IMPACT OF MECHANICAL VENTILATION ON FIRE SEVERITY

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IMPACT OF MECHANICAL VENTILATION ON FIRE SEVERITY

Presentation Objective:

Demonstrate the impact of mechanical ventilation on fire severity when conducting fire hazard assessments.

Examine how mechanical ventilation can impact fire severity in room sizes typical of nuclear power plants.

Fire severity results using mechanical ventilation will be compared to natural ventilation through door openings.

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COMMON ROOM SIZE & CONSTRUCTION

Room Dimensions Width x Length x Height (m)	Boundary Materials	kpc ($\frac{kW^2s}{m^4K^2}$)
6.0 x 4.5 x 4.5	Concrete	2.9
6.0 x 4.5 x 6.0	Concrete Block	1.2
9.0 x 6.0 x 4.5	Brick	1.7
9.0 x 6.0 x 6.0	Gypsum Board	0.18
9.0 x 9.0 x 6.0	Glass Fiber Insulation	0.0018

NUREG 1805, NRC Fire Dynamics Tools, Chapter 2

Unique Large Spaces:

- Turbine Halls
- Reactor Vaults
- Access-ways
- Storage Rooms/Warehouse
- Cable Spreading Rooms
- Production/Process Areas

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FIRE HEAT RELEASE RATES

Mechanical Ventilation

$$\dot{Q}_{max,FA} = \frac{\rho_{air}\Delta H_{c,air} X_{ACH} V_{Room}}{3{,}600}$$

Natural Ventilation

$$\dot{Q}_{max,NV} = \Delta H_{c,air}[0.5 A_O \sqrt{H_o}]$$

Room Dimensions W x L x H (m)	Ventilation Controlled - Peak Heat Release Rate (kW)					
	2 ACH	4 ACH	6 ACH	12 ACH	Single Door Opening	Two Door Opening
6.0 x 4.5 x 4.5	239	478	717	1,434		
6.0 x 4.5 x 6.0	319	637	956	1,912		
9.0 x 6.0 x 4.5	478	956	1,434	2,867	**4,400**	**8,800**
9.0 x 6.0 x 6.0	637	1,274	1,912	3,823		
9.0 x 9.0 x 6.0	956	1,912	2,867	5,735		

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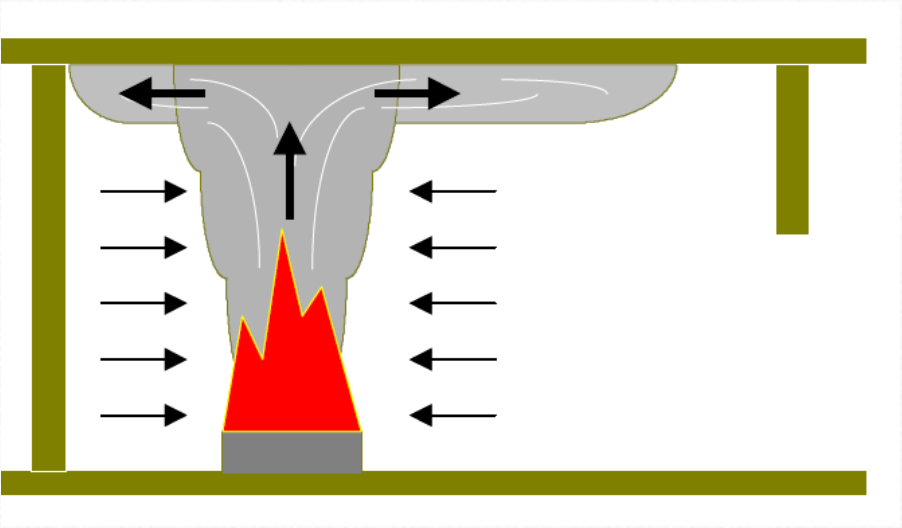
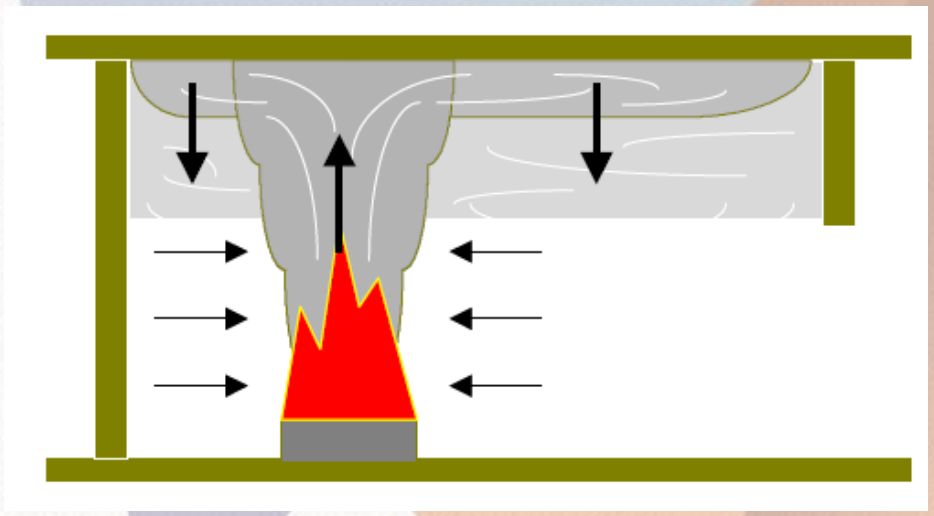
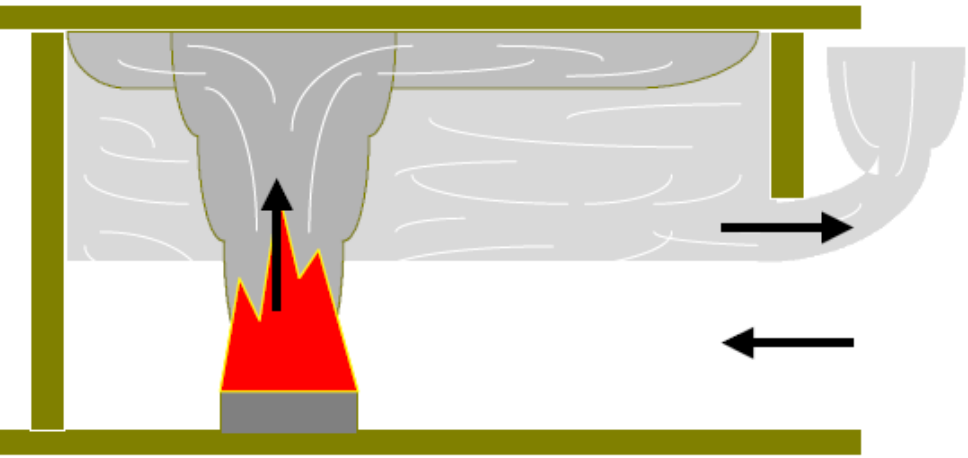
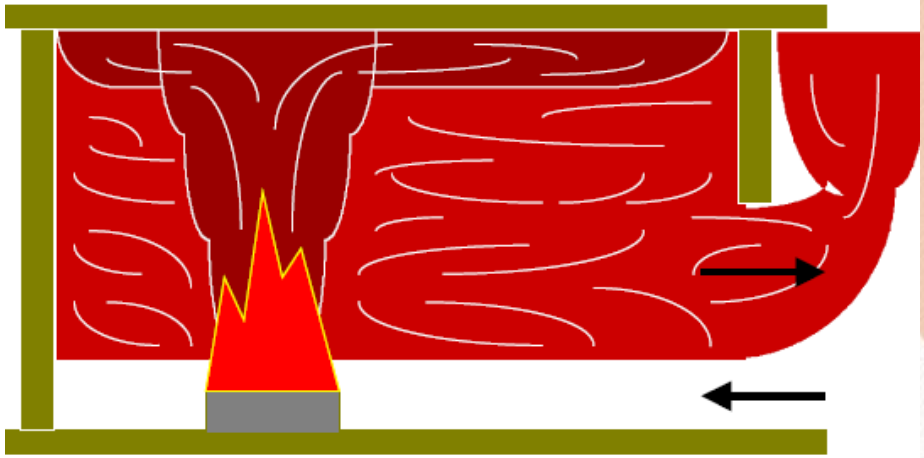
SFPE Handbook, 4th Edition, Section 3, Chapter 6

COMPARTMENT TEMPERATURES









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COMPARTMENT TEMPERATURES

Room Dimensions W x L x H (m)	Peak Upper Gas Layer Temperature after 30 minutes (° C)					
	2 ACH	4 ACH	6 ACH	12 ACH	Single Door Opening	Two Door Opening
6.0x4.5x4.5	186	277	340	430	710	935
6.0x4.5x6.0	194	286	349	408	647	854
9.0x6.0 x4.5	208	302	375	400	564	727
9.0x6.0x6.0	218	313	372	398	516	684
9.0x9.0x6.0	235	330	386	391	453	603

CFAST – Consolidated Model of Fire Growth and Smoke Transport (Version 6)

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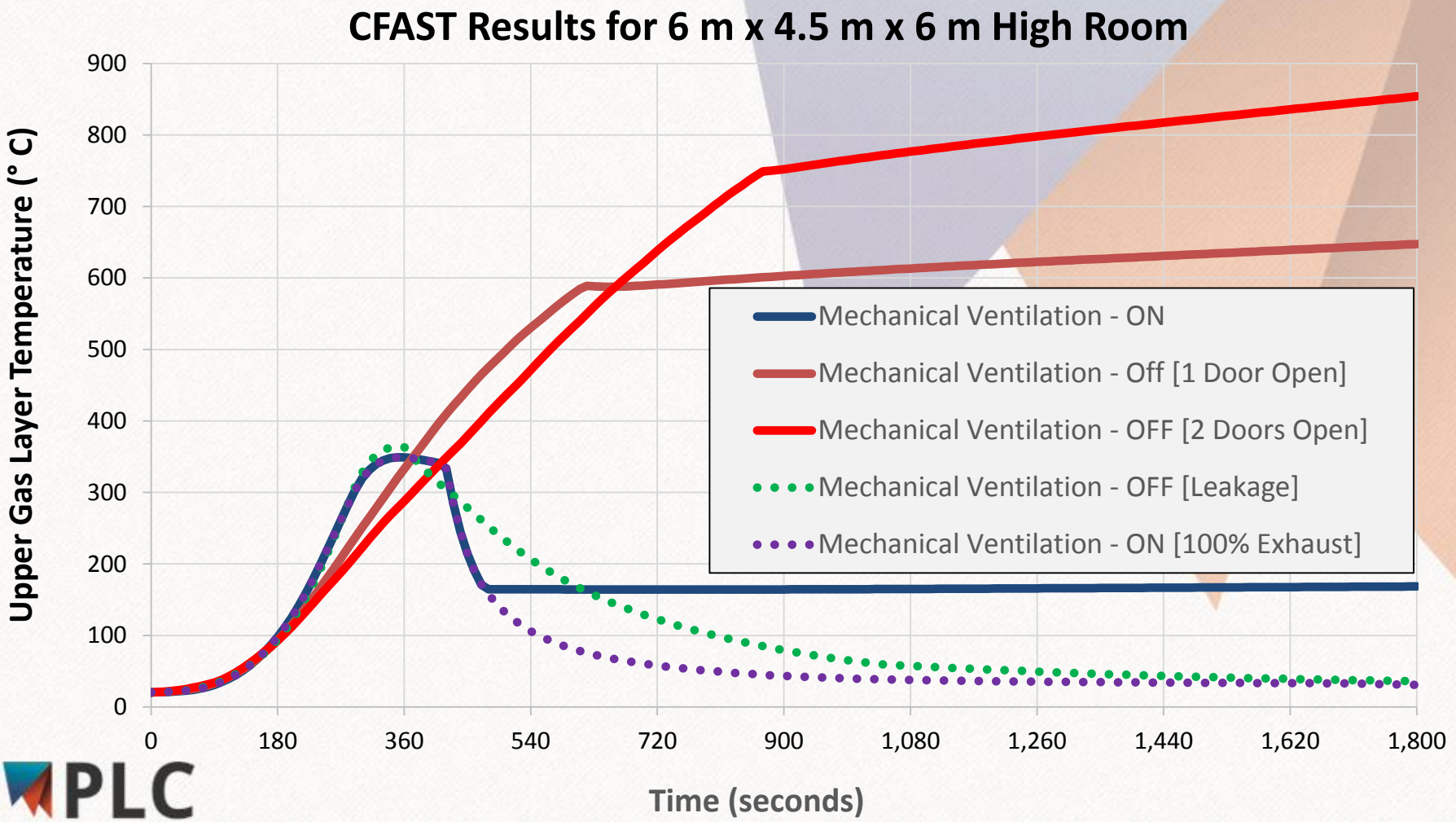
Each result was based on a medium growth rate fire that originates on the floor with no suppression system present. The fire duration used was 30 minutes.

MECHANICAL VENTILATION VS. NONE

Example 1 – Room 6 m x 4.5 m 6 m high (6 ACH)



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MECHANICAL VENTILATION VS. NONE

Example 2 - Large Space

Combustible Liquid Spill Fire
60 MW Heat Release Rate (15 minutes)
2.5 MW Cable Tray Fire
Concrete Boundaries
37m x 37m x 30m High
Supply / Exhaust Rates = 4.72 m^3/s (ACH ≈ 0.5)

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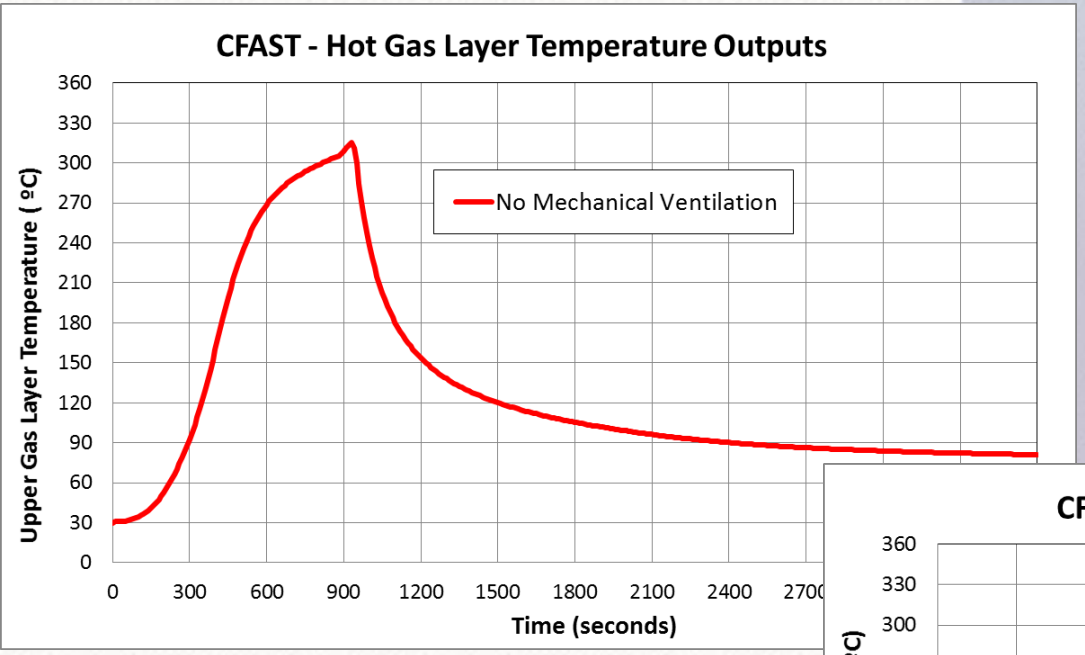
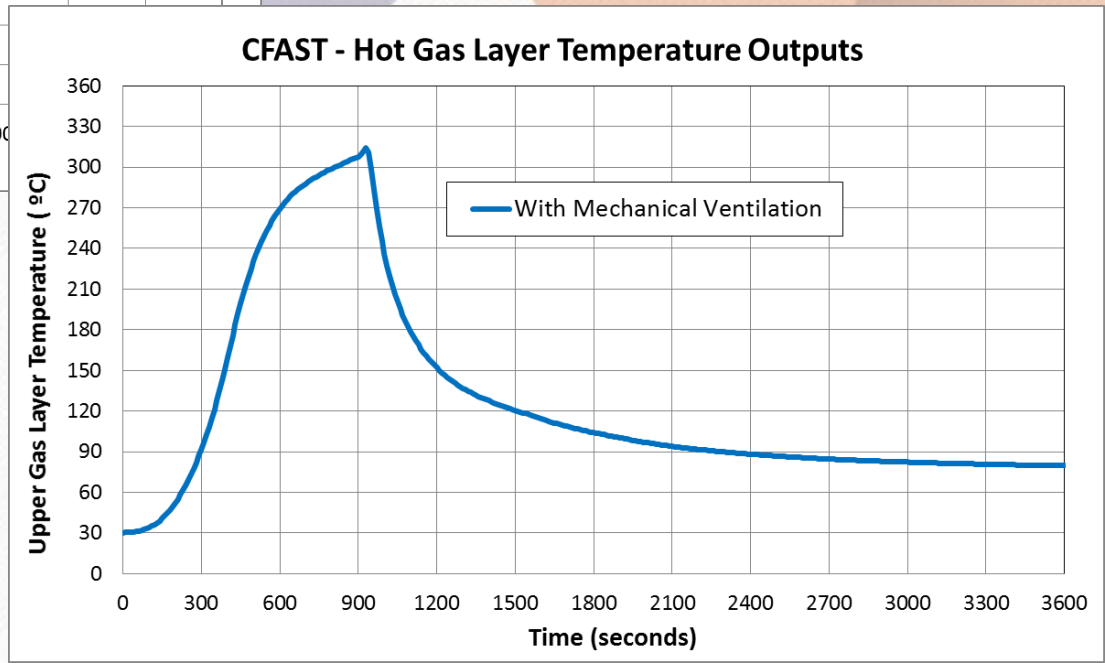
MECHANICAL VENTILATION VS. NONE



Example 2 - Large Space

Liquid Spill Fire



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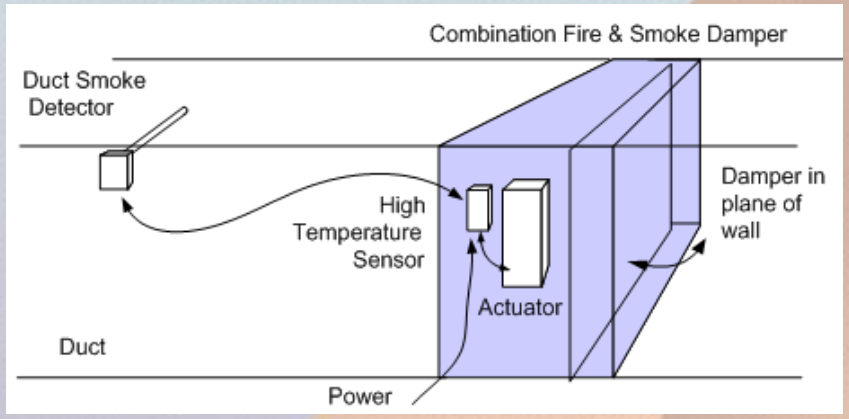
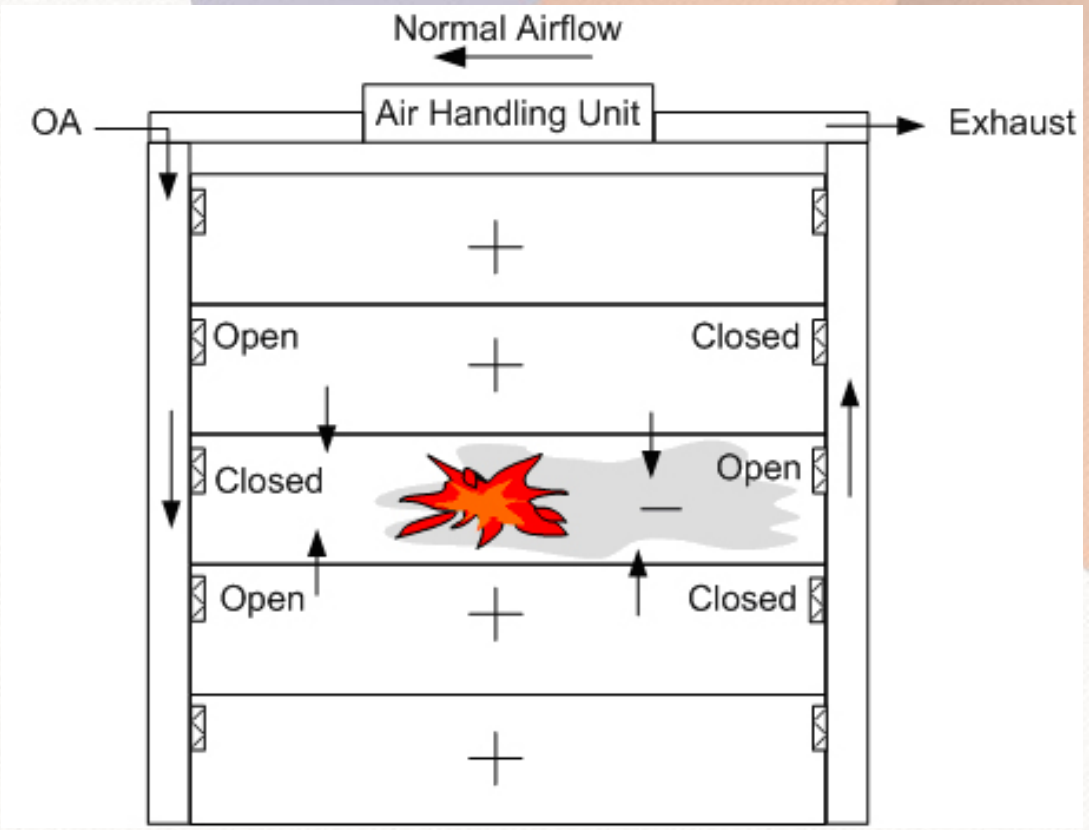
SMOKE / FIRE SPREAD CONTROLS

- Fire / Smoke Detection
- Fire / Smoke Dampers
- Ventilation Smoke Controls





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VENTILATION CONTROLS VS. NO CONTROLS

Example 3 – Large Electrical Room with Smoke Control System:

High Voltage Switchgear Room
Transformer Fire (Silicone Liquid Filled)
Transformer Fire spreads to Cable Trays
12 MW Peak Heat Release Rate
Concrete Block Walls and Concrete Floor/Ceiling
48m x 15m x 7m High
Supply / Exhaust Rate = 14 m^3/s [ACH ≈ 10]

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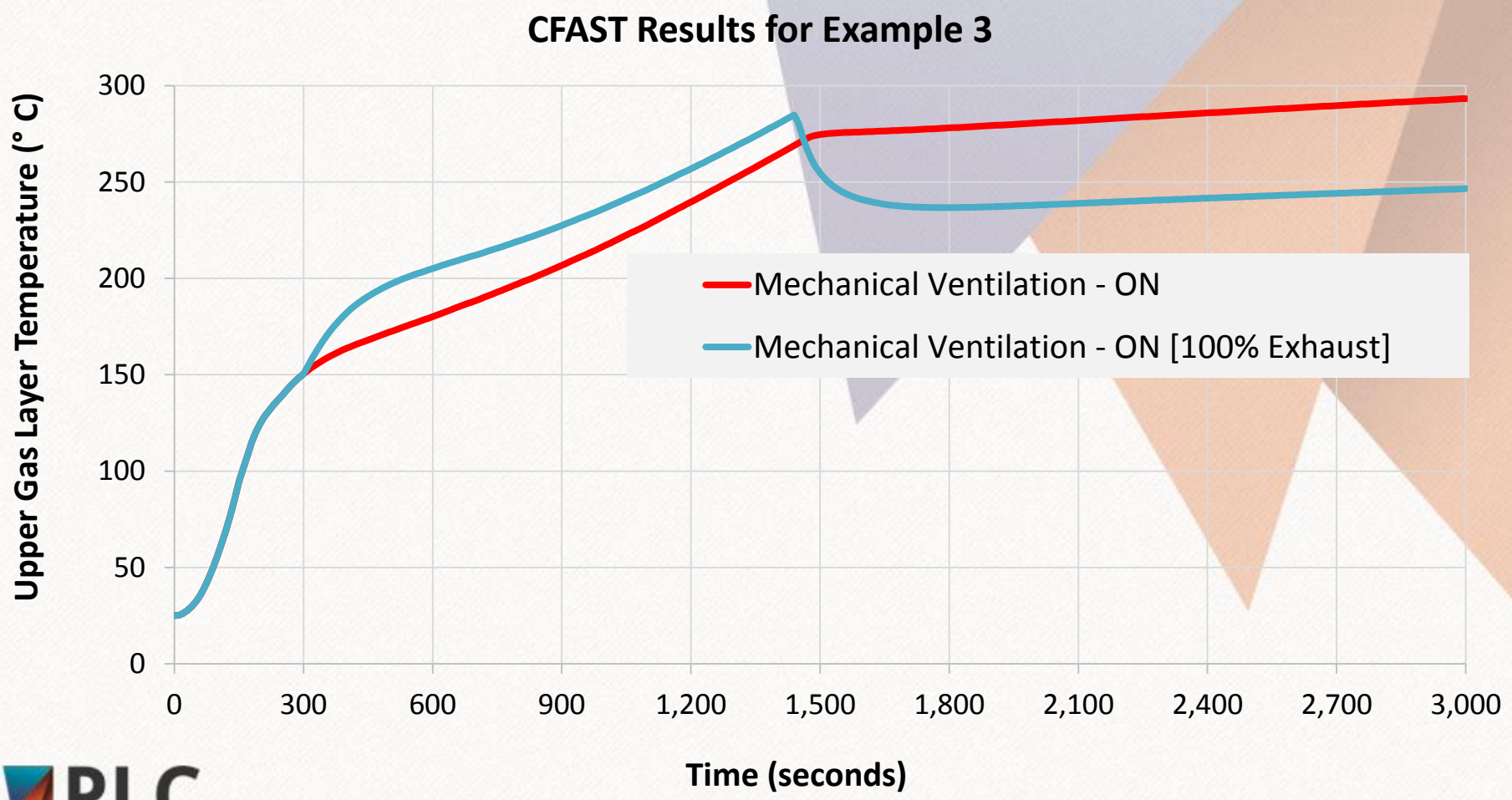
MECHANICAL VENTILATION VS. NONE

Example 3: Transformer/Cable Tray Fire



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CONCLUSIONS

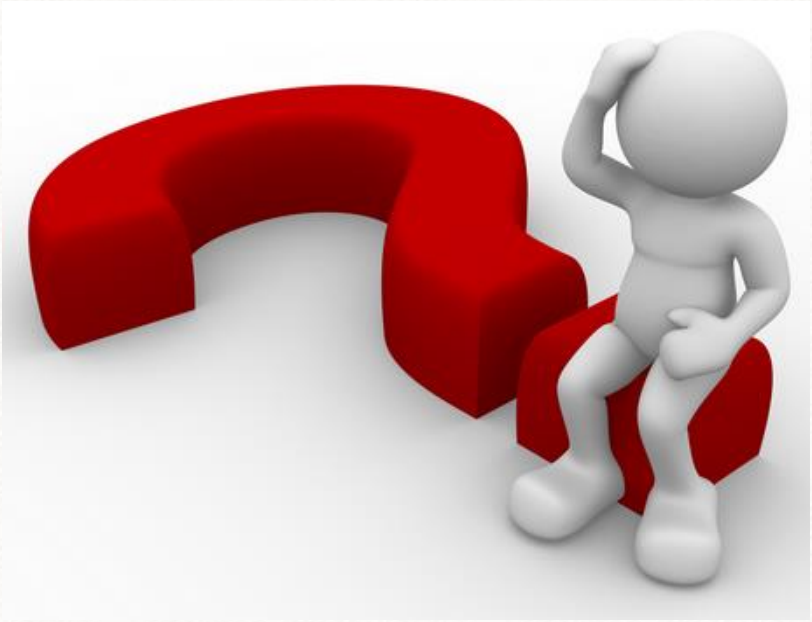
1. For the common room sizes evaluated (i.e. 6mx4.5mx4.5m – 9mx9mx6m), natural openings such as doors will allow more air flow into a room. This can result in more severe heat release rates and compartment temperatures.

2. For the common room sizes evaluated (i.e. 6mx4.5mx4.5m – 9mx9mx6m), mechanical ventilation and smoke control operations did not impact peak compartment temperature results when compared to no mechanical ventilation (i.e. room leakage). However; temperature levels do become less severe over time when crediting smoke control or the mechanical ventilation system being shut-down following fire detection.

3. For very large spaces with low ACH, mechanical ventilation had no impact on the upper gas layer temperature results.

4. Large rooms having smoke control systems showed lesser benefit than the smaller / common rooms (see Example 3). This was attributed to the greater air volume within the larger space to support higher heat release rate fires for longer durations.

QUESTIONS?



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