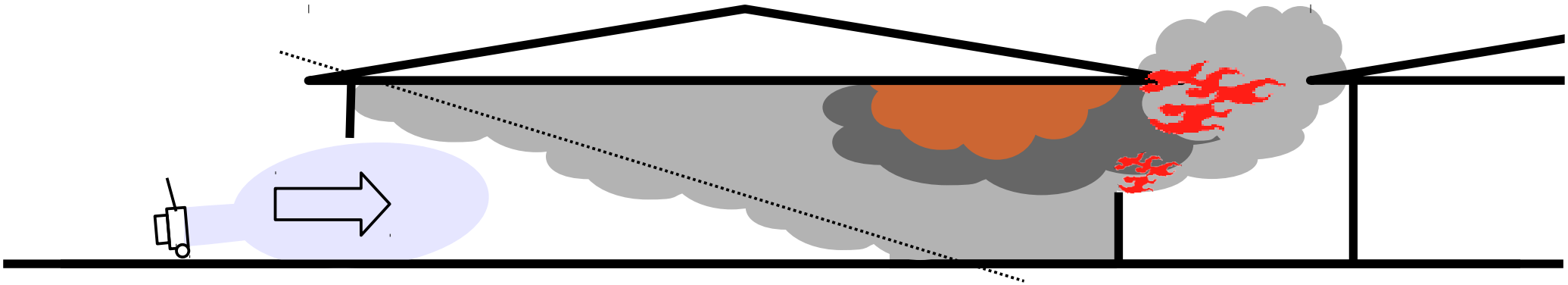
→ **Don't use PPA if fan capacity is insufficient.**

→ **Don't use PPA against wind conditions.**

→ **Provide enough exhaust (>1,5 times entry).**

→ **Open exhaust, then open entry.**

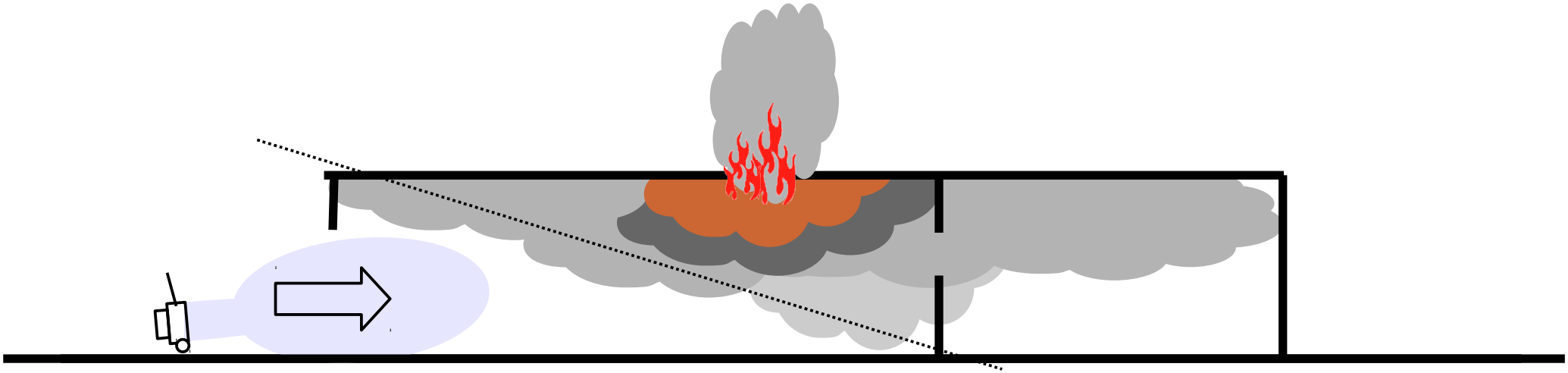
PPA risks/safety measures – Fire propagation



- Exhaust gases ignite as they contact fresh air propagating fire to close exposures.

→ **Exposure control with water line when necessary.**

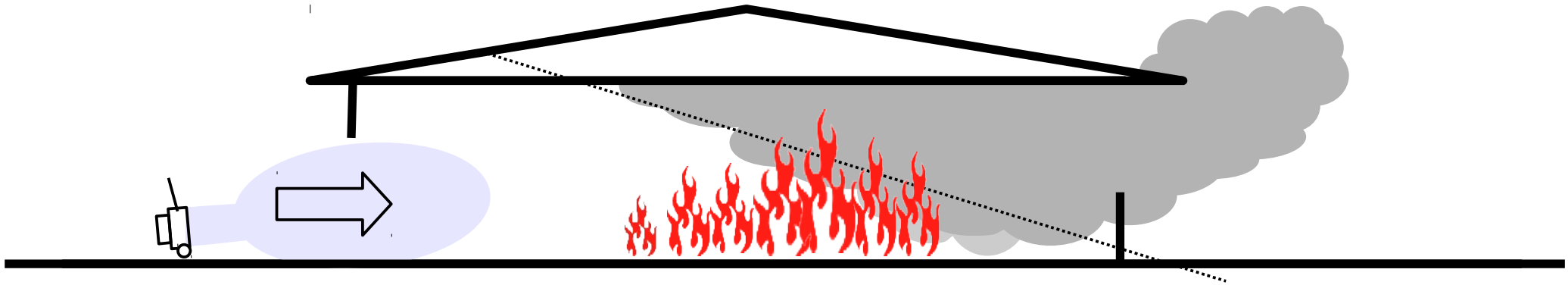
PPA risks/safety measures – Fire propagation



- Smoke reaches undesired areas spreading fire and smoke damage.

  → **Ensure correct smoke path towards exhaust.**

PPA risks/safety measures – Fire propagation



- As a result of a slow advance of crews through interior, lack of water at nozzle or no water line fire intensifies and spreads.

→ **ASAP interior conditions improve, perform an aggressive fast attack.**

→ **Water line must be ready and charge before exhaust opening.**

PPA risks/safety measures – Coordination

- **Lack of coordination during PPA may have undesired and severe consecuences.**
- **Unrecommended situations during a PPA:**
  - Applying fan before exhaust opening
  - Water line not ready to advance.
  - No water at hose line.
  - Sudden stop of fresh air stream or exhaust closing.
  - Crews in interior overpassing fire seat.

  → **PPA needs consistent education and proper training.**

PPA risks/safety measures – Class B/dust fuel fire

- Ventilation on highly volatile class B (e.g. gasoline, benzene, solvents,...) fuels and dust fuels (e.g. flour, coal dust, sawdust, fertilizers) generates a richer atmosphere.

→ **Don't use PPA on class B or dust fuel fires.**

Photo: Deutsche Gesetzliche Unfallversicherung

Positive Pressure Attack

FAQ

(regarding technical background)

Extra 1: **Fire heat release vs air flow rate**

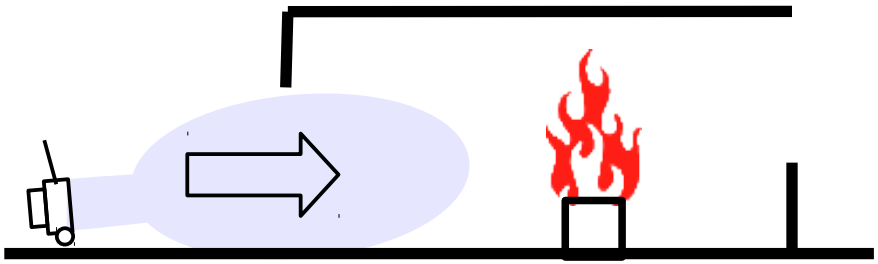
Does air flow into a confined fire increase heat release?

Extra 1: **Fire heat release vs air flow rate**

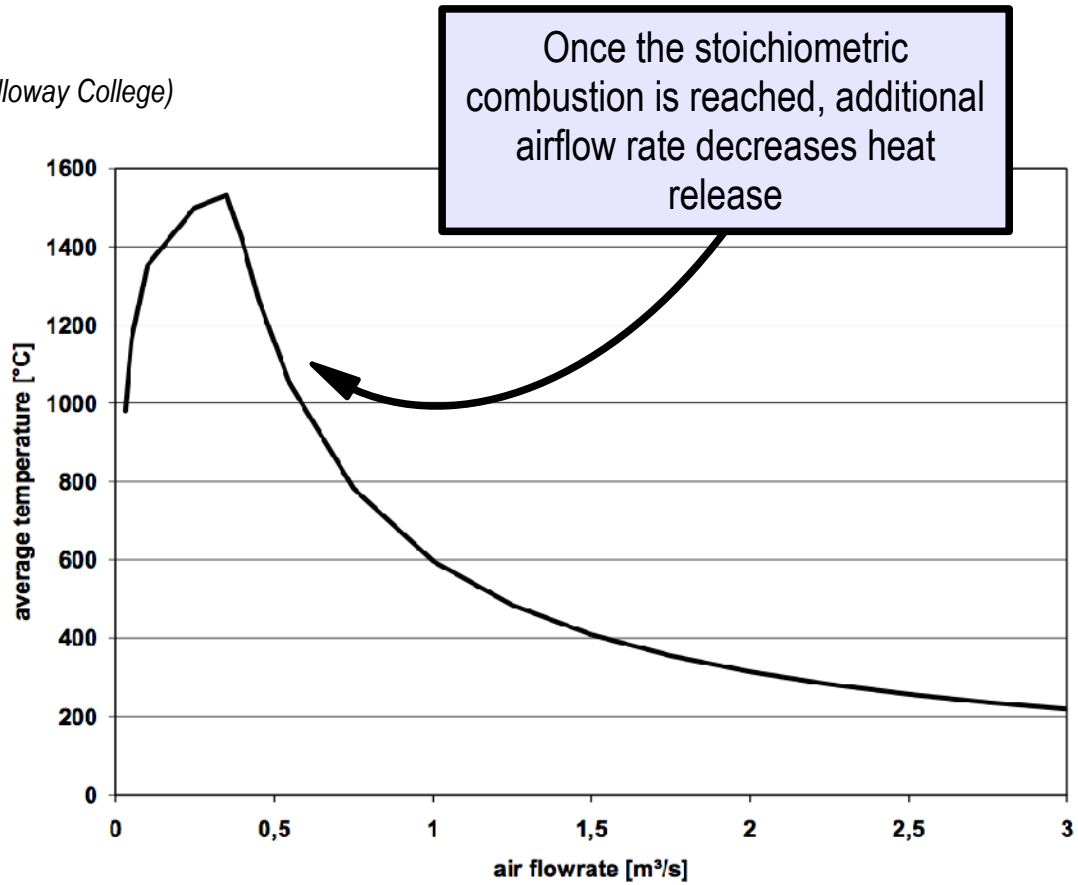
Thermodynamic analysis of the temperature in a compartment that is a fueled with a gas burner

(Ofodike A. Ezekoye, Stefan Svensson & Robert Nicks INTERFLAM 2007 Royal Holloway College)

- 1MW gas burner
- 100m3 confined space
- Radiative loss fraction 30%



1,2 kg/s CH4
~1MW



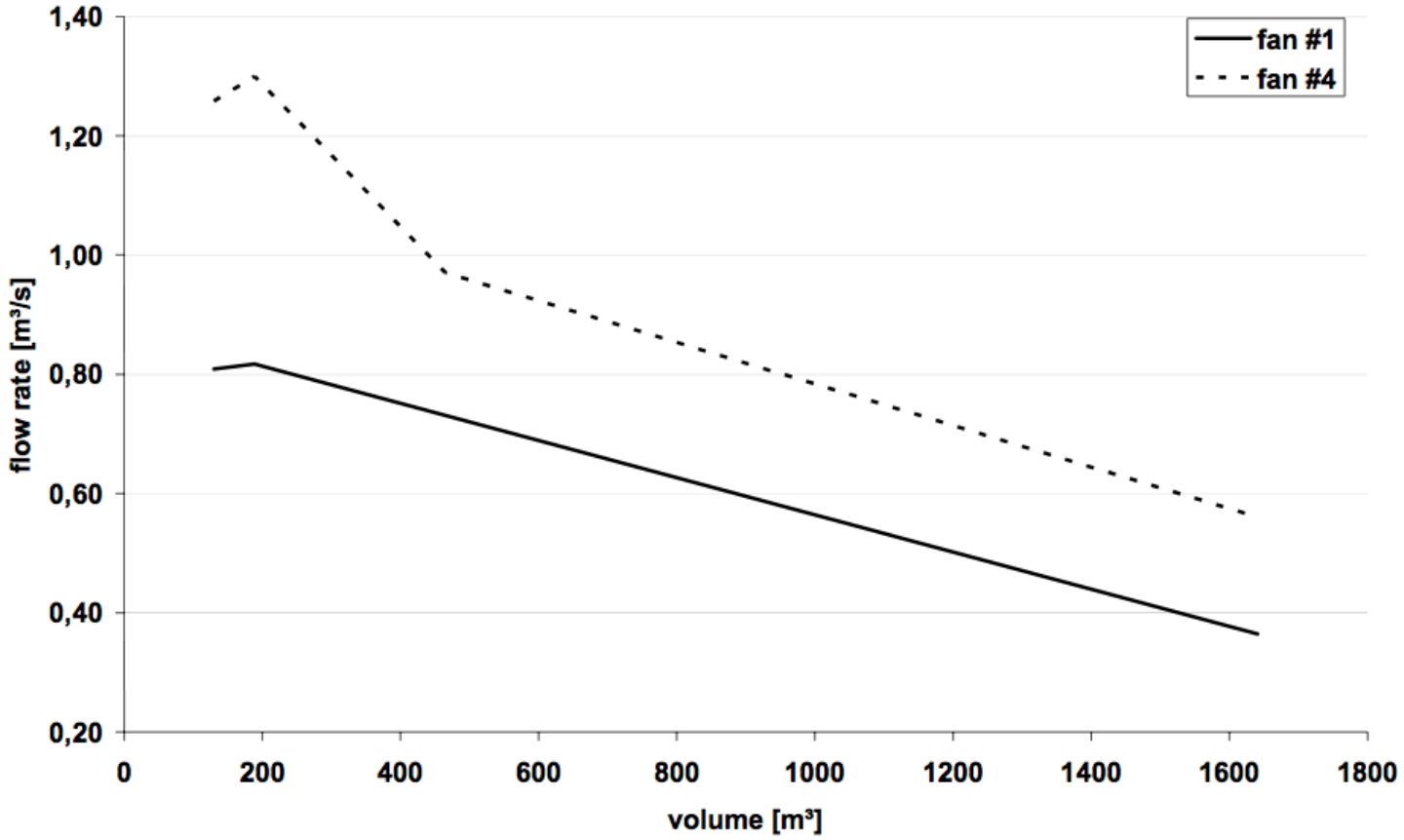
Does air flow into a confined fire increase heat release?

Only true in a Ventilation Controlled Fire.
Once fire reaches a stoichiometric combustion any additional air supply implies a decrease in heat release and temperature.

Extra 2: **Influence of building volume**

Exhaust rate as a function of building volume .

(Ofodike A. Ezekoye, Stefan Svensson & Robert Nicks INTERFLAM 2007 Royal Holloway College)

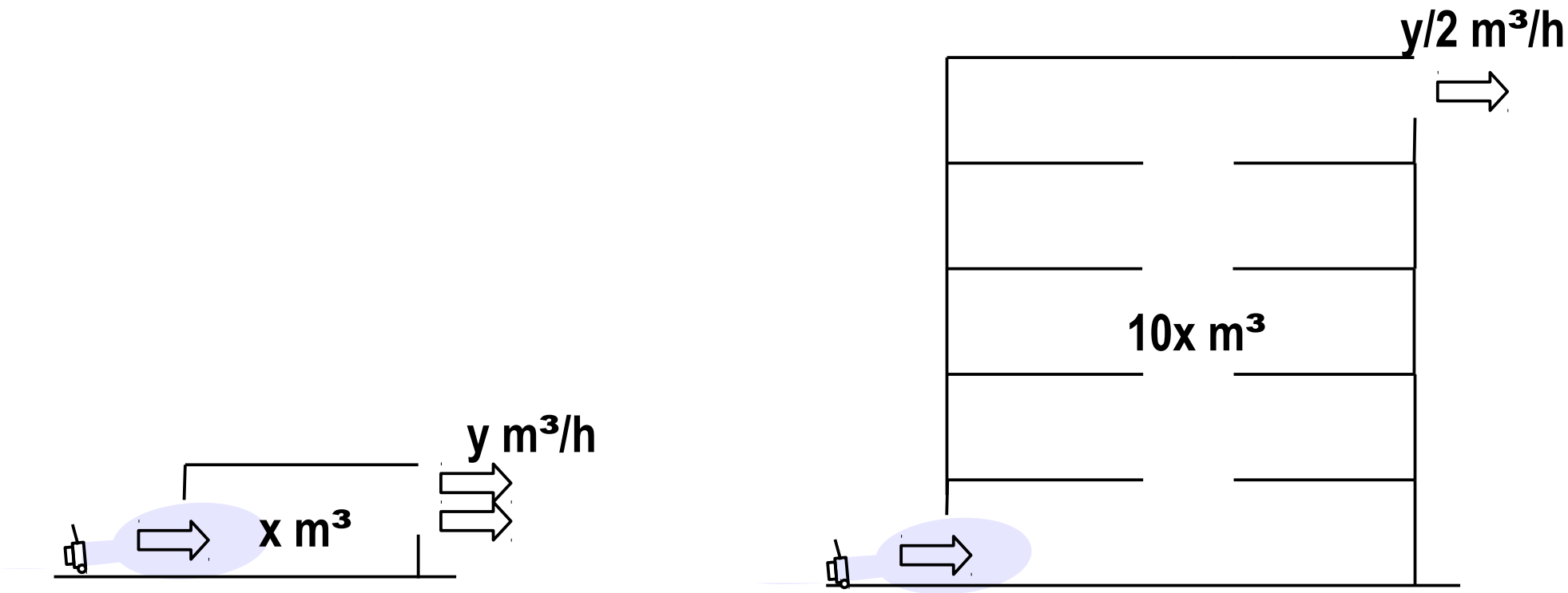


Extra 2: **Influence of building volume**

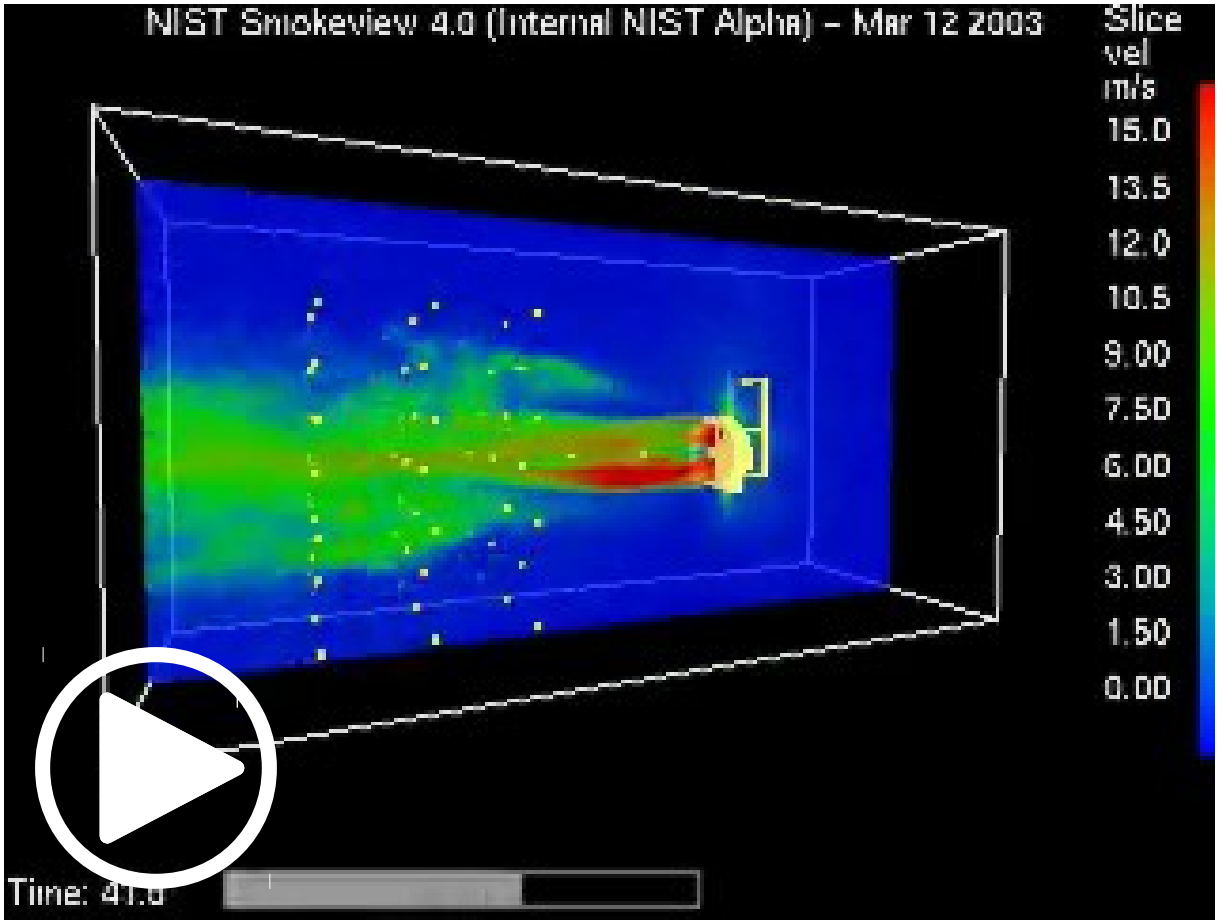
- **Increasing volume 10 times = reducing exhaust rate 50%**

  (As on Ofodike A. Ezekoye, Stefan Svensson & Robert Nicks experiment)

- **Other factors (sealing and friction) have greater influence on exhaust rate.**

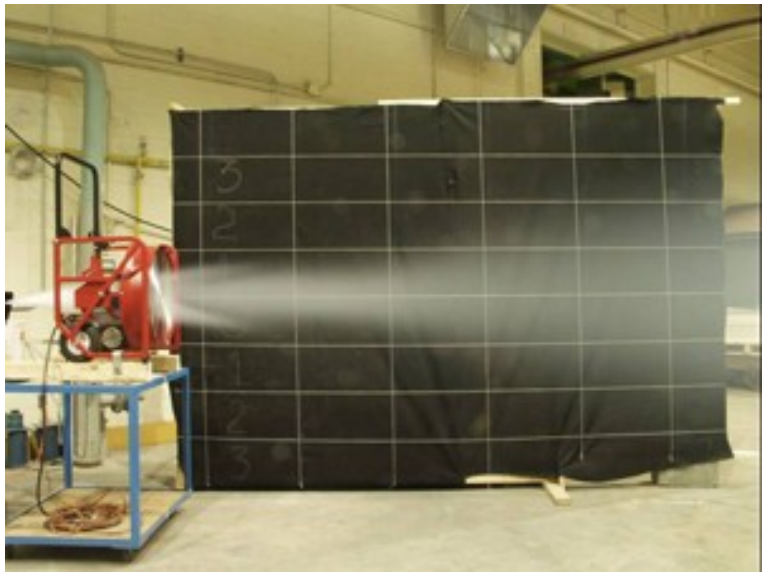


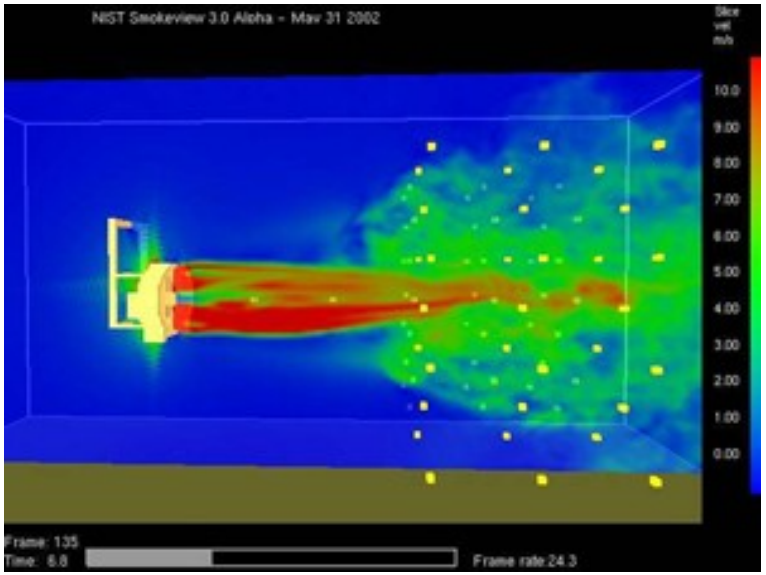
Extra 3: **Fan “footprint”**



Video: Fan model Smokeview – Madrzykowski, NIST 2003
http://www.youtube.com/watch?v=e2Om-RLVwyA

Extra 3: **Fan “footprint”**





Photos: Madrzykowski, NIST 2003

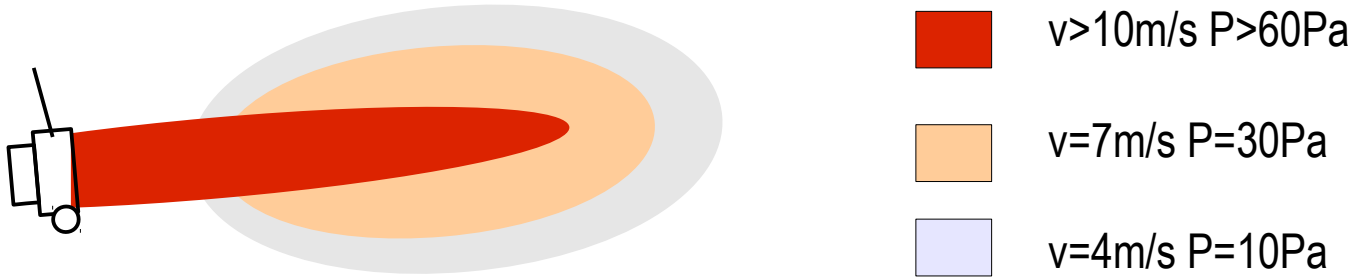
Extra 3: **Fan “footprint”**

Two clear areas to be found on a fan “footprint”:

- High speed cone – v>10m/s P>60Pa
- Dragged air bulb – speed and pressure decrease from inside to outside

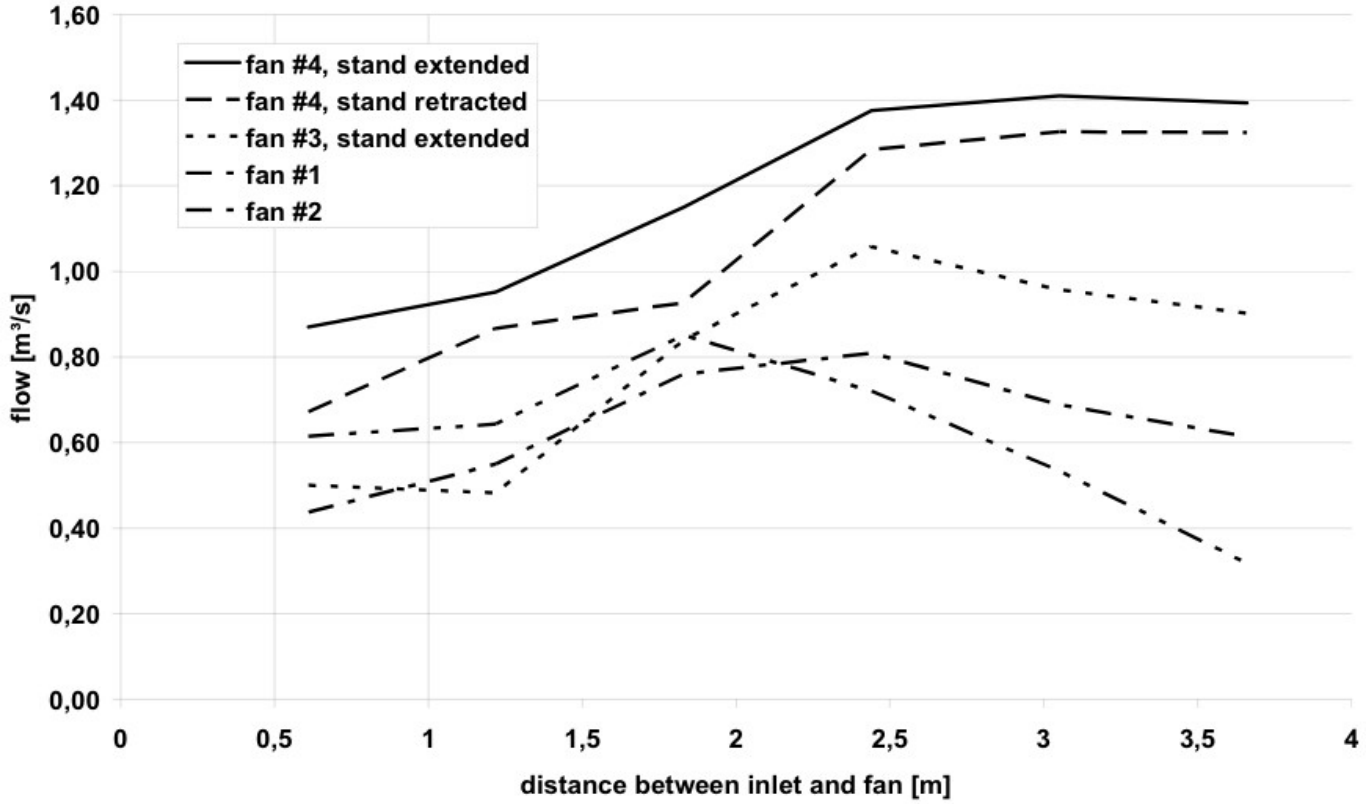
Speed (v) and pressure (P) in any given fluid (d as density) are linked by Bernuolli's Equation:

$$P = \tfrac{1}{2} \cdot d \cdot v^2 \rightarrow v = \sqrt{2 \cdot P / d}$$



Extra 4: **Fan to inlet distance**

- Fan should be placed where air speed and pressure allow the highest flow rate.
- For every fan and inlet size there is an optimum setup distance.

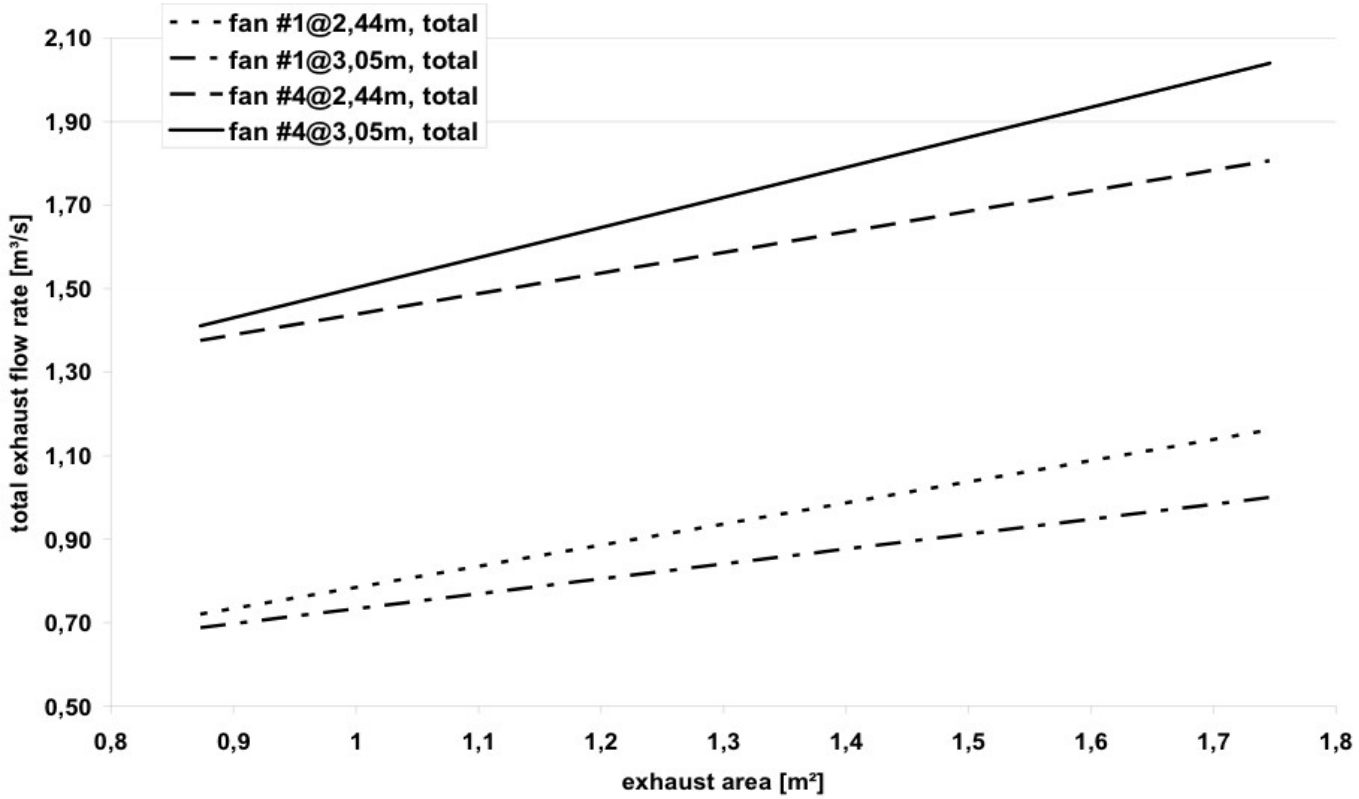


(Ofodike A. Ezekoye, Stefan Svensson & Robert Nicks INTERFLAM 2007 Royal Holloway College)

Extra 5: **Exhaust size**

Flow rate increases with exhaust size.

The following experiment shows a linear increase in 4 different situations with exhausts ranging from 0,8m² to 1,8m²



(Ofodike A. Ezekoye, Stefan Svensson & Robert Nicks INTERFLAM 2007 Royal Holloway College)

Extra 5: **Exhaust size**

Flow rate increases with exhaust size.

Pressure (P), fluid density (d) and velocity (v) are linked by Bernuolli's Equations

$$P = \tfrac{1}{2} \cdot d \cdot v^2 \rightarrow v = \sqrt{2 \cdot P / d}$$

Exhaust rate (Q) depends on average air velocity (v) and exhaust cross section (A)

$$Q = A \cdot v$$

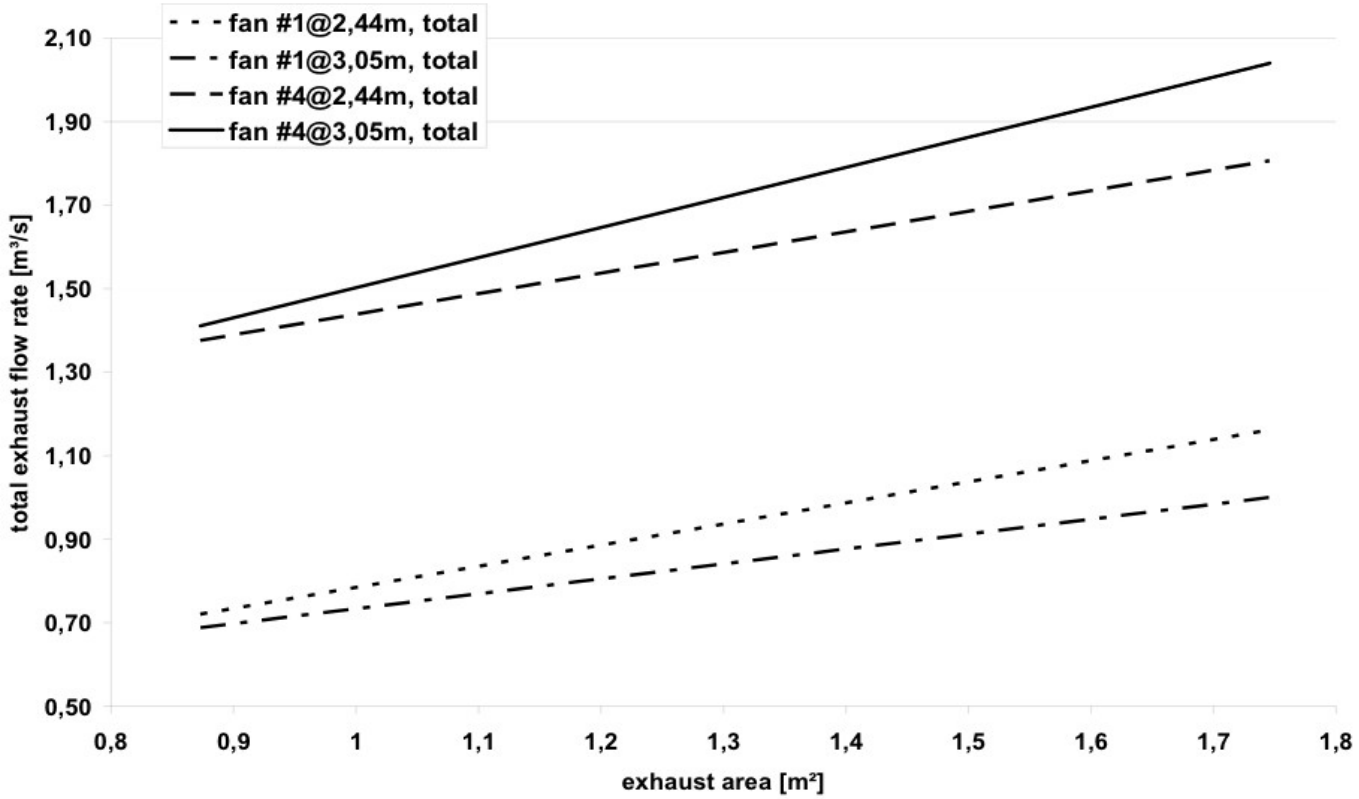
$$\boldsymbol{Q = A \cdot \sqrt{2 \cdot P / d} \quad (*)}$$

As seen in equation (*), exhaust size (A) has a greater influence on flowrate (Q) than pressure (P) which would be the only parameter increasing as exhaust size decreases.

Extra 5: **Exhaust size**

Flow rate increases with exhaust size.

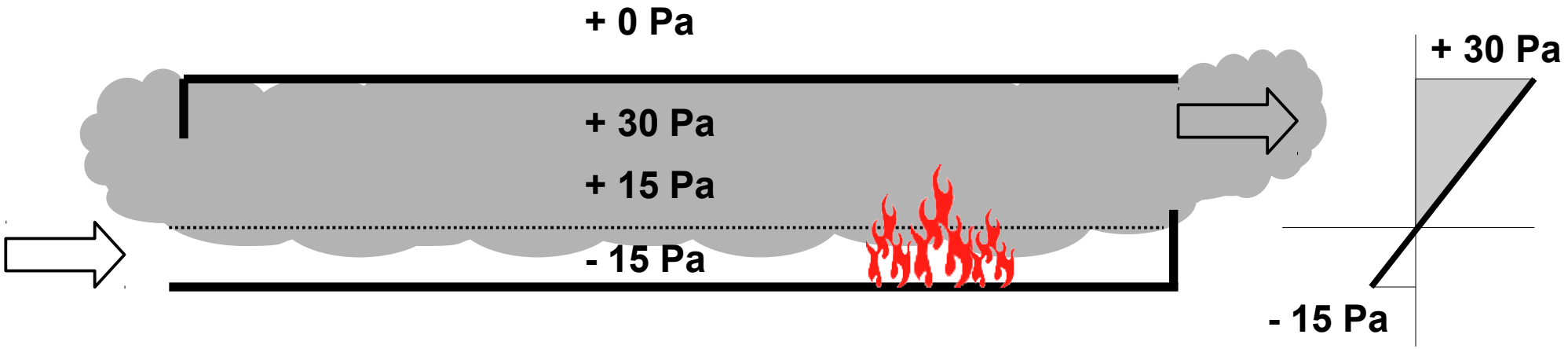
The following experiment shows a linear increase in 4 different situations with exhausts ranging from 0,8m² to 1,8m²



(Ofodike A. Ezekoye, Stefan Svensson & Robert Nicks INTERFLAM 2007 Royal Holloway College)

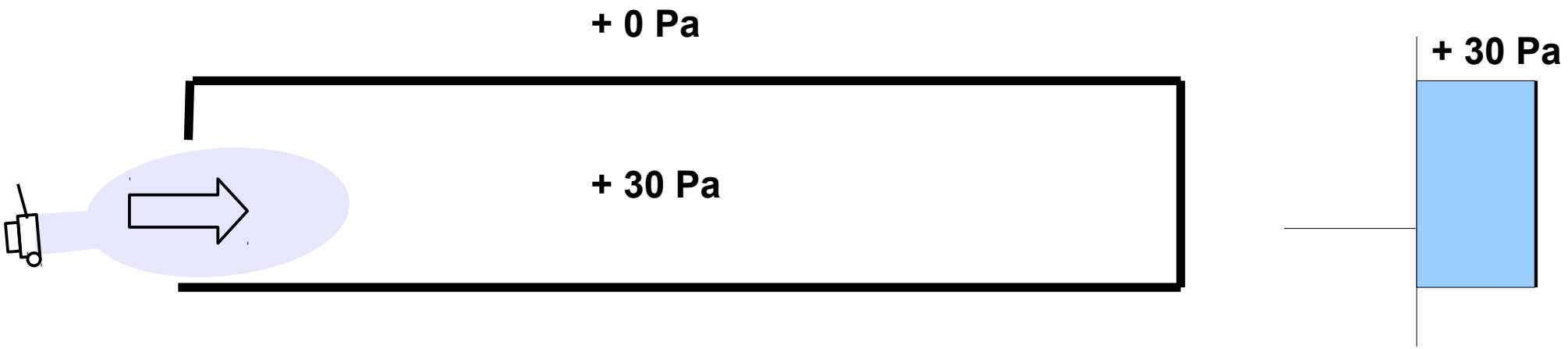
Extra 6: **Pressure values within fire compartment**

Typical values for pressure in a confined fire with natural ventilation



Extra 6: **Pressure values within fire compartment**

Compartment pressurized by fan

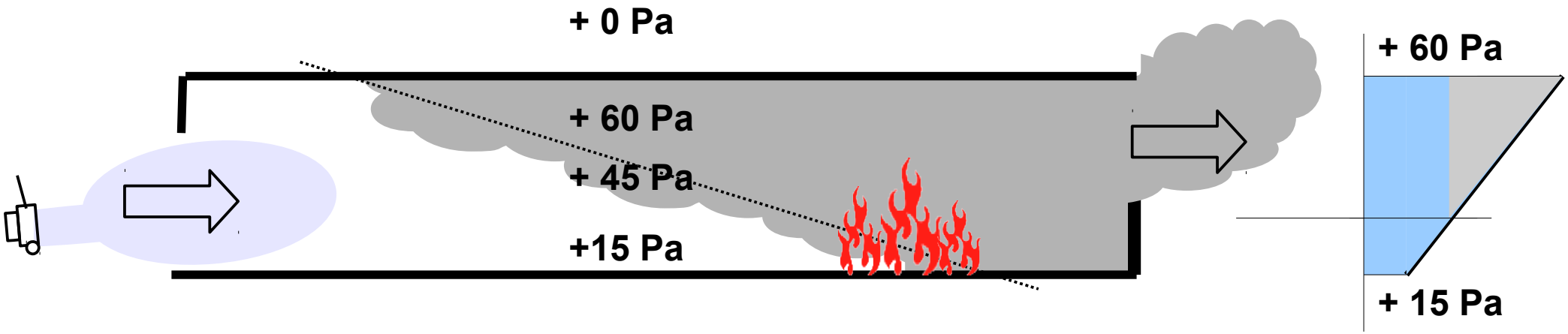


Pressure values for a 40.000m³/h fan and a 1,6m² cross section inlet:

$$P = ½ \cdot \rho \cdot v^2 = ½ \cdot 1{,}25 kg/m^3 \cdot (40000\ m^3/h / (3600\ s/h \cdot 1{,}6 m^2)^2 = 30 N/m^2 = 30 Pa$$

Extra 6: **Pressure values within fire compartment**

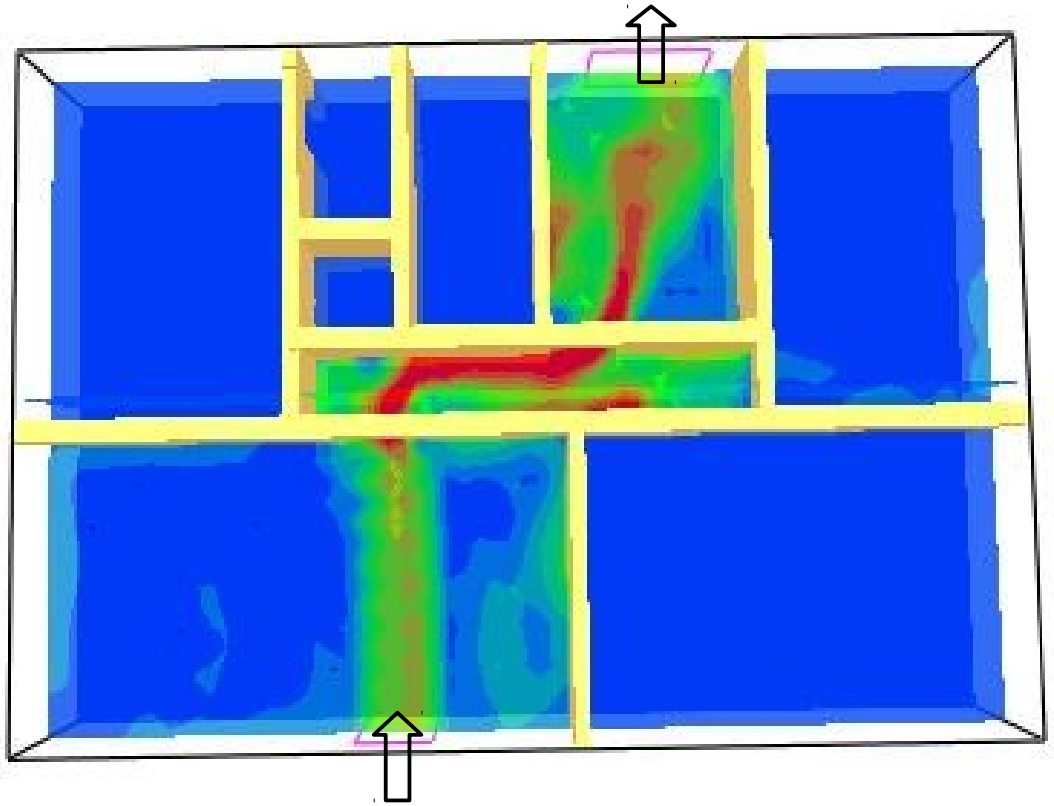
Typical pressure values during a PPA

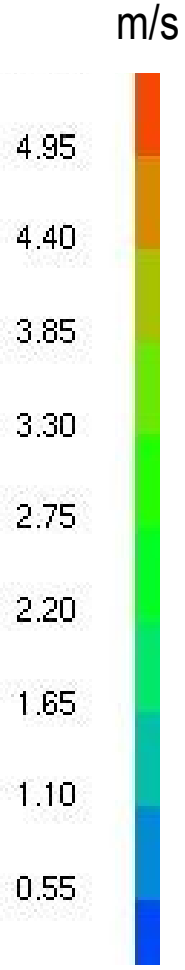


Extra 7: **Air stream within structure**

Longer path → More friction → Slower air stream → Reduced flow

Firefighters along the air stream force air stream to bend around increasing friction loss.

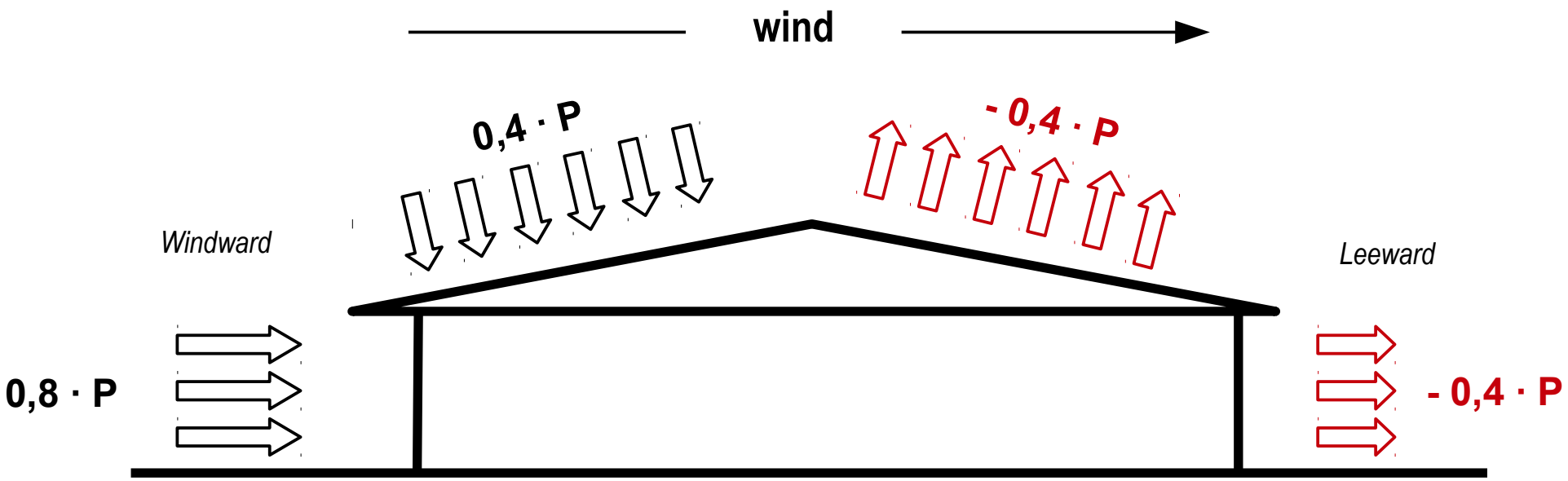




Extra 8: **Wind effect on ventilation**

Wind pressure on building

As of NBE-AE88, Art. 5.4, roof at 40º



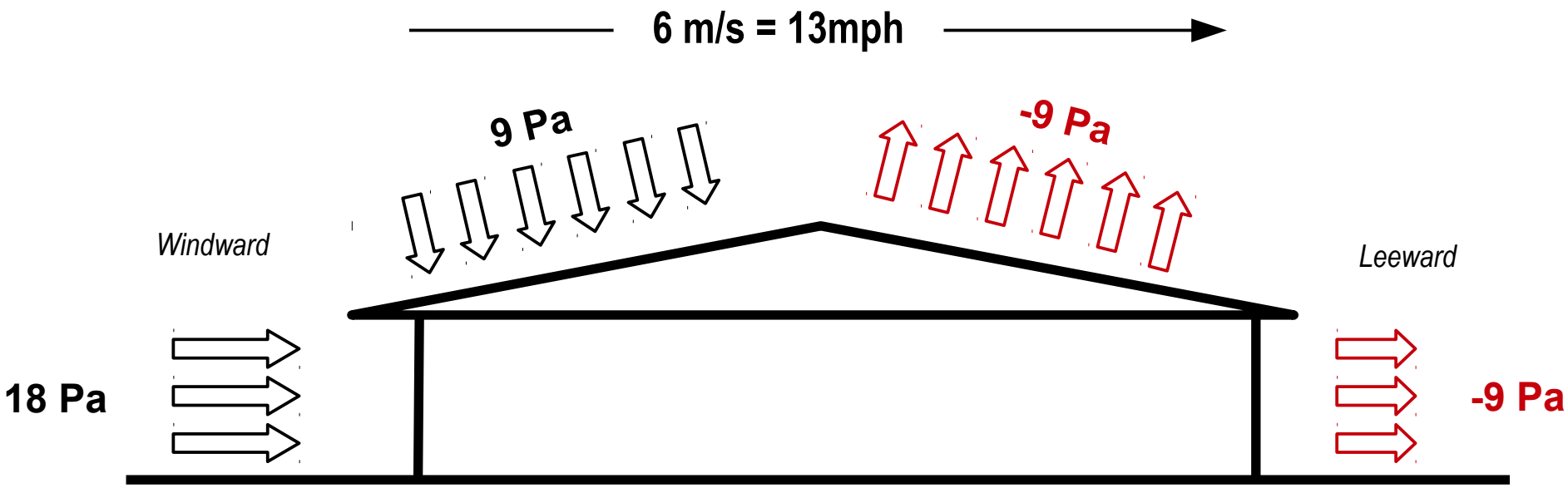
Basic wind pressure

$$P = \tfrac{1}{2} \cdot \rho \cdot v^2$$

Extra 8: **Wind effect on ventilation**

Wind pressure on building

As of NBE-AE88, Art. 5.4, roof at 40º



Downwind ventilation → 27 Pa of extra pressure

Upwind ventilation → 27 Pa to overcome

Extra 8: **Wind effect on ventilation**

- During a PPA, observed interior pressure depends on pressure provided by fan and wind pressure balance between exhaust and inlet.

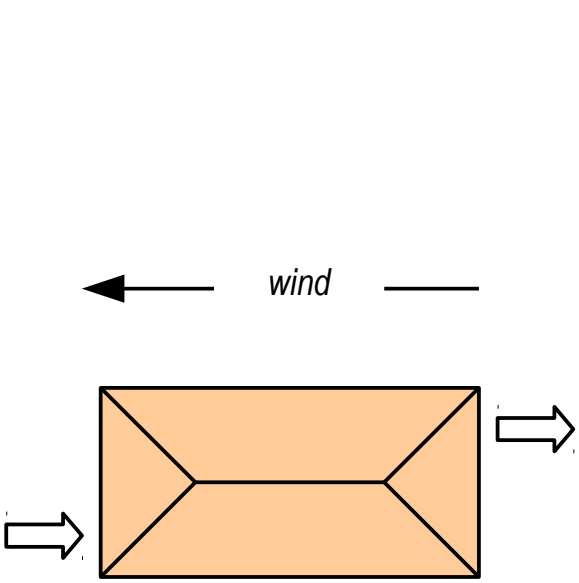
$$P_{interior} = P_{fan} + P_{wind@inlet} - P_{wind@exhaust}$$

- Wind speeds over 7 m/s (15mph) generate a wind pressure on the building that equals or exceeds conventional 20” fans.

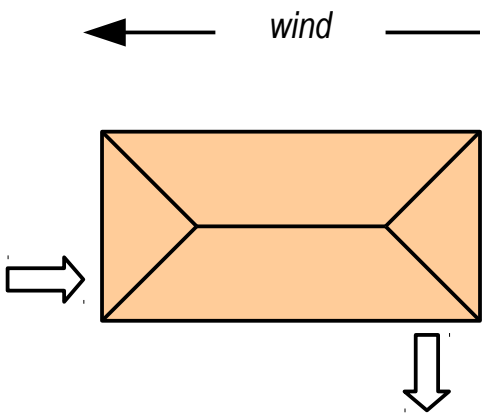
- **Don't ventilate upwind with wind speeds over 4 m/s (9mph).**

Extra 8: **Wind effect on ventilation**

- **Search for wind assisted ventilation patterns**
- **Searh for 90º patterns to avoid wind reverse effect**



NO



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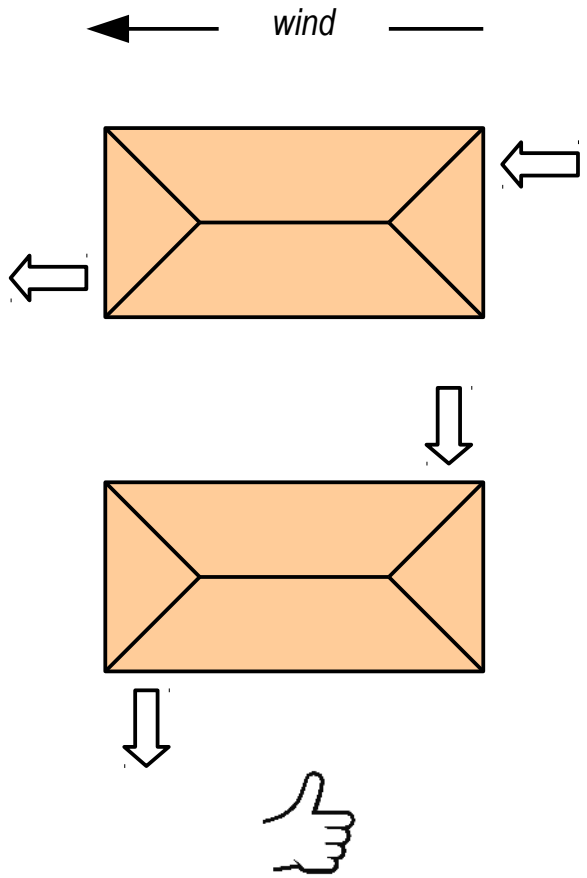


Positive Pressure Attack

TACTICS

PPA Tactics

STARTING POINT

- We know what a PPA is.
- We understand the physics and the technical background of PPA.
- We know risks of PPA and the Safety Measures to observe.

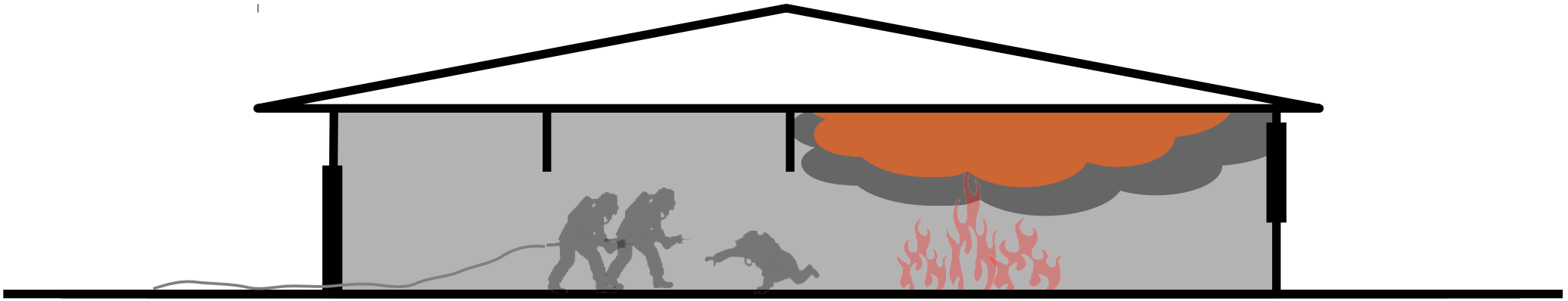
LET'S GET REAL

- For every final purpose of the PPA technique there is step-by-step procedure.
- **During operations, tactics should be evaluated and altered if needed.**

Firefighting techniques overview

- **Confined Space Extinguish**
- Natural Ventilation
- Vertical Roof Ventilation
- Positive Pressure Ventilation

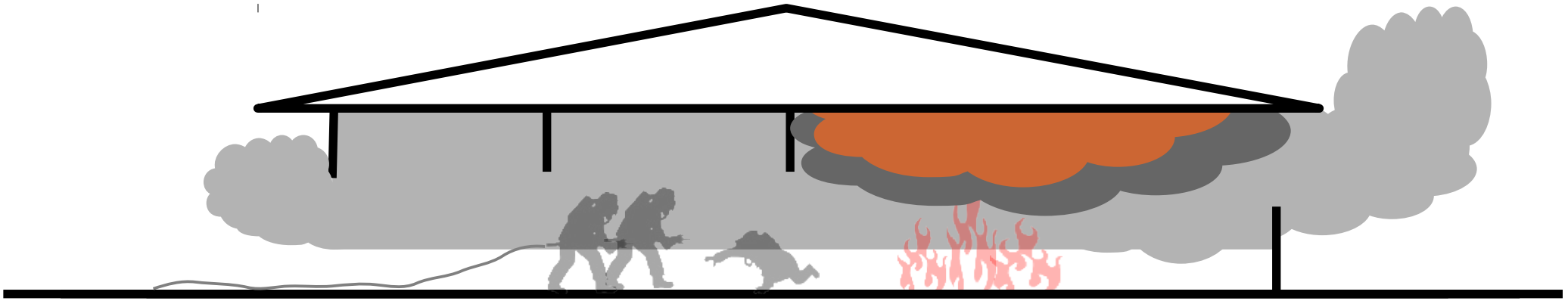
- **Fire is completely confined, hot gas layer is cooled down with pulsating nozzling, walls are "water painted" and fire seat is put down with solid direct nozzle.**
- Developed in Sweden.
- Common in Europe.



Firefighting techniques overview

- Confined Space Extinguish
- **Natural Ventilation**
- Vertical Roof Ventilation
- Positive Pressure Ventilation

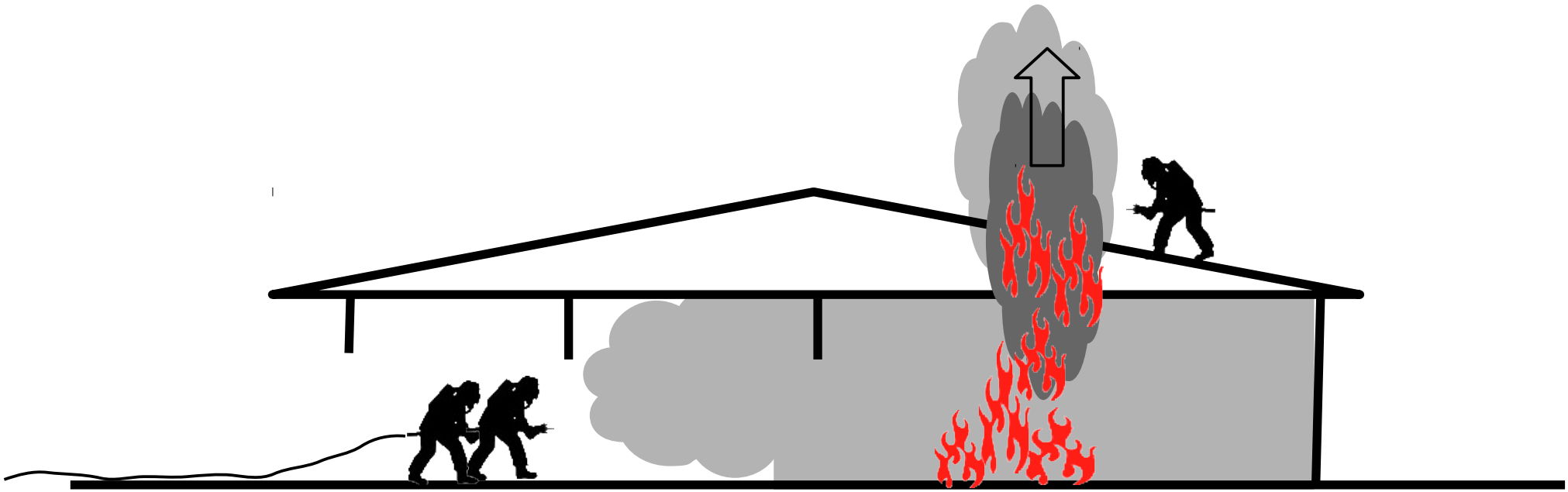
- **Compartment is vented, fire reaches its own thermal balance, interior conditions improve as compared with confined fire conditions but fire may still produce large amounts of smoke.**
- Common in Europe.



Firefighting techniques overview

- Confined Space Extinguish
- Natural Ventilation
- **Vertical Roof Ventilation**
- Positive Pressure Ventilation

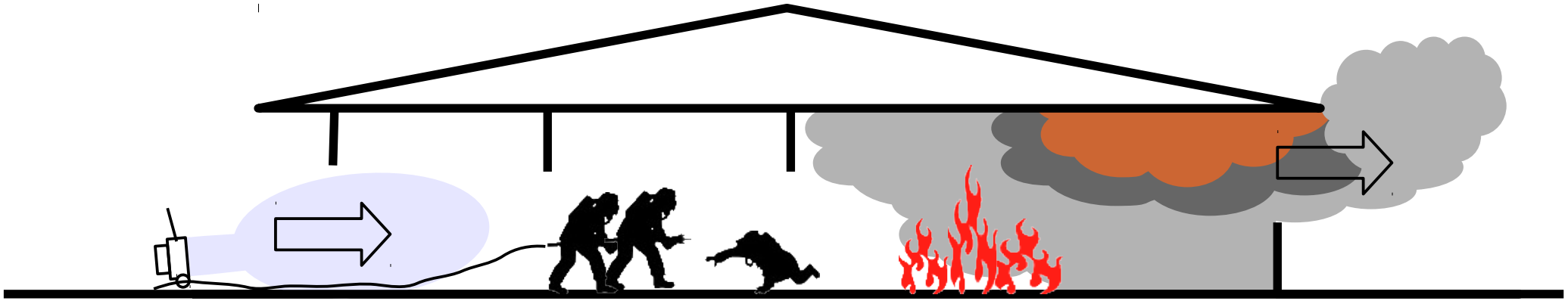
- **A hole is made in the roof to remove smoke and let interior conditions improve.**
- Traditional in the USA.
- Firefighters above fire face dangerous situations.
- Rarely used in Europe.



Firefighting techniques overview

- Confined Space Extinguish
- Natural Ventilation
- Vertical Roof Ventilation
- **Positive Pressure Ventilation**

- **Coordinated pre-knockdown attack assisted with mechanical ventilation.**
- Developed in the USA.
- Safe interior conditions from very beginning for victim and firefighters.



PPA advantages

A breathable, clean, cool, not flammable atmosphere implies:

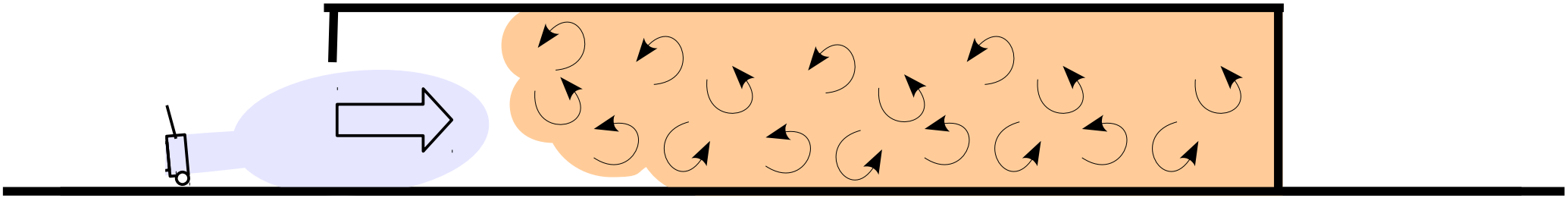
- **Improved safety for firefighters**
- **Better victim survivability**
- **Faster operations**
- **Reduced property damage**

Don't use PPA if...

- There is no exhaust.
- There is no water line ready to advance.
- Upwind prevailing conditions (9mph).
- Not a clue to where fire seat is.
- Exhaust path for smoke is not clear.
- Unable to do a 360º size-up.
- Imminent backdraft conditions.
- Victim or crews on exhaust.
- Volatile class B or dust fuel fire.

Hands-on tips – **Open exhaust first, then open inlet**

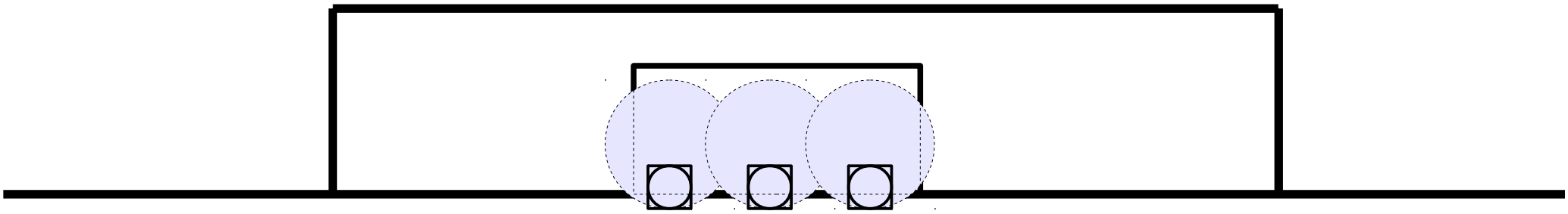
WTF – Windows Then Fan



BACKDRAFT RISK!

Hands-on tips – **Inlet**

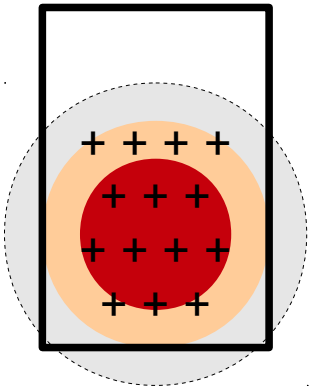
- **Use single inlet**
- **Generally entry door**
- **Ideal size 2m²** (25 sq feet – 7' x 3') for 20" fans rated at 40.000m³/h (25.000cfm)
- **Use parallel fan setup for large entries**

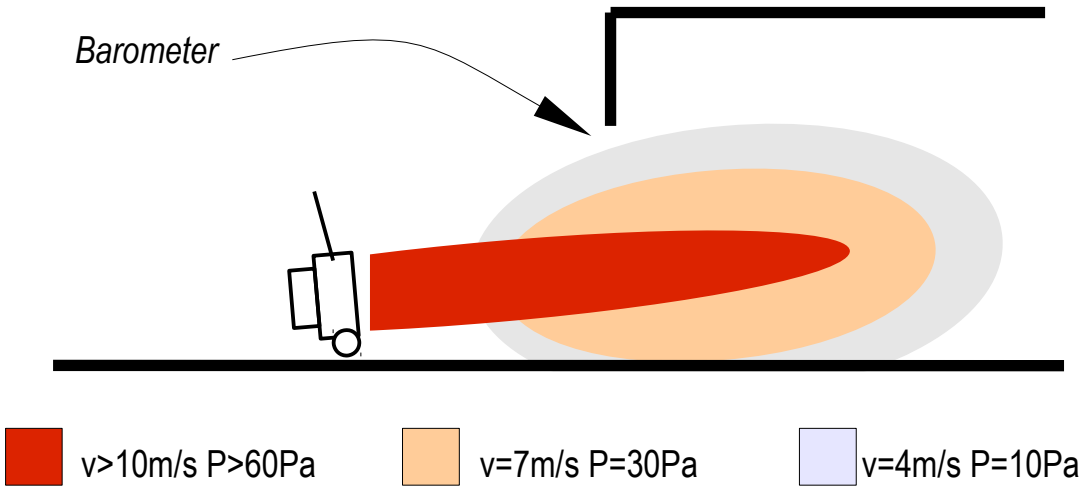


Hands-on tips – **Inlet**

Hands-on tips – **“Barometer” at inlet**

- Fan is setup so that pressure in upper part of inlet is lower (aprox 15% of height – 25cm / 10").
- “Barometer” allows to evaluate ventilation from entry point.
- “Barometer” will only work when placing fan just behind a fully involved smoke compartment.





Hands-on tips – **“Barometer” at inlet**

Smoke constantly coming out from barometer... ...something is going wrong!

= insuficient fan power, not enough exhaust, interior door closed,....

⇨ **STOP VENTILATION, ASSESS AND ALTER VENTILATION**

Barometer

Hands-on tips – **“Barometer” at inlet**

Video: Bakersfield PPA Academy 2013
http://www.youtube.com/watch?v=UDVoaCsf-tg barometer behavior @1:30

Hands-on tips – **Fan to inlet distance**

- **For every fan, there is a an optimum fan-to-inlet distance.**
- **When in doubt, better off farther than closer.** (see FAQ Extra 4: Fan to inlet distance pg80)

VENTRY 20GX160

30.000m³/h 4,8HP 33Kg

3m – 10'
extended legs

LEADER MT236 / MT245

40.000m³/h 6HP 52Kg

2m – 7'

HALE 30W22

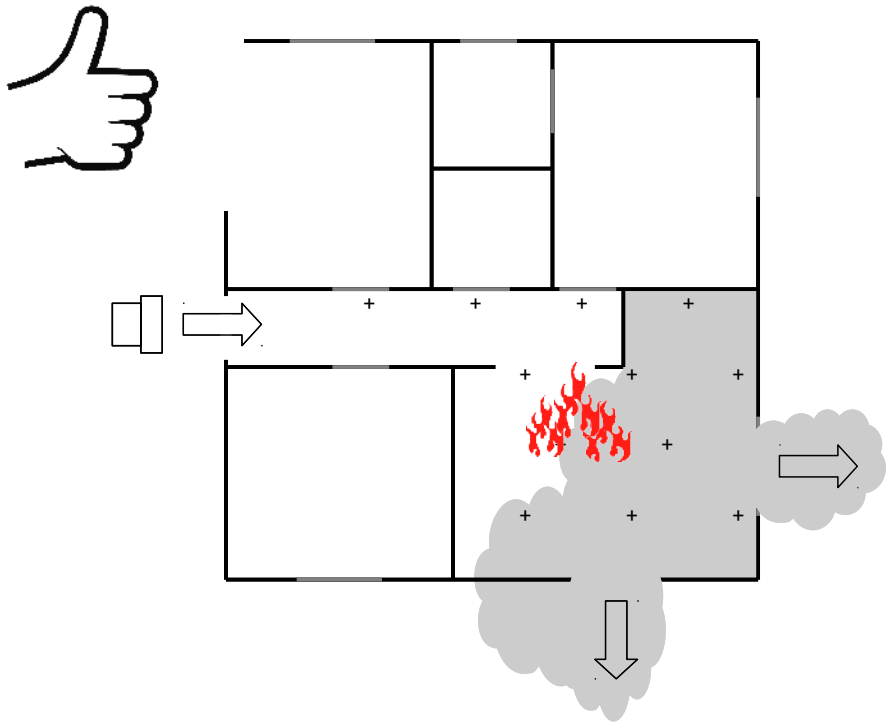
77.000m³/h 22HP 40Kg

1,8m – 6'

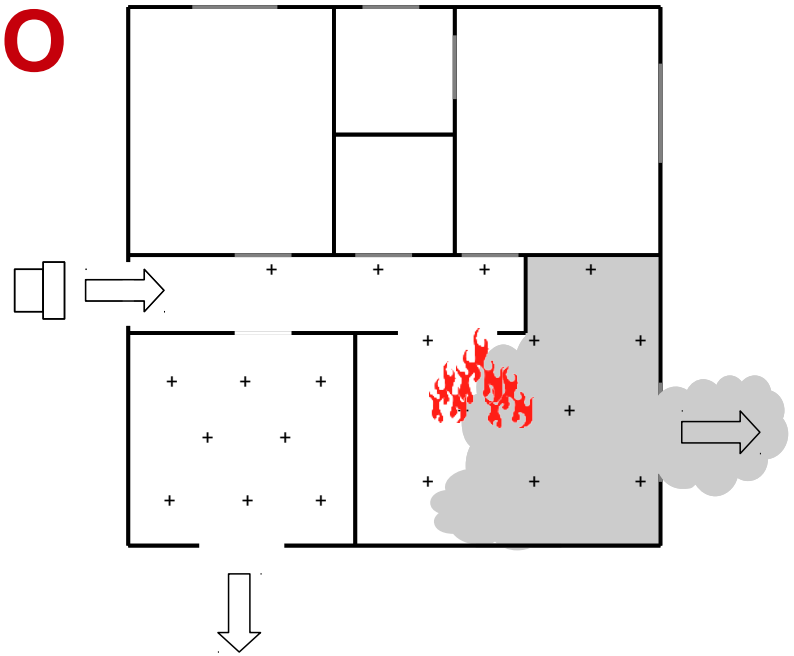
Just a sample for fans operated by CEIS Guadalajara.
Manufacturer's ratings for CFM may be measured according to different standards and mislead to real fan performance. Test yourself.

Hands-on tips – **Exhaust**

- **The closer to fire seat the better**
- **Optimum exhaust size values start at 1,5 times inlet size**
- **Single exhaust or multiple exhausts as long as there is no pressure loss**



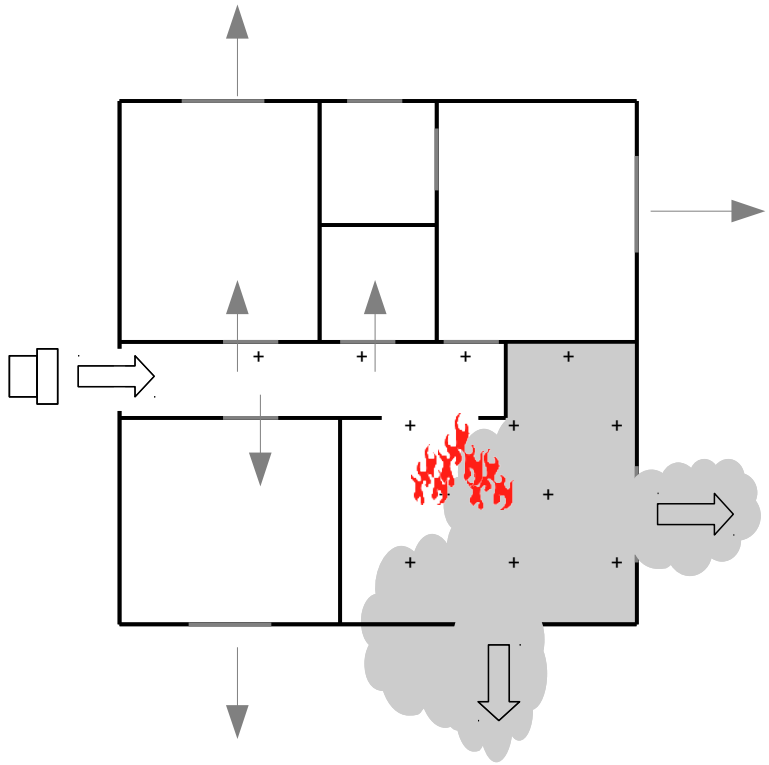
NO



Hands-on tips – **Pressure loss**

Pressure losses to accounted for

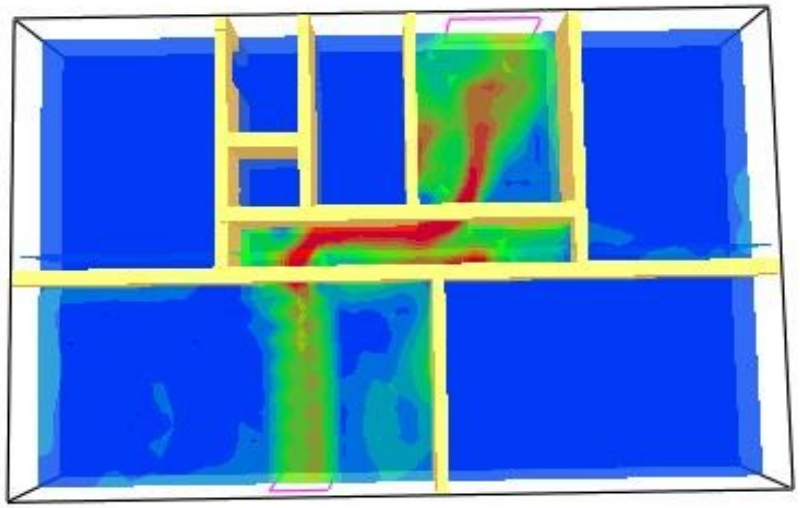
- **Bad sealing → Close/confine any possible outlets and bad sealing areas**
- Friction loss
- Building volume



Hands-on tips – **Pressure loss**

Pressure losses to accounted for

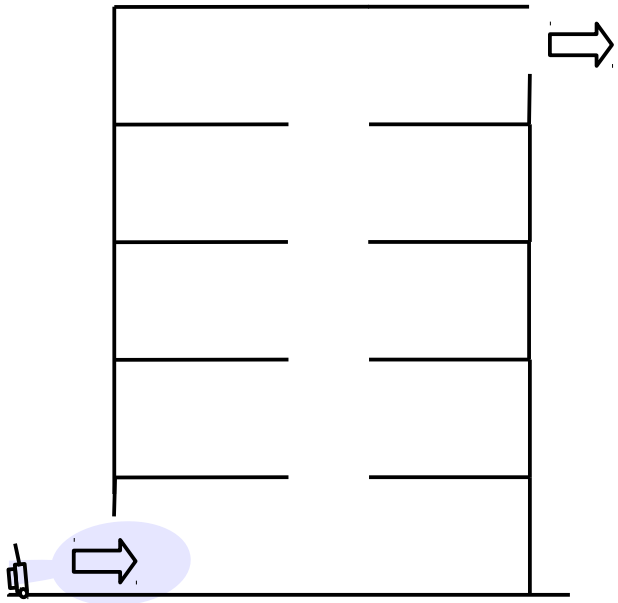
- Bad sealing → Close/cofine any possible outlets and bad sealing areas
- **Friction loss → Use fans in series**
- Building volume



Hands-on tips – **Pressure loss**

Pressure losses to accounted for

- Bad sealing → Close/cofine any possible outlets and bad sealing areas
- Friction loss → Use fans in series
- **Building volume → Use fans in series**



Hands-on tips – **Fans in series**

Fans in series allow to work around pressure losses.

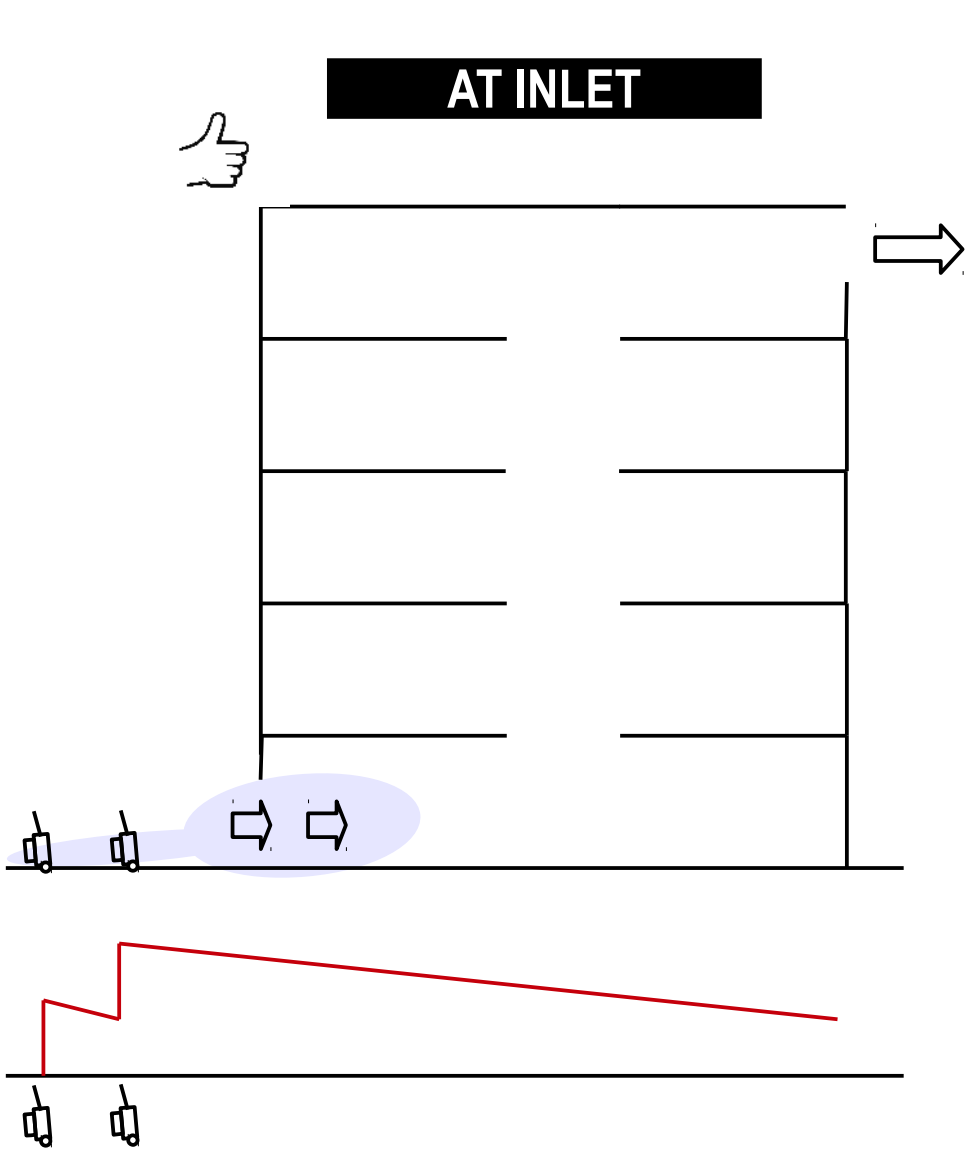
Same approach used in water pumps in series:

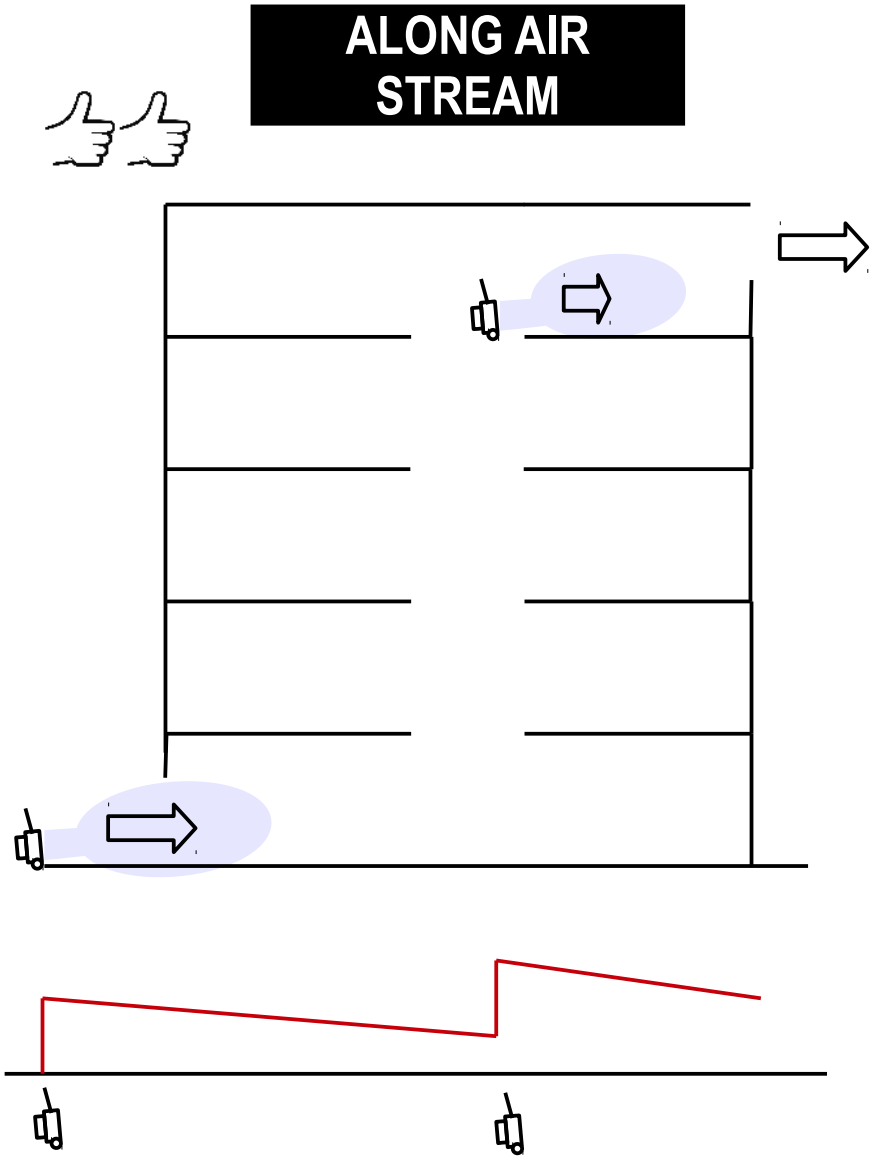
FLUID	water	air
DEVICE	pump	fan
PROBLEM	hose friction	friction loss
	heigth	bad sealing

2 different setups for fans in series:

- at inlet
- along air stream

Hands-on tips – **Fans in series**





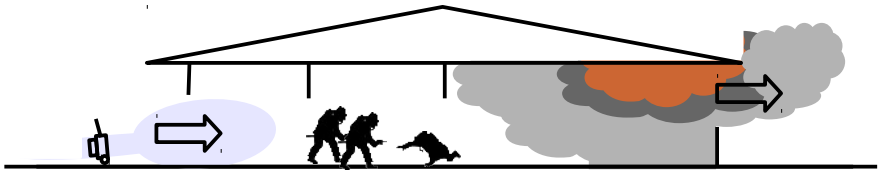
Hands-on tips – **Safety Waiting**

- **Allows ventilation evaluation before crews enter structure.**
- **Crews enter with improved interior conditions.**
- **Reduces backdraft and flashover.**
- **10s to 30s depending on structure volume and conditions should be enough.**
- **Safaty Waiting to be made a at a safe position:**

  outside smoke filled structure → general rule, always in thick/high temperature smoke conditions

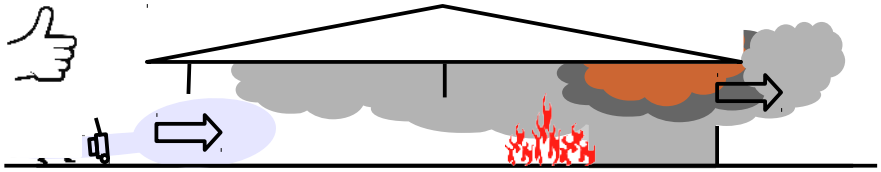
  inside structure sufficiently covered → as an exception for light smoke/low temperature conditions or high rise structures

Hands-on tips – **Safety Waiting**



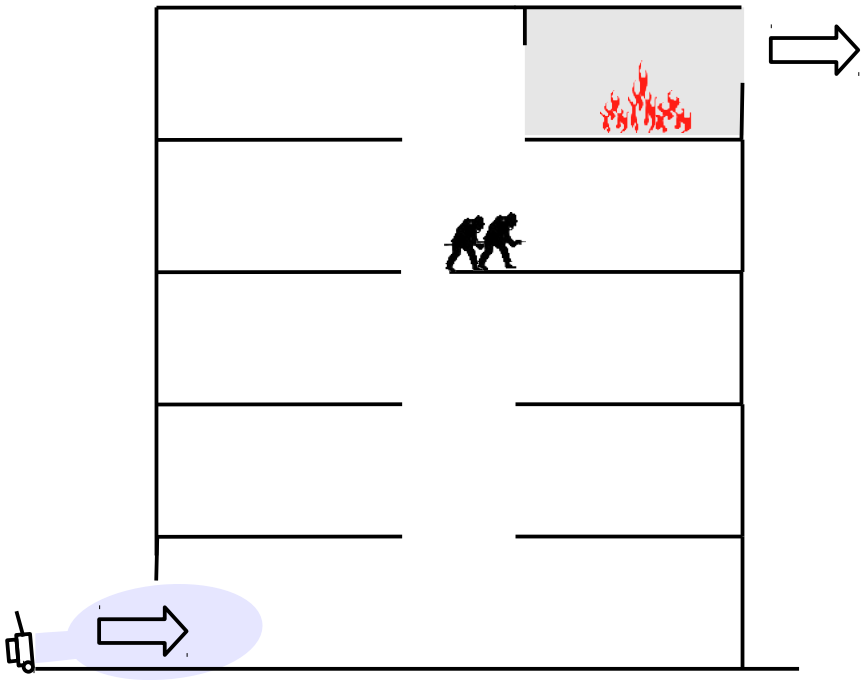
COVERED IN STRUCTURE INTERIOR

victims in interior
light smoke
low temperature
better off if fire is confined



OUTSIDE SMOKE FILLED STRUCTURE

general rule
thick smoke
high temperature



ONE LEVEL BELOW FIRE

high rise structure

PPA tactics

OFENSIVE

1. PPA Venting for Fire

→ Smoke is removed to help out locate fire seat in a clean, not flammable atmosphere.

DEFENSIVE

2. PPA Venting for Life

→ Smoke is removed to provide a tenable atmosphere for victims and help search&recue operations.

3. PPA Venting for position

→ Smoke is removed to help crews gain position and improve safety in further operations.

4. APP Venting for exposure control

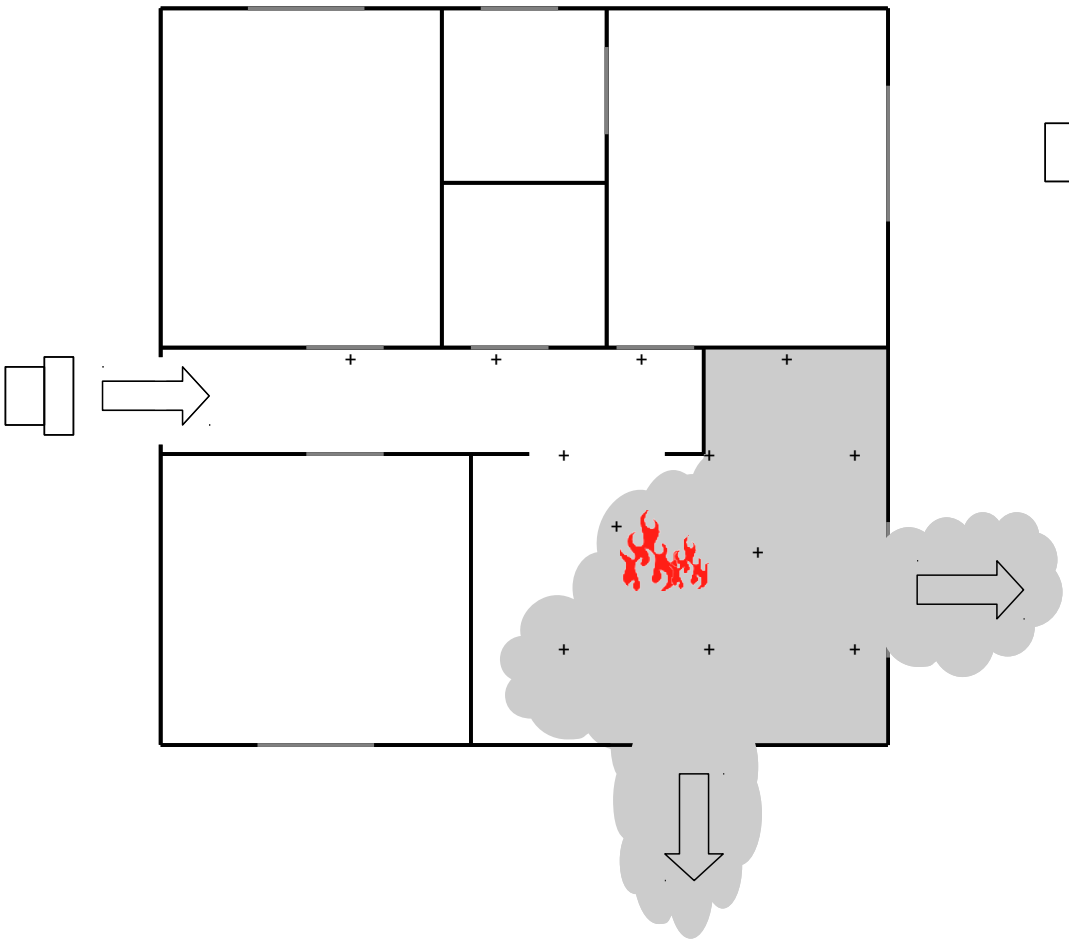
→ Non affected rooms or structures are pressurized for exposure control.

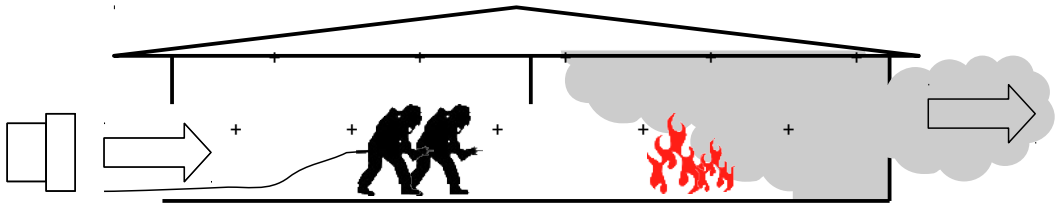
PPA Venting for Fire

OFENSIVE

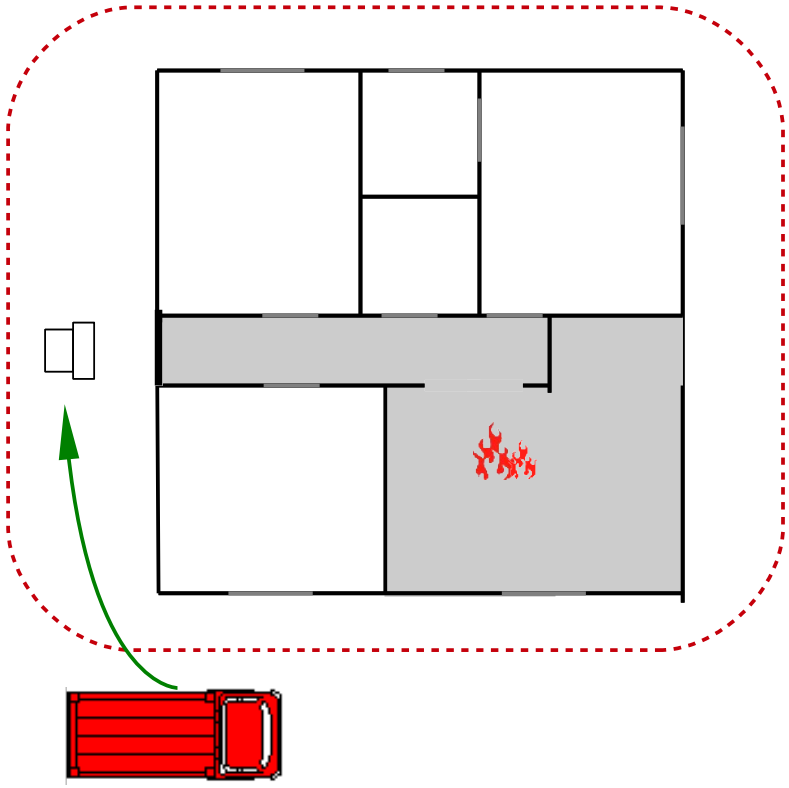
- **Attack purpose is fire control and knockdown.**
- **Attack is assisted with positive pressure ventilation to remove smoke and introduce a cool, clean, breathable atmosphere that provides safe conditions for interior crews to advance, locate and extinguish fire.**
- **Venting for Fire allows:**
  - lower interior temperatures
  - non toxic breathable atmosphere in case of SCBA trouble
  - visibility
  - fire seat spotting
  - faster operations
  - reduced property damage

PPA Venting for Fire





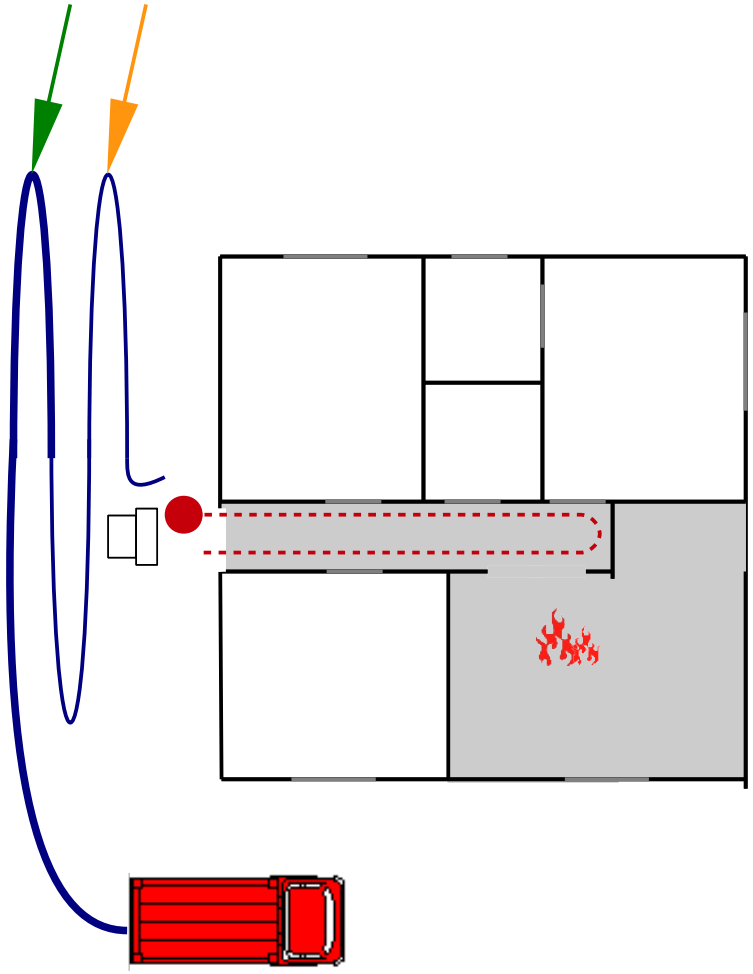
PPA Venting for Fire Evolution



BACKUP TEAM **ATTACK TEAM** **COMMAND**

- **360º SIZE-UP**
- **FAN SETUP**
- CHECK FOR INTERIOR CONDITIONS
- WATER LINE READY FOR ADVANCE
- CALL FOR VENTILATION
- FAN STARTED AND POINTING INLET
- EXHAUST OPENING
- ENTRY OPENING
- SAFETY WAITING
- AGRESSIVE ATTACK

PPA Venting for Fire Evolution



BACKUP TEAM ATTACK TEAM COMMAND

360º SIZE-UP

FAN SETUP

CHECK FOR INTERIOR CONDITIONS

WATER LINE READY FOR ADVANCE

CALL FOR VENTILATION

FAN STARTED AND POINTING INLET

EXHAUST OPENING

ENTRY OPENING

SAFETY WAITING

AGRESSIVE ATTACK

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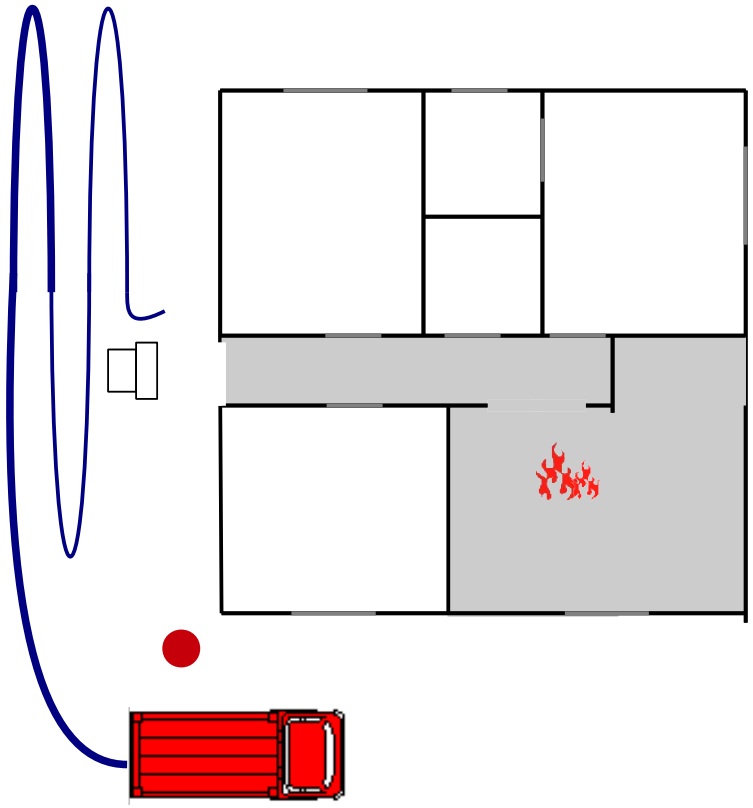

BACKUP TEAM ATTACK TEAM COMMAND

360º SIZE-UP

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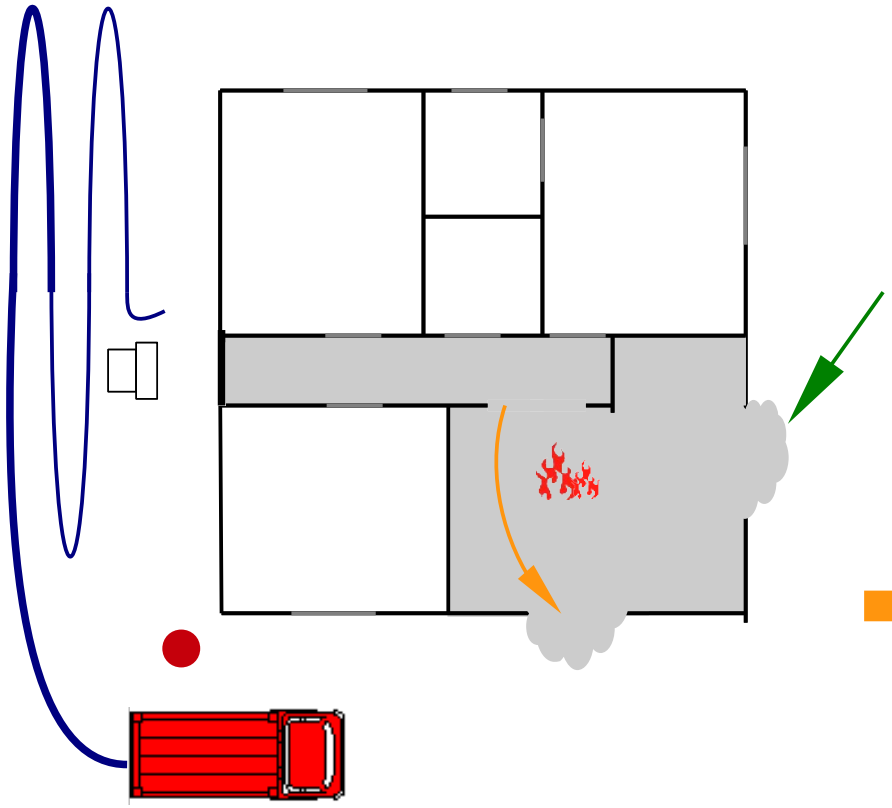

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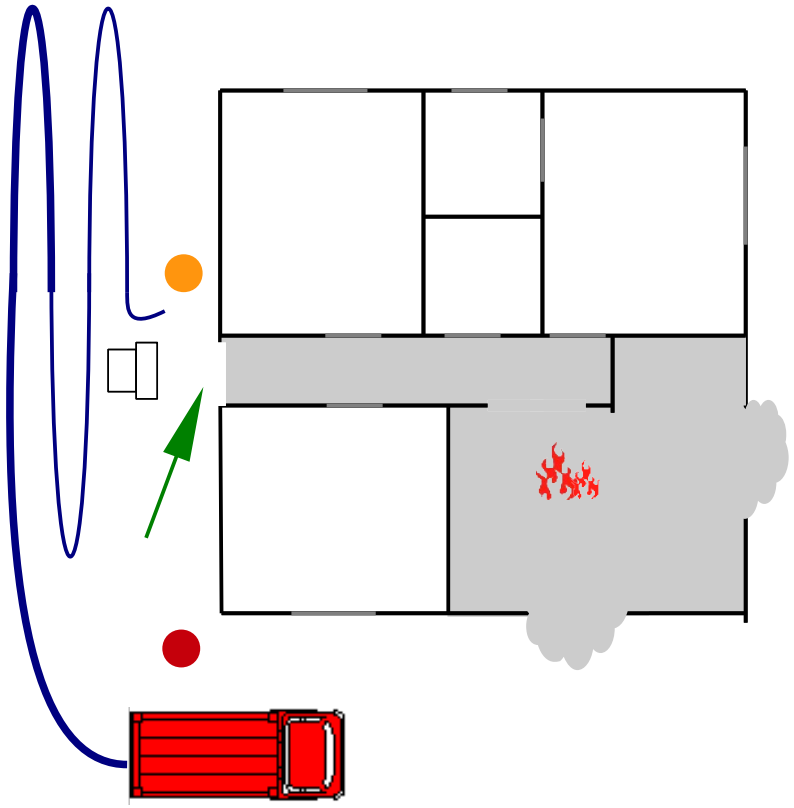

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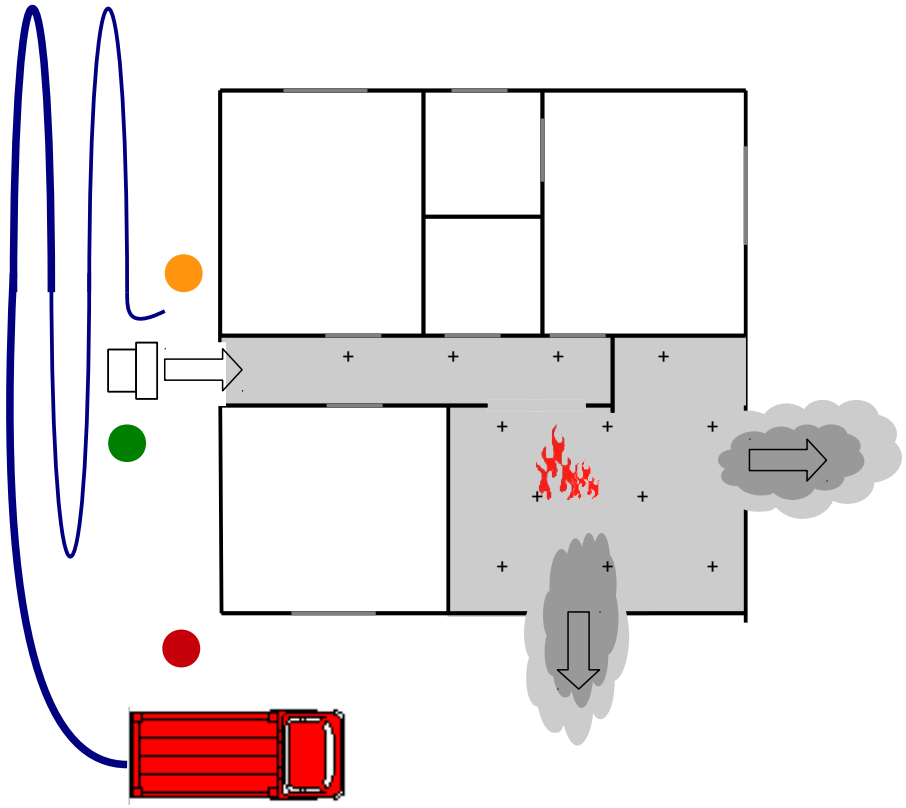

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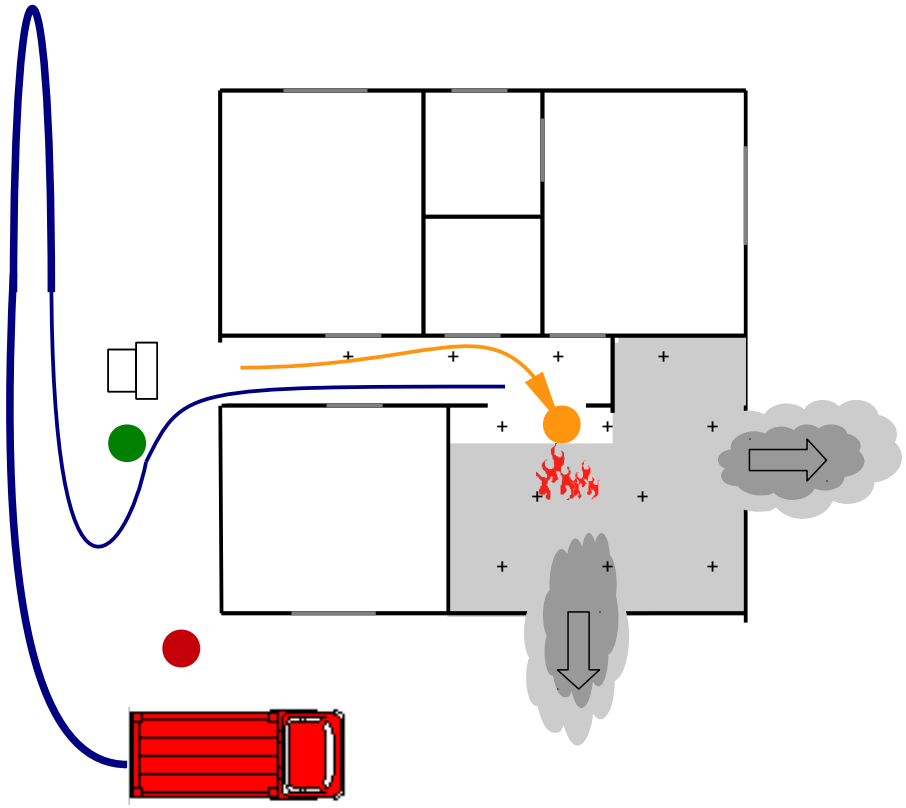

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360º SIZE-UP

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ENTRY OPENING

SAFETY WAITING

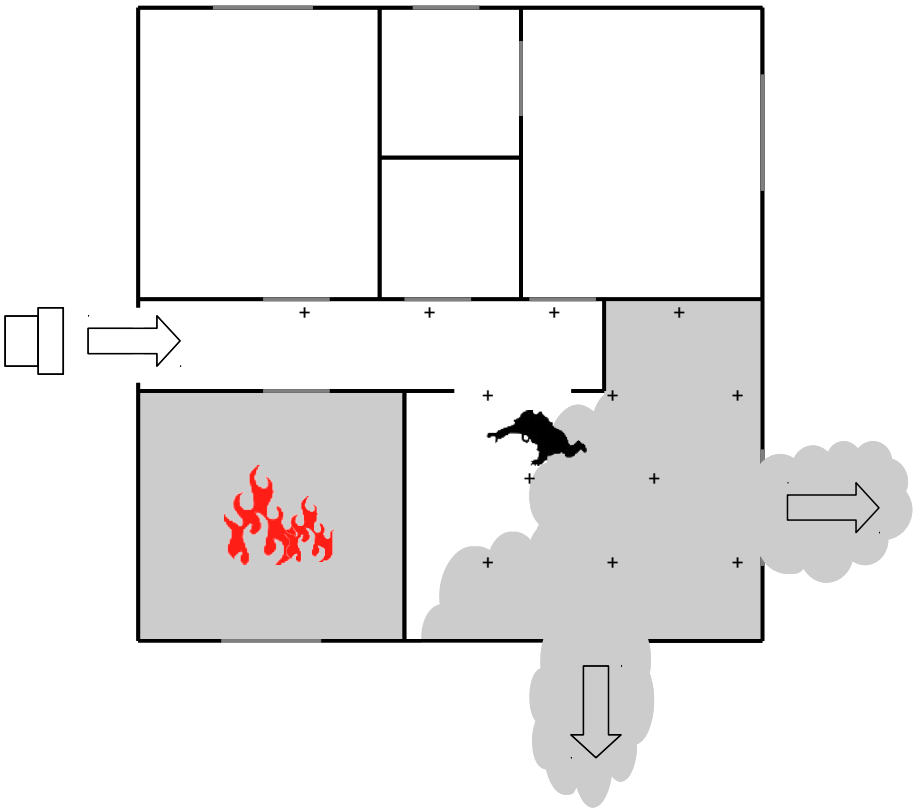
→ AGRESSIVE ATTACK

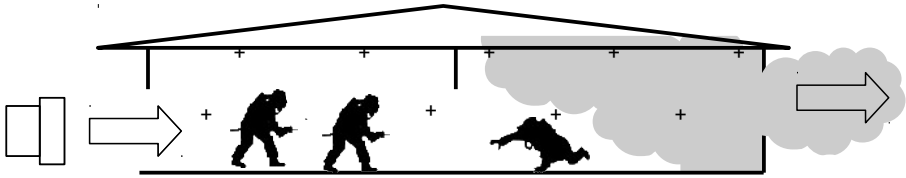
PPA Venting for Life

DEFENSIVE

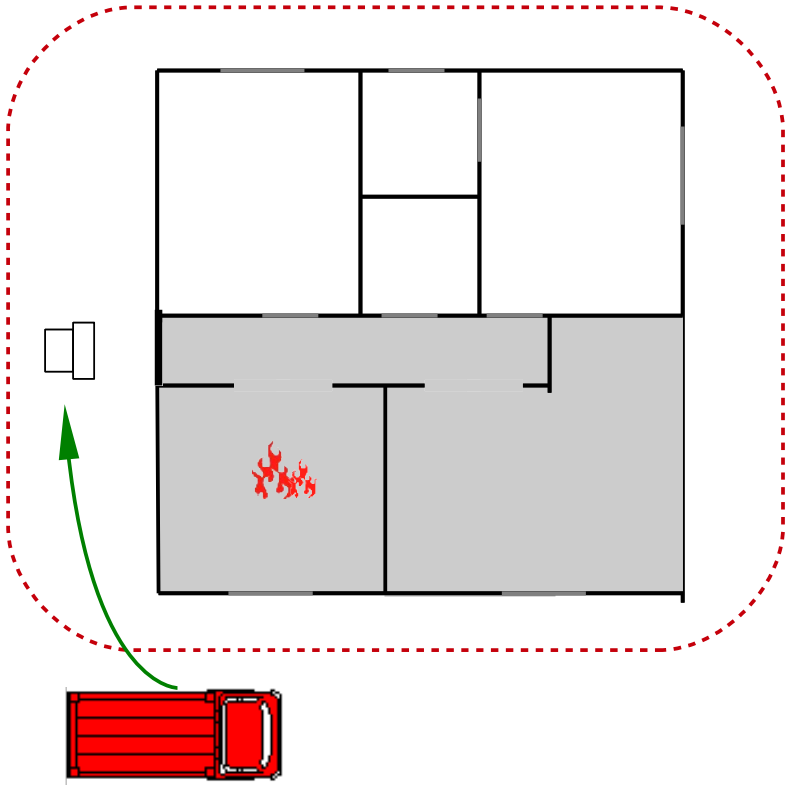
- **Attack purpose is victim search and rescue.**
- **Fire room is confined whenever possible, attack is assisted with positive pressure ventilation to remove smoke and introduce a cool, clean, breathable atmosphere that provides tenable conditions for victims and good visibility for faster search and rescue.**
- **Venting for Life allows:**
  - lower interior temperatures
  - tenable conditions
  - visibility
  - faster search and rescue operations

PPA Venting for Life





PPA Venting for Life Evolution



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CALL FOR VENTILATION

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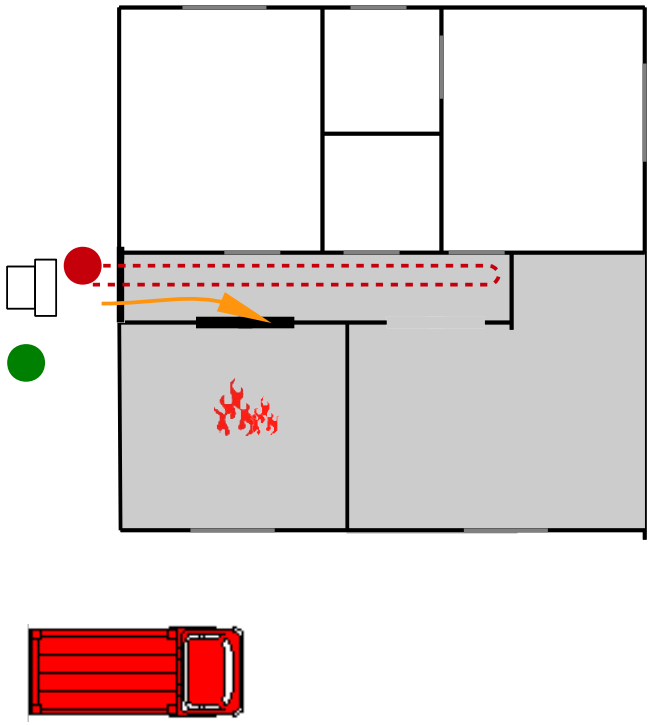
ENTRY OPENING

SAFETY WAITING

AGRESSIVE ATTACK, SEARCH&RESCUE

BACKUP TEAM ATTACK TEAM COMMAND

PPA Venting for Life Evolution



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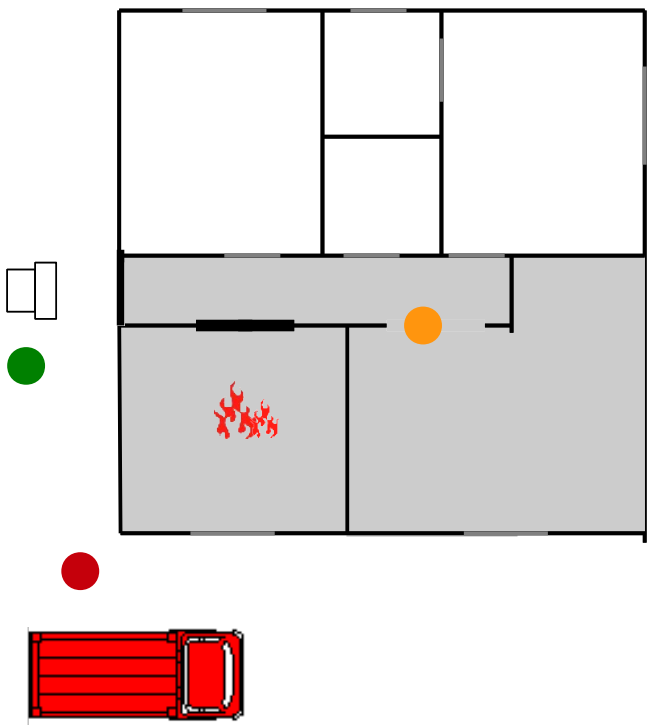

BACKUP TEAM ATTACK TEAM COMMAND

360º SIZE-UP

FAN SETUP

CHECK FOR INTERIOR CONDITIONS
FIRE ROOM CONFINEMENT

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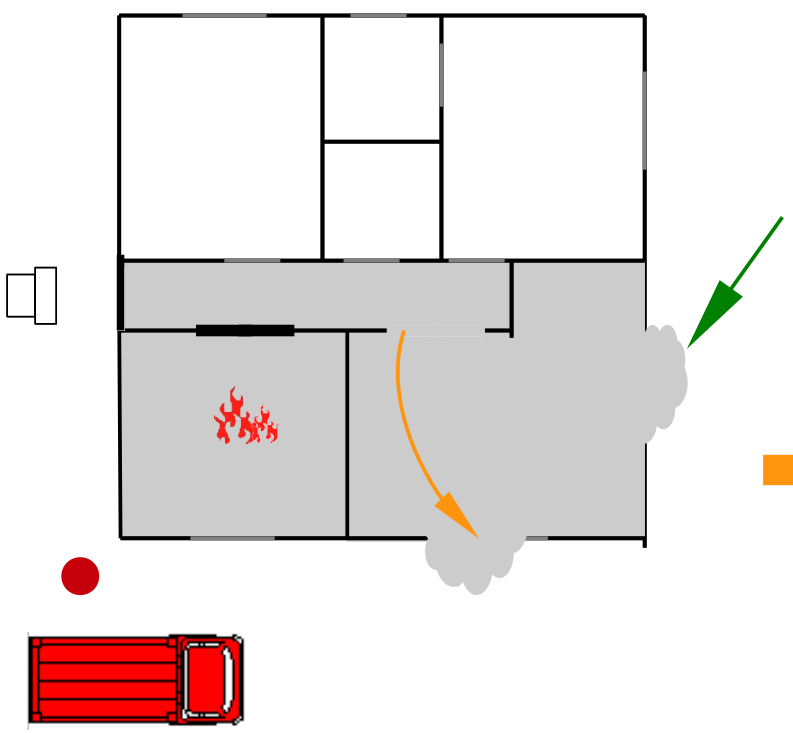

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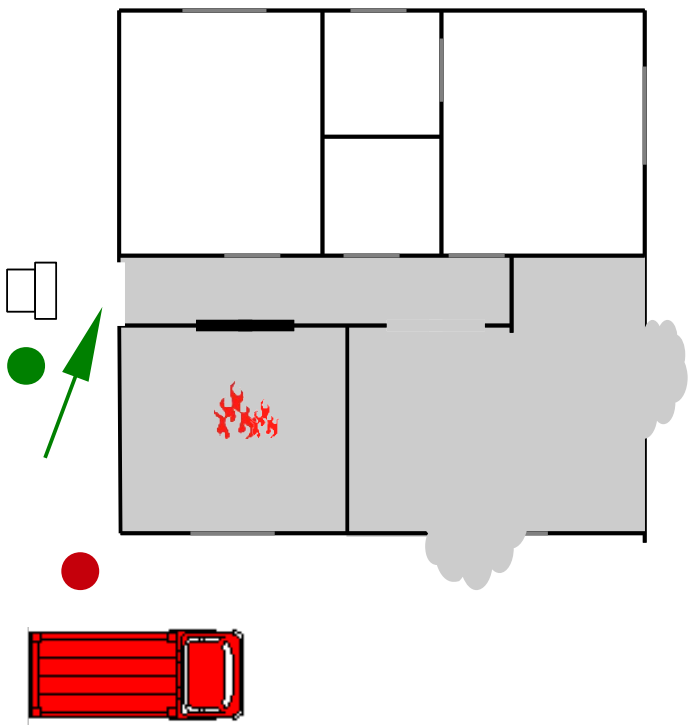

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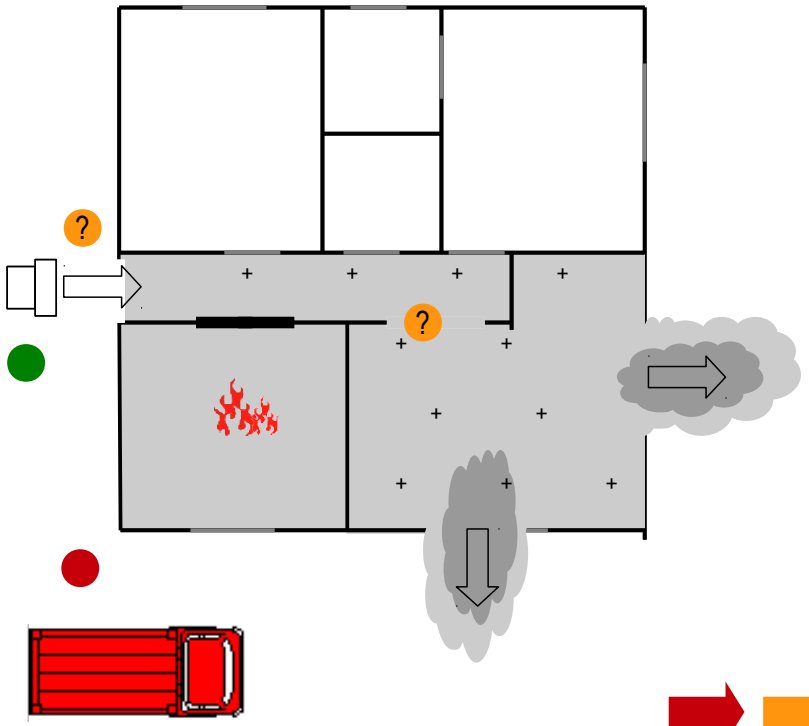

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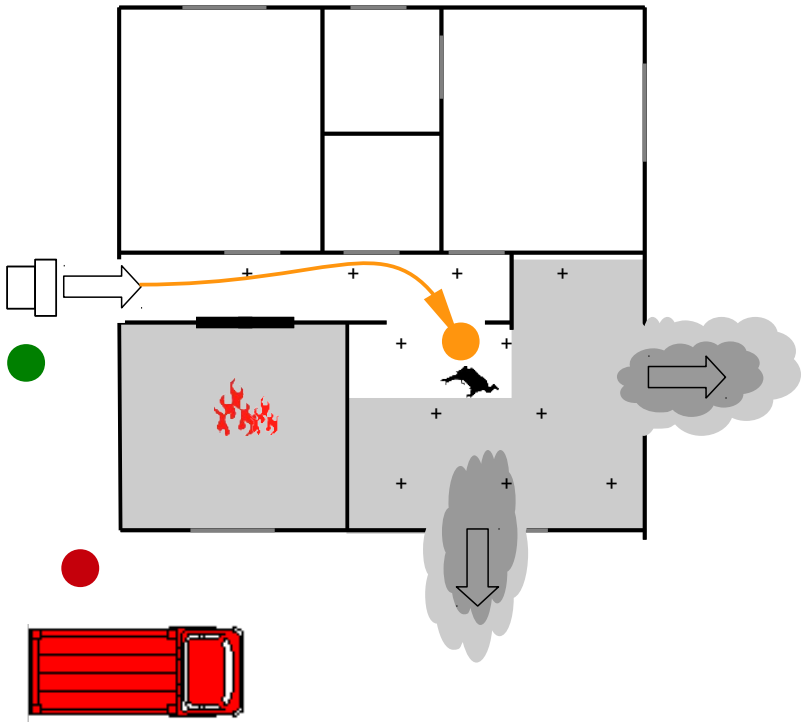

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ENTRY OPENING

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AGRESSIVE ATTACK, SEARCH&RESCUE

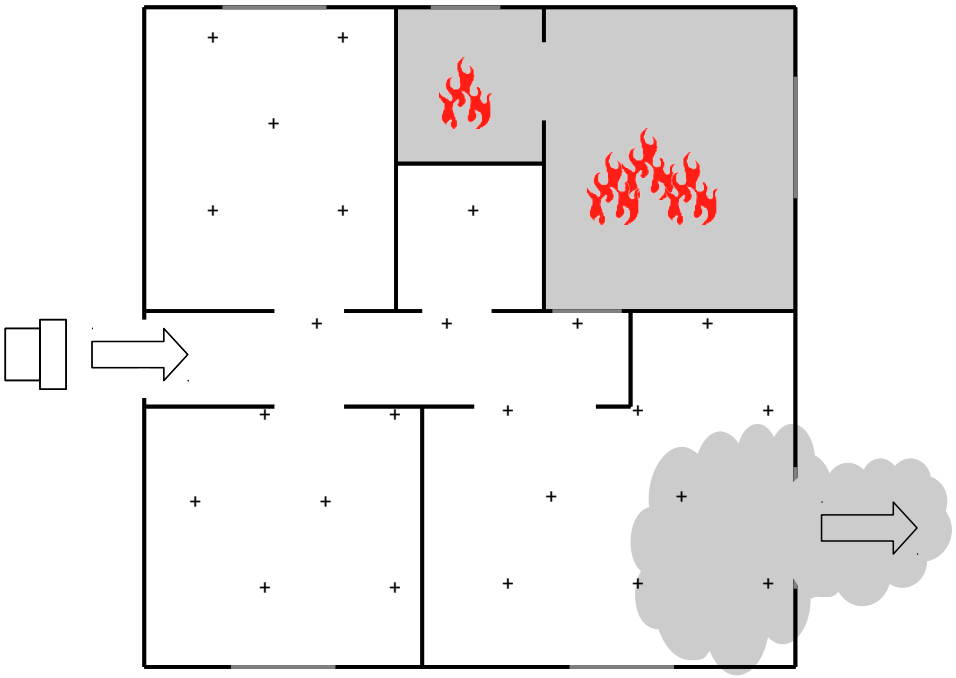
BACKUP TEAM **ATTACK TEAM** **COMMAND**

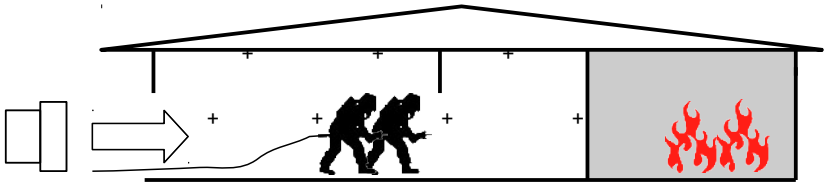
PPA Venting for Position

DEFENSIVE

- Attack purpose is to gain position, to provide safer and faster progression conditions for firefighters and to ensure safer evacuation conditions for victims.
- Fire room is confined whenever possible, attack is assisted with positive pressure ventilation to remove smoke and introduce a cool, clean, breathable atmosphere in the way to fire room.

PPA Venting for Position



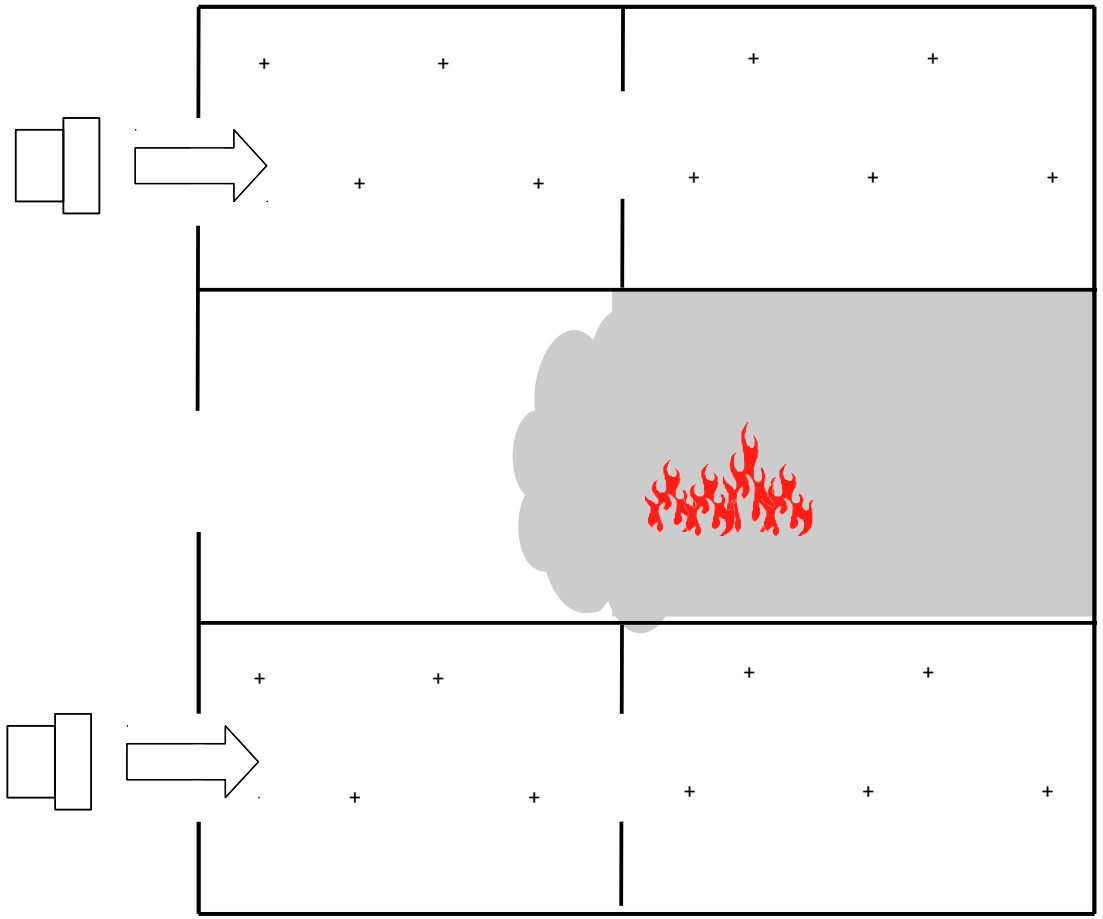


PPA Venting for Exposure Control

DEFENSIVE

- Attack purpose is to avoid fire spread to non affected areas.
- Non affected areas/rooms are pressurized to avoid smoke and reduce property damage.

PPA Venting for Exposure Control



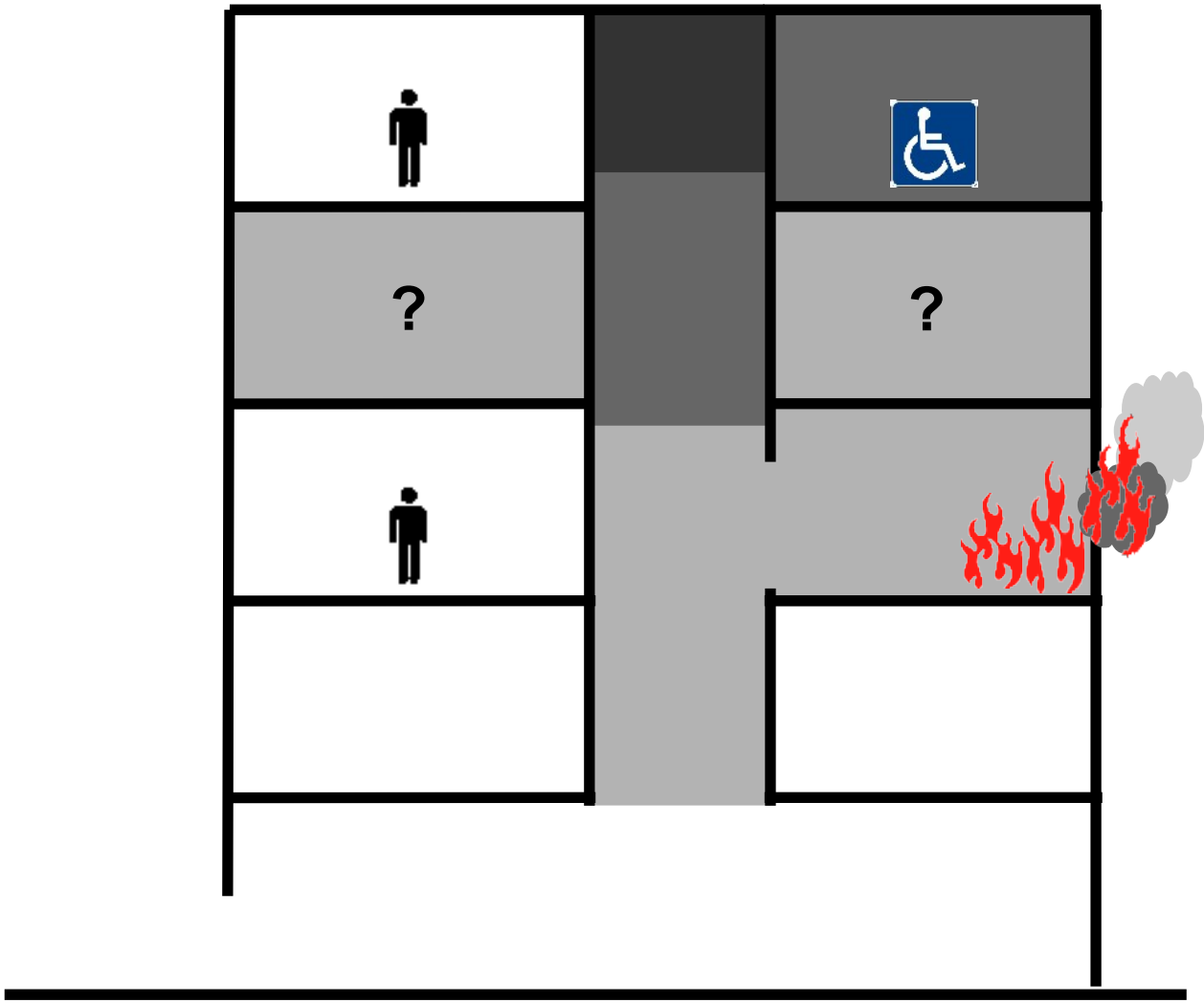
INCIDENT

C/ Libertad, Azuqueca (Spain)
18h30m 2013.03.06

4 story apartment building
8 large apartments – total area 15.000sq feet
3 trapped victims confirmed (1 disabled)
unknown conditions on 2 apartments

1 engine (Lieutenant + 3 Firefighters)
1 ladder (2 Firefighters)
1 Battalion

Fire scene at arrival



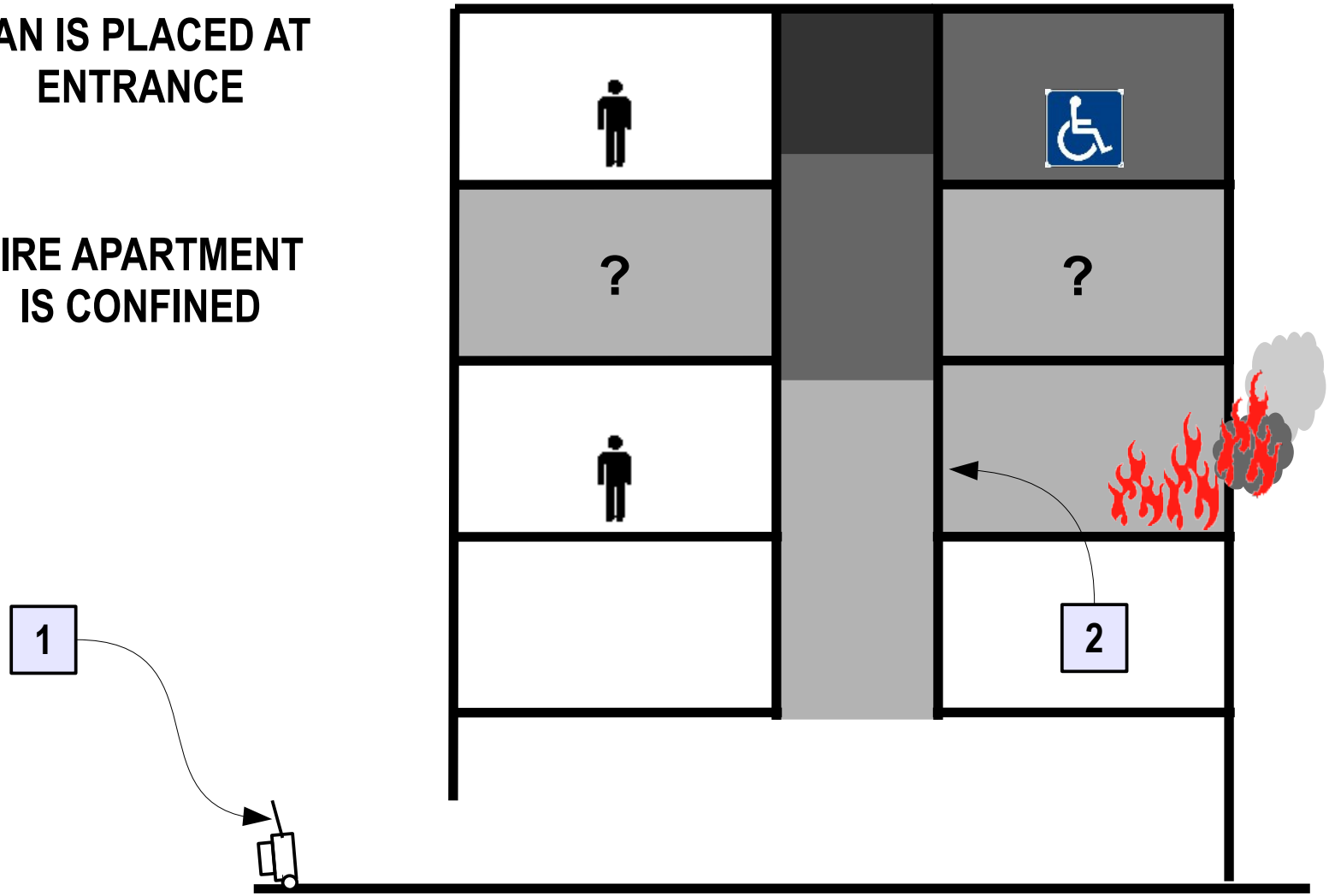
Think for a moment how would we operate if there was no fan.

Then, let's see how PPA makes a difference.

Command calls for PPA Venting for Life

FAN IS PLACED AT ENTRANCE

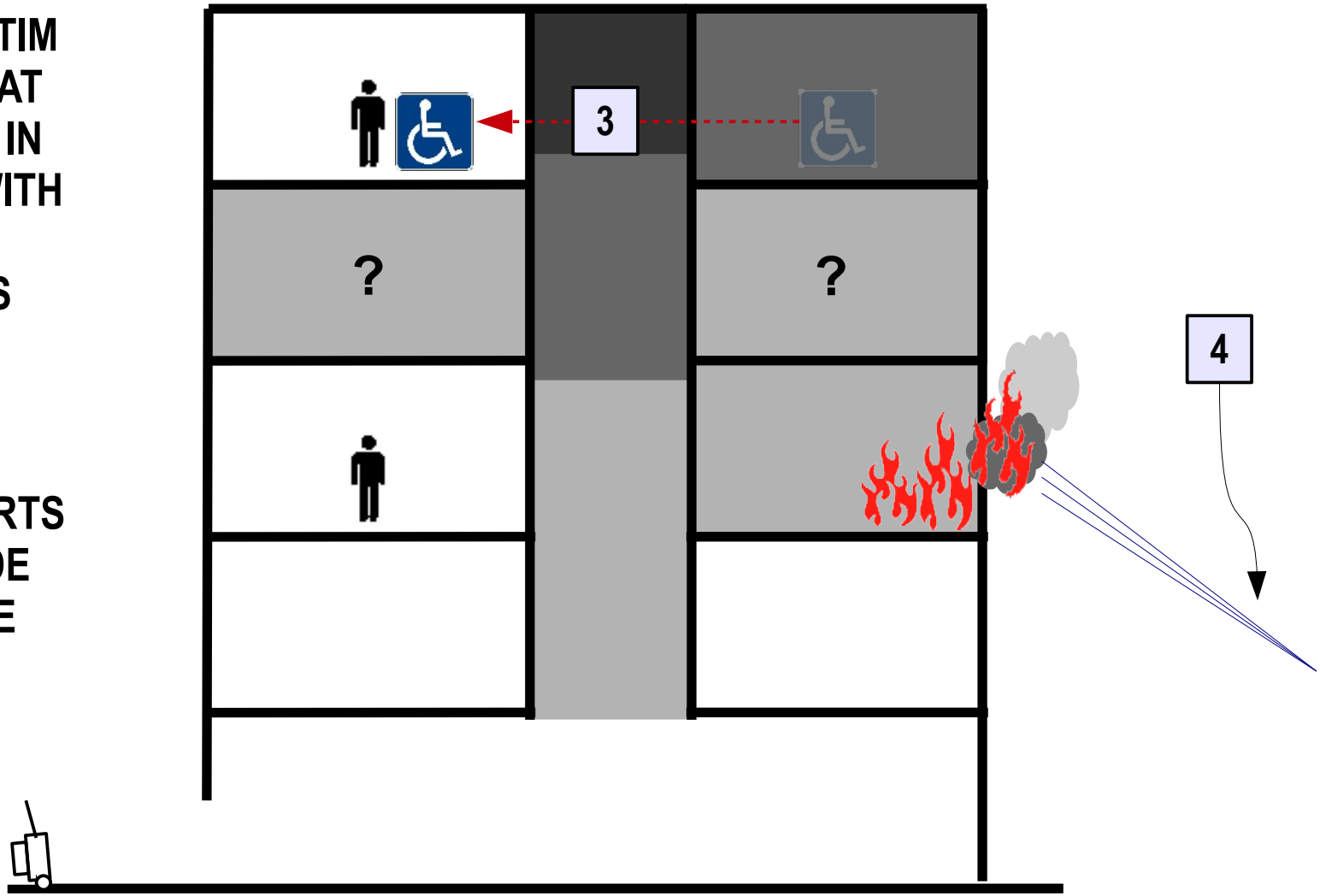
FIRE APARTMENT IS CONFINED



Victim confinement, exterior exposure control

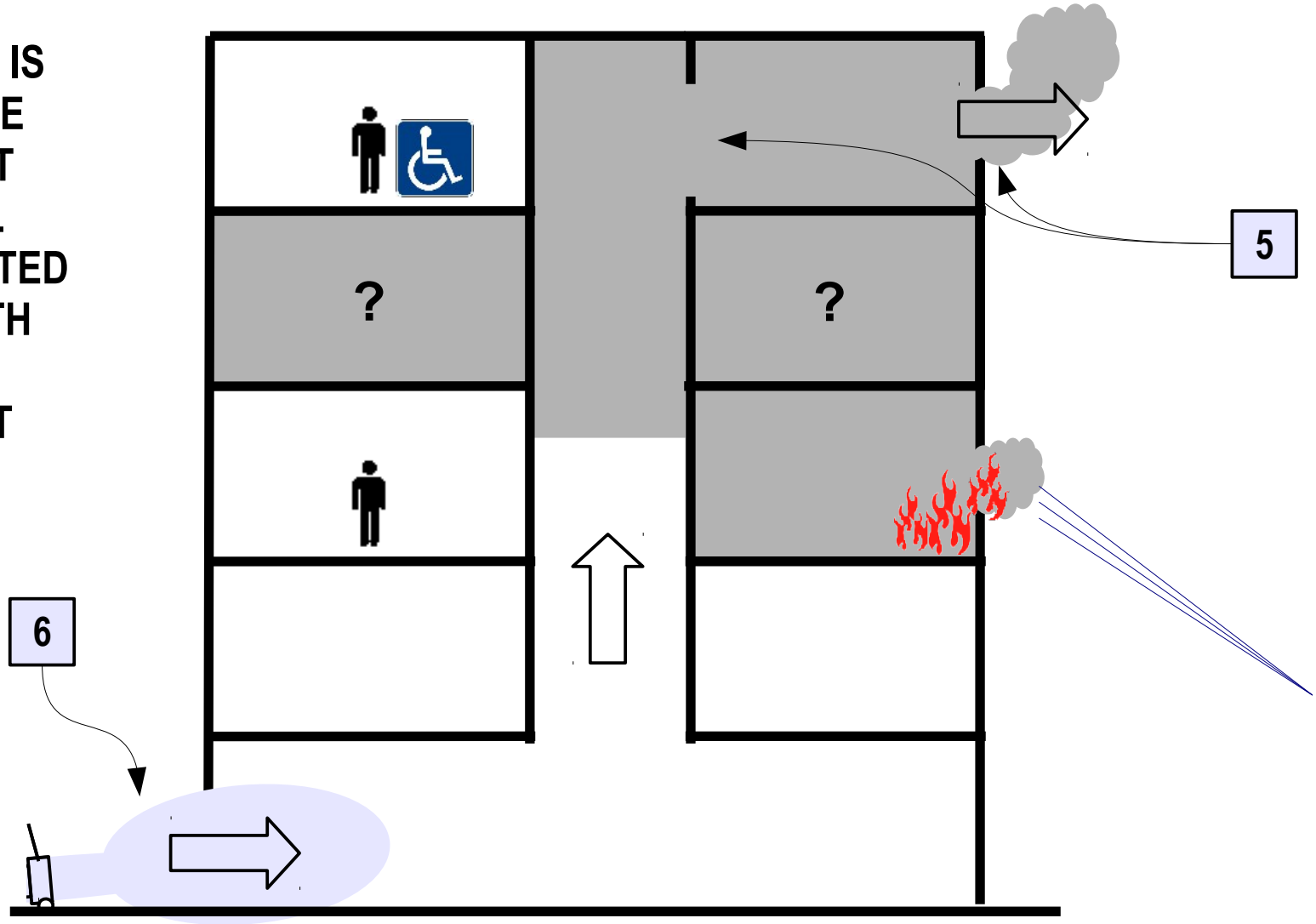
DISABLED VICTIM IS CONFINED AT SAME FLOOR IN APARTMENT WITH TENABLE CONDITIONS

EXPOSURE CONTROL STARTS WITH OUTSIDE ATTACK LINE



Venting for Position

SINCE THERE IS NO POSSIBLE EXHAUST AT STAIRWELL SMOKE IS VENTED THROUGH 4TH FLOOR APARTMENT

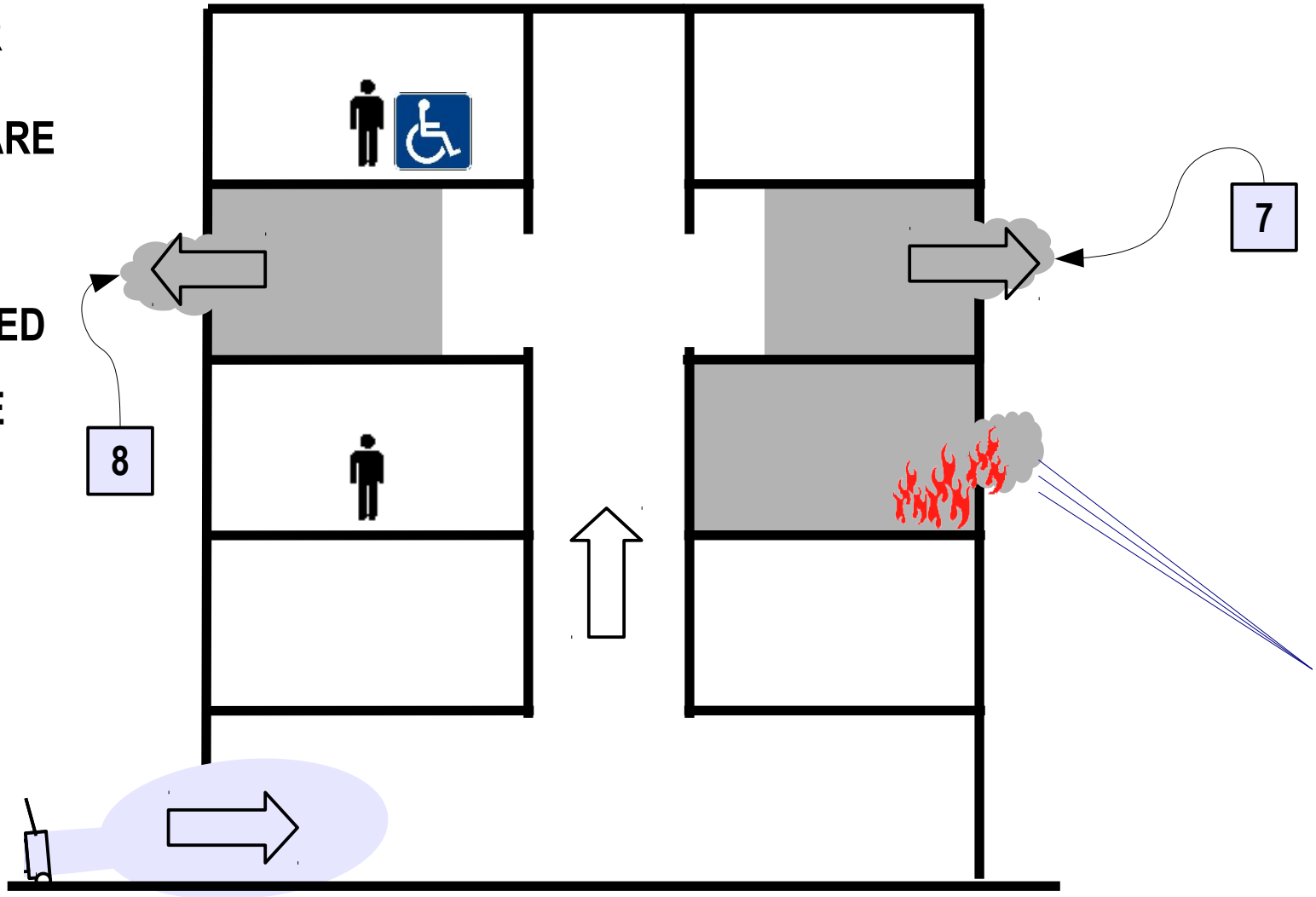


Venting for Life

3RD FLOOR UNKNOWN CONDITIONS ARE CHECKED

SEARCH ACCOMPLISHED

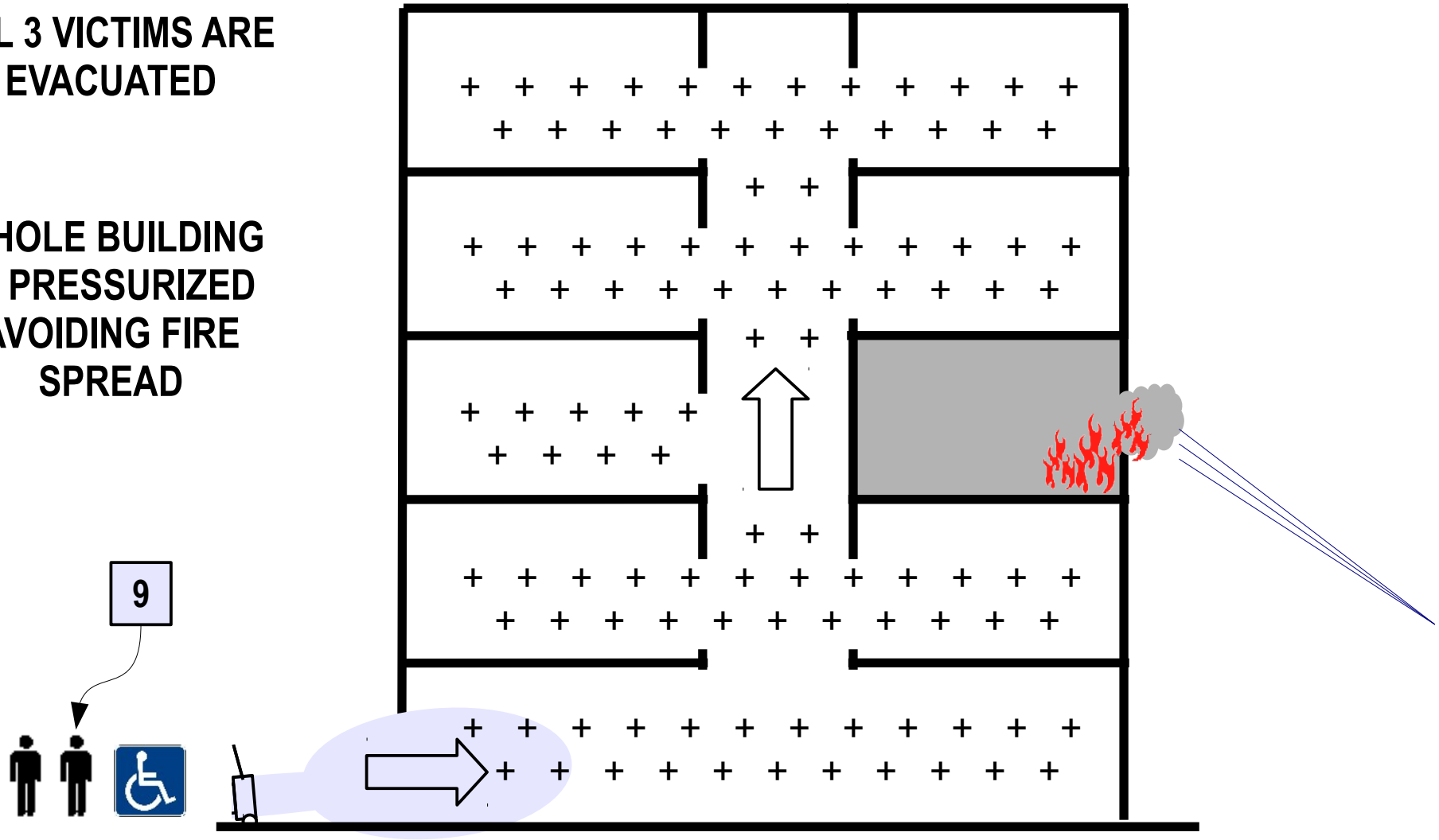
NO RESCUE NEEDED



Evacuation, Venting for Exposure Control

ALL 3 VICTIMS ARE EVACUATED

WHOLE BUILDING IS PRESSURIZED AVOIDING FIRE SPREAD



Venting for fire

PPA ATTACK TO FIRE APARTMENT