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Fire Spread and Smoke Development in Buildings

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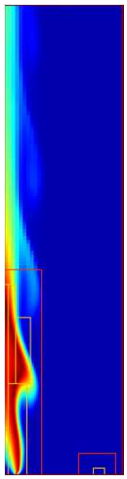
Fire development

- Basically, fire development in enclosed spaces like buildings is related with so-called **buoyant, turbulent diffusion flame.**
- Fire dynamic depends on both **oxygen transport** to flame reaction zone and **amount of fuel** (furniture, floor and ceiling materials, clothes, equipment...).
- Oxygen transport to flame reaction zone is caused by two phenomena:
  - a) diffusion (molecular level)
  - b) air flow convection (macro level)



Fire development

- Fire development in enclosed spaces

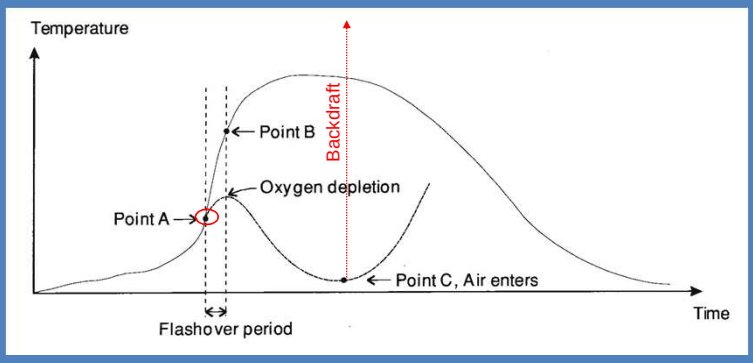


Figure 1 Fire development, expressed by smoke temperature

Fire development

- Simplified fire stages

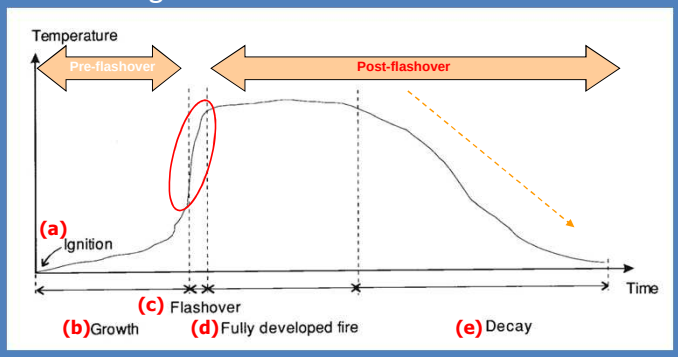


Figure 2 Characteristic fire stages on time scale

Fire development

Goals of fire protection measures:

- **Pre-flashover** period (app. t < 500°C):
  - Safety of people (tenable conditions for evacuation → low temperature exposure, no smoke, no toxic gases)
- **Post-flashover** period (app. 600 °C < t < 1200°C):
  - Fire protection of the building (stability, integrity, construction collapse prevention) and firemen protection (time limited!)

Smoke generation and propagation

- Smoke generation depends on many influenced factors. In fuel-controlled fires (with sufficient oxygen transport) smoke production can be calculated related to the characteristic **PLUME MODEL**.
- There are basically 3 plume models:

a) **axisymmetric plume**
b) **balcony-spill plume** — Pre-flashover phase
c) **window jet plume** — Post-flashover phase

- **IMPORTANT:** For the same Heat Release rate (HRR) smoke generation (mass flow) is different for different plume models! Differences could be up to 50% for the same geometric characteristics of the enclosure!

Smoke generation and propagation

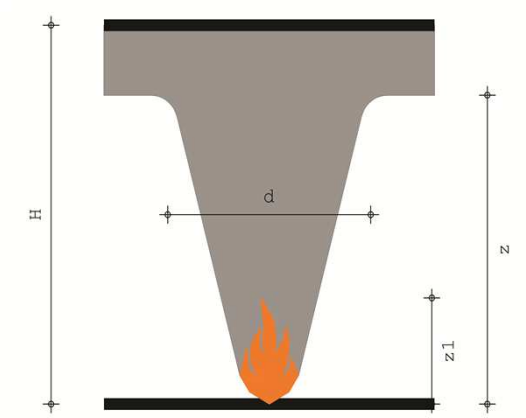


Figure 3 Axisymmetric plume – no obstructions in neighboring zone (atriums, halls)

Smoke generation and propagation

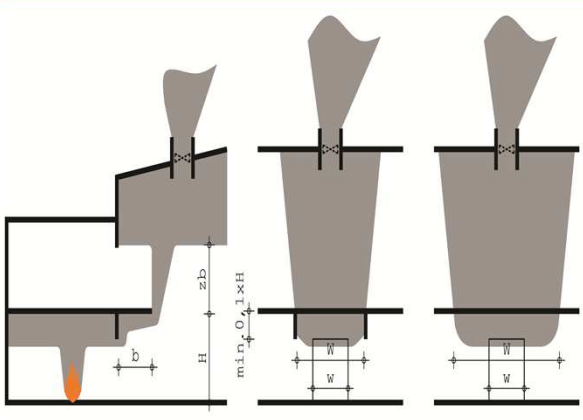


Figure 4 Balcony-spill plume – architectural elements like malls

Smoke generation and propagation

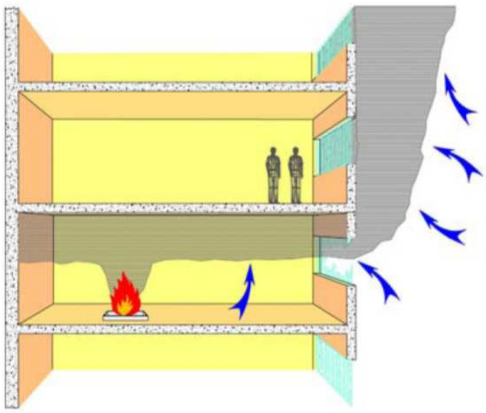


Figure 5 Window jet plume – window or façade elements collapse

Smoke generation and propagation

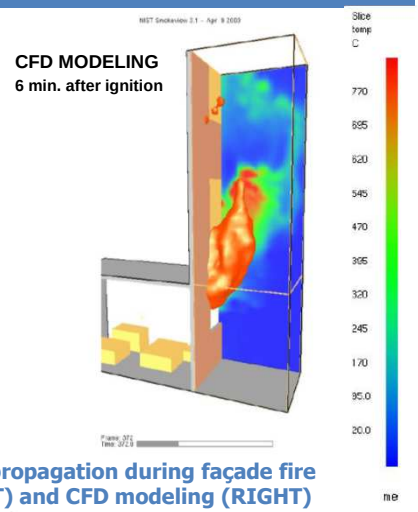


Figure 6 Flame and smoke propagation during façade fire
Comparison of real fire (LEFT) and CFD modeling (RIGHT)

More about window plume model on Façade Fire Test!

Thank you for your attention!