Governors Island, NY to Reading, OH:

Applying the UL Ventilation Study to Modern Firefighting Strategies

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Certification Statement

I hereby certify that this paper constitutes my own product, that where the language of others is set forth, quotation marks so indicate, and that appropriate credit is given where I have used the language, ideas, expressions, or writings of another.

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Abstract

Over the past 30 years the rate of firefighter deaths in the United States has decreased by 64%, however during that same time the rate of traumatic injuries while operating within a structure fire has increased by 67%. This increase of injuries has been attributed to changes in building construction and building materials. While the buildings that fires are fought in have changed, the tactics employed by the fire service have remained the same, handed down from generation to generation.

In December of 2010 the Underwriters Laboratories (UL) released a study entitled “Impact of Ventilation on Fire Behavior in Legacy and Contemporary Residential Construction.” “The results of this study should cause you to consider changes in the way you approach the most dangerous fires we face: house fires” (Knapp 2011). This study was later reinforced by experiments conducted by the National Institute of Standards and Technology (NIST), UL, and the Fire Department of the City of New York (FDNY) on Governors Island in July 2012.

In this paper I will look into these experiments and the results that they produced. I will address the science of firefighting in buildings of modern construction, and what firefighters can do to safely combat these fires.

I will also take a close look at the steps the Reading, Ohio Fire Department has taken to implement this study from administrative, training, and utilization perspectives.
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Introduction

In the late 1970’s there was an average of 1.8 line of duty deaths per 100,000 fires in the United States. By the late 2000’s an average of 3.0 line of duty deaths per 100,000 fires was occurring. “More than 70% of reported home fires and 84% of fatal home fire injuries occurred in one- or two- family dwellings, the remainder in apartments or similar properties. For the 2001 – 2004 period, there were an estimated annual average of 38,500 firefighter fire ground injuries in the U.S. The rate for traumatic firefighter deaths when occurring outside structures or from cardiac arrest has declined, while at the same time, firefighter deaths occurring inside structures has continued to climb for the past 30 years. Ventilation is believed to be one significant factor that is contributing to this continued climb in firefighter deaths” (Kerber 2010).

Background

“The changes in modern building design and materials have altered the nature of structure fires, with modern homes able to reach flashover eight times faster than homes built 50 years ago” (Kerber 2010).

Underwriters Laboratory completed experimentations comparing fires involving modern fuels versus legacy fuels. The legacy room was furnished with furnishings constructed of natural fibers, such as cotton and wool. The modern room was furnished with the same amount and types of furnishings, however the furnishings were constructed of synthetic materials, such as polyurethane foam. The results of the experiments found that the modern fire building became ventilation limited in five minutes whereas the legacy construction took
approximately twenty minutes. Once the structures were ventilated, after reaching ventilation limited status, flashover occurred two minutes and fifteen seconds later in the modern building whereas it took eight minutes and thirty seconds in the legacy building.

Modern constructed houses are built with energy conservation in mind, causing them to be insulated well and air tight. These buildings combined with furnishings made of synthetic materials are causing fires within these buildings to become ventilation limited and fuel rich. Once air is introduced to this fuel rich environment the right mixture of air and fuel is reached. This combined with the amount of heat energy released by modern furnishings creates conditions that rapidly worsen, creating flashover conditions. Average modern furnishings have the following heat release rates; as an example:

- Chair – 1.8 megawatts
- Small Sofa – 2.5 megawatts
- King size Bed – 4.3 megawatts

It takes approximately two megawatts of heat energy to cause a typical residential sized room to flashover.

In 2010 UL set out to research the development of modern fires and the impact that ventilation has on the development. UL constructed houses within a laboratory to study the development of fire with modern construction and conditions.

In one experiment a fire was ignited in a first floor bedroom of the house, the fire became ventilation limited after about two hundred seconds, The fire room
window was ventilated at approximately the two hundred and fifty second mark. In the first two hundred seconds of the fire the heat release rate was about one megawatt of energy, once the ventilation occurred the energy release rate rapidly rose to fourteen megawatts. In terms of temperatures, at the two hundred second mark the floor in the bedroom was about one hundred degrees Celsius with ceiling temperatures at seven hundred degrees Celsius. The room is vented at two hundred and fifty seconds; by two hundred and eighty seconds the room is in excess of one thousand degrees Celsius floor to ceiling. The living room of the house, which was remote from the bedroom, saw similar results. At two hundred seconds the floor temperature was fifty degrees Celsius and ceiling temperature was two hundred and fifty degrees Celsius. The fire room was ventilated at two hundred and fifty seconds; by three hundred and forty seconds the living room was approximately seven hundred degrees Celsius floor to ceiling.

The venting of the bedroom window created a flow path to occur between the bedroom, down the hall and to the living room. The vented bedroom window allowed an inlet source of fresh air. Fire gasses will travel from hot areas to cold areas within a structure. This is based on the scientific rule that the gasses will move from an area of higher pressure to areas of lower pressure. In this example a flow path was created that moved the fire gasses from the higher pressure of the bedroom to the lower pressure of the living room. The flow path in this experiment had a flow velocity of between eight and twelve miles per hours, there were no natural or simulated wind conditions.
“UL conducted a series of 15 full-scale residential structure fires to examine this change in fire behavior and the impact of firefighter ventilation tactics. This fire research project developed the empirical data that is needed to quantify the fire behavior associated with these scenarios and result in immediately developing the necessary firefighting ventilation practices to reduce firefighter death and injury” (Kerber 2010).

**Governors Island Experiments**

In July of 2012 UL, NIST, and FDNY set out to apply the findings of the ventilation study to actual residential buildings. Over the course of about one and a half weeks hundreds of burns were conducted. The experiments had the following objectives:

To improve firefighter safety and building occupant survivability by:

- Examining the control of ventilation and flow paths to reduce the occurrence of ventilation induced flashover
- Examining the use of exterior fire attack to reduce firefighter exposures to high thermal conditions
- Examining tenability conditions of victims as a result of these tactics

(Weekend Firefighter 2013)

The buildings utilized were two story row houses with full basements. Each floor was approximately 850 square feet, class III building construction. The second floor consisted of bedrooms, some three bedrooms, and some four bedrooms. Heat censors were placed in the two bedrooms to the rear of the building; one bedroom
door was closed during the experiments one door was left opened. The first floor consisted of a kitchen in the front of the building and living room areas from middle to rear of the building. Censors were placed near the front door, center of level near stairways to basement and second floor, and two censors in the living room, one in center of the level and one towards the rear of the structure. The basement had an exterior entrance to the rear of the building and a window to the front. The basement had a living room type area to the front and a bedroom to the rear. Four censors were placed in the basement, one in the living room area, one in the bedroom area, one near the exterior entrance and one near the interior stairwell in the center of building.

Some examples of the experiments conducted are as follows, all results are measured in degrees Fahrenheit.

**Example 1: Fire in first floor living room**

Fire was ignited on the first floor in the living room near the center of the building. The window, in the bedroom with door open, was opened. A flow path was created between the front door that was opened, up the stairwell, and out the second floor window. The living room proceeded to flashover. Water was applied through the front door with a smooth bore nozzle; the water never reached the seat of the fire in the rear living room. Applying the water to the heated gasses through the front door had the following effects on temperatures.

- **Living room front:** 1,200 degrees to 300 degrees
- **Bottom of Stairs:** 1,800 degrees to 800 degrees
- **Top of Stairs:** 900 degrees to 500 degrees
Open bedroom:  600 degrees to 350 degrees

Closed bedroom:  160 degrees before and after (protected by door)

Lesson learned: Cooling the gasses can greatly improve interior conditions even when not applying water directly on the seat of the fire.

**Example 2: Fire in first floor living room**

Fire was ignited in same location as example one however all windows were closed for this experiment. Opening the front door created the flow path, inlet was to the bottom of the door while the outlet was to the top of the doorway. No water was applied to the fire however the following conditions were noted when opening then closing the door:

Living room front: 400 degrees to 1,200 degrees door opened

1,200 degrees to 600 degrees door reclosed

Top of Stairs: 250 degrees to 750 degrees door opened

750 degrees to 450 degrees door reclosed

Open Bedroom: 250 degrees to 650 degrees door opened

650 degrees to 450 degrees door reclosed

Lesson learned: Controlling the flow path helps to control the fire. Less oxygen allowed into the building will result in lower temperatures.

**Example 3: Fire in Basement**

Fire was ignited in front of the basement. Inlets for the flow path were the basement window and doorway; the flow path outlet was the front door. In this experiment water was flowed from the top of the stairway into the basement to
“protect” the first floor. After twenty five seconds of water the following before and after temperature readings were documented:

- Basement front: 1,200 degrees to 1,500 degrees
- Base of Stairs: 1,250 degrees to 1,450 degrees
- Top of Stairs: 600 degrees to 400 degrees
- Front Door: 275 degrees to 260 degrees

**Lesson learned:** Flowing water from the top of the stairs into the basement has little effect on temperatures throughout the structure.

### Example 4: Fire in Basement

Fire ignited in front of the basement with all conditions the same as example 3. Water was flowed into basement window with the stairwell left unprotected.

- Basement front: 1,700 degrees to 300 degrees
- Base of Stairs: 1,200 degrees to 400 degrees
- Top of Stairs: 600 degrees to 200 degrees
- Front Door: 250 degrees to 200 degrees

**Lesson learned:** Flowing water to cool the gasses improves conditions throughout the building. There was not an influx of heat up the stairs from the basement to the first floor despite no line in place to protect the stairwell.

A similar experiment was conducted except water was flowed into the basement through the exterior entrance to the basement. Similar results were obtained as when flowing water into the window. An important side note that was made by the researchers was that the fire never extended to the first floor through the interior stairwell. Every time there was extension to the first floor it was
through the plumbing chases in the kitchen. This resulted in the kitchen cabinets
being ignited and the kitchen floor often failing.

**Example 5: Multiple fires on first floor**

Fires were ignited in the kitchen and middle room of the first floor. Water
was applied through the kitchen window in the front of the building. The kitchen
window served as the inlet. There was no outlet, therefore no flow path in this
experiment. The attempt was to push the fire from the front burned side to the rear
unburned side of the structure. The following results were recorded:

- **Kitchen:** 1,400 degrees to 200 degrees
- **Middle Room:** 600 degrees to 300 degrees
- **Rear Room:** 500 degrees to 300 degrees

*Lesson learned:* Fire cannot be pushed by the flow of water. Conditions will improve
with the flow of water. The only thing that can “push” the fire is improper control of
the flow path.

A similar experiment was conducted on the second floor with a fire ignited in
a bedroom. Water was applied from the exterior ground level into the second floor
window. Similar results were noted as with the first floor fire experiments.

**Example 6: Fire in first floor living room**

Fire was ignited in the first floor living room near center of building. The
inlet for the flow path was the front door. A flow path was created when both
second floor windows were ventilated in order to conduct vent enter isolate search
(VEIS). After the windows were ventilated the opened bedroom door was closed,
the closed door in the other room remained closed. This was to test the isolate part of the VEIS procedure. The following results were recorded:

- **Top of Stairs:**
  - 350 degrees to 950 degrees windows broken
  - 700 degrees to 350 degrees door closed

- **Open Bedroom:**
  - 350 degrees to 600 degrees window broken
  - 15 MPH flow path velocity at bedroom window
  - 450 degrees to 150 degrees door closed

- **Closed Bedroom:**
  - Remained relatively unchanged due to door remaining closed the whole time

*Lesson learned:* Controlling the flow path is key to occupant survival. Isolating the victims from the fire and flow path by closing a door will greatly increase the victims chances of survival.

**Modern Fire Tactics**

Current fire ground tactics are based upon aggressive interior fire attack. Lloyd Layman developed the acronym RECEO VS in the early 1950s and it has been used ever since. The acronym stands for:

- **Rescue**
- **Ventilation**
- **Exposure**
- **Salvage**
- **Confinement**
- **Extinguish**
- **Overhaul**

The first five were conducted in priority order; rescue of victims was the first priority. Fire attack was completed by first protecting the exposures, if needed, then
confining the fire to the smallest area possible, then extinguishing the fire, finally
overhauling it to confirm the fire was fully extinguished. Ventilation and salvage
were completed as needed at anytime during the fire attack. “Given what we knew
and believed at the time, the RECEO VS concept gave us a platform to make
decisions on the fire ground for many years” (Buchanan 2013). “A handful of
firefighters took to the white board armed with the firm understanding of the latest
fire dynamic concepts looking to reframe the tactical mindset” (Buchanan 2013).
“At the heart of the training evolution is an updated operational acronym, SLICERS,
which drives us to consider the importance of an awareness of flow path and cooling
during fire attack” (Milan and Reeder 2014).

Size up  Rescue

Locate the fire  Salvage

Identify and control the flow path

Cool the space from the safest location

Extinguish the fire

Similar to the original acronym, SLICERS is similar in that the first five are
completed in order while the last two are completed at anytime when the
opportunity arises.

SLICERS begins with a good scene size-up. A 360-degree view of the building
should be completed, unless obstacles or terrain make it impossible to complete. A
360-scene size up will locate the fire a majority of the time. Once the fire is located,
crews should identify the flow path and control it if possible. The UL experiments
showed the benefits of simply closing a door to control the flow path until a hose
line is in place. The next step is to cool the space from the safest location possible. Often times this will be from the exterior of the fire building. Many departments call this “resetting” the fire. The objective of cooling the space is to cool the superheated gasses within the building and return the fire to the contents only. The research showed the dramatic cooling effect that flowing water into the structure (to cool the gasses) had on the overall building, even when water was not directly applied to the contents that were on fire. Flowing water from the exterior to cool the structure prior to entering should be considered an offensive tactic, just because the fire attack is starting from the exterior does not mean it is a defensive tactic. Once the gasses are cooled and the fire has been returned to the contents only it is safer to enter the structure to make the final extinguishment of the fire. Rescue should always be addressed when the situation arises. However, it is important to note that flowing water to achieve the SLICE part of the acronym may be the safest and most efficient way to protect the victims that need to be rescued. Salvage remained a function that should be completed as needed whenever the opportunity arises.

Ventilation is no longer part of the model. “Given the research, ventilation has been reclassified as a specialty action. It requires direct orders from the IC and generally occurs after the main body of fire has been subdued. No longer can anyone break anything at anytime for no particular reason” (Buchanan 2013).

The basic concept of confining the fire, controlling the fire, and extinguishing the fire has remained the same. However by utilizing the SLICERS acronym, developed as the result of the scientific studies, companies are able to dramatically improve conditions in a safer and more efficient manner.
City of Reading Fire Department

When adapting new procedures there are three elements that should be addressed in the implementation: administrative requirements, training, and utilization. Administrative policies such as standard operating guidelines (SOGs) should be reviewed and updated as needed to support the final goal. The new procedure should be trained on so all members have an understanding of the concepts. Finally the new procedure should begin to be utilized on the fire ground.

The Reading Fire Department has begun the process of implementing the results of the UL study into procedures.

Administrative

The Reading Fire Department began by reviewing the current SOGs that address structural firefighting. Current SOGs were found to not be out of line with the recommendations of the UL study. Ventilation has always been considered an objective that needs to be closely coordinated with fire attack. Crews removing any and all windows in a structure has never been tolerated, and are viewed as a dangerous act of freelancing. Currently the department is updating SOGs to apply the terminology and actions that were developed as a result of the UL study.

Recommendations: The department should continue to update SOGs so they are not only in line with the results of the UL study but also share common terminology such as “flow path”, “door control”, and “SLICERS”. The International Society of Fire Service Instructors released a sample SOG for Residential Firefighting Strategy and Tactics that the Reading Fire Department could utilize as a model guide.
Training

The Reading Fire Department began training on the results of the UL study almost immediately after the report was released. The first trainings focused on the study itself utilizing the training resources provided by UL and NIST. Members also attended conferences such as FDIC and brought information from these classes back to all members of the department. After a solid base of training was completed more practical exercises were utilized. These exercises ranged from completing hose evolutions that involved implementing a doorman to control the opening as well as to help advance hose, and vent-enter-isolate-search training with importance placed on making entry and immediately going to and closing the door to isolate the firefighter and victim from the rest of the structure. Other practical exercises involved watching videos of fires from resources such as YouTube and attempting to identify the flow path as well as ways to control the flow path and deployment of resources.

Recommendations: The department should develop a plan for continuing education on the topic of the UL study. The department should also develop an initial training plan that addresses the study for new members.

Utilization

The Reading Fire Department has begun to utilize tactics that fall in line with ventilation-controlled fires as described in the UL study. As stated above under the administrative goals, many of the tactics are not different from the previous tactics utilized. However members are now more aware of controlling the flow path, especially as it pertains to the front door. In the past as one member of the company
was pulling the hose line, another would be going to the entry point to force the door. Once forced the members mask up and make entry with the hose line. The front door is now being left closed as long as possible, the door is still forced, however now it is reclosed to control the flow path. The last member in is now considered the doorman and is charged with controlling the door, both to control the flow path as well as to protect the primary exit of the interior crews.

**Case Study:** Reading FD units were dispatched to a working structure fire in January 2014. Upon arrival the first due Engine Company reported heavy fire from the C-D corner of the house, with impingement on the D side exposure. The officer declared an offensive strategy and established command. He then completed a 360-degree size up of the building noting fire from the C and D side windows. The officer had a member of the company pull the first hose line to the D side of the structure, another member pulled a line to the A side front door to prepare for entry. The first hose line was operated on the D side initially on the exposure to cool the melting siding, then through a window of the fire building cooling down the fire gasses, darkening the fire down. The line only needed to be operated into the building for about thirty seconds before achieving desired results. After the fire was “reset” that line was shut down and entry was made from the A side with the second line by the officer and remaining firefighter, they were able to safely go in and knock down any remaining fire and begin overhaul.

**Conclusion**

The results of the ventilation study conducted by UL were confirmed through the experiments that were conducted on Governors Island in New York. The results
proved that increasing ventilation in buildings can be dangerous to both the buildings occupants, as well as firefighters. It also proved that being in the path of a flow path can be a very dangerous position due to how quickly a ventilation-limited fire can transition to flashover. The fire service, including the Reading Fire Department, have taken note of the results of this scientific study and have started to change the way structure fires are approached, both from an administrative standpoint, such as SOGs, and from a tactical standpoint, in training and on the fire ground.

“This is a sentinel moment in the fire service and these gentlemen behind me (FDNY, NIST, and UL Technical Panel) are largely responsible for this sentinel moment” –Chief Bobby Halton
References

Retrieved on March 24, 2014 from

www.ul.com/global/documents/offerings/industries/buildingmaterials/fire service/ventilation/DHS%202008%20Grant%20Report%20Final.PDF

Retrieved on March 17, 2014 from


http://www.youtube.com/watch?v=jGEgr9877j4&list=PLeDTEhgchmb05SWrKXgQ-iZPqEzE75MfX.