


CIFR

Congreso Internacional Fuego y Rescate



Compartment Fire Development & Flashover *Foundational Knowledge*

**Valdivia, Chile
January 2010**

CFBT-US 
Not just what and how, but why!



In order to carry on your business properly, it is necessary for those who practice it to understand not only what they have to do, but why they have to do it...

No fireman can ever be considered to have attained a real proficiency in his business until he has thoroughly mastered this combination of theory and practice.

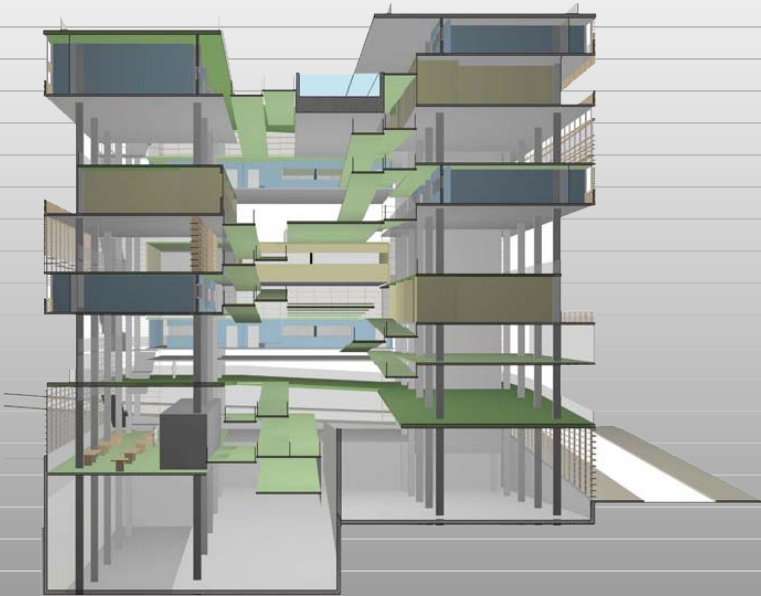
Fire Protection, 1876
Sir Eyre Massey Shaw
Chief, London Fire Brigade

Learning Outcomes



- ▶ Identify factors that influence fire development in a compartment.
- ▶ Describe the general development of a compartment fire, including:
 - *Heat release rate*
 - *Stages of fire development*
 - *Burning regime*
- ▶ Define flashover
- ▶ Recognize factors that influence fire development and flashover.

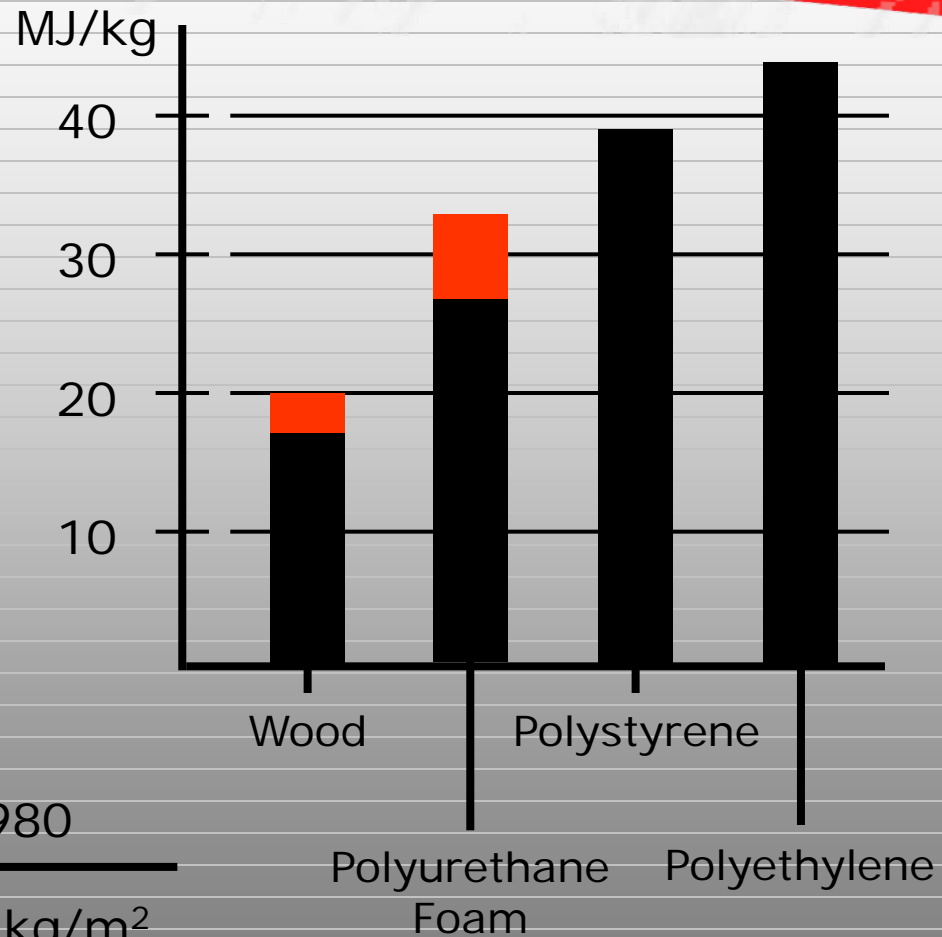
The Built Environment



- ▶ Fire Load
- ▶ Size
- ▶ Compartmentation
- ▶ Thermal properties
- ▶ Ventilation profile

Fire Load

The mass and burning characteristics of the fuel encountered in compartment fires has changed over time.



Fuel Load		
	1942	1980
Low	9.9 kg/m ²	29.3 kg/m ²
High	64.4 kg/m ²	125.5 kg/m ²

Size & Compartmentation

- ▶ Fire develops more quickly in a small compartment.
- ▶ Highly compartmented buildings may slow fire spread.
- ▶ Large compartments contain more air and may have a substantial fuel load.



Thermal Properties



- ▶ Effective insulation prevents heat loss
- ▶ Normally this is a good thing.
- ▶ What effect does this have on fire development?

Brick Wall _____
December 3, 1999
Asphalt Impregnated Cork _____
Worcester MA
Styrofoam _____
Foam Glass _____



Ventilation Profile



Existing and Potential Openings

- ▶ *Normal building ventilation and compartmentation*
- ▶ *Ventilation openings created by exiting civilian occupants*
- ▶ *Tactical action taken by firefighters*
- ▶ *Unplanned ventilation*



All changes to the ventilation profile may influence fire behavior!

Stages of Development

Heat Release Rate

Burning Regime



Building Blocks for Understanding
Compartment Fire Behavior

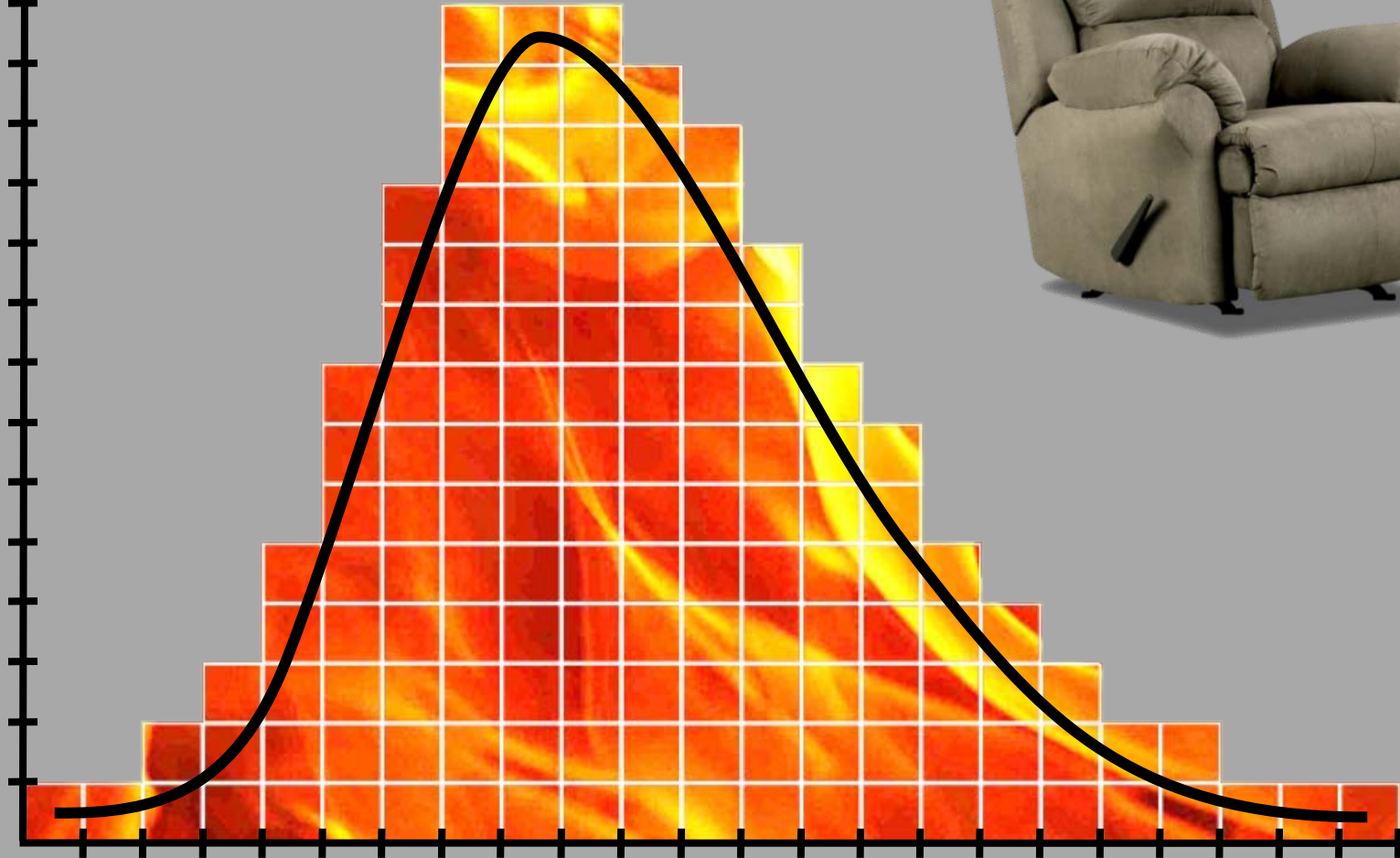
Release of Energy



- ▶ Heat of Combustion
 - *Energy Released*
 - *Joules*
- ▶ Heat Release Rate (HRR)
 - *Energy Released Over Time*
 - *Watts*

HRR

Fuel
Controlled



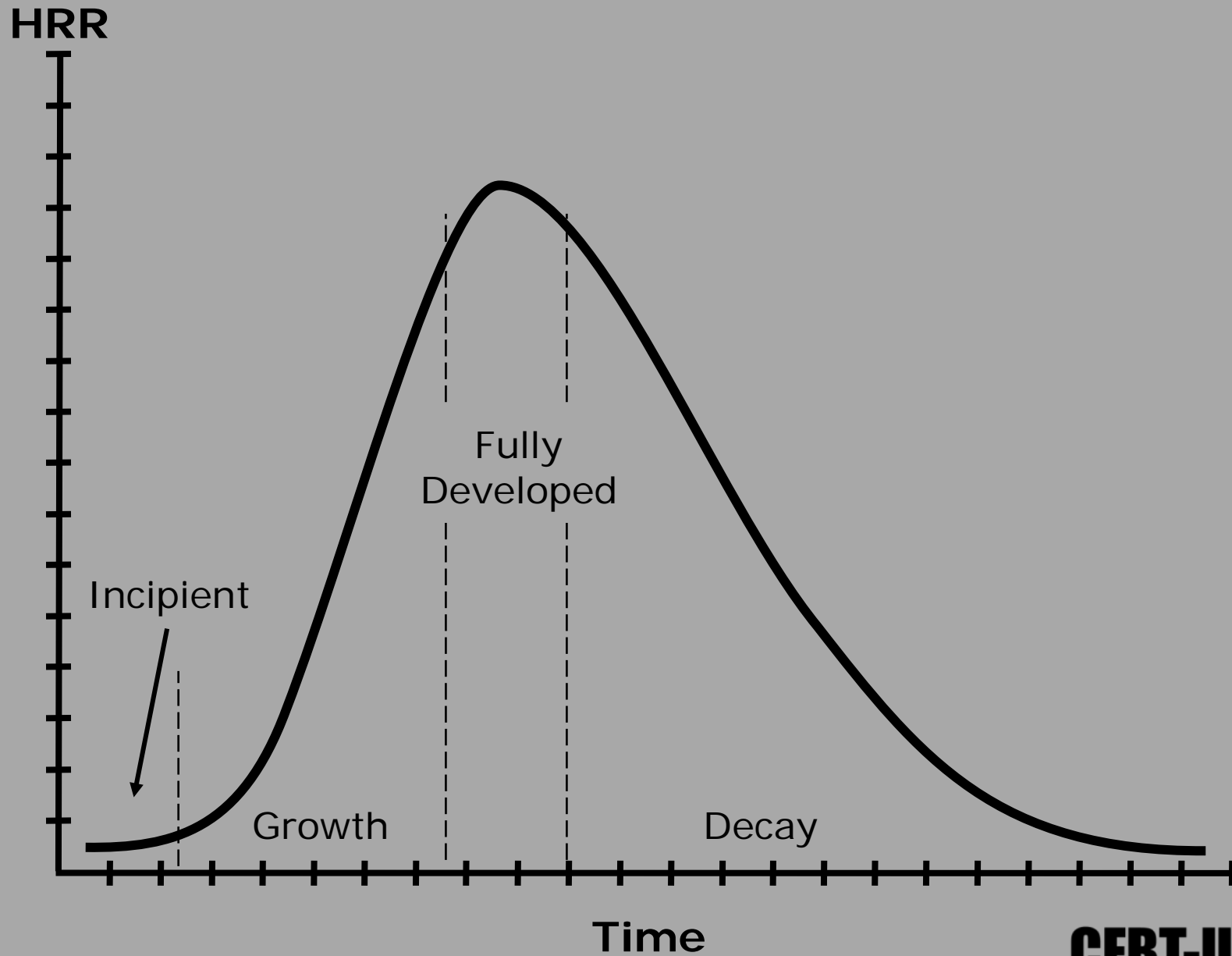
Time

Activity

Compartment Fire



Watch this video clip to get a general sense of fire development within a compartment.



Stages of Fire



- ▶ The stages of fire describe the complex process of fire development.
- ▶ Fire development is influenced by many variables.
- ▶ Not all compartment fires will develop through each of the four stages as described.

Burning Regime



- ▶ Fuel Controlled

Fire growth is predominantly limited by the fuel availability and characteristics

- ▶ Ventilation Controlled

Fire growth is predominantly limited by the available oxygen supply

Fuel Factors

Fire growth in the incipient stage is influenced primarily by fuel characteristics and configuration.



- ▶ *Chemical makeup of the fuel*
- ▶ *Physical configuration (state, surface to mass ratio, and arrangement)*
- ▶ *Thermal thickness*
- ▶ *Quantity of fuel available*

Ventilation Factors

As a fire moves through the growth phase it may become ventilation controlled:



- ▶ *Size of the compartment*
- ▶ *Existing building openings*
- ▶ *Leakage of air and smoke*
- ▶ *Compartmentation*
- ▶ *Loss of compartmentation (e.g., failure of window glazing)*

Flashover



- ▶ Flashover is the rapid transition from the growth to fully developed stage.
- ▶ Convective and radiant heat transfer increase the temperature of additional fuel packages within the compartment.
- ▶ Given sufficient heat and air, these fuels may ignite, with the fire transitioning extremely rapidly to the fully developed stage

In a post-flashover fire most fuel within the compartment is involved in the combustion reaction to some extent



An Alternative Path

A compartment fire may become ventilation controlled before reaching flashover.

This results in the following:

- ▶ *Heat release rate (HRR) slows*
- ▶ *Pyrolysis continues*
- ▶ *Flammable pyrolysis products and products of combustion accumulate in the compartment.*

HRR



Ventilation
Controlled

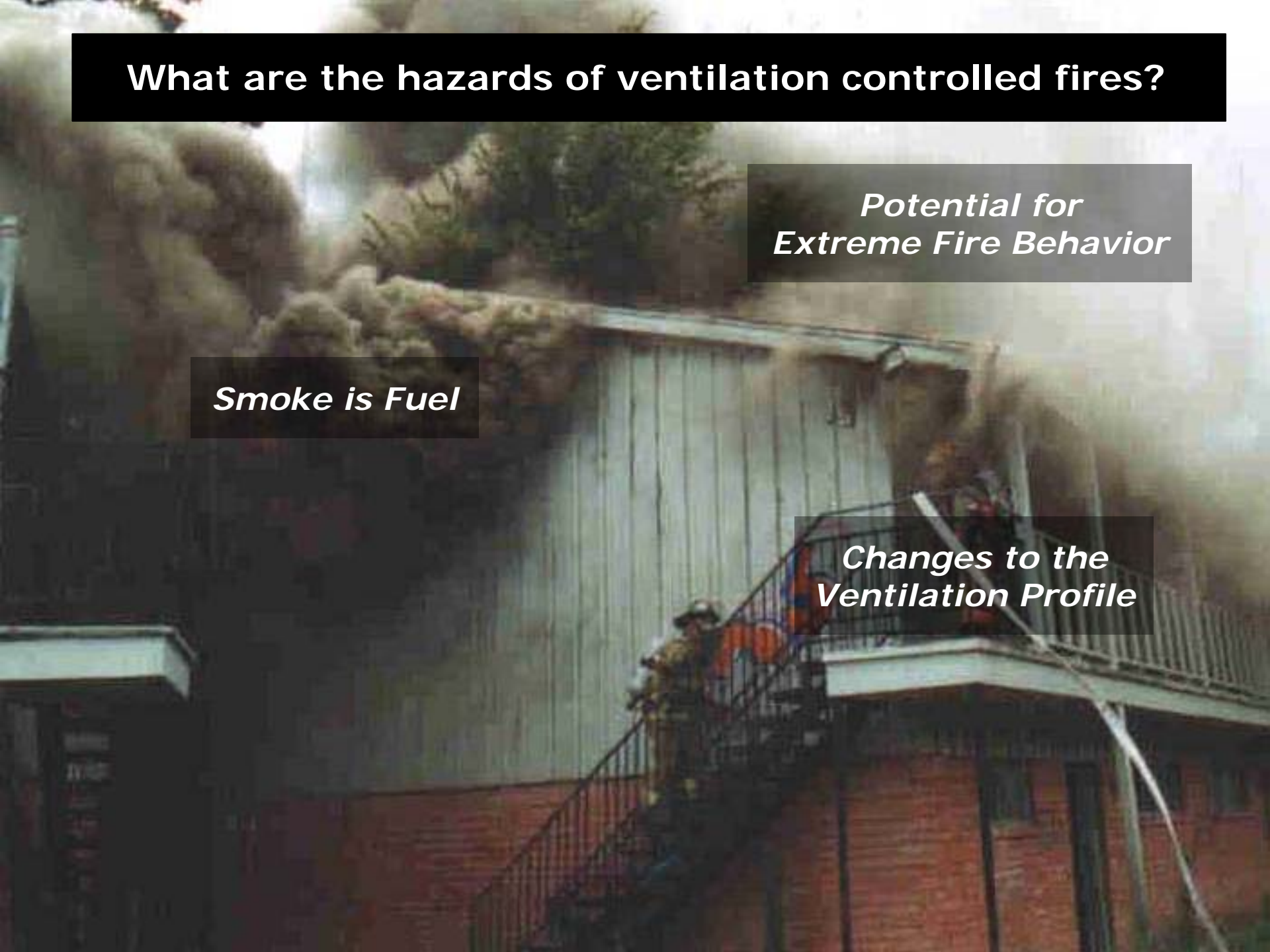
Time

What are the hazards of ventilation controlled fires?

*Potential for
Extreme Fire Behavior*

Smoke is Fuel

*Changes to the
Ventilation Profile*

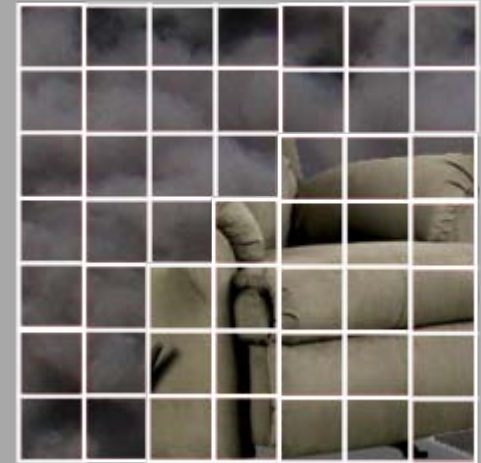


Ventilation Induced Flashover

HRR

Increased Ventilation

Time



Vent Controlled Fires



- ▶ Most fires that progress beyond the incipient stage are ventilation controlled at the point where the fire department arrives.
- ▶ If the ventilation profile changes to increase ventilation the fire can rapidly increase in intensity.
 - *Appropriate ventilation can significantly improve conditions inside the building.*
 - *Inappropriate or unplanned ventilation can adversely impact conditions and speed fire development.*
 - *Anticipate the effect of changes to the ventilation profile*

Extreme Fire Behavior

Phenomena that result in rapid fire progression and present a significant threat to firefighters

Rapid transition and sustained increase in HRR

Ignition and rapid or explosive combustion

Step Events

Fuel Controlled



Flashover

Ventilation Controlled



Vent-Induced Flashover

Moderate Fuel/Air Concentration

HRR Sufficient to Result in Full Surface Involvement

Transient Events

Overpressure

Confined



Smoke Explosion

Pre-Mixed Flammable Fuel/Air Concentration



Backdraft

High Fuel/Air Concentration



Flash Fire

Pre-Mixed Fuel/Air Concentration Limited Mass or Confinement

Minimal Overpressure

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