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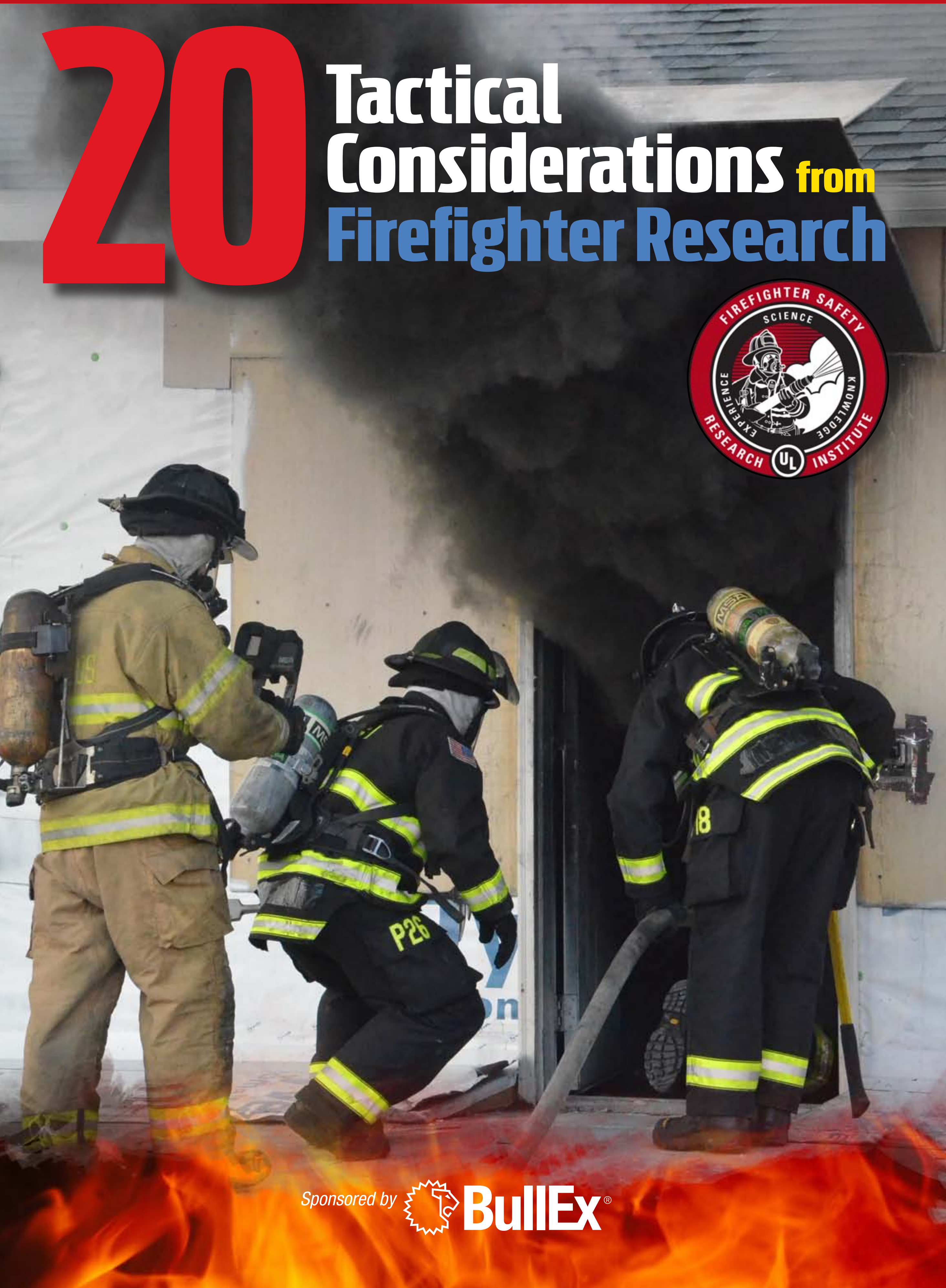
20 Tactical Considerations from Firefighter Research



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Introducing the 20 Tactical Considerations from Firefighter Research

"You simply can't ever know enough, or know it soon enough, and you certainly can't afford to wait for experience alone to educate you."

Underwriters Laboratories (UL) has been conducting research with the fire service for nearly a decade. Our mission at the Firefighter Safety Research Institute (FSRI) is to increase firefighters' knowledge so that they can better serve the communities they swore to protect, reducing deaths and injuries and keeping them safe while doing so. And that is also the purpose of this unique supplement—the 20 Tactical Considerations from Firefighter Research.

Topics such as structural collapse, the evolution of the fire environment, fire suppression, ventilation, basement fires and many more have been studied in detail to examine fire dynamics and firefighting tactics. These studies generate information, data and observations that UL technical panels—composed of firefighters from the United States and around the world—develop into tactical considerations. The tactical considerations are tools that can be used to share science in such a way that firefighters can connect it with their experience and then integrate it into their departments' operations.

This integration of knowledge and experience enables the fire service to better evaluate its strategies, tactics and tasks, ensuring that they remain as effective and efficient as possible. The great thing about science is that once you understand how things work, you can also understand things that you have not yet experienced.

Gaining experience in the fire service is very complex. It is more than going to fires; it is understanding what is going on in front of and around you, much of which you can't see or feel. Even those things you do observe are being impacted by the fire dynamics, the structure and the actions of other firefighters on scene. No individual at a fire can truly know the conditions throughout the building. You simply can't ever know enough, or know it soon enough, and you certainly can't afford to wait for experience alone to educate you.

For a variety of reasons, our training environment does not always replicate reality. So how do we know our tactics are best? Research, testing, measuring and then repeating (i.e., using science) can help us do just that. As the firefighters' work environment changes, new technologies are developed and new tactics are considered to meet the new threats. Research can create a realistic test bed to help us understand the impact of all of this change. Of course, research alone is never the answer. Experience, knowledge and firefighters with the desire to implement what they have learned must come together so that research can be weaved into the fabric of local realities (i.e., staffing, equipment, response time). Firefighter effectiveness is an evolution. There is no one answer today and we aren't going to solve it tomorrow. It is a process that is ongoing and that we all need to be invested in.

As we have conducted this research over the past decade, several tactical considerations have become consistent themes across the projects. In the segments that follow, four experienced fire service leaders and UL Firefighter Safety Research Advisory Board members—Derek Alkonis, Sean Gray, Todd Harms and Peter Van Dorpe—share 20 Tactical Considerations from Fire Service Research.

For more information about where these considerations came from and to see many more, visit ULfirefightersafety.com.

Sincerely,
Steve Kerber

20 Tactical Considerations

By Derek Alkonis, Sean Gray, Todd Harms & Peter Van Dorpe

#1: There's no substitute for knowledge

As firefighters, we sometimes get caught up with the equipment and technology that can help us do our job, rather than the knowledge that is critical to do our job. The fact is that no amount of technology will replace the need for a firefighter to know things about his or her profession. For a firefighter to be able to leverage technology to perform more effectively requires knowledge of how to use it, knowledge of where to use it and knowledge of its limitations. Knowledge is the key. And in a structure firefighting context, knowledge means understanding how fires develop in enclosed structures. It means keeping one's knowledge current. It means understanding the UL and NIST research and how to apply the findings tactically to save more lives and protect more property. *—Derek Alkonis*

Despite great advances in technology related to our turnout gear, SCBA, thermal imagers, etc., the technology is useless unless firefighters have the necessary knowledge and training on its uses and limitations. *Photo by FIREGROUND360°*

#2: Your workplace has changed; you need to evolve

Structure fires have changed over time. Forty-plus years ago, structures were built using old growth, full-thickness lumber, and the furnishings inside were made of mostly natural fibers. This made for a fire environment that progressed slowly toward flashover. Compared to today's fires, firefighters typically had time to do a search for victims, find the seat of the fire and extinguish the blaze before the fire's intensity overcame the firefighters' ability to control the environment.

The firefighting tactics employed by a previous generation of firefighters were based upon a built environment and the firefighting and safety equipment they had available to them. Today's firefighters are faced with a different fire problem. The modern fire environment consists of structures constructed of lightweight building materials, open floor plans, double-pane windows and furnishings constructed of materials capable of releasing enough heat energy to flash over a room in seven minutes or less. Fire conditions that increase in intensity at these speeds require more knowledge of fire behavior and fire dynamics. *—Derek Alkonis*

The modern fire environment consists of structures constructed of lightweight building materials capable of releasing enough heat energy to flash over a room in 7 minutes or less, causing premature structural collapse. *Photo by Michael Daley*

#3: Follow the rules of live-fire training

Reading about the modern fire environment and modern firefighting tactics is one thing, but is there hands-on training where the modern fire environment can be witnessed and where firefighters can control the fire using modern firefighting tactics? Yes and no.

If you're thinking of recreating today's fire environment by burning modern furnishings inside a concrete or metal burn building, you're headed in the wrong direction. The current NFPA 1403 standard makes it clear that wood products shall be used as a Class A fuel in training fires. This means that creating a live-fire training experience that is the same (not similar, but identical) as a real structure fire with modern furniture and wall and window coverings is simply just not possible. The training environment and the real thing have too many elements that are different, which results in the fire being different. As such, our ability to teach suppression and ventilation is limited. Here's how the training environment is different than the real thing:

Burn buildings are a great way to teach firefighters about fire dynamics in the modern fire environment, but we must ensure that our live-fire training programs are in compliance with NFPA 1403. *Photo Courtesy Phoenix Fire Department*

FEATURES	TRAINING FIRE	REAL FIRE
Construction materials	Concrete and steel, although acquired structures can be more like the real thing.	Wood, drywall, metal and masonry.
Floor plan	Mostly fixed, although some have movable wall partitions. Ceilings typically low.	Large variety. Many of today's homes are designed with an open concept and have high ceilings.
Fuel types (contents)	Class A. Slower burning and lower heat release rates.	Anything and everything. Modern furnishings and household chemicals. These fuels release more energy than wood fuels.
Fuel arrangement	Burn buildings usually designed to keep fire in a few locations.	Anywhere and everywhere. Highly variable.

Instructors must inform the students of the limitations of the training experience. They must explain that although the skills required to suppress and ventilate may be similar to an actual fire, the fire that is being controlled is different. When you are only burning wood products in a concrete structure, the smoke behaves differently; the amount of heat released per unit time is less, and where the fire goes is known.

This is not to say there is not value in using live-fire training experiences to better educate firefighters about fire behavior and how to recognize and control the fire's flow path. If the training is performed by skilled and qualified instructors, there is a lot to be learned from observing how fires develop in enclosures that are different from the real thing.

Use live fire to practice 360 size-ups and evaluate smoke conditions to identify where the fire is located and where it is moving (flow path); practice getting water on the fire from the most effective location (which could require the use of an exterior stream) as quickly as possible; practice deploying hoselines to the door and controlling the door to prevent the influx of air; practice cooling the interior environment with your hose stream; and lastly, and most importantly, exercise coordination of interior fire attack and ventilation so students can experience fire conditions where suppression and ventilation teams work together.

Now, before you embark upon training your firefighters using live burn exercises, consider starting at a step prior to the live burns by using existing props and giving consideration to the products and technologies on the market today. Begin by educating your personnel on the recent fire dynamic research from UL and NIST. Then, set up "non-fire" training experiences where they must demonstrate the tasks required to control the flow path, search and rescue victims, cool the environment, extinguish the fire and ventilate. These "non-fire" training opportunities that incorporate readily available props and technologies will improve their skills in a safe and predictable environment where multiple repetitions of controlling the flow path and suppressing the fire in a coordinated fashion can be performed.

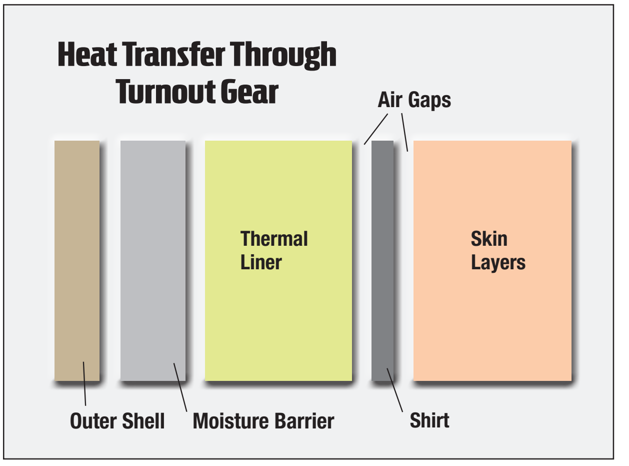
—Derek Alkonis

#4: Understand how heat transfers through turnout gear

One of the most important lessons we as firefighters must understand is the use and limitations of our PPE. While manufacturers continue to improve the ergonomics and thermal protective levels of our turnouts, we must still be aware of two critical factors—heat saturation and cumulative heating.

The thermal protection provided by our turnouts (aka, thermal protective performance, or TPP) is essentially designed to provide the minimum level of protection necessary to gain access to fight/control a fire. The larger majority of this thermal protection is *supposed* to be used as a protective reserve that allows us to safely exit if/when conditions change. As such, we must operate within the levels of protection we've been provided and avoid going everywhere our turnouts allow us to go.

Another critical point to keep in mind is that our turnouts are specifically designed to absorb heat (energy) as a means of protection. When our turnouts become overexposed due to elevated temperatures or prolonged operations in a high-heat environment, they become heat saturated and can no longer provide the same level of protection. At this point, our gear has reached its limit, and we immediately become vulnerable to thermal insult/burns. While we may not be able to out-perform the thermal limitations of our turnouts, by applying the right tactics, we can certainly enhance our operational effectiveness and reduce the potential for thermal insult/injury. *—Sean Gray*



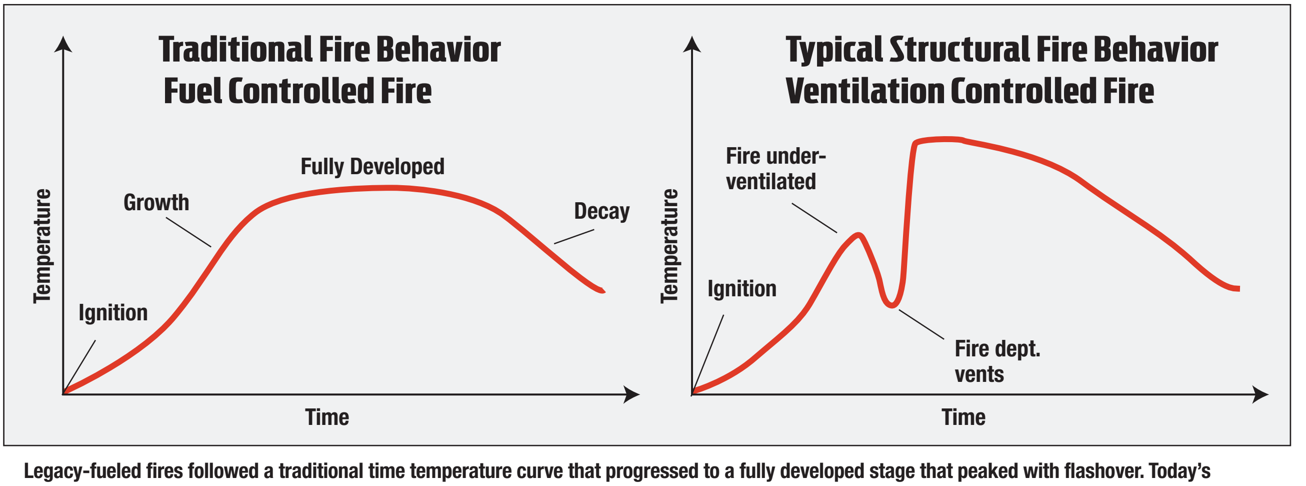
Multiple barriers and air gaps exist between the fire and the firefighter's skin. *Images Courtesy UL*

#5: Fire development changes when a fire becomes ventilation-limited

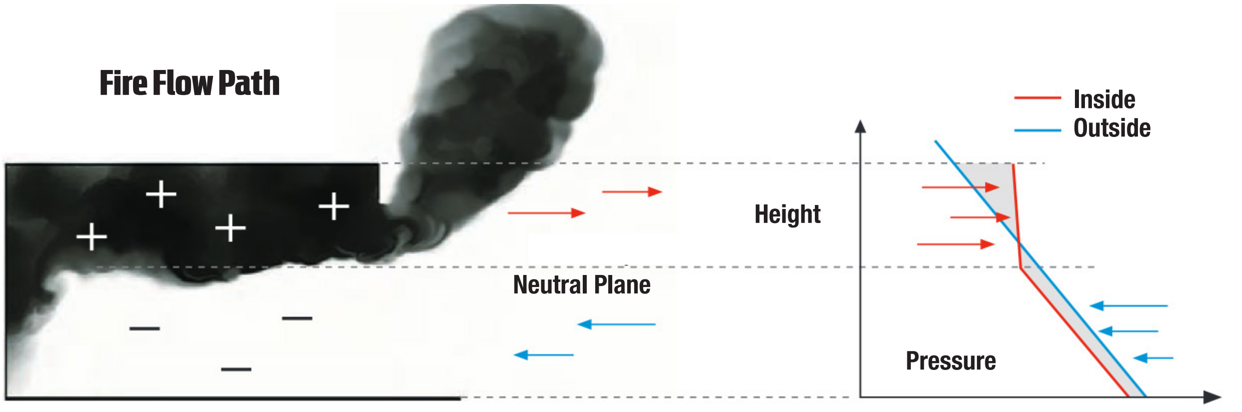
One of the first things every firefighter learns about fire is the fire triangle. Fire needs fuel, heat and oxygen to survive. Many of our instructors who began their careers decades ago showed us the stages of fire development where the fire grew gradually over time, releasing heat over a 20-minute period to ultimately rise sharply when the room had the right amount of unburned, heated fuel, oxygen and heat to erupt into flashover. The graph (or time-temperature curve, below) resembled a large ski jump where there was one drastic rise in temperature and then a sharp decay phase.

The stages of fire development of today's fires are essentially the same, with one small addition. Instead of the fire progressing slowly to one large sharp increase in heat release rate as the fire goes to flashover, today's fire will likely be snuffed out due to the lack of available oxygen, go into decay and then rise sharply again with greater heat released when more oxygen is introduced. This second increase in temperature is the result of a ventilation-induced flashover.

Fire growth is definitely related to the amount of fuel and heat that is available, but it is the amount of oxygen that is making the difference in how fast the fire is allowed to release heat. Control the oxygen, and you have control of the fire. *—Derek Alkonis*



Legacy-fueled fires followed a traditional time temperature curve that progressed to a fully developed stage that peaked with flashover. Today's ventilation-controlled fires reach a peak, become ventilation-limited and then spike with ventilation (whether accidental or fire department-initiated).



The flow path is the volume between an inlet and an outlet that allows the movement of heat and smoke from the higher pressure within the fire area toward the lower pressure areas accessible via doors and window openings. *Image Courtesy Swedish Rescue Services Agency*

#6: Fire flows from high pressure to low pressure

In a compartment, the fire acts like a pump. As the fire burns, hot fire gases (high pressure) collect at the ceiling and move toward low pressure, creating a flow path of heated fire gases to the outside. Outside air (carrying oxygen) is drawn into the base of the fire through openings in the building (doors, windows, roof). As long as the fire has air entering from the outside, the fire will continue to grow. This is an important principle: A fire in a room with modern furnishings will grow in direct proportion to the available oxygen. The more oxygen that is available, the faster the fire will release heat energy and the greater the risk of rapid-fire development.

—Derek Alkonis

#7: Nothing showing means nothing

Initial companies arriving on scene with nothing showing or light smoke from the structure must remain aware and alert for the possibility of hidden (ventilation-limited) fire conditions. Once an opening is made, crews must read the building.

During a number of residential research burns at UL, heavy smoke conditions were observed pushing from the building, indicating a well developed fire deep-seated within the structure. As the oxygen levels inside the building were decreased, the exterior smoke conditions went from heavy to light smoke, even though the fire had continued.

Modern building construction is so tight that the fire consumes all of the available oxygen and becomes ventilation-limited. Double- and triple-pane windows, better insulation and advanced technologies create a "tight building syndrome" that can present an initial size-up of nothing showing or very limited signs of smoke, while inside there is a smoldering fire in need of oxygen. In the past, fire growth would slowly progress from ignition to free burning and eventually flashover or fully developed stage. As the fuel and oxygen were depleted, the fire would then start to decay. Anywhere along the way, the fire department would show up to one of these stages and begin their fire attack.

—Todd Harms

NIST research captured fire development in a burn building. 3:31: Fire is free-burning prior to the fire department's arrival. Notice outward signs of smoke indicating a free-burning fire with plenty of oxygen.

4:02: The fire department arrives on scene. Fire has become ventilation-limited, causing a reduction of pressure inside the building and little to no outward signs of smoke are visible. *Images Courtesy NIST*

5:08: The fire department forces the front door and prepares to make entry. Fire receives a rush of fresh air through the open front door (flow path) and rapidly returns to the free burning state eventually reaching flashover conditions.

#8: Keep the wind at your back

When entering a structure or initiating fire attack, knowing the wind direction is a critical fireground factor. Winds greater than 5 mph will directly affect the rate at which the fire develops and potentially jeopardize the safety of the advancing crew(s). Knowing whether the wind is at your back or if you are going against the wind is a key size-up factor. Entering into the wind is like fighting your way down a chimney. As the winds increase, the fire growth and speed of spread will increase, too.

—Todd Harms

When entering a structure or initiating fire attack, it is critical to control the flow path whenever possible and keep the wind at your back.
Photo by Jon Androwski

#9: Flow path and suppression must be considered together

For years we trained firefighters to open the bale of the nozzle only when they got to the seat of the fire. We told them to move from the uninvolved to involved portions of the building—for all structure fires, never deviating because we didn't want to "push" the fire to areas of the structure where there was no fire. We instructed them that search and rescue of victims was the first task, even if it meant allowing the fire to grow. Today's fires require a different approach.

Suppressing a fast-moving fire in the modern fire environment requires that we first evaluate the fire to find how the fire and smoke will affect our ability to perform search and rescue. This means we need to know where the fire is located and where it is moving (flow path). Once we know this information, we are better positioned to make decisions on how best to limit its growth so we can buy more time for the victims. Limiting the growth of the fire requires getting water on the fire from the most effective location and limiting the amount of oxygen feeding the fire. It is this simple. The faster a firefighter can pull back on the bale and distribute a stream of water on the fire (yes, this sometimes means spraying water from the outside) and the more quickly the firefighter can restrict the amount of oxygen to the fire (shutting doors to cut off a flow path), the less toxic gases are produced by the fire, the less heat the fire produces and the less the fire grows. Add some coordinated ventilation into the operation and you have effective modern firefighting. What's the result? Improved survivability for victims and rescuers.

—Derek Alkonis

The faster the firefighter can restrict the amount of oxygen to the fire (shutting doors to cut off a flow path), the fewer toxic gases are produced by the fire, the less heat the fire produces and the less the fire grows. *Photo by Glen Ellman*

2006
- Structural Stability of Engineered Lumber under Fire Conditions

2007
- Firefighter Exposure to Smoke Particulates

2008
- Impact of Horizontal Ventilation

2009
- Firefighter Safety and Photovoltaic Systems
- Basement Fires (NIST ARRA)

OVERVIEW OF UL

FREE ONLINE FIRE

LIGHTWEIGHT COLLAPSE

HORIZONTAL VENTILATION

VERTICAL VENTILATION

ATTIC AND EXTERIOR FIRES

2010
- Impact of Vertical Ventilation
- Governors Island Testing with FDNY and NIST

2011
- Exterior Fire Spread and Attics Fires

2012
- Study of Positive Pressure Ventilation in Homes

2013
- Impact of Fire Attack Utilizing Interior and Exterior Streams
- Cardiovascular and Carcinogenic Risks of Modern Firefighting(IFSI)

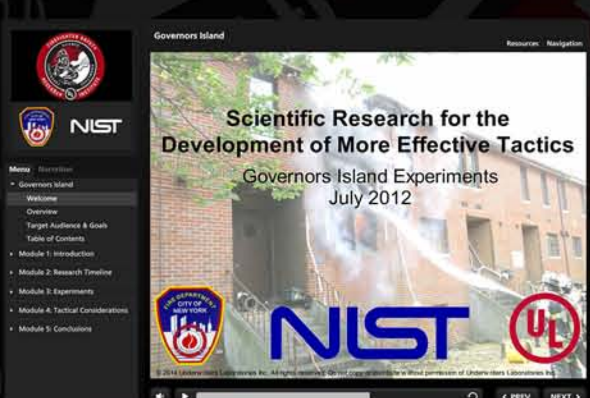
2014
- Study of the Fire Service Training Environment: Safety, Fidelity, and Exposure

FIREFIGHTER RESEARCH

SERVICE TRAINING

BASEMENT FIRES

PV FIREFIGHTER SAFETY



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It has long been thought that exterior streams push fire and put potential victims/occupants at risk. Repeated tests have demonstrated otherwise. The most effective means of extinguishment is to put water on the fire from the quickest and safest position possible. *Photo by Glen Ellman*

#10: Water does not push fire

Of all the tactical considerations that have come out of the UL/NIST body of work, the ones that reference applying fire streams from outside the building during offensive operations seem to generate the most controversy. Many firefighters have (or know someone who has) been made very uncomfortable, and perhaps even injured, when they found themselves on the wrong side of a fire stream. More often than not, this fire stream was being played into the building from the outside when the injury occurred. It should not surprise anyone that such an event would be described as "having the fire pushed on us."

The concept of pushing fire (more accurately, pushing the products of combustion) with a fire stream is also supported in some of the texts that laid the foundation for modern firefighting, particularly the works of Lloyd Layman, as well as Keith Royer and Floyd W. (Bill) Nelson. Layman routinely talks about moving fire gases throughout a building when applying fire streams. What many of us have forgotten, or perhaps never had the opportunity to learn, is that Layman's statements are made on the assumption that we would be using a wide-angle fog stream when operating inside a building during the initial attack. In "Attacking and Extinguishing Interior Fires," he states quite unequivocally, "Little, if any progress can be made toward improving the tactical employment of water in fire-fighting until the fire service recognizes the gross inefficiency of the solid stream form of application. Progress … demands that water be applied in the form of finely divided particles."

It is also interesting to note that the often repeated but seldom understood dictum to "always attack the fire from the uninvolved side of the building" was based on the same set of assumptions. (Another critical point that must be put into perspective when interpreting Layman's theories was that SCBAs were not routinely used during interior firefighting. Remember, these gentlemen were conducting their research in the 1940s and 50s). Layman never stated that it was the water pushing the products of combustion, but in hindsight, he never clearly stated what WAS. Clearly something caused those gases to move—and that something is air. It is possible to entrain enough air in a fire stream to cause disruption and/or displacement of the fire gases in the compartment, thus making it appear that the stream (i.e. the water) is pushing fire.

We have, as a practical necessity, used the work of Layman, Royer, Nelson and others to develop "rules of thumb" that help us apply what they learned to the modern fireground. These rules served us well until or unless we forgot the foundations upon which they were built. When that happens, we risk misapplying them. We also risk using them in situations they were never intended for. Case in point: How many of you are still applying, teaching or advocating the use of a wide-angle fog during the initial knock down stages of your interior fire attack? I am going to assume few, if any, and ask you this: Having elected to use an attack very different from what Layman advocated, should you not then also take another look at the "rules" that went along with his approach?

Contrary to what far too many of us assume, neither UL nor NIST set out to prove that water doesn't push fire. In fact, they don't ever set out to prove anything. What they set out to do is learn, by observation and measurement. In the case of fire streams, what they have observed and measured so far includes this: All fire streams entrain air, but the amount of air they entrain (at any given gpm) varies greatly depending on 1) the shape of that stream and 2) the amount of movement that is applied with the stream. In addition, this variation in the amount of air entrained is not only measurable, but its effect on the movement of fire gases throughout a fire building can be significant.

My observation and experience may be telling me that fire is being pushed by the water being applied, but that is likely because I can see the water but not the air. What laboratory observation and measurements help us understand is that the air entrained with a fog stream, and even by the whipping, circular motion of a straight stream, can reverse the direction of the fire gases, causing what appears to be "pushing fire." What we have learned through observation and measurement, and what can be demonstrated repeatedly on the fireground is that water isn't pushing fire gases; entrained air is. I always try to convey it this way, "Have you ever used a fog stream to ventilate a room during overhaul?" and "Does it surprise you that it works just as good from the outside in as it does from the inside out?"

There is another important part to this discussion that has little to do with air entrainment but is still a critical part of understanding the use of exterior streams during offensive fire attack. It has to do with stream shape and nozzle motion. Fog streams of any shape, straight streams whipped vigorously (as we train to do on the interior) and streams operated too far from the opening may essentially "fill or block" the opening, preventing the continued ventilation of fire gases and any steam being produced. You can effectively "shut" a window or door with your stream. If gases can no longer exit to the exterior, where will they go? (And go somewhere, they must.)

So, let's put the pieces together. If I want to use an exterior stream for knock down before or as I am making entry into the building, I need to be able to minimize my air entrainment while maximizing my gpms to the seat of the fire. Achieving this is simple and easily applied on the fireground.

- NO—and we mean NO—use of fog streams from the exterior during an offensive attack. Straight or solid streams ONLY so you minimize air entrainment.
- Get as close to the objective as possible. This does two things for you: 1) It allows you to have the stream enter the opening at a very acute angle, which helps minimize air entrainment, and 2) it ensures that your stream is still tight (i.e., compact and not breaking up) and therefore not blocking the opening.
- Keep nozzle movement to a minimum. Aim for the ceiling as close to the top of the window as possible so that water wets as many surfaces in the room as possible and move your nozzle deliberately and slowly side-to-side.
- There is no set time to flow. Keep the line open until you have the desired effect. Look for the burning gases to be suppressed and the fire to return to contents on fire.
- Observe. Smoke and fire gases should continue to exit the opening. So long as they do so, you are being effective and not pushing anything anywhere.
- Upon knockdown, reposition to the interior or have a second line in place to do so. There is plenty of fire left inside the building that you need to go and "get."

The UL/NIST studies help us understand many things if we are open to them. Some overt and some subtle. One of the more subtle things they have helped me understand is that our choice of words matters. Our catch phrases and rules of thumb are intended to convey complex ideas in a simpler, more applicable manner. Therefore, they must be and remain technically accurate. We need to revisit them from time to time in order to ensure that they are still serving us well. I hope that we soon get to the day when the phrase "pushing fire" no longer has any currency in the fire service. It needs to go the way of "never put water on smoke" and "save your air for when you really need it." It is most emphatically NOT just a matter of semantics. The term has come to be taken literally, to the point where it is leading to bad decisions and, worse yet, being used to enjoin firefighters not to use a proven life-saving tactic.

—Peter Van Dorpe

#11: Initiate your firefight on the level the fire is on

If we take the lessons learned in the ventilation, attic and basement fire studies and generalize them to interior firefighting overall, we are led to the statement above. However, doing so is not always as obvious or easy as it sounds. For instance, exterior access to the lower level(s) of a home (i.e., a walk-out basement) is generally from Side C only. Sloping terrain, fencing and other obstacles may deter firefighters from initiating their attack at the appropriate level of the home. These same obstacles can hinder and, in some cases, even prevent a proper 360-degree size-up.

If your department has not preplanned, written an SOG and then trained for these situations, don't be surprised when your first-in companies get caught in the flow path of a lower-level fire racing up the interior stairs to their upper-level entry point, pinning them down or cutting off their egress. Residential basement fires should not be considered routine; they should be considered target hazards. Plan for them accordingly. Review apparatus positioning, hose loads, firefighter assignments, tool assignments, etc. Can you effectively stretch to, attack on and subsequently advance to the interior from Side C? If not, get to work!

—Peter Van Dorpe

Obstacles such as sloping terrain or fencing may deter firefighters from initiating their attack at a lower-level access point (i.e., a walkout basement); however, they should try, whenever possible, to initiate the firefight at the appropriate level of the home. *Photo by Jay Bradish*

Both lab and acquired structure experiments show that water through the eaves is the most efficient way to get water to the underside of the roof deck. *Photo by JJ Cassetta*

20 Tactics

#12: Get water in the eaves for attic fires

Attic fires present many of the same challenges as basement fires: limited access, lots of fuel, lots of concealed spaces and a high probability of ventilation-limited conditions transitioning rapidly to flashover. Both "half-story"-occupied attics and those smaller spaces used only for storage or even completely sealed to routine access present similar problems.

One of the many benefits of this research has been the ability to observe and measure (and therefore learn) things that we simply cannot learn on the fireground. It surprised me, and I think even the researchers, to learn that in attic fires, the fuel that contributes the most to the fire's growth and development is the underside of the roof deck. When you stop to think about it, it makes perfect sense. Attic spaces (the concealed part anyway) are designed to promote airflow to keep the space dry. More often than not, this airflow rides along the underside of the roof deck. Fires starting anywhere in the attic will be drawn to and burn most efficiently along this designed-in airflow. Both lab and acquired structure experiments show that water through the eaves is the most efficient way to get water to the underside of the roof deck. If the eaves aren't accessible because of height, topography, construction techniques or for any other reason, quick access can be created by creating an opening along an outside wall from the interior of the structure. When on the second story of a single-family home with a central hallway, the opening can be made down the hall and the line played back and forth from the peak down the rafter bays.

For me, the larger lesson of the UL/NIST studies, and the attic fire studies in particular, is to gain a better appreciation of how fuel configuration (both contents and building materials), building design and firefighting tactics (particularly search and ventilation techniques) may combine to either assist or impede our suppression efforts. The most important question to be answered during your size-up and as you attack the fire is, "What is really burning here, and what is the fastest way to get it wet?" This is especially true for attic fires. The risk of flashover, backdraft or a smoke explosion is very real at these fires. Every attempt needs to be made to cool the space and wet as much fuel as possible while at the same time limiting openings that will feed air to the fire. Your built environment may look very different than the ones used in the studies, but the physics (and therefore the principles) are the same. At attic fires, the question to be answered is, "How do I get maximum wetting with minimum openings? As often as not, the answer will be, "Through the eaves." If the eaves aren't accessible, find or create the nearest equivalent. —*Peter Van Dorpe*

#13: The door closest to the apparatus should not dictate line/stream placement

Let's keep this portion of our discussion limited to one- and two-family occupancies, where the greatest loss of life and property from fire happens in the United States. More often than not, the first line stretched on the fire goes through the front door. More often than not, that is where the first line stretched should go. But why? If we don't understand the "why" behind the rule, then we will never know when to make exceptions to it. If your "why" is because, "That is the door facing the street and therefore closest to our apparatus upon arrival and therefore the quickest way into the house for our aggressive interior firefight," then you have a dangerously incomplete reason for doing what you are doing. The reason for using the front door as your default entry into the building has to do with the interior layout, NOT with the door's relation to the street.

Despite the fact that many Americans do not use their front door as their primary means of entering or leaving their house on a daily basis, most homes in America are still designed as if they do. The practical end result of this is that most of the house is most readily accessible from the front door and that is why the front door has become our default entry point. We should not lose sight of the fact that home design is slowly evolving with our usage habits and that homes built in planned communities, on lakes and rivers, etc., will often have a very different orientation in relation to the street. Therefore, an entry door's relation to our first-arriving apparatus, while it may orient us to our most likely means of access to the interior should never dictate initial line or stream placement. I happen to live on a small lake in a suburb of Chicago. The floor plan is oriented to the lake. If you were to enter my "front door," you will be taken down to the basement and a room that was once the attached garage. Getting to the living area requires one 180-degree and then two 90-degree turns and up a half-flight of stairs. Two more turns and another half-flight to get to the bedrooms. Not the fastest way by any stretch. Bottom line: The fastest water on a kitchen fire in my place is through the window on the B side. And the fastest way to get water on the occupied part of the lower level is through the A-, B- or D-side windows. Same goes for the upper-level bedrooms. Fastest way to access and search all parts of the interior is through the door off the deck on the C side. The interesting thing is that my house's floor plan really isn't all that unusual; it's just not oriented to the street in the usual way.

My point is this: Your line, and therefore your stream placement, should be based on the fire's size and location and what you know, or can learn during your size-up, about the interior configuration of the building, not on an entry door's proximity to your apparatus. The fastest water is the best water. Plan on initiating your fire attack with this in mind, and you will make better decisions on the fireground —*Peter Van Dorpe*

#14: Forcing the front door must be thought of as ventilation

Today's building construction and fire environment are very different. Modern construction features are geared toward lowering heating and cooling costs and overall energy efficiency for the homeowner. Homes are sealed up tight with dual-pane windows and airtight exterior enclosures. Fire growth and fire spread are faster than ever before due to the overabundance of synthetic-based materials, yet the available oxygen in the home is rapidly decreased. The fire ignites and grows to an under-ventilated stage due to a lack of oxygen. The exterior signs of this ventilation-limited fire initially present heavy smoke conditions and then progress to very limited or light smoke condition upon the fire department arrival. As firefighters force open the front door (introducing an airflow to an oxygen-starved fire), conditions deteriorate quickly. This initial ventilation can lead to a sudden and potentially explosive fire development. If not prepared, the possibility of firefighter injuries is greatly increased. Firefighters have to be fully turned out with an attack line and ready for these rapidly changing conditions.

Forcing the front door needs to be considered the same as any other form of horizontal ventilation. We never really thought of it that way, but the front door is a large opening and will affect the flow path. As such, coordinating ventilation, even opening the front door, must be controlled and coordinated with the all of the other support activities on the fireground. Door control is a key component to controlling fire growth.

As firefighters force open the front door, conditions deteriorate quickly. This initial ventilation leads to a sudden and potentially explosive fire development. Firefighters must be fully turned out with an attack line and ready for these rapidly changing conditions.
Photo by FIREGROUND360°

Prior to entering, crews need a plan of action, the need to be fully turned-out, masks on, with a charged attack line in place and ready to flow water. As the door is opened, a quick observation of conditions will give that initial engine company a size-up of interior conditions and the risk potential of a vent-limited fire. What is the smoke doing? What color is it? Is it exiting the building or is the exterior air entering the building at a rapid flow? As we enter the building we must be aware that we could be entering the flow path of the fire, which, in very basic terms, means the fire is going to be coming towards us seeking the path of least resistance. —*Todd Harms*

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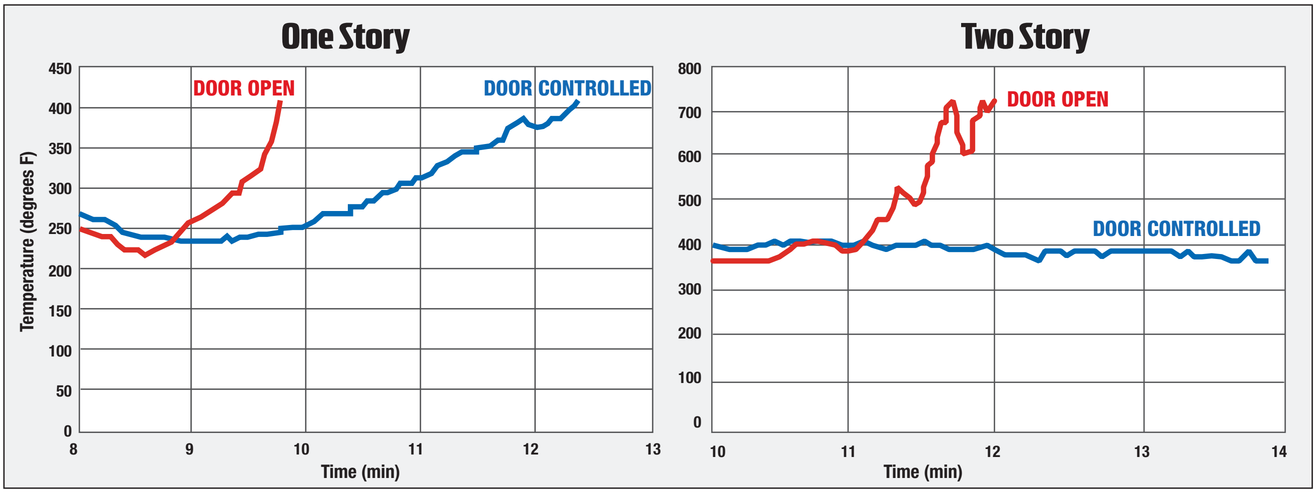


Controlling (i.e., partially closing) the door as we search for and/or advance to the seat of the fire can effectively slow the growth of the fire and prevent a ventilation-limited condition from transitioning to flashover. *Images Courtesy UL*

#15: Controlling the door limits the air and size of the fire

Probably the most important lesson that I have personally taken away from the UL/NIST studies is that I underestimated the importance of controlling ventilation at structure fires. I always thought of ventilation as something I was there to create more of—and the faster the better. I now look at ventilation as something I need to control. If I were to try to capture the lessons of the studies in a single sentence, it would be this: "We need to slow down our ventilation operations and speed up our suppression operations." This is not a "this or that" decision. It is a question of timing and tempo. Airflow to the seat of the fire needs to be kept to a minimum unless and until we are ready to flow effective water. The most obvious way to do this is to limit the taking of windows until the engine crew(s) calls for ventilation. However, as the studies clearly show, a fully opened door is more than enough ventilation to bring a room to flashover in as little as 90 seconds or even less. Controlling (i.e., partially closing) that door as we search for and/or advance to the seat of the fire can effectively slow the growth of the fire and prevent a ventilation-limited condition from transitioning to flashover. Do not underestimate the impact of an open door!

Furthermore, I think we do a less-than-stellar job of teaching our firefighters to use door control as a means of protecting the occupants and themselves during search operations. Think about this: We have all been taught to immediately seek out and close the door upon entering a room during a Vent, Enter, Isolate and Search (VEIS) operation, thereby closing off the flow path we created upon entry and isolating our search area from the fire area. Why then don't we teach this same technique when we are conducting room-by-room searches on the interior? In my mind, the interior search protocol would go something like this: Enter the room, close the door, locate and open a window(s), locate and search areas behind any closed doors in the room (i.e., closets, master baths) as the room ventilates, thoroughly search the rest of the room, exit the room and close the door behind you, proceed to the next room. Your searches will proceed much faster this way.

Door control can be established by simply closing the door to a position that reduces the overall flow path as much as possible without limiting the forward advancement of the attack line. *Photo Courtesy UL*

Crawling around the perimeter of a room while it continues to fill with hot toxic gases from the fire below doesn't seem like a very good idea to me anymore. There are, in fact, numerous fireground tragedies that could have been prevented if we had taught ourselves to routinely isolate our position from the fire whenever possible as we move through the building searching for victims and for fire extension. Many of our brethren from other countries, particularly those in Germany, routinely use what they call "anti-ventilation" as a suppression technique. Teams advance ahead of the hoselines with deployable fire curtains that they use to close off the fire area from the rest of the building. This not only stops the spread of fire gases but also begins the suppression of the fire by limiting airflow into the fire compartment (anyone remember the fire triangle?). Hose teams follow, crawl under and/or through the curtain, and extinguish the fire. It immediately drops closed behind them, continuing the protection of the rest of the structure. What's not to like about this tactic? Door control, exterior and interior, needs to become one of the "fundamentals" of interior firefighting.

—Peter Van Dorpe

Before opening the door, crews should ensure that they are prepared to go to work—PPE fully deployed, handline in place, water at the nozzle. *Photo by Tom Carmody*

#16: Never get stuck between the fire and where it wants to go without water or a door to close

One of the first points that we must begin to acknowledge and understand is that the point of entry, typically the front door, is a ventilation opening or flow path unless we control it and close it behind us. In a typical fireground scenario, the initial engine company opens the front door, and observes the conditions and any changes that might be developing overhead as they advance into the structure. Acknowledge that the point of entry is now considered a flow path and that any delays in advancing to the fire with the door in an open position will allow the fire to grow and develop. It's critical that we control the flow path and limit the amount of air being fed to the fire.

Before opening the door, crews should ensure that they are prepared to go to work—PPE fully deployed, handline in place, water at the nozzle. If the door needs to be forced, force the door, pull it shut and prepare to make entry. Once crews are ready and a charged line is in place, open the door and advance toward the fire. *—Todd Harms*

#17: Well-timed and coordinated ventilation leads to improved conditions

The need for ventilation on the modern fireground is just as critical as it was in the past. But today, more than ever, ventilation must be coordinated with the crews working on the interior. In the past, when you were working on the interior of a working fire, you would hear the ladder company on the roof cutting a ventilation hole. You would feel the heat lift and see improved visibility as the ladder punched through the interior ceiling. There was a true feeling of relief. We were always told that ventilation would lead to increased fire growth, but that was OK because there was a line in place and you could immediately put water on the fire. With today's synthetic modern fuels, ventilation can create rapid and dangerous fire growth and jeopardize the safety of advancing crews. As such, it is critical that ventilation and fire attack be coordinated more effectively than has been done in the past. The margin of error is less forgiving and can potentially be disastrous for an advancing crew(s). *—Todd Harms*

Today, more than ever, ventilation must be coordinated with the crews working on the interior. *Photo by Jarod Trow*

Along with opening the front door, it is critical that we coordinate vertical ventilation with the initial attack lines for a successful, organized fireground operation. *Photo by Peter Danzo*

#18: Coordination of vertical ventilation with fire attack must occur just like with horizontal ventilation

It all comes down to controlling the flow of oxygen in and out of the structure. This is why, along with opening the front door, it is critical that we coordinate vertical ventilation with the initial attack lines for a successful, organized fireground operation. Ventilating a structure without a handline in place to immediately control or extinguish the fire could lead to rapid, uncontrolled fire growth that may overwhelm the capabilities of advancing crews. As such, the attack/fire control function must be in place (preferably applying water to the fire) when ventilation is requested. Bottom line: Vertical ventilation and the initial attack need to occur simultaneously. —*Todd Harms*

#19: TIs can't assess structural integrity from above

Many fire service textbooks stress that thermal imagers (TIs) should be considered during size-up to help indicate floor collapse. However, research has demonstrated otherwise. TIs are an incredibly important piece of equipment to have on the fireground. In fact, we routinely rely on TIs because of the valuable information they can provide. But we must also have a thorough understanding of their use and limitations.

TIs identify heat sources in shades of gray, and as temperatures increase, they will display varying colors from yellow to red. When attempting to assess interior conditions, a TI reading should be considered as one piece of a multi-part size-up—never the sole indicator for predicting a potential flashover or collapse.

Newer technology TIs have improved clarity and definition, which enhance our ability to recognize the critical signs of fire development and directional flow paths.

Another critical point to remember when using a TI is that they identify surface temperatures. The surface temperatures of floor coverings (foam padding, carpets, etc.) may show little or no signs of heat from below the floors surface and therefore may dismiss any potential warning signs of a floor collapse. It is critical to identify the conditions in the basement prior to performing operations on the floor above. TIs can be a great tool for determining if there is a basement fire, but they should not be used to determine structural integrity of a floor system. In much of the research conducted, there were no identifiable signs seen through the TI that could be considered a predictive indicator of floor collapse.

The key here is to know your equipment and remember that TIs are one of the many tools in the toolbox used to assist us in becoming more effective on the fireground. —*Sean Gray*

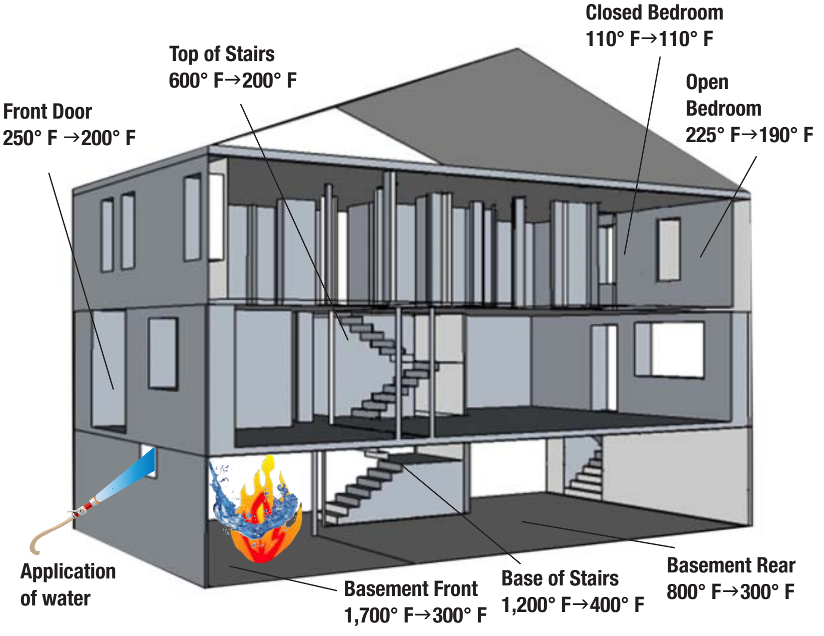
Like any technology, thermal imagers have limitations. Tests have proven that common floor coverings (i.e., carpet) can mask the signs of floor collapse. Use technology to compliment your size-up and search efforts. *Photo by Glen Ellman*

#20: Basement fires: Don't fall through or get caught in the flow path

Basement fires can be extremely difficult to control and extinguish once they have gotten beyond the incipient stage. Access and ventilation opportunities are limited, floor plans are often anything but standard, and fuel loads can be extraordinary and unpredictable. Firefighters get injured and killed at these fires when the floor below them fails or when they get caught in the flow path of the fire.

In many jurisdictions, the traditional approach to basement fires in residential and mercantile occupancies has been to advance a line down the interior stairs. Why do it this way? Three reasons: 1) It is often the most accessible (and sometimes the only) means of getting personnel into the basement. 2) We want to "cut off the advance of the fire" up the interior stairs and into the rest of the structure. 3) We want to avoid "pushing" fire up the interior stairs when advancing a line from an alternative location. These are all valid reasons, but they do not preclude us from exercising some options. Let's look at each in turn.

In contrast to our traditional methods of advancing a line down the basement steps, tests have proven that a more effective tactic is to put rapid water on fire from an exterior position (whenever possible). Once the fire is reset or knocked down, crews should then make entry and complete extinguishment from the interior.
Photo by Steve Silverman



A short burst of water from the exterior can provide for a quick knockdown and reduced temperatures for the crews who eventually make entry and advance into the basement and other areas throughout the structure. *Image Courtesy UL*

First, while it is extraordinarily important that we get into the basement for search and for complete extinguishment, it is even more important that we knock down the source of the problem as fast as possible. Placing our nozzle and our body between the fire and the occupants or the rest of the building doesn't accomplish anything. Water on the seat of the fire does. A quick hit on a basement fire through a window or exterior door makes your advance into the building and down the stairs a whole lot faster. Faster is better—for the occupants, for the building and for the firefighters.

Second, we bring the line into the building to cut off the advance of the fire up the interior stairs. To some extent, we answered this above. Water on the seat of the fire stops its "advance" much more effectively than fighting your way to it while in the flow path. In addition, fire extension from a basement through the rest of the house is largely via the void spaces, stud spaces and pipe chases, etc., and not the interior stairs. The voids simply provide more readily combustible fuel and a better flow path than the interior stairs. The experiments help us understand this by providing measurements that show that flowing water at the top of the stairs has little impact on conditions behind it, while conditions in the basement continue to worsen.

Third, let's consider the misconception about pushing fire with water in the context of fire moving up interior stairs from the basement. Firefighters who have had bad experiences with fire moving up through the interior stairs have most often underestimated the contribution that ventilation, both intentional and unintentional, has had on the outcome. If I have learned anything from the UL/NIST studies, it has been an enhanced understanding of the effects of ventilation at structure fires. We need to redefine ventilation as "controlling air" rather than as "opening up." More is not necessarily better, especially when you haven't yet got control of the fire.

Pushing down the interior stairs as a first tactic may work well during the incipient or growth stages of a fire, but when a fire has reached ventilation-limited conditions or has already flashed over, pushing down the interior stairs is extraordinarily dangerous and does NOT usually result in a faster knockdown and control of the fire. While you are slowly fighting your way down the stairs, everything is getting worse for the occupants behind and above you and the building is being demolished all around you. This has been demonstrated through both NIOSH and NIST investigations of fires and subsequently validated through UL and NIST experimentation. Even when successful, the fact of the matter is that it takes longer than the alternatives. Look for ways to accomplish your objectives faster. —*Peter Van Dorpe*

Meet the Authors

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Over his 25-year career, Assistant Chief Derek Alkonis has been instrumental in establishing the Los Angeles County Fire Department as a leader in fireground safety and fire service wellness/fitness. A firm proponent of training, Alkonis has developed and implemented innovative programs supporting fireground tactics, survival and firefighter health. He is a member of the IAFF/IAFC Fire Service Joint Labor Management Wellness-Fitness Initiative Technical Committee and UL's Firefighter Safety Research Institute Advisory Board. Alkonis holds a bachelor's degree in biology from the University of California, San Diego.

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