
Fire Dynamics

Compartment fire phenomena III

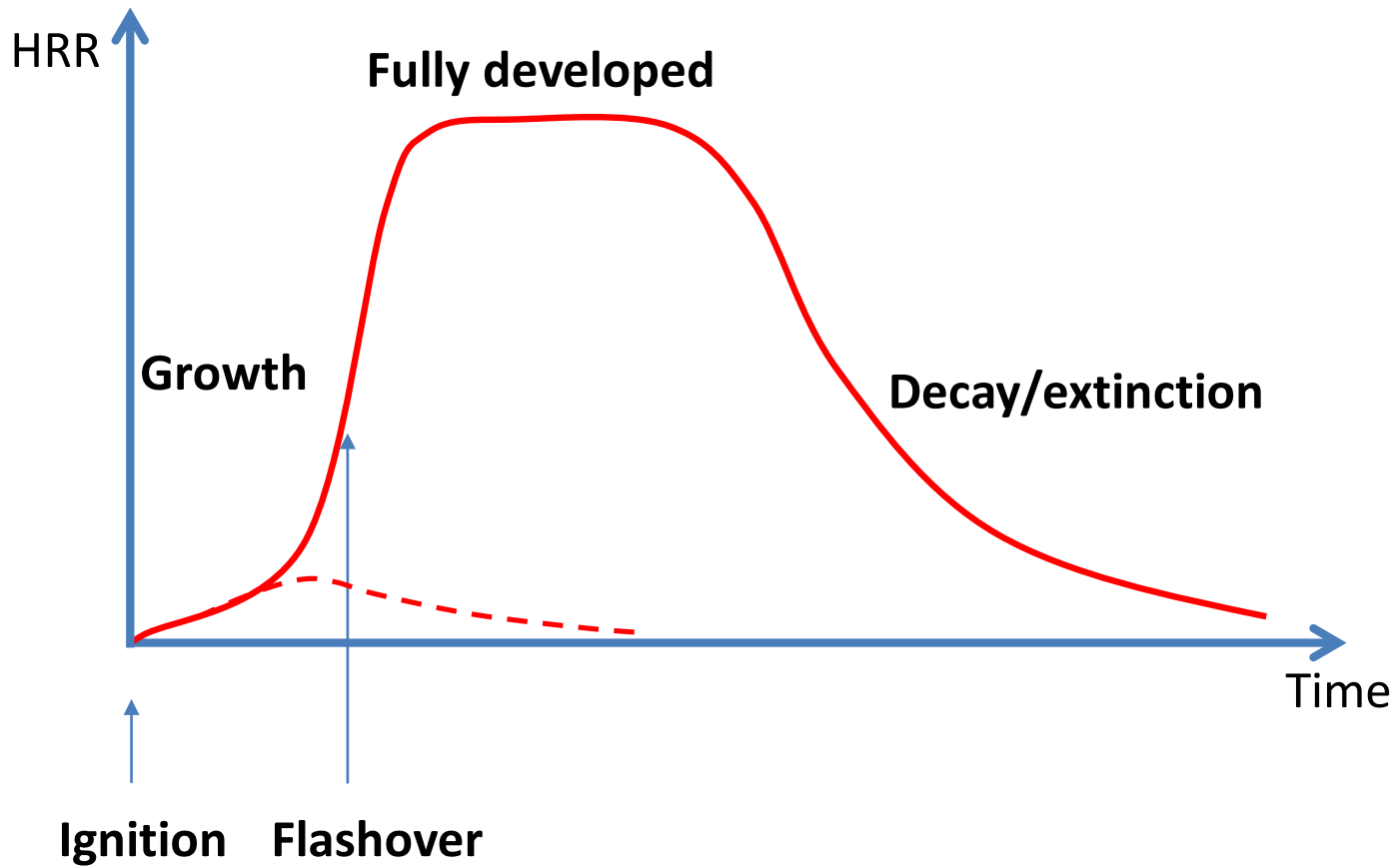
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Objectives

- Understanding post-flashover phenomena and structural fire safety

Compartment fire HRR curve



Concerns in post-flashover

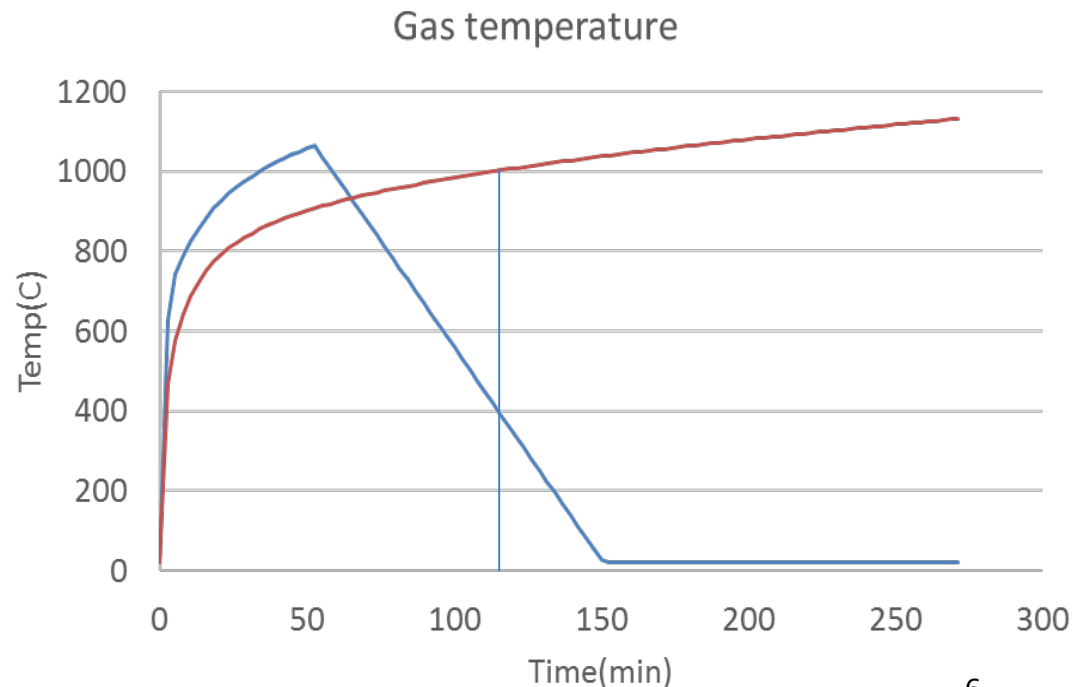
- Occupants life safety is already determined!
- Fire spread beyond the fire compartment (property protection)
 - Performance of passive systems
 - Performance of active systems
- Structural stability (property protection, firefighters' life safety)

Passive system/structural element performance

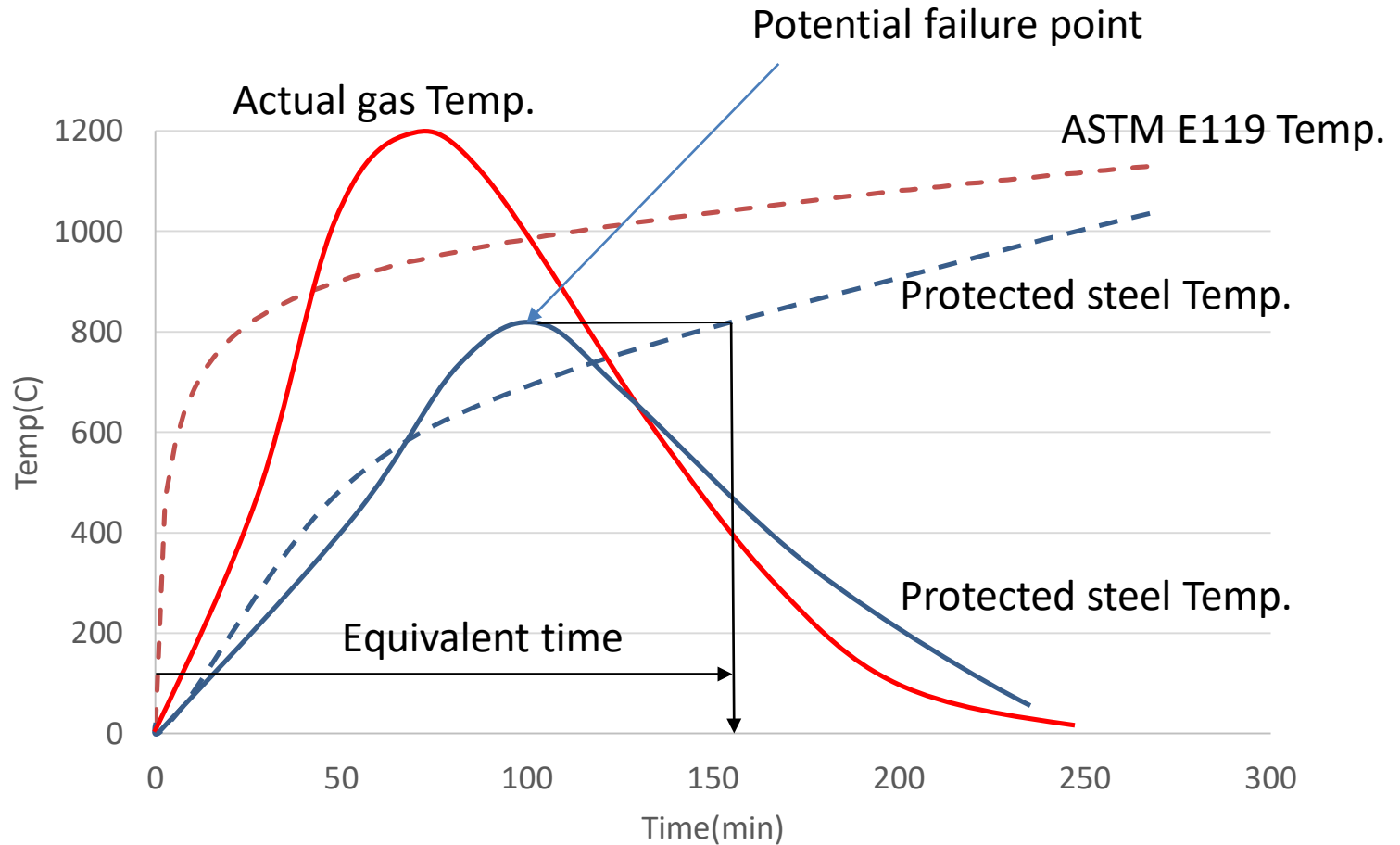
- Fire-resistance rating (ASTM E119)
 - At least 2 hr or at most 2 hr?
 - <https://www.youtube.com/watch?v=hUrDtttCwRE>
 - <https://www.youtube.com/watch?v=J0j54i7zArY>
(1:42 sec)

Passive system performance

- 2 hr fire-resistance rating
 - Per ASTM E119 (standard time temp. curve)
 - Parametric fire (Eurocode BS EN 1991-1-2-2002)
 - Real fire ?



Equivalent time concept



Equivalent time formula

$$t_e = e_f k_b w_f$$

where,

t_e : Equivalent time to the standard test [min]

e_f : Fire load density [MJ/m²]

k_b : Heat loss factor

w_f : Ventilation factor

Fire load density

- Eurocode fire load density [MJ/m²]

Occupancy	Average	80% Fractile
Dwelling	780	948
Hospital (room)	230	280
Hotel (room)	310	377
Library	1 500	1 824
Office	420	511
Classroom of a school	285	347
Shopping centre	600	730
Theatre (cinema)	300	365
Transport (public space)	100	122

Equivalent time formula

Depending on the wall surface materials,

- Thermal conductivity [J/m-K]
- Density [kg/m³]
- Specific heat [J/kg-K]

k_b [min/MJ-m ²]	$\sqrt{k\rho c}$ [J/s ^{0.5} -m ² -K]
0.08	<720
0.055	720< <2500
0.045	>2500

Equivalent time formula

$$w_f = \left(\frac{6.0}{H} \right)^{0.3} \left[0.62 + \frac{90(0.4 - \alpha_v)^4}{1 + (b_v \alpha_h)} \right] > 0.5$$

where,

$$\alpha_v = \frac{A_v}{A_f} = \frac{\text{Opening area on walls}}{\text{Enclosure floor area}} \quad 0.05 \leq \alpha_v \leq 0.25$$

$$\alpha_h = \frac{A_h}{A_f} = \frac{\text{Opening area on the roof}}{\text{Enclosure floor area}} \quad \alpha_h \leq 0.25$$

$$b_v = 12.5(1 + 10\alpha_v - \alpha_v^2)$$

Practical meaning of equivalent time

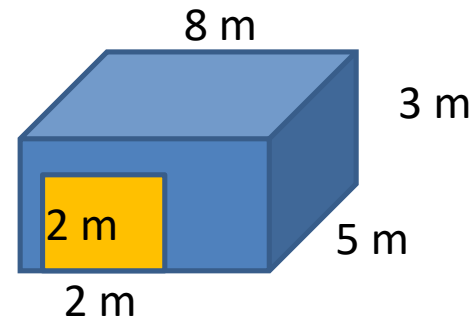
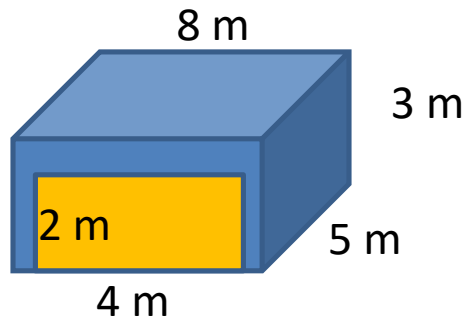
- Comparison of the estimated failure time (=equivalent time) to the time unit in the fire resistance rating of actual construction
- Equivalent time \ll fire rating in hr : safe

Fire ratings

- UL Fire Resistance Directory website

Example

- Calculate equivalent times for the following compartments. If the structural loadbearing walls are 1 hr fire rated, is it deemed to be structurally safe?



- Retail shop
- Thermal conductivity = 0.2 W/m-K
- Density = 800 kg/m^3
- Specific heat = 1200 J/kg-K