



NEW SCIENCE  
**FIRE SAFETY**  
ARTICLE

# INTERRUPTING THE FLOW PATH

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## NEW SCIENCE **FIRE SAFETY** OVERVIEW

UL's dedicated team of scientists, engineers and researchers is creating New Science in a variety of ways. From live experiments to computational modeling, statistical analysis to quantification of risk, we are constantly seeking to improve products, techniques, methodologies, processes and standards.

## WHY INTERRUPTING THE FLOW PATH MATTERS

Structure fires today are very different from those faced by prior generations of firefighters, and in many ways, they are more hazardous. Because of the changes to the modern fire environment, traditional firefighting methods may not always be the safest and most effective. Interrupting the flow path — disrupting the flow of the fire within the burning structure — involves tactics that are innovative and sometimes counterintuitive, but our research shows that these methods can reduce heat within the structure, minimize the potential for flashover and greatly enhance the survivability of both occupants and firefighters.

## CONTEXT

A structure fire was reported every 66 seconds in the U.S. in 2012, causing 1.7 civilian injuries every hour.<sup>1</sup> And the rate of firefighter fatalities due to traumatic injuries while operating inside of structures has increased by 67% since the late 1970s.<sup>2</sup> Although the overall fire death rate in the U.S. has decreased by 64% over the past three decades,<sup>3</sup> it is clear that modern structure fires pose significant hazards to both firefighters and building occupants. During this period, there has been a steady change in the residential fire environment that has played a central role in the increased hazards of structure fires.<sup>4</sup> In our previous “Modern Residential Fires” article, we detailed some of the most important reasons for increased risk, which include larger homes, different home geometries, increased synthetic fuel loads and new construction materials.<sup>5</sup> Other experiments showed that new materials have decreased the failure time of wall linings, windows and interior doors, which can also speed the rate of fire growth.<sup>6</sup> Together, the changes can speed up the stages of fire development, creating an increased potential for ventilation-limited — or oxygen-starved — fire conditions prior to fire department arrival.<sup>7</sup>

The two key issues related to ventilation-limited fires are:

1. They can make it more difficult to determine the specific location of the fire from outside the structure, which is generally the top priority of the incident commander.<sup>8</sup>
2. Traditional ventilation tactics may feed oxygen to the fire, rapidly intensifying it.<sup>9</sup>

In modern structure fires, the time between tactical ventilation and flashover is two minutes, compared to eight minutes in a traditional fire, giving firefighters 25% of the time they previously had to recover from poorly timed ventilation.<sup>10</sup>



*Over the past three decades, there has been a steady change in the residential fire environment that has played a central role in the increased hazards of structure fires.*



In order to formulate safer, more effective ventilation tactics, it is imperative to better understand flow paths. The flow path is the space through which fire, heat and smoke progress, moving from an inlet and the high-pressure fire area to where the fire wants to go — toward lower pressure oxygen sources, outlet areas such as door and window openings.<sup>11</sup> Based on varying building configurations, there may be several flow paths within a structure. Firefighting or rescue operations conducted in a flow path will place firefighters and residents at significant risk.<sup>12</sup>

## WHAT DID UL DO?

Over the last three years, the research team at UL has worked with fire service professionals throughout the country to implement a series of full-scale tests to better understand the modern fire environment, specifically focusing on the implications of modern fire conditions and the effectiveness of traditional and innovative firefighting tactics.<sup>13</sup> One set of live-fire experiments was funded by the Fire Department of New York (FDNY) and carried out in partnership among UL, the FDNY and the National Institute of Standards and Technology (NIST). The experiments were conducted on a series of unoccupied homes on Governors Island. The structures were two-story townhouses with full basements, approximately 800 square feet per floor, concrete block walls, brick exterior and wood-framed interior walls and flooring systems. The fuel load included real furniture of common construction — wood frame, polyurethane foam, polyester batting and fabric — to simulate current hazards. The furniture was consistent from home to home to enable comparison among experiments. All of the Governors Island experiments were consistent with the previous room-and-contents fire experiments conducted by NIST and UL. These experiments resulted in ventilation-limited, fuel-rich fires.<sup>14</sup>

We then used the homes to test a variety of experimental scenarios and focused on examining several traditional beliefs about structure fires. These included the notion that venting equals cooling, and the best way to aid victims is to vent the building and search before suppression tactics are employed. The experiments were structured to examine the impact of controlling ventilation and flow paths on reducing the occurrence of ventilation-induced flashover.<sup>15</sup>

One of the important outcomes was quantifying how much more hazardous ventilation can make fire conditions. In one experiment, the first floor living room was ignited, creating a fuel-rich, ventilation-limited fire. The front door was then opened and bedroom windows were vented, creating a flow path from the front door through the open bedroom window.



*[Click to view the Governors Island video](#)*

The bedroom door was then closed, blocking the flow path.<sup>16</sup> Less than 90 seconds after the front door was opened, and before the bedroom windows were vented, the temperature at the front door rose from approximately 75 degrees to over 550 degrees Fahrenheit. At the same time, the temperature in the living room (front and rear) — where the fire had started — almost doubled, reaching flashover.<sup>17</sup>

The Governors Island experiments showed that adding ventilation or being in the exhaust flow path of the fire reduced potential survival time. Importantly, we demonstrated the viability of closing the door behind the firefighters once Vent, Enter, Isolate and Search (VEIS) operations have commenced. The idea of a firefighter entering a burning building and closing the door behind him or her is both contrary to traditional practice and counterintuitive. However, the experiments definitively show that closing the door interrupts the flow path, reducing oxygen in the structure, lowering its temperature and improving both victim and firefighter survivability.<sup>18</sup>

Another important and counterintuitive finding in our experiments relates to the impact of venting on oxygen and carbon dioxide levels in the open bedroom. Opening the front door and the windows in the open and closed bedrooms led to a decrease of oxygen in the air in the open bedroom from 21% to 8%. At the same time, the carbon dioxide levels rose to 9% of the air, creating a highly hazardous environment for any occupants in that room. Closing the door to the bedroom almost immediately began to reverse the effects. Within two minutes, oxygen had risen to 16% of the air, while carbon dioxide dropped to 4%.<sup>19</sup>

The experiments also showed that interrupting the outlet of a flow path can help slow a fire. In one specific experiment, the front door was closed after the basement fire reached flashover. This interrupted the flow path that had run from an open basement window and Bilco door to the previously open front door. While opening the front door led to flashover in several areas of the home, closing the door reduced room temperatures by as much as 70%.<sup>20</sup>



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## IMPACT

The Governors Island experiments advanced our understanding of fire behavior relative to flow paths and helped validate new, more effective tactics to enhance survivability. We discovered that increasing ventilation by opening doors, clearing windows or cutting the roof in a ventilation-limited structure fire may lead to a rapid transition to flashover. In addition, anyone in the exhaust path — between the fire and its direction of travel — is in danger. Conversely, interrupting the flow path by closing doors or windows can limit fire growth and reduce temperatures.

We are presenting our findings and recommendations to the Fire Department Instructors Conference and Fire Rescue International. UL is also sharing our insights with the International Society of Fire Service Instructors, the International Fire Service Training Association and the National Fire Protection Association.<sup>21</sup> We are committed to helping advance the safety and effectiveness of firefighting operations in an effort to continue to save lives and protect property.

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## RELATED ARTICLES

Since you were interested in reading Interrupting The Flow Path, we thought you might find the following related articles of interest.



INNOVATING FIRE  
ATTACK TACTICS



MODERN  
RESIDENTIAL FIRES



REDEFINING SMOKE

## SOURCES

- <sup>1</sup> "The U.S. Fire Problem," National Fire Protection Association, 2013. Web: 13 Nov. 2013. <http://www.nfpa.org/research/fire%20statistics/the%20us%20fire%20problem.aspx>.
- <sup>2</sup> Fahy, R., Ph.D., "U.S. Fire Service Fatalities in Structure Fires, 1977-2009," National Fire Protection Association, June 2010. Web: 20 July 2013. <http://paramountalarm.info/2010-NFPA-US-Fatalities-In-Structures.pdf>.
- <sup>3</sup> "Fire Death Rate Trends: An International Perspective," U.S. Fire Administration, July 2011, Volume 12, Issue 8. Web: 16 July 2013. <http://www.usfa.fema.gov/downloads/pdf/statistics/v12i8.pdf>.
- <sup>4</sup> Kerber, S. and Sendelbach, T.E., "What Research Tells Us about the Modern Fireground," FirefighterNation, 6 June 2013. Web: 19 July 2013. <http://www.firefighternation.com/article/strategy-and-tactics/what-research-tells-us-about-modern-fireground>.
- <sup>5</sup> "Modern Residential Fires," UL, 2012. Web: 7 Nov. 2012. <http://www.ul.com/global/eng/pages/newscience/firesafety/>.
- <sup>6</sup> Ibid.
- <sup>7</sup> Kerber, S., "Study of the Effectiveness of Fire Service Vertical Ventilation and Suppression Tactics in Single Family Homes," UL Firefighter Safety Research Institute, 2013. Web: 7 Oct. 2013. [http://ulfirefightersafety.com/wp-content/uploads/2013/06/UL-FSRI-2010-DHS-Report\\_Comp.pdf](http://ulfirefightersafety.com/wp-content/uploads/2013/06/UL-FSRI-2010-DHS-Report_Comp.pdf).
- <sup>8</sup> Roden, E.J., "Ventilation-Limited Fires in Residential Buildings," Fire Engineering, 1 July 2013. Web: 14 Nov. 2013. <http://www.fireengineering.com/articles/print/volume-166/issue-7/features/ventilation-limited-fires-in-residential-buildings.html>.
- <sup>9</sup> Kerber, S., "Study of the Effectiveness of Fire Service Vertical Ventilation and Suppression Tactics in Single Family Homes," UL Firefighter Safety Research Institute, 2013. Web: 7 Oct. 2013. [http://ulfirefightersafety.com/wp-content/uploads/2013/06/UL-FSRI-2010-DHS-Report\\_Comp.pdf](http://ulfirefightersafety.com/wp-content/uploads/2013/06/UL-FSRI-2010-DHS-Report_Comp.pdf).
- <sup>10</sup> Ibid.
- <sup>11</sup> "Examination of the Impact of Ventilation and Exterior Suppression Tactics on Residential Fires," UL, National Institute of Standards and Technology (NIST) and the Fire Department of the City of New York, July 2012. Presentation, May 2013.
- <sup>12</sup> Ibid.
- <sup>13</sup> Kerber, S. and Sendelbach, T.E., "What Research Tells Us about the Modern Fireground," FirefighterNation, 06 June 2013. Web: 19 July 2013. <http://www.firefighternation.com/article/strategy-and-tactics/what-research-tells-us-about-modern-fireground>.
- <sup>14</sup> Ibid.
- <sup>15</sup> Ibid.
- <sup>16</sup> Ibid.
- <sup>17</sup> Ibid.
- <sup>18</sup> Ibid.
- <sup>19</sup> Ibid.
- <sup>20</sup> Ibid.
- <sup>21</sup> Ibid.

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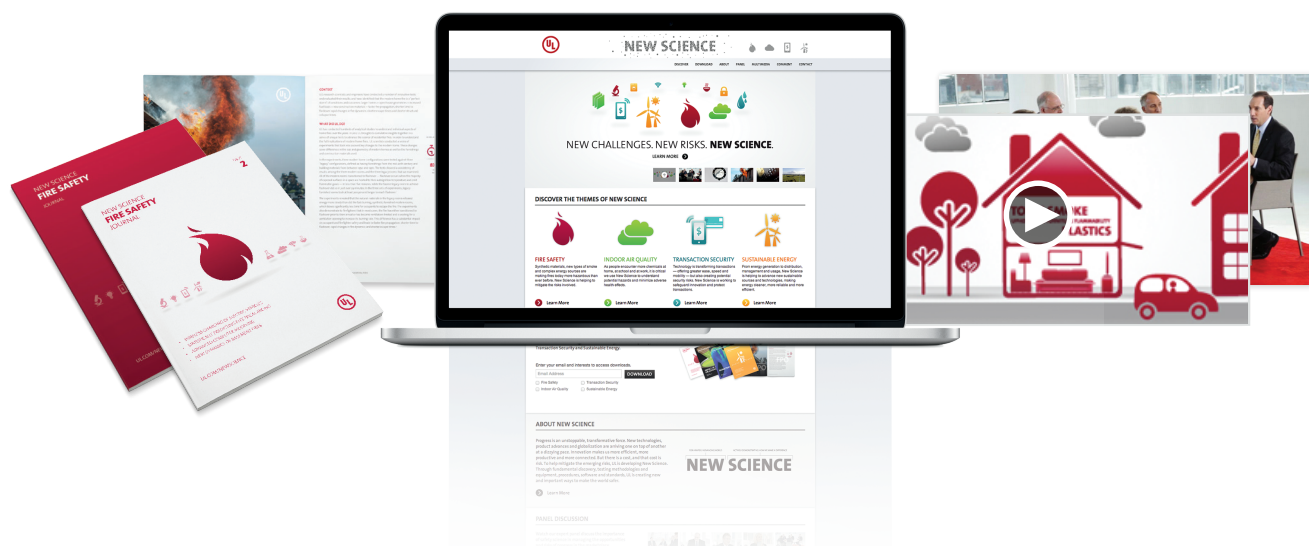
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