The use of water within the fire service

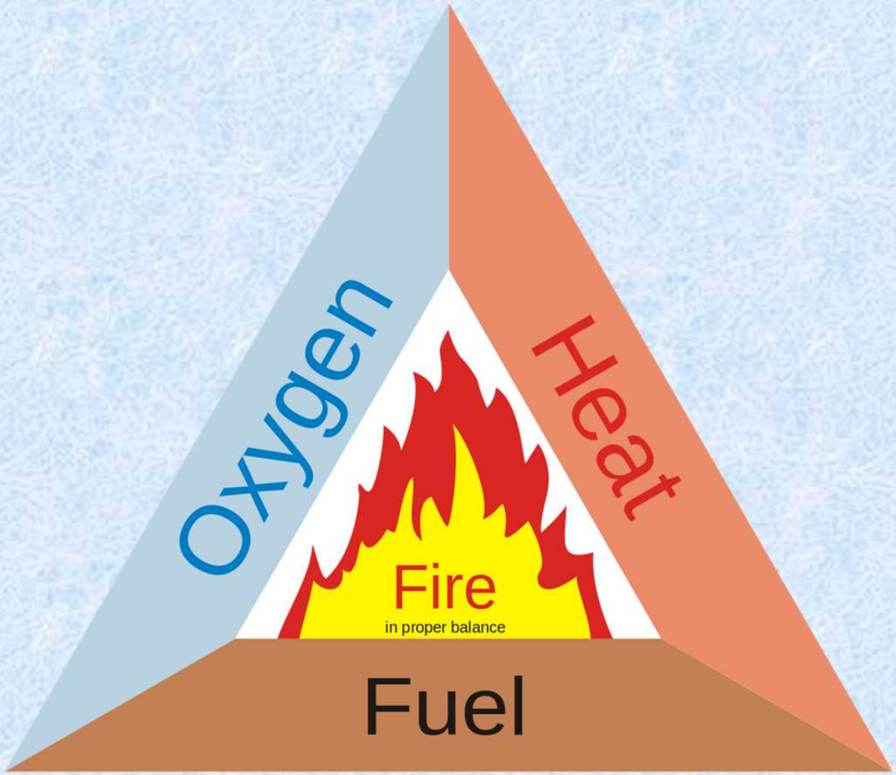
Karel Lambert

Contents

- What is a fire?
- Why does water extinguish?
- Extinguishment principles
- Gascooling
- Exterior attack

What is fire?

- Why does the fire keep on going once it is started?
  - Fuel
  - Air
- How can we explain that in detail?



What is fire?

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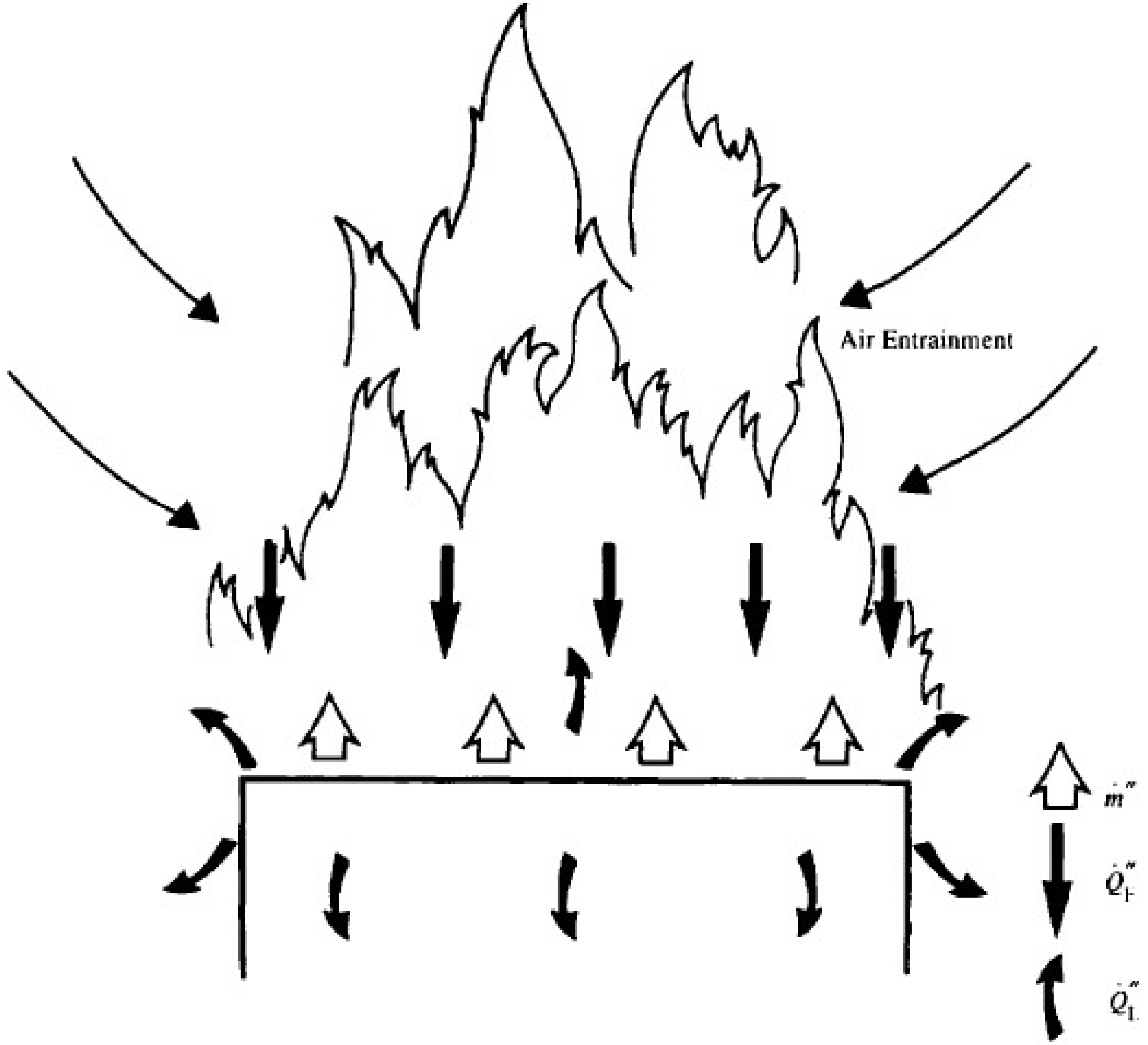

Figure 1.4 Schematic representation of a burning surface, showing the heat and mass transfer processes. $\dot{m}''$, mass flux from the surface: $\dot{Q}''_F$, heat flux from the flame to the surface; $\dot{Q}''_L$, heat losses (expressed as a flux from the surface)

What is fire?

1. Production of fuel

Black arrows:
Heat transport (energy)

White arrows:
Mass transport (pyrolysis gasses)

2. Combustion

Pyrolysis gasses mix with oxygen
➔ Combustion

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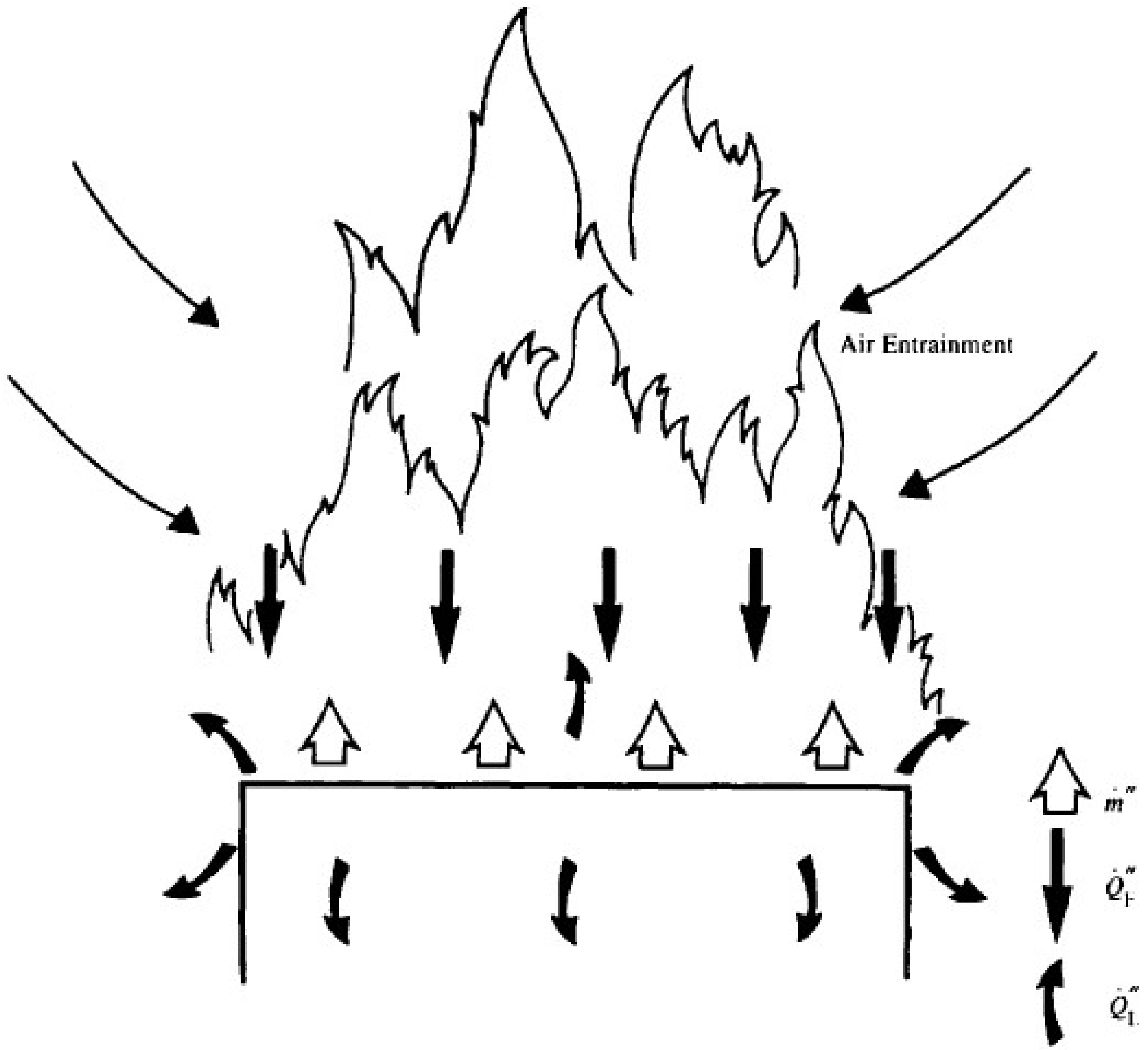

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Fire produces heat

- How much?
- Does it vary?
- Is it an important variable for the fire service?
- How can we compare fire size?

What is the unit of heat release rate?

How large is this fire?

© NIST

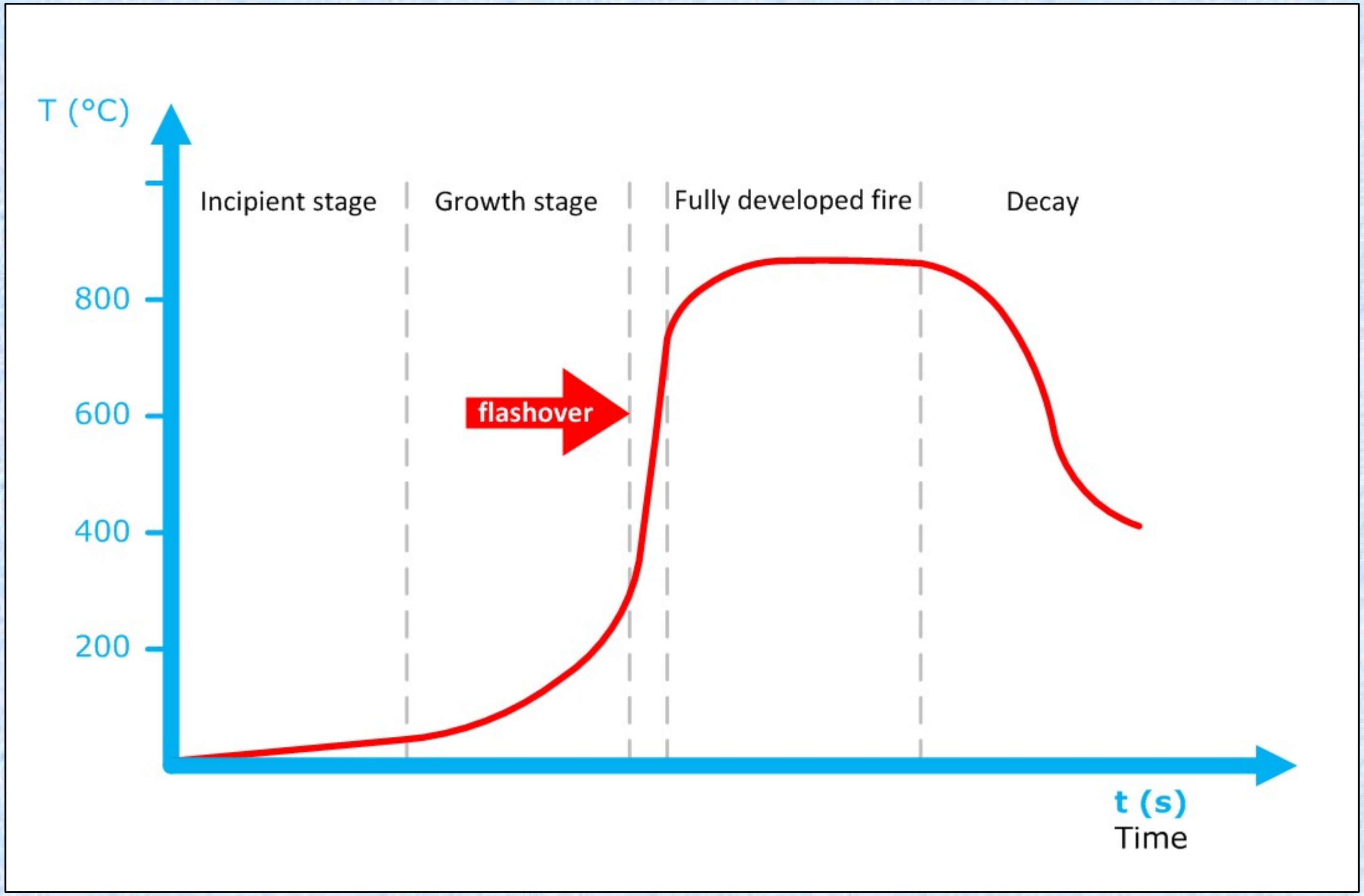
Unit of heat release rate?

- Heat is measured in Joules [J]
- 1 kJ = 0.948 BTU's
- Heat release rate is measured in Watt [W]
- 1 W = 3.41 BTU/hour
- In kW of MW
- Peak: 3.3 MW

Fire development

- In growth stage fire produces smoke.
- Smoke layer depth increases
- Temperature of smoke layer increases
- Smoke layer radiates heat to objects underneath
- Roll-over

Important risk: Flashover



Why does water extinguish fire?

- What happens when we *put the wet stuff on the red stuff?*
- Does it matter how we do it?
- Does it matter how much water we use?
- Is the flow rate an important factor?

Extinguishment principles

- Water works in several ways:
  1. By cooling the surface:
     - The fuel surface is hot.
     - As long as its temperature is above the pyrolysis threshold, the fuel will produce pyrolysis gasses.
     - Water will cool the fuel surface temperature.
     - Pyrolysis will slow down and eventually stop.
     - Fire will stop

Extinguishment principles

- Water works in several ways:
  2. By cooling the flames:
     - The flame temperature will decrease
     - Flames will disappear
     - The fire will be suppressed (temporarily)

Extinguishment principles

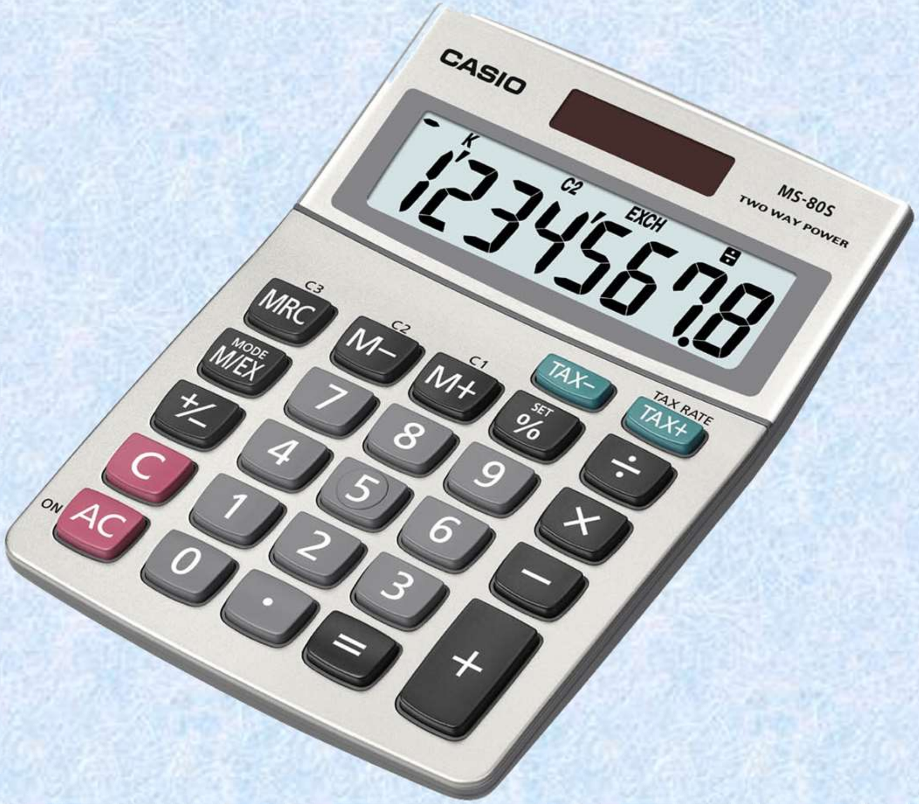
- Water works in several ways:
  3. By diluting:
     - Water turns into steam
     - 1 L water turns into 1.7 m^3 of steam at 100 °C (212 °F)
       ➔ 1:1700 expansion ratio
     - 1 L water turns into 3 m^3 of steam at 400 °C (752 °F)
       ➔ 1:3000 expansion ratio
     - Steam pushes other gasses out (a.o. oxygen)
     - Fire stops (temporarily)

How do we compare the cooling capacity of flows?

How to express the power of cooling?

- MW
- 1 liter of water can absorb 3 MJ of energy.
- 1 liter per second (60 lpm or 15.8 gpm) = 3 MJ/s = 3 MW
- Important remark: firefighters are not 100% effective!

Do we need calculators on the fire ground?



- Belgium:
  - High Pressure (HP) booster line: 180 lpm
  - Low Pressure 1’ ¾ line: 400 lpm
- Practical:
  - HP: 30 m² (323 ft²) fully involved
  - LP 1’ ¾ : 60 m² (646 ft²) fully involved
- What about Canada?

Extinguishment techniques

1. Direct attack

   Goal: Apply water onto the burning combustibles to reduce the surface temperature of the solids. (surface cooling)

2. Indirect attack

   Goal: Evaporate water (by applying it onto walls or ceilings, or into flames) to produce steam that pushes the oxygen out of the enclosure.

Direct attack

- Straight stream or smooth bore is the best way to apply this
- Water droplets need to be sufficiently large to reach the fuel surface.

- Penciling ➔ Painting ➔ Full capacity of the nozzle

"How much water?

As much as necessary!"

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Indirect attack

Indirect attack

- 30° cone – circular movement
- Limited in duration
- Goal: knock down of the flames
- Fuel remains very hot

  ➔ reignition

- Follow-up with direct attack

Indirect attack: Closed volume

- Indirect attack with piercing nozzle
- Expansion of water into steam creates overpressure
- Displacement of gasses through cracks and openings

Indirect attack: Closed volume

3rd application: Gascooling

- What is the goal of gascooling?

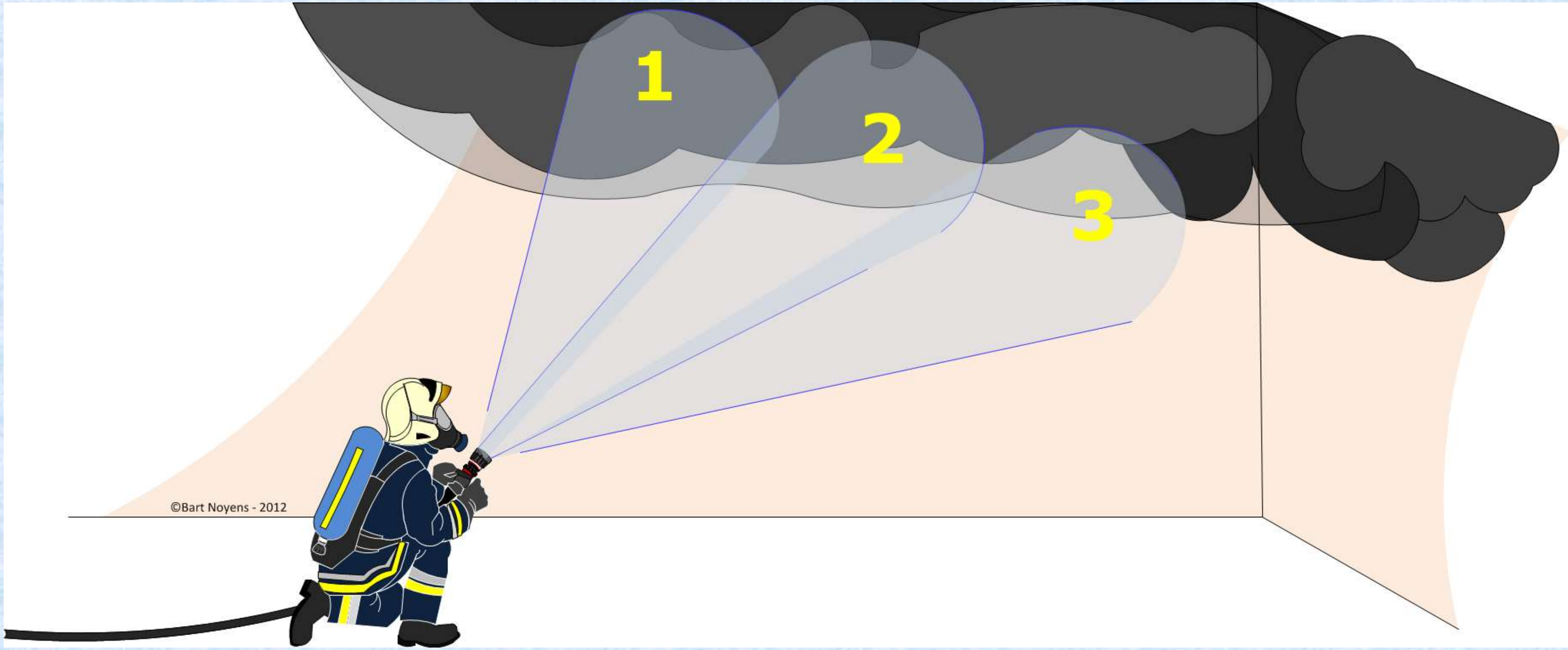
Gascooling

Gascooling

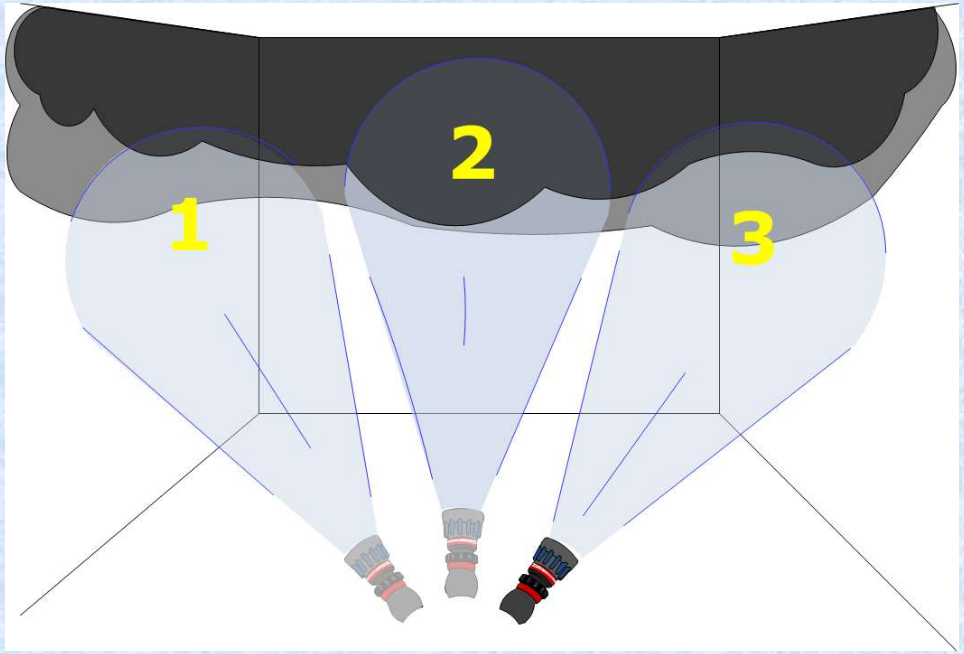
- Goal: Provide safety on the route from the entry towards the seat of the fire
- Long pulses
- Short pulses
- Droplet size too small: upper part of smoke layer is not cooled
- Droplet size too big: droplet goes though smoke layer.
- Ideal droplet size: 0.3 mm

Long pulse vs short pulse

Gascooling



Gascooling



- Application of bursts of water droplets into the overhead
- Energy is absorbed

➔ Smoke layer temperature drops

- Water is transformed into steam
  ➔ Flammability of smoke layer decreases
- Number of bursts dependent on geometry

Gascooling

- Gascooling ≠ extinguishment
- Goal:
  - Temperature smoke ↘
  - Inject steam ➔ Flammability ↘
    ➔ Thermal ballast ↗

➔ Create a safe workplace between the door and the seat of the fire

What is our intent?

- Each firefighter should know what he/she wants to achieve:
  - Direct
  - Indirect
  - Gascooling

Exterior Attack

- What could be the goal?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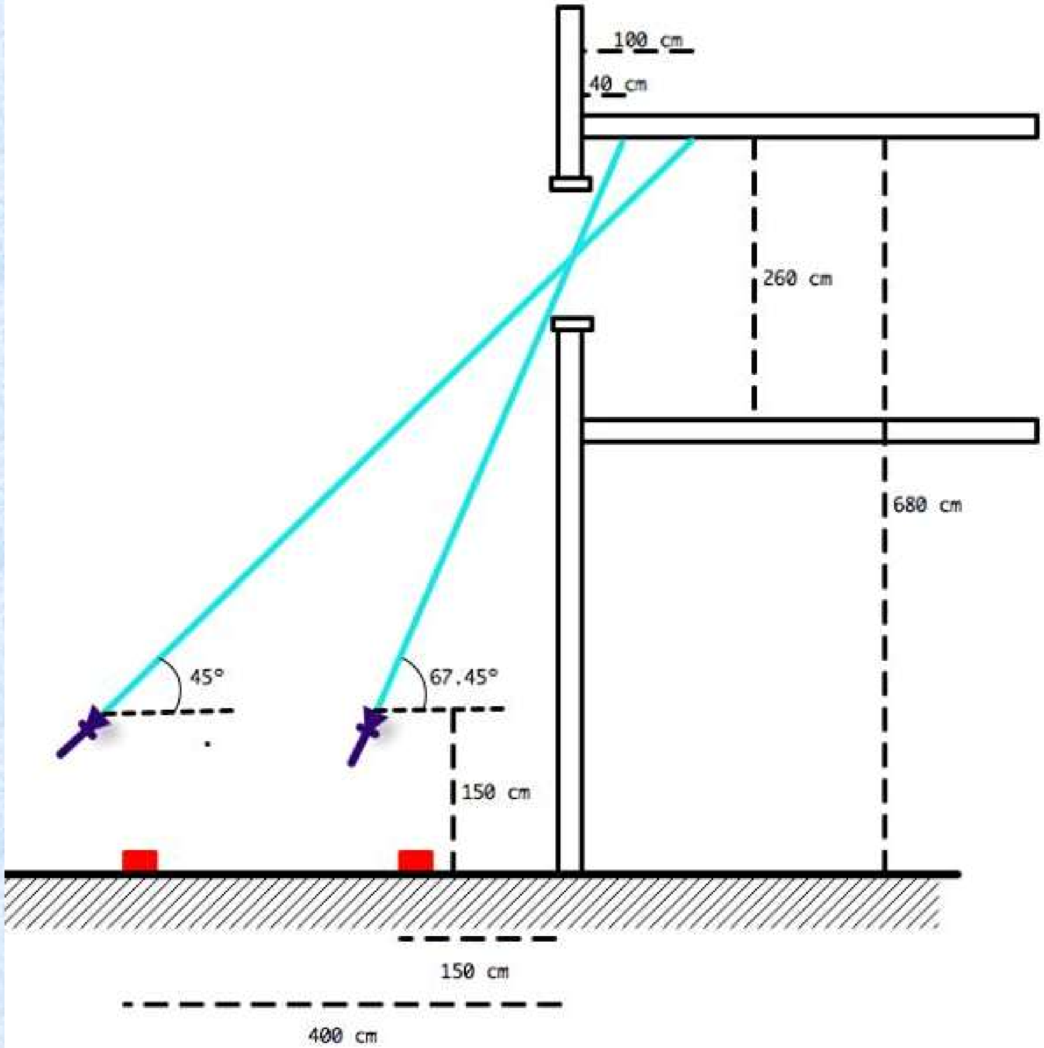
Exterior attack: Goal

- Direct attack
  - Water hits ceiling, bounces and hits burning fuel
  - Sufficiently high
  - Until knockdown!

Proposition:

- Till 4th floor: Ø 45 (1’ ¾)
- 5th till 8th floor: Ø 70 (2’ ¾)
- Till 14th floor: ladder truck

Drawing and next pictures: © Pablo Boj Garcia




300
200
100
500
300
200
120


300
200
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120

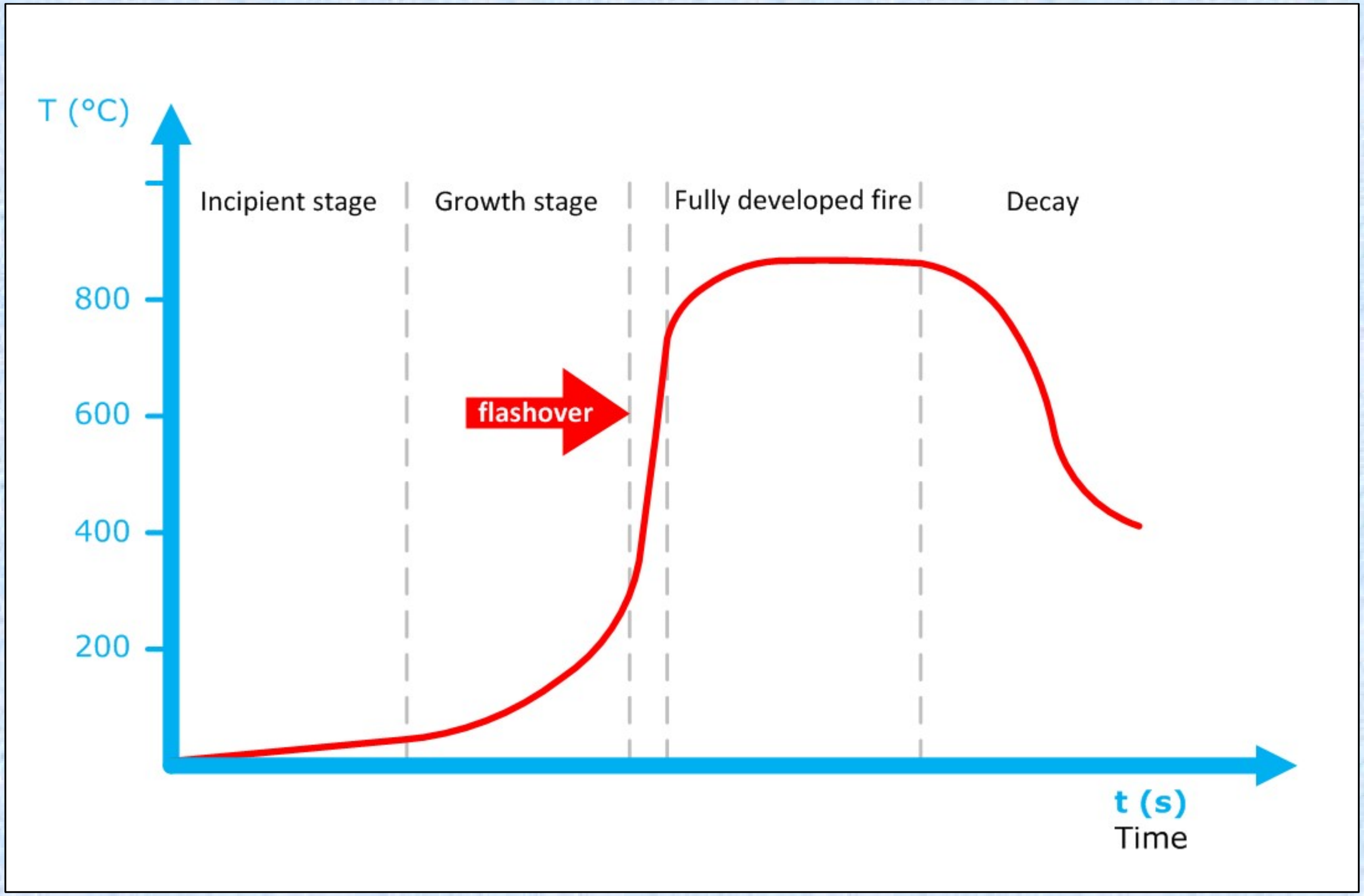

300
500
300
200
120

UL firefighter safety research institute

- UL FSRI is working on exterior streams.
- Results of full scale studies are to be expected.

Case

Important risk: Flashover in the next room



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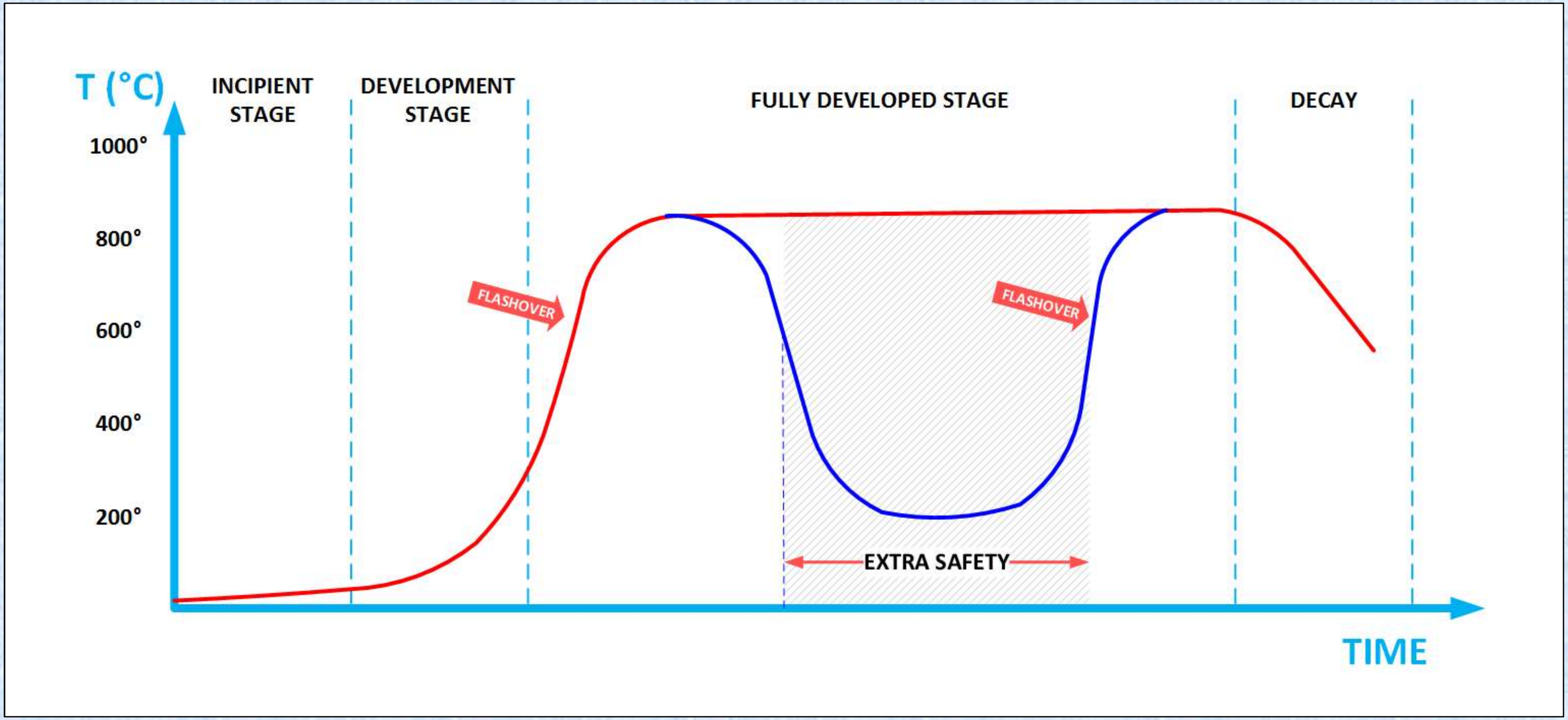
Transitional attack: exterior followed by interior



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