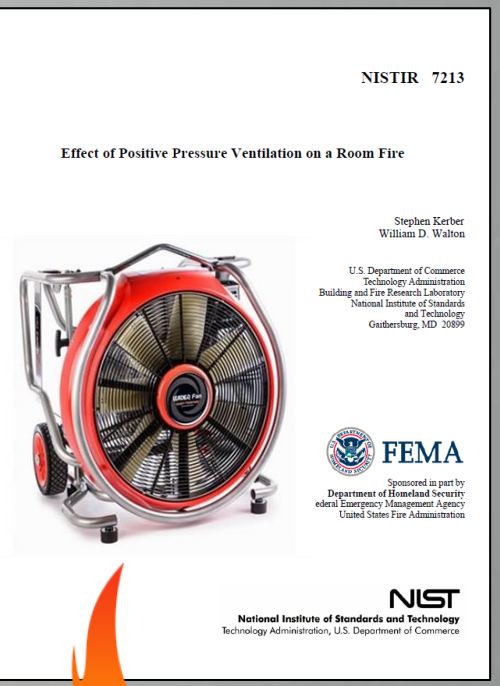
FLOW-PATH – Using a large PPV fan, a velocity of at least 5 m/s was required at the fire room door to reverse flaming from a **NON**-wind-impacted 12 MW fire, directing the fire out of the open window.

Room Fire Pressures


NISTIR 7213

Effect of Positive Pressure Ventilation on a Room Fire

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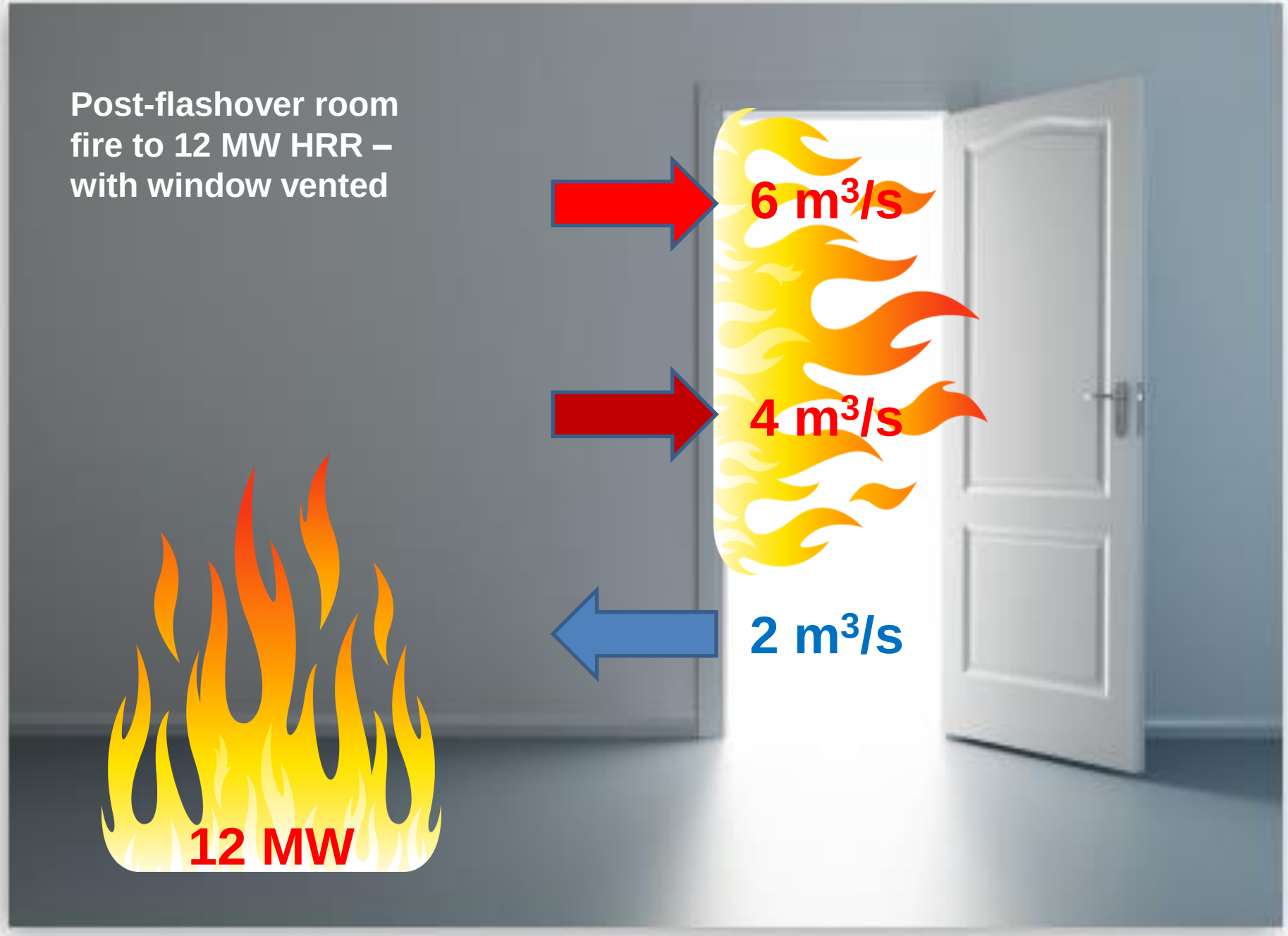

Post-flashover room fire to 12 MW HRR – with window vented
6 m³/s
4 m³/s
2 m³/s
12 MW

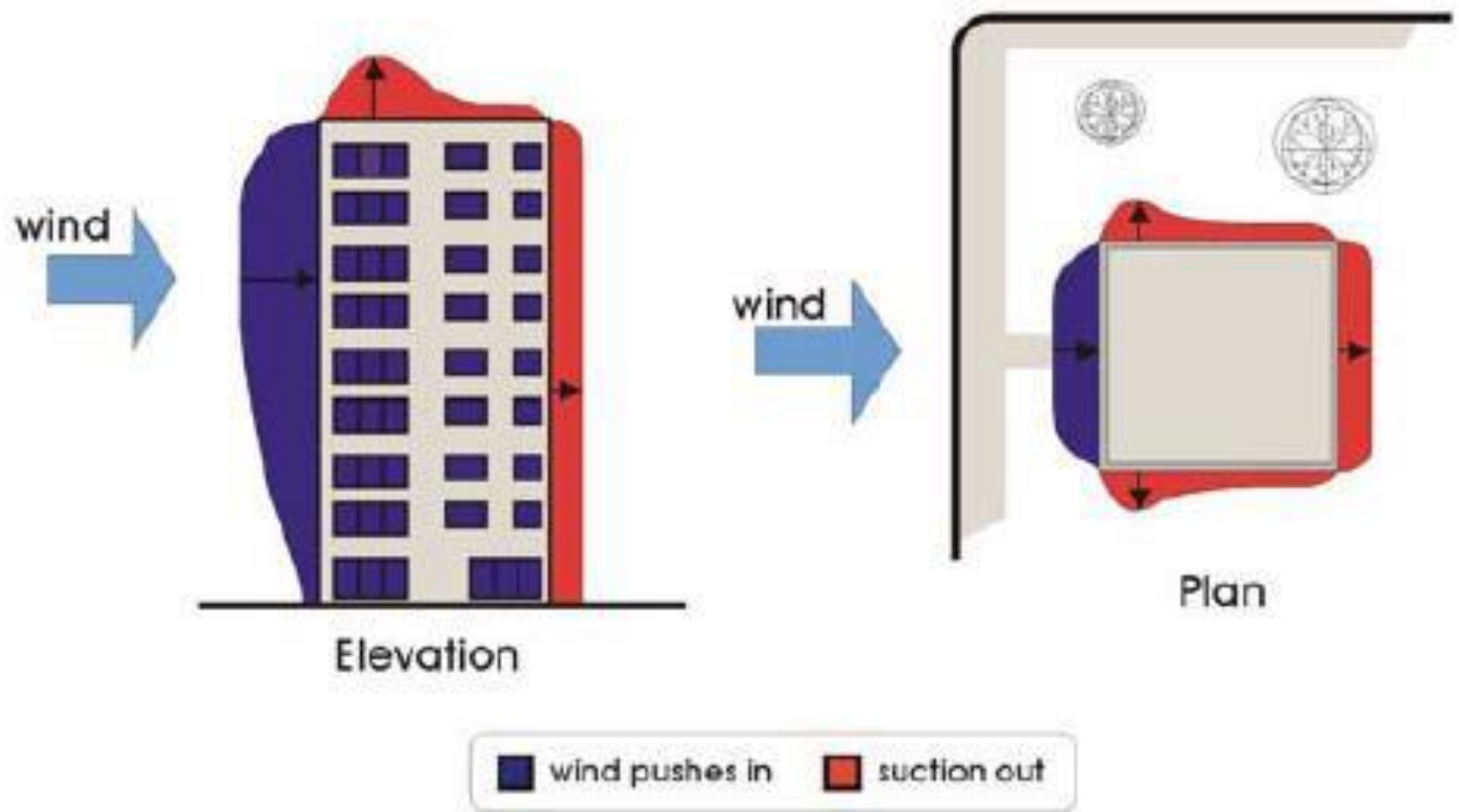
Overall, airflow entering the room from PPV at 8 m^3/s (28,800 m^3/hr) reversed pressure flows within 3 minutes, out of the vented window.

8 m^3/s

8 m^3/s

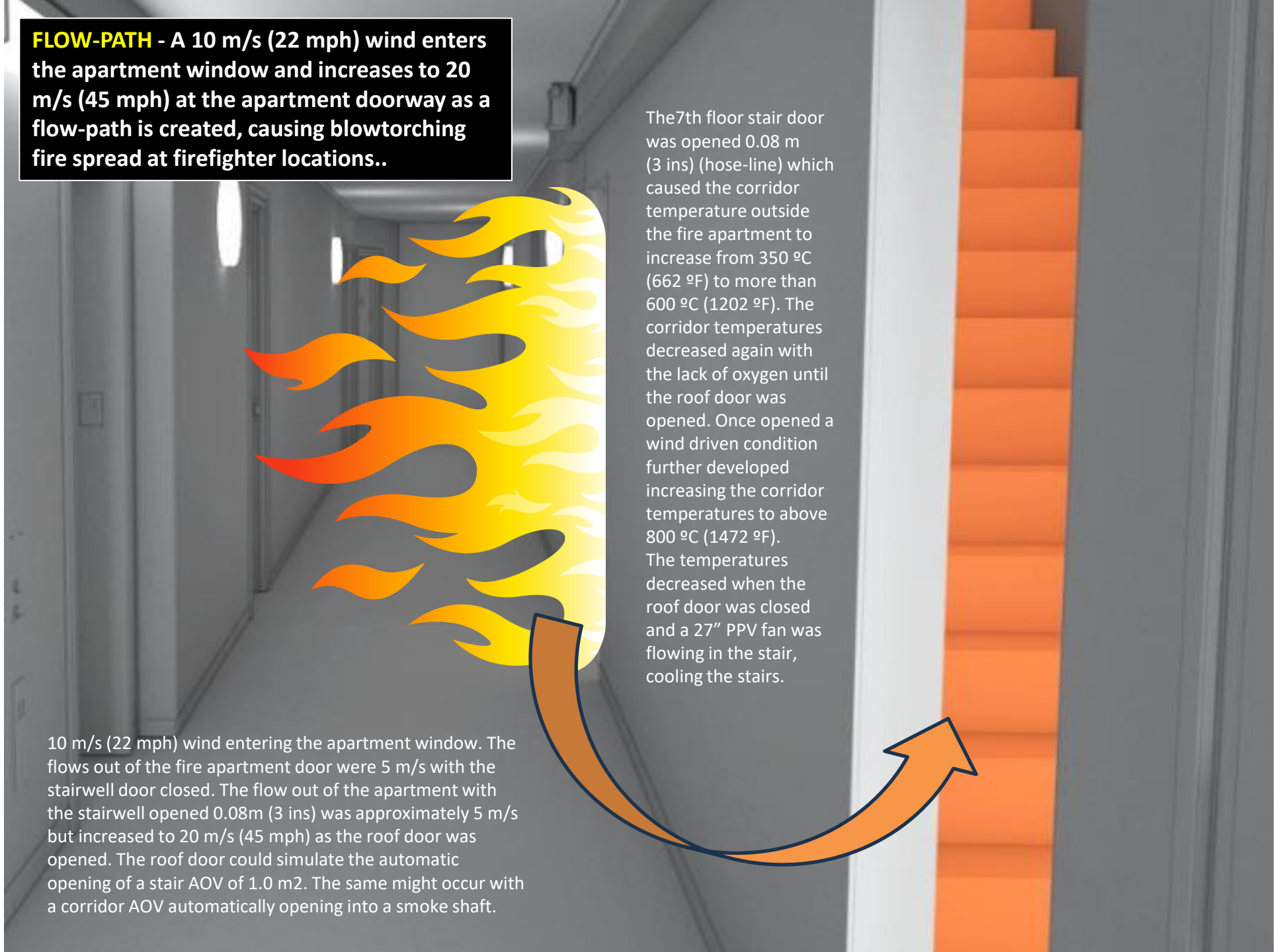
8 m^3/s

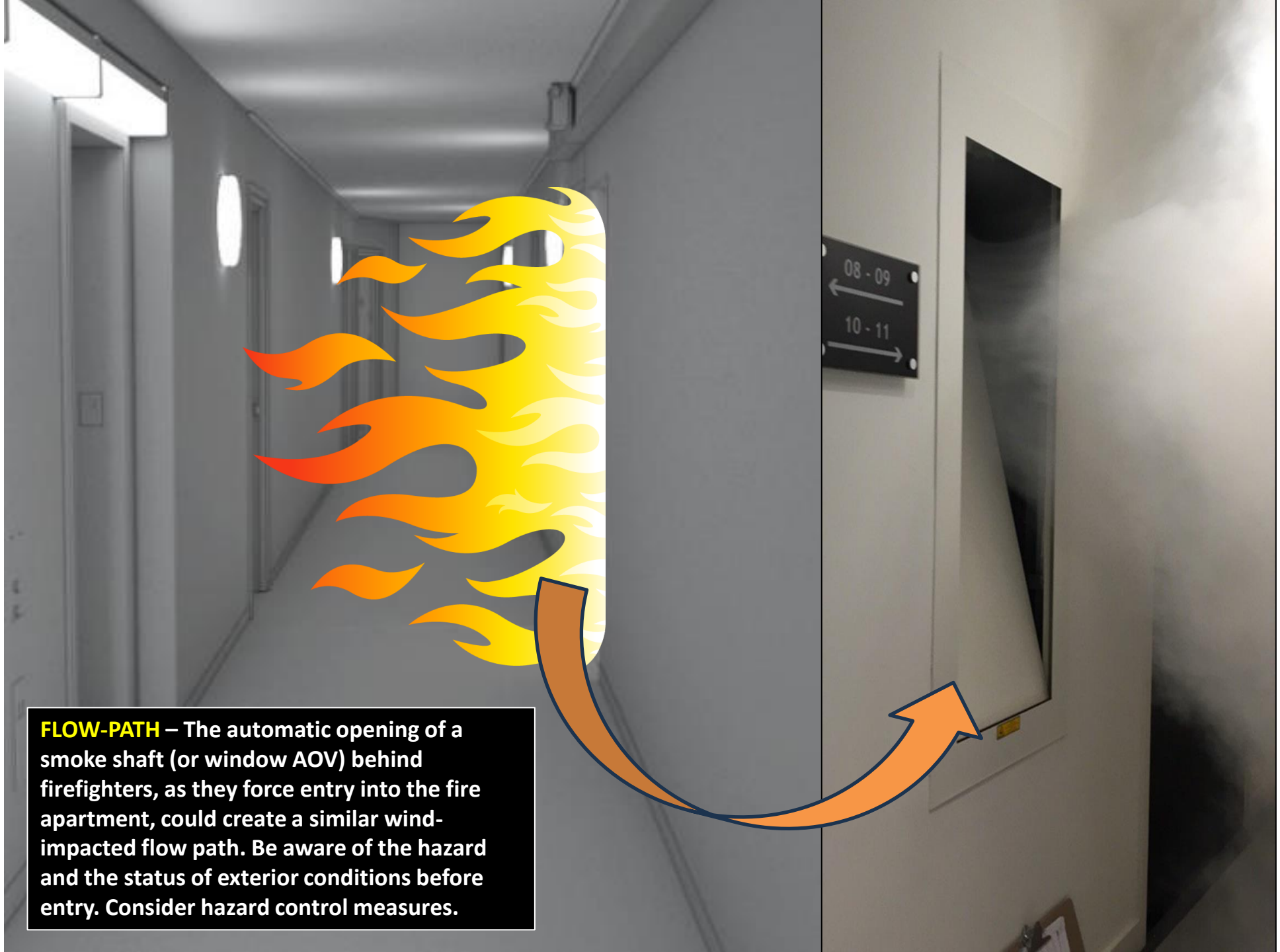
So, if a PPV is flowing 30,000m3/hr. the application must be 100% efficient to achieve 5m/s through the fire room doorway. If 50% is lost to leakage, then more like 2.5m/s (4.5m3/s or 16,200m3/hr. will flow through door.


wind
Elevation
wind
Plan
wind pushes in
suction out

WIND DRIVEN FLOW-PATH – The larger the window opening is, the greater volume (m3/s) of wind (air) can enter. This will likely translate to even greater velocities (blowtorching flames) at interior doors and hallways as the 'point to point' flow-path is created.


WIND DRIVEN FLOW-PATH - A 10 m/s (22 mph) wind enters the apartment window and increases to 20 m/s (45 mph) at the apartment doorway as a flow-path is created, causing devastating blowtorching fire spread at firefighter locations..


FLOW-PATH - A 10 m/s (22 mph) wind enters the apartment window and increases to 20 m/s (45 mph) at the apartment doorway as a flow-path is created, causing blowtorching fire spread at firefighter locations..
The7th floor stair door was opened 0.08 m (3 ins) (hose-line) which caused the corridor temperature outside the fire apartment to increase from 350 ºC (662 ºF) to more than 600 ºC (1202 ºF). The corridor temperatures decreased again with the lack of oxygen until the roof door was opened. Once opened a wind driven condition further developed increasing the corridor temperatures to above 800 ºC (1472 ºF).
The temperatures decreased when the roof door was closed and a 27" PPV fan was flowing in the stair, cooling the stairs.
10 m/s (22 mph) wind entering the apartment window. The flows out of the fire apartment door were 5 m/s with the stairwell door closed. The flow out of the apartment with the stairwell opened 0.08m (3 ins) was approximately 5 m/s but increased to 20 m/s (45 mph) as the roof door was opened. The roof door could simulate the automatic opening of a stair AOV of 1.0 m2. The same might occur with a corridor AOV automatically opening into a smoke shaft.



FLOW-PATH – The automatic opening of a smoke shaft (or window AOV) behind firefighters, as they force entry into the fire apartment, could create a similar wind-impacted flow path. Be aware of the hazard and the status of exterior conditions before entry. Consider hazard control measures.

Wind Driven Fires and PPV

Table 5
Effect of wind conditions at the fire floor (fifth floor) for fire without PPV.

Location	0 m/s (ΔT, °C)	2.5 m/s (ΔT, °C)	5 m/s (ΔT, °C)	7.5 m/s (ΔT, °C)	10 m/s (ΔT, °C)
Stairwell	153.96	208.32	328.86	401.24	464.79
Stairwell door	266.47	307.88	449.53	504.09	581.07
Corridor	301.51	324.57	528.12	537.27	486.11
Apartment door	296.19	322.06	602.58	570.06	501.85
Apartment	912.91	884.82	764.43	487.91	275.68

Table 6
Effect of wind conditions at the fire floor (fifth floor) for fire with PPV.

Location	0 m/s (ΔT, °C)	2.5 m/s (ΔT, °C)	5 m/s (ΔT, °C)	7.5 m/s (ΔT, °C)	10 m/s (ΔT, °C)
Stairwell	0.34	1.08	8.06	17.44	66.61
Stairwell door	90.83	192.78	355.96	455.36	486.39
Corridor	255.89	320.09	404.38	415.92	437.64
Apartment door	130.30	168.67	207.64	370.52	541.61
Apartment	1095.69	1054.22	774.58	637.91	505.31

Temperatures at Firefighter locations above 150°C are hazardous, whilst temperatures above 200°C are extreme and life threatening to Firefighters. PPV from ground floor exterior into stairs, to fire on 5th floor.

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Positive Pressure Ventilation for fighting wind-driven high-rise fires: Simulation-based analysis and optimization

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ABSTRACT

In high-rise buildings wind can greatly impact fires, creating extremely dangerous and life-threatening environments for both the firefighters and the building's occupants. Positive pressure ventilation (PPV) is found to be a successful tactic, not only to mitigate wind driven fires in high-rises, but also to significantly improve firefighters' safety. The efficacy of PPV is strongly influenced by various parameters, mainly structural layouts, wind conditions, and fan deployment configurations. To optimize the application of PPV in high-rise fires, this paper investigates the impact of wind speed (0–10 m/s; 0–5 Beaufort wind scale) and relevant operational parameters on temperatures and smoke conditions using computational fluid dynamics model - the Fire Dynamics Simulator (FDS 5.0). The temperature results demonstrate that the effectiveness of PPV decreases with increasing wind speed necessitating the use of wind control devices (WCDs) in conjunction with deployment of PPV fans to mitigate the flow of heat and reduce the temperatures at primary vantage points (stairwell and public hallway). This tactic ultimately provides a safer environment for firefighters.

1. Introduction

Fires in high-rise buildings create unique challenges to the safety of the building's occupants and firefighters. When combined with wind driven conditions, such fires are recognized as some of the most destructive and deadly fires in the United States. An analysis conducted by the NFPA's (National Fire Protection Association) Fire Protection Research Foundation of 565 fire incidents shows that the combination of both, i.e., high-rise fires that are wind driven, presents one of the most dangerous environments that a firefighter can face [1]. With the growing concentration of high-rise buildings and the increasing number of fatalities and injuries, the review of existing fire fighting tactics and the development and dissemination of new fire fighting strategies become a necessity for today's fire services [2–4].

Positive Pressure Ventilation (PPV) can drive away the smoke and heat or prevent the smoke and heat from entering the building stairwell and public hallways, thereby keeping these tactically important locations clear and improving the safety of firefighters and building's occupants. This is achieved by creating a high (positive) pressure zone in the stairwell by directing a significant amount of airflow into the stairwell. Specially designed fans are deployed at the entrance of stairwell (and / or other appropriate locations of the stairwell). The static pressure created by PPV fans must be greater than that created by spread of fire so that PPV fan deployment can drive away the flow of smoke, heat, and other combustion products [2,5]. It can assist firefighters in the venting of smoke and high temperature combustion products with increased efficacy and make the fire-rescue / suppression operation safer than without PPV. The positive pressure zone is influenced by a number of parameters such as fan deployment techniques, control of doors, location of fire, layout of the space, wind speed and others [6,8,5,9,10,7].

One of the first demonstrations of the use of PPV tactics for high-rise fires was conducted in 1972 that established the feasibility of using stair pressurization as a means for ensuring smoke-free conditions in high-rise buildings [11]. Since then, many lab-scale and full-scale burn experiments have been conducted to investigate and validate the use of PPV tactics for fires in residential as well as high-rise structures [1,6,13,12,14,15]. These studies show that PPV fans, when positioned properly and deployed in a strategic manner, can create higher pressure zone to mitigate or control the spread of fire for improving the safety of firefighters and building's occupants.

In the last decade, as the number of fatalities and injuries from wind-driven high-rise fires has increased, a series of fourteen burn experiments were conducted that were mainly focused towards understanding the impact of ventilation and wind conditions on high-rise fires, and developing strategies to safely tackle these fires [6,8,5].

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