Wind Driven Fires
and
Looking at the Future of Fire Engineering in the Next 25 Years

Casey C. Grant, P.E.
Fire Protection Research Foundation

THE FIRE PROTECTION RESEARCH FOUNDATION

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FPRF Fire Service Research

Fire Protection Research Foundation

FPRF Mission: Plan, manage and communicate research in support of the NFPA mission

One Batterymarch Park, Quincy, MA USA 02169-7471
Phone: 617-984-7284 Email: cgrant@nfpa.org
www.nfpa.org/foundation

Wind Driven Structure Fires
PART 1

Part 1: Presentation Summary

- A) Overview of Wind Driven Fires
  - Historical Summary (& 2 Case Studies)
  - Fire Dynamics for the Fire Service
- B) Examining Fire Fighting Tactics Under Wind Driven Conditions
  - NIST Reports on PPV and Wind Driven Fires
  - FPRF/NIST Laboratory Project
  - FDNY/NYU-Poly/NIST Field Project
- C) Next Steps

1A) Historical Summary

- Historical Review of Wind Driven Structure Fires
  - Interior structural fire fighting has traditionally not focused on exterior wind conditions
  - Multiple events now being acknowledged
  - Certain events have raised significant attention
  - Appendix A of NIST/FPRF Report, issued Jan/09

1A) Case Studies

Vandalia Ave, NYC – 18 December 1998

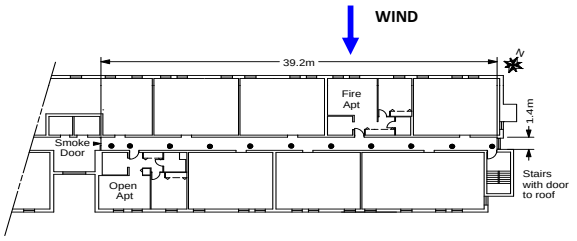
Downwind side

Upwind side

Which apartment was on fire?

1A) Case Studies

Vandalia Ave, NYC – 10th Floor Layout



1A) Case Studies

Prince William County, VA – 16 April 2007

- "Sustained winds of 25 mph, gusts to 48 mph"
- "High wind impact on fire development and spread"

1A) Case Studies

- Question: What is the phenomenon occurring at these fires?
  - Rapidly changing conditions (e.g. change in temperature by thousands of degrees (F) in tens of seconds

1A) Fire Dynamics for the Fire Service

Wind Driven Structure Fires:
What do we want to accomplish?

- Improve safety of fire fighters and building occupants by enabling a better understanding of wind driven fire dynamics and by developing tactics to fight wind driven fires
  - Educate &train fire fighters & supervisors
  - Improve fire service Standard Operating Guidelines

1A) Fire Dynamics for the Fire Service

Units of Measurement for Fire

- Temperature (°C, °F)
  - Measure of the degree of molecular compared to reference point
  - PPE degradation at > ~300 °C (~570 °F)
- Heat Energy (Joule, BTU, Calorie)
  - Energy needed to change the temp. of an object
  - Temp. vs. Heat Energy: 1 candle vs. 10 candles
- Heat Release Rate (Watts, J/s, BTU/s)
  - Cigarette ~5 W; Coffeemaker ~40 kW; Sofa ~ 3 to 5 MW
- Heat Flux (kW/m^2)
  - Sunshine ~1 kW/m^2; Flashover @ floor ~20 kW/m^2

1B) NIST Reports on PPV & WD Fires

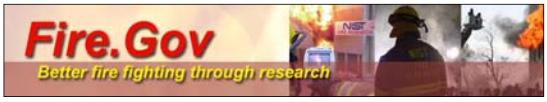
NIST Reports

- 1) "**NISTIR 7065**, Characteristics of Positive Pressure Ventilation Using Computational Fluid Dynamics", 2/03.
- 2) "**NIST SP 1021**, Cook County Administration Building Fire, Chicago IL, 10/03: Heat Release Rate Experiments and FDS Simulations", 7/04.
- 3) "**NISTIR 7213**, Effect of Positive Pressure Ventilation on Room Fire", 3/05.

1B) NIST Reports on PPV & WD Fires

NIST Reports

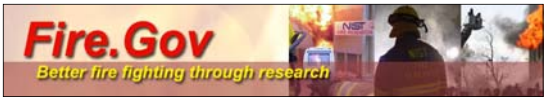
- 4) "**NISTIR 7315**, Evaluation of Ability of Fire Dynamic Simulator to Simulate Positive Pressure Ventilation in Laboratory and Practical Scenarios", 4/06.
- 5) "**NISTIR 7342**, Full-Scale Evaluation of Positive Pressure Ventilation in a Fire Fighter Training Bldg", 7/06.
- 6) "**NISTIR 7412**, Evaluation Positive Pressure Ventilation in Large Structures: Hi-Rise Pressure Experiments", 3/07.



1B) NIST Reports on PPV & WD Fires

NIST Reports

- 7) "**NISTIR 7468**, Evaluation Positive Pressure Ventilation in Large Structures: Hi-Rise Fire Experiments", 11/07.
- 8) "Fire Fighting Tactics Under Wind Driven Conditions", FPRF, 1/09.
- 9) "Strategies for Suppression of Wind Driven Fires in Hi-Rise Buildings", NIST/FDNY/NYU-Poly, 5/09.



1B) Laboratory Experiments

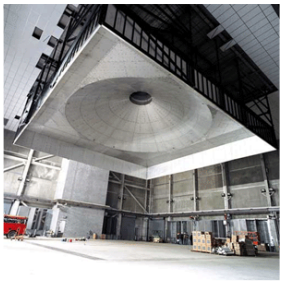
Objectives

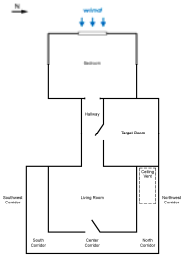
- Characterize the impact of wind in terms of temperature, heat flux, oxygen concentration, pressure, and heat release rate.
- Examine the impact of window blankets
- Examine the impact of limited amounts of water.

NIST Homeland Security

1B) Laboratory Experiments

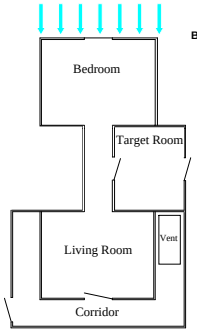
NIST Laboratory Facility





1B) Laboratory Experiments

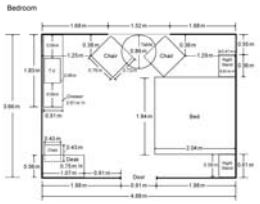
Floor Plan
Bedroom – room of origin



Wind Speed:
Ranging from 3 m/s to 9 m/s (7 mph to 20 mph)

1B) Laboratory Experiments

Experimental Arrangement



Room of origin, looking toward corridor

1B) Laboratory Experiments

Test Sequence

WDF Test	Experiment Description
1	Baseline, No Wind
2	Large wind control device
3	Large wind control device
4	Small wind control device, low flow window nozzle
5	Small wind control device, low flow window nozzle
6	No WCD, fog nozzle, hand line
7	No WCD, 15/16 in smooth bore, hand line
8	No WCD, 15/16 in smooth bore, hand line

1B) Laboratory Experiments

Test #5: Typical Test Sequence

1B) Laboratory Experiments

Test 5: Timeline

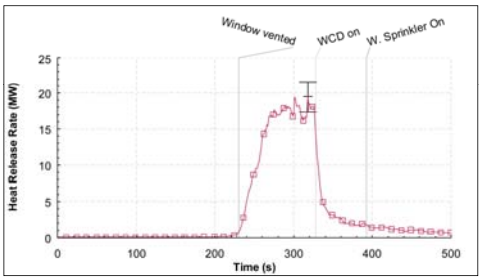
Table 5.5-1. Experiment 5 Timeline

Time (s)	Event
0	Ignition
90	Visible smoke layer
230	Window vented partially
233	Hot gas flow to floor in corridor IR
235	Window cleared
328	WCD on
392	Window sprinkler on
506	Fan off
513	WCD off
595	Sprinkler off
653	Test complete

Typical timeline for each test sequence

1B) Laboratory Experiments

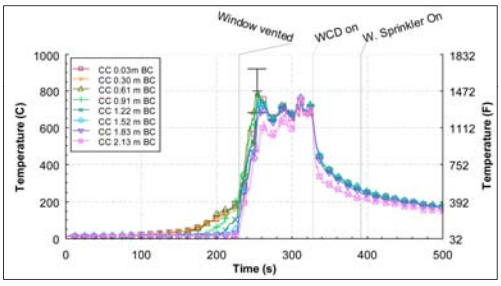
Test 5: Heat Release Rate



Heat release rate versus time

1B) Laboratory Experiments

Test 5: Temperature



Temperature versus time from the corridor center thermocouple array

1B) Laboratory Experiments

Discussion: What does this mean?

- Based on previous research at NIST, a fire fighter in full PPE, exposed to temperatures in excess of 260 ºC (500 ºF) combined with heat fluxes in excess of 20 kW/m^2 suggest that survival time would be limited to less than 30 seconds.
- In all of the experiments in this series, conditions in excess of 260 ºC (500 ºF) and 20 kW/m2 occurred in the corridor, prior to using one of the mitigating tactics, indicating that conditions in the corridor were not survivable for a firefighter in full PPE.

1B) Laboratory Experiments

In Summary:

- Results confirm sudden and dramatic change in fire conditions that results with window breakage
- Test series has provided valuable technical data for modeling and other future work
  - For FDS and other models
  - Being used for investigations, design, training
- Effectiveness of wind control devices and exterior water application demonstrated

1B) Field Experiments

Governors Island Experiments

NIST NYU·poly POLYTECHNIC INSTITUTE OF NYU Homeland Security

1B) Field Experiments

Objectives

- Evaluate Stairwell Pressurization with Portable Fans
  - Maintain Stairwells Clear of Smoke & Heat
  - Equalize Pressure of a Wind Driven Fire
- Address Wind Management and Control
  - Blocking Wind with (WCD) *Wind Control Device*
  - Fire Curtains / Blankets
- Validate Alternate Strategies of Attack
  - Flanking from Adjoining Space
  - Deployment of Outside Streams with *High Rise Nozzle*

1B) Field Experiments

Floor Plan

1B) Field Experiments

Fire Floors: 3, 5, & 7
Instrumentation Floors: 2, 4, & 6

1B) Field Experiments

1B) Field Experiments

Fire Pulse Phenomenon

1B) Field Experiments

Stairwell Pressurization with Portable Fans

1B) Field Experiments

Wind Control Device

1B) Field Experiments

High-Rise Nozzle

1B) Field Experiments

Tactical Considerations

- Respect wind conditions as part of size-up
- An event can be triggered by: Window failure or ventilation, Door opening (fire apartment, stairwell, bulkhead), wind shift
- Pay attention to flow paths created
- Consider alternate tactics, direct attack can be ineffective
- Conditions change quickly, operate defensively
- Not only a high-rise building issue

1C) Next Steps

Continued Interest on Topic

- Submittal to the latest round of DHS fire grants
- Submitted 6 March 2009
- Notification summer 2009

Homeland Security

Looking at the Future of Fire Engineering in the Next 25 Years

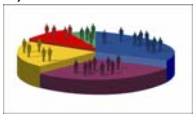
PART 2

2) The Next 25 Years

Looking Beyond: What are the major trends?

Fire Protection and Safety: The Next 25 Years
November 17 & 18, 2008
Ronald Reagan Building, Washington, DC

- a) Societal
- b) Technological
- c) Environmental



2) The Next 25 Years

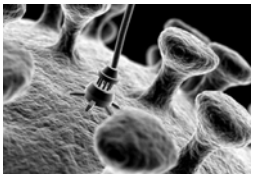
a) Social & Demographic

- Demographics – health, disability, aging, language
- Urban growth patterns – highrise/density, building at the wildland interface
- Transportation trends – road tunnels, public transportation
- Human behavior, - risk tolerance, security concerns
- Political and Economic issues – globalization, affluence, terrorism

2) The Next 25 Years

b) Materials and Technology

- New materials – nanotechnology, nature of fire "loads", super conductors
- New construction techniques – impact on building shape and size
- Intelligent sensors, robotics



2) The Next 25 Years

c) Environment, Energy and Sustainability

- Water supply, Air supply
- Hazards of alternative energy and fuel sources
- New definitions of hazardous materials, restrictions on fire fighting techniques
- Climate change - wildland fires
- Aging infrastructure

Wind Driven Fire Report, "Next 25 Year" Report, and other FPRF Reports are available for free download at:

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Contact Information:

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