

Fire Behavior in Underground Car Park Buildings

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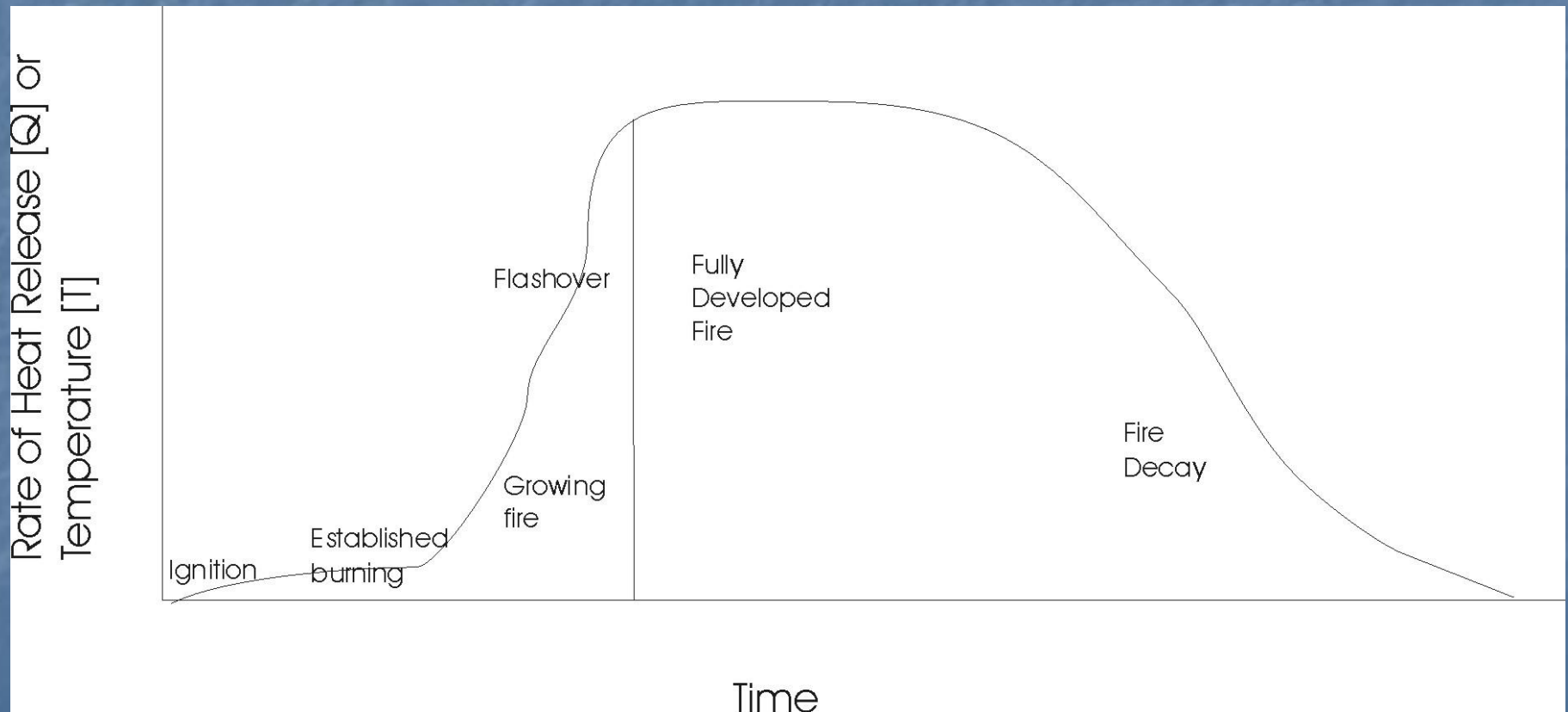
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Fire Growth

- Fire growth is composed of processes of ignition, flame spread and burning rate.



Heat Release Rate



Ignition

- The first step in the process of fire growth is ignition.
- For this stage of fire development it is significant that the fire behaves as if it is burning in the open air for most of the period. In a compartment fire is usually followed by a **flashover**.

Flashover

- Flashover marks a dramatic increase in fire conditions due to the confinement of a room. It can be caused by several situations:
 - the rapid ignition and flame spread of materials due to heat flux increasing,
 - the accumulation of rich gases and their sudden exposure to air,
 - the increase in the burning rate and the sudden extension of flames through the room.

Flashover

- When a flashover occurs fire becomes fully developed. This stage is marked by flames fully encompassing the room, with the likelihood of flames emerging from windows or doors. All of the fuel is involved to its maximum potential. This period involves possible structural damage, and heat flux conditions in the room can reach as high as 150 kW/m^2 .

Flashover

- The dominant mechanism for reaching full room or garage floor involvement is by flashover. Flashover in a closed underground car park building is characterized by following:
 - Fire starts somewhere underneath a car or in a car.
 - A fire plume forms and a hot layer of heated gases of combustion and soot develop at the generally low ceiling.
 - Ventilation provides sufficient air to support combustion.
 - Hot layer radiation and some radiation from the flames pyrolyzes other unburned fuels (adjacent cars) in the garage floor.
 - Ignition of adjacent cars in the garage floor occurs.

Flashover

- Depending on the available air supply, this stage may or may not be ventilation limited.
- In an underground garage when smoke management system and ventilation is applied forced ventilation may occur. Forced ventilation is considered to occur when significant air is supplied by a ventilation system.

Decay

- Fully developed fire is continued with a decay stage. Decay occurs as the fuel becomes consumed, and the heat release declines. The fire may change from ventilation to fuel controlled during this period.

Meaning of Fire Growth Data

- The fire growth potential is a **key descriptor** that identifies the relative hazard that is caused by the room contents like number and type of the cars, their arrangement, as well as the room geometry and thermal conditions that affect fire development in the space. Key point that we all are aware of is full room involvement, when fire in underground garage will mainly become uncontrolled.

Meaning of Fire Growth Data

There are approximately 6 benchmarks and realms linked to a fire growth potential:

- **pre-burning** – the period of heating and volatilization from the condition of overheat until ignition occurs.
- **initial burning** – the period during which the first fragile flame that defines ignition attempts to generate some substance and strength and grow to an established burning.
- **vigorous burning** – the domain in which an established burning grows within the fuel package and develops a strength and stamina of its own.
- **interactive burning** – the fire exceeds the enclosure point and continues to grow. This is usually a result of interactive burning between cars for ex. Or within a large single fuel package. The fire power when the flames touch the ceiling is normally in range of 800 kW or 1MW.
- **remote burning** – fire ceiling jet develops and radiates heat energy to other fuels causing an increased rate of volatilization. Some fuels (for ex. cars) remote from the initial ignition may experience auto ignition and additional fires may start in the room.
- **full room involvement** – flashover will occur as a rapid fire involvement of all of the exposed combustibles.

Fire Growth Analysis

What we are trying to define and analyze are **predictions and chances that fire will terminate before:**

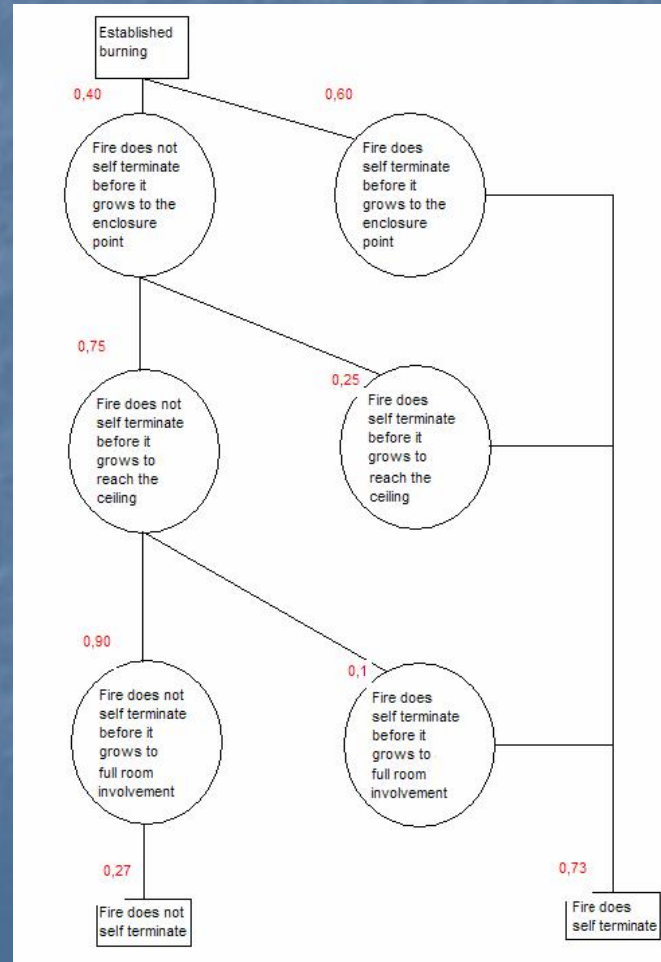
- it grows to the enclosure point,
- it grows to reach the ceiling,
- it grows to full room involvement.

Fire Growth Analysis

- The fire growth model is capable of predicting fire conditions that develop during the pre-flashover stages of a compartment fire. The fire growth model consists of value network and values that based on statistical, engineering and experienced values.

Fire Growth Analysis

- Possible fire development stages like fire growing to the enclosure point, fire growing to reach the ceiling, and fire growing to full room involvement can be analyzed using value networks. Network diagrams are used to organize an analysis and to structure evaluation³.



Conclusions

Continuous value networks are used to describe the thought process for a scenario evaluation. There are several reasons for detailed analysis of scenario:

- codes and regulations where the fire safety concepts and scenario are required,
- fire modeling software where pre determination of fire input parameters and detailed description of fire scenarios is recommended and sometimes required as well.
- continuous value network diagrams can be used as a valuable tool while predicting fire severity and fire progress in a compartment like underground car park.