<u>UL… The rest of the story</u>

By now most of the American fire service has worked a building fire where the call was made to put water through a self-vented window or door rather than stick to the principles of traditional interior firefighting. Recently my crew worked such a fire in a bi-level SFD with fire self-venting from a rear kitchen window. The resident was outside reporting everyone was out of the home and there were no exterior exposures. The initial crew pulled a 1-3/4 around the back of the home and played water into the fire window as my companies stepped off their rigs. The order for us was to go through the front door and start a search. The collective question: Enter opposite the attack line? As ordered we made our way to the front door and as I entered I was greeted with hot dense smoke to the floor with a penetrating cloud of steam that violently pushed over top of me. Only 1 foot inside I quickly backed out of the front door and gave the steam a second or two to lighten up. Even though I had the protection of a hood, that experience was not a pleasant one. My crew in tow, we made the stairs to the second level bedrooms and completed the search. More confusion was audible as the attack crew finished extinguishing the kitchen and then started to search the first floor and lower level. This became complicated as the nozzle team ran into the other search crews also ordered to enter opposite the hose line. This strategy of multiple points of entry is not our standard procedure and neither is the transitional attack on a single room fire. One could argue that the confusion was a command and control issue but I would point to the growing phenomena that the Underwriter Laboratory studies have generated, as the fire service jumps onto the bandwagon of "hitting it hard from the yard". At this bread and butter fire, all would have been smoothly completed if the initial order was to enter from the front door, use the reach of the stream and push into the kitchen with an open nozzle. This would have protected the stairs for search crews, all but eliminated the steam condition, and promoted better communications and accountability.

My experience in the fire service includes 20 years working for a single engine fire department which is a close suburb of Cleveland Ohio. My fire duty could be summed up as typical suburban firefighting. As such my fire department worked less than 50 fires in 2013. When compared to 5 year veteran of my nearby metropolitan city, I need more training and off the job experiences to fill in the needed time to be worthy of my opportunity of being a career firefighter. With all that said I have looked for every live fire training opportunity and even ride along programs, to get me as personally ready for interior fire attack as possible. This plan for personal development has provided great opportunities to learn from the best firemen I could find and in turn, pass that wisdom down as a fire service instructor for the last 10 years. On my journey through the fire service I have learned one thing for sure. We must jealously guard our profession as we investigate the evolving strategy of fighting fire, and we must do so without sacrificing traditional lifesaving principles for modern fire ground management.

Since 2011 UL has provided the fire service with more practical science than has been published in many years. They have tiredly studied and practiced several scenarios as it pertains to residential fires. One thing missing is the perspective of those of us that are not scientists who want to ask some questions. First, if the definition of science is the observation, identification, description, experimental investigation, and theoretical explanation of phenomena, then all possible variables must be accounted for. Is it possible to account for every possible variable for residential structure fires? And if not, is interior firefighting in an occupied structure a science?

The accumulated data from hundreds of years of interior firefighting is the bedrock of our principles. The first of which is to protect human lives. We need to be focused on what makes the building and the byproducts of combustion behave as we want them to, and we should be moving these away from those we are sworn to protect. Unwittingly, the current paths the UL studies have put the fire service on, are in my opinion going away from these truths. There are scenarios for softening the target, transitional attack, or hitting hard from the yard but that plan should not be the first one at every fire that is self-venting. I am not dismissing the great information and scientific facts that resulted from the UL studies. I am concerned that no one is talking about the facts that we do not know, and the future results given by abandoning what we know saves lives.

My intent of this article is to bring your attention to the limited association these studies have on the real world of a dynamic fire ground. These include: the long list of unknowns at a “real” fire, the difference in the water application, and the relationship between our suppression efforts and the harmful effects of steam. These are the excerpts from the UL study "you can't push fire" that grabbed my attention:

"The second two pictures were captured 10 seconds later and the gases from the water application are forced into the bedroom in the flow path with the open window. This did not occur with the use of the straight stream water application but the fog stream was more effective at cooling during these experiments. While steam was "pushed" along the flow path there was no fire "pushed"."
A common argument against flowing water onto the fire prior to entry is the belief that conditions beyond the fire would be made worse. Data from this experiment showed otherwise. Temperatures (ONLY!) were measured in the hallway just outside the room and in the other bedrooms on the second floor, (Figure 6.29). As shown in Figure 6.29, 25 gallons of water directed off of the ceiling of the fire room decreased fire room temperatures from 1792 °F to 632 °F in 10 seconds and the hallway temperature decreased from 273 °F to 104 °F in 10 seconds.

There are dramatic reductions in temperature and I appreciate these as fact. However; the tradition of the American fire service is to fight these fires whenever possible from the inside out. Why is this? Because our value as a service is directly related to our *ability and willingness* to get between the fire and the people trapped inside. As long as we hold that value as our driving force, then this job will be a dirty, hard, and sometimes a painful one. The conversation surrounding "transitional attack" is an over simplification of the ***art*** of interior firefighting. As with compressed air foam attack and ventilation controlled fires, there is some value and a place for these applications. These scenarios however do not belong to fire attack in an occupied building. Essentially, water is the answer! If we all agree, and UL has proven, that today's fires are hotter and faster, then why are we not talking about getting inside between the fire and the people so we are moving the byproducts of combustion from a position that protects the egress for our citizens? Some have argued that an interior hose team cannot be as fast as water from the outside, and my rebuttal is that the steam production from the outside is faster. Most importantly it is faster at killing our citizens.

For the sake of clarity and this article, let's define the common terms of heat, temperature, and latent heat of condensation. Heat and temperature as NFPA 921defines it: Heat Energy is a form of energy characterized by vibration of molecules and capable of initiating and supporting chemical changes and changes of state. Temperature is a measure of the degree of molecular activity of a material compared to a reference point (degrees). Latent Heat of Condensation is defined as the quantity of heat needs to be transferred to convert a unit mass of a substance in gaseous phase into liquid phase at its condensation point at one atmosphere pressure. When energy is transferred to a substance, usually, temperature of the substance increases. If the substance is at higher temperature then the surroundings, temperature of the substance decreases, as heat is transferred from the system or substance to the surroundings. From this we can conclude that a substance undergoes change in temperature whenever flow of energy transfer between system and its surroundings takes place.

Now, what is the science behind the statement: dry heat is not as harmful as a wet heat?

Answers:

There's more energy (heat) in the steam. To raise the temperature of one gram of water from 37ºC (temperature of skin) to 100ºC (the boiling point) requires 63 calories (one calorie per degree). To convert that gram of water to steam requires another 540 calories. So the energy (heat) in the steam is 9-fold greater than the energy in the same weight of water at the boiling point. This energy (as heat) is released when the steam condenses to water and the water cools to the temperature of skin. Steam will be substantially more injurious.
Answered by: David Kessel, Ph.D., Professor, Wayne State University, Detroit

More on the physics of steam injuries…Steam burns do have to potential to cause more damage than scalding. The reason has to do with the latent heat of vaporization. This is the amount of heat energy necessary to change the phase or state of matter from liquid to gas. This energy is absorbed by the liquid, but does not change the temperature. Conversely, when a gas condenses, it must release this latent heat and become a liquid before it can cool below its boiling temperature. The latent heat of vaporization for water at sea level is about 2250 J/g, as compared to the specific heat of water of about 4 J/g•°C. All that extra heat has to go somewhere, mostly to the surrounding air. If, however, you place your hand into a jet of steam, much of that heat will be absorbed by your skin - very unhealthy. And what's worse, as the steam condenses onto your skin, it will still be at 100°C!

Answered by: Grant Coble, B.S., Physics Teacher, Hollywood High, Hollywood California.

To summarize: Steam has a very high latent heat capacity. Steam filled air transmits the energy as the moisture turns to water (boiling temperature), and continues to burn human flesh. Dry air is much more breathable because air is a very efficient insulator. My Conclusion: The moist air conducts the energy (heat) to the respitory tract and exposed skin with rapid speed and long lasting, destructive duration.

In addition it is reasonable to deduce that steam is hotter in smaller areas of confinement like hallways and stairways, as well as “exhaust” openings like a windows or doors. Steam temperature is a direct result of its pressure, i.e. density. This further underlines the fact that we must control not only the air current to and from the fire as UL concluded, but as well as the steam production from our hose stream. We are there for the people and their property, not the fire. If we do harm by quickly darkening the fire from a "safe location" yet expose the victims to the scalding and deadly steam, we have failed our mission albeit safely for us. We should not be a team of exterior sprinkler systems.

A further investigation of the properties of steam and how they affect the survivability of those we swore to protect is in order as UL has noted. UL has documented that their studies are only starting the conversation when it comes to fighting fires in occupied buildings and in the future perhaps they will be able to qualify the physics of steam in a fire building. However; most of the type A firefighters I know are not looking at the words clearly written in these reports. Examples:

"*the experiments did not simulate water being applied from inside the structure by an advancing hoseline. It is understood that this happens on most fires."*

"The second two pictures were captured 10 seconds later and the gases from the water application are forced into the bedroom in the flow path with the open window. This did not occur with the use of the straight stream water application but the fog stream was more effective at cooling during these experiments. While steam was "pushed" along the flow path there was no fire "pushed"."

These statements clearly illustrate a few points lost on many of us. First, we all know what it is like to be "steamed" while working a fire but are forgetting to associate that situation to the people in the building without a BA and turn out gear. Secondly, we must consider the fact that the UL studies are only one side of the fire ground operation. Until a study is done with the "water being applied (nozzle open) inside of a structure by an ***advancing hose line***" we will only have half of the story. Thirdly, we need to rediscover the principles and experience driven deductions by those that have applied their life to this subject, namely William Clark, Andy Fredericks, David Fornell, Jeff Shupe, and recently Aaron Fields. Each one standing on the shoulders of those that came before them to build the knowledge needed for this specific skill set known as interior firefighting.

The casualty of these 400+ page studies has been the down grading of the importance of interior hand lines for an occupied structure, and the importance of vertical ventilation. In my opinion the UL study leads people away from these conclusions by contradicting itself and not advocating what clearly helps victims in a building fire as it pertains to breathable air. This contradiction is listed under section 6.11 paragraphs 1 and 2. The first explains

6.11. You Can't Push Fire

You cannot push fire with water. The previous UL ventilation study included the concept of pushing fire in the data analysis. That study generated a lot of discussion, and stories surfaced from well-respected fire service members who had experienced the phenomenon of pushing fire, or had perceived that it had happened. The specific fires recalled by the firefighters were discussed in detail. In many of these situations, the firefighters were in the structure and in the flow path opposite the hoseline. In most cases, the event described occurred while fire attack crews were advancing on the inside, and not while applying water from the outside into a fully developed fire. All of the experiments in this study were designed to examine the operations and the impact of the initial arriving fire service units. It is not suggested that firefighters position themselves in a flow path opposite the hoseline. However, there are times when this may happen so the experience of these firefighters should not be discounted. Also, the experiments did not simulate water being applied from inside the structure by an advancing hoseline. It is understood that this happens on most fires.

1) A flow path is changed with ventilation and not water application. When the firefighters are opposite the hoseline, in many cases they entered from a different point than the hoseline and left the door or window open behind them. This flow path is entraining air low, where they are crawling, and hot gases are exiting over their heads. As the fire reacts to the added air, the burning moving over their heads increases and conditions could deteriorate quickly. If an attack crew is preparing to move in or is inside, the experience of the firefighters opposite the hoseline could be blamed on the hoseline. However, the fire was just responding to the air and the added flow path and not to water flow. Often this occurs in close timing of water application and occurs without coordination (Figure 6.34).

Then in paragraph 2

A flow path is changed with water. Opening a wide fog changes the flow path or plugs a flow path (Figure 6.35 and Figure 6.36); this can also be accomplished with a straight stream when whipped in a circular pattern (Figure 6.37 through Figure 6.39). This can disrupt the thermal layer and move steam ahead of the line, which is why firefighters do it. If a firefighter is downstream, they may get the impression of pushing fire or elevated heat, especially if they are in the cool inflow of another vent location.

This leaves the interpretation of the study to the reader, who may not consider the consequences of flowing water into an occupied building fire that has self-vented because, there has been no UL study done on the dire effects of super-heated moist air filling the survivable space. I am asking the questions: How much steam is resulting from "10 seconds of water directed at the ceiling from outside of the window"? And do you realize that the UL study had their nozzle set at 100 gpm?

Another disconnect from the fire service from the facts in the UL study is the definition of "fire". When a firefighter hears the word fire we instantly picture not just the orange and red stuff but the super-hot gasses that burn and kill, including steam. The summarization that we cannot push fire is therefore incorrect, in a practical, injury causing definition. We cannot push fire with our hose stream but we DO push steam and hot gasses. UL even makes note of that fact.

If we understand fire as a rapid oxidation process, which is a chemical reaction resulting in the evolution of light and heat in varying intensities, then it is easy to understand how water puts out fire. The water absorbs the heat (energy) needed for fire growth. The life safety question I am raising is what are we doing with that energy as it is carried away by steam?

Nozzle Forward instructor Aaron fields also has a question. He asks "How much air does your nozzle move?" Most cannot qualify that with an answer of course, but it is a legitimate question when considering the scope of what affect we are having on the atmosphere inside the building, and not just the measured temperature but the gasses that actually kill our civilians. Aaron Fields states that a smooth bore nozzle at 150 gpm, can move up to 800 cubic feet of air per minute with an aggressive O pattern. These deductions are sited from an earlier fire service mentor named David Fornell in his book Fire Stream Management Handbook. UL agrees that all nozzles move air by the reason they give in the horizontal ventilation study: *"firefighters can close off the exhaust with a fog or circular patterned straight stream".*

Clearly we are the "weather maker" inside of the building. We are the weather front moving into the building and pushing air with our open nozzle. As Fields has said "an open nozzle is the truest form of positive pressure attack." We should be concentrating on moving the by-products of destruction out of the building from an opening of our choosing. We do this by flowing water **while moving** into the fire area and putting water on what is burning, the leading gasses as well as the seat, with a nearly simultaneous opening of an exterior window or ceiling/roof.

If a fire is already vented to the outside and the interior door is open, there is no question in my mind, that water from the outside will produce steam and that steam will move into and throughout the structure. It will absorb energy (heat) snuffing out some of the fire and push into any survivable space replacing the breathable air with energy transmitting steam.

There has been much study and computer mapping done on the subject of breathable air. Referring to a paper authored by Christina Cossell, Jan Ma, Samantha Spindel, and Yang Wang. Computer Aided Engineering: Applications to Biomedical Processes Professor Ashim Datta Cornell University, Ithaca, NY May 4, 2007. In this research it is established that "A person can ideally inhale air under 358

Kelvin (185 degrees F) for 20 seconds without sustaining significant tracheal tissue damage." And furthermore; "Certain gasses may burn the trachea quicker than others and some gasses may react with itself or upon contact with the trachea, causing further deterioration of tissue. Also, the model does not include the effects of densely hot wet air, such as water vapor, where phase change heat transfer must be considered."

It is this author's belief that it is very likely to have an unconscious person just on the other side of a room on fire, clinging to life and laying on the floor breathing nearly 200 degree, dry air. The applications of water from the exterior without knowing that a barrier, i.e. a door that is closed between the victim and the fire, will be catastrophic to the interior exposure, as Aaron Fields calls the unprotected respitory tract of the fire victim. We train to not get caught opposite the nozzle for obvious reasons. I'm asking the question: Why are we not arguing that reason for the citizen?

More from UL study on vertical ventilation:

There was not a ventilation hole size used (4 ft. by 4 ft. or 4 ft. by 8 ft.) in these experiments that slowed the growth of the fire. All vertical ventilation holes created flashover and fully developed fire conditions more quickly. Once water was applied to the fire, however, the larger the hole was, and the closer it was to the fire, allowed more products of combustion to exhaust out of the structure, causing temperatures to decrease and visibility to improve.
Ventilating over the fire is the best choice if your fire attack is coordinated.
If a ventilation limited fire receives air, it will increase in size.
Additionally, the closer the source of the air to the seat of the fire, the quicker it will increase in size. If you ventilate in coordination with fire attack (the hose stream is removing more energy than is being created), it does not matter where you ventilate, but the closer to the seat of the fire, the more efficient the vent will be in removing heat and smoke, which will improve conditions for the remainder of the operations taking place on the fire ground.

In conclusion I would like you to consider the impact of super-heated moist air pressurizing inside of the building and that effect on the breathable air in the egress/access points.

UL is not misleading or omitting data to bring about change to the fire service. It is some of the fire service that is only reading the highlights and reasoning to put more emphasis on "hitting it hard from the yard". My academy instructor Jeff Shupe has said; "Fire departments always need to look at the changes in tools and equipment from the past to the present." but, he never has mentioned changing our values and principles! Secondly, vertical ventilation is difficult and dangerous but the benefits to those without breathing apparatus in the building are clear. UL continues to illustrate the critical event of coordinated ventilation as the most important task in fire suppression. This act of coordination is where our emphasis should be. Teaching patience to the outside horizontal vent crew and speed and efficiency to the roof crew. Thirdly, and the most important lesson, is that we must be able to apply overwhelming pressure (volume of water) to the fire and have an exit in mind for those super-heated gasses.

These three things in the context of where are our priorities are and where they should be is important. Therefore; I have more questions for the fire service. Are we really changing the way we protect lives for the right reason? Does this transitional attack on smaller fires make the incident more survivable for our citizens? What does this transitional attack mindset do to our argument for staffing levels and training? Are we moving towards a priority of stopping the fire versus saving lives?

So how do we balance this old tactical truth of interior firefighting being an art, with the new science of fire suppression in a modern furnished building? It is my opinion that we as a service must re dedicate ourselves to the basics of applying water from an **advancing** hose line. More funding for the practice and training of moving a flowing hand line is a tangible and measurable item. We must have the ability to advance a **flowing** hose line in a smoothbore configuration from an entry way to the room of origin and change the "weather" inside of the building. Moving while flowing water is the "new science"! So save the transitional attack for the scenarios that call for it. Namely when you arrive to a 40%-90% involved structure, 2 or more floors with fire, or if there is an un avoidable delay in getting an interior attack line in service.

Wisdom is defined as truth from all perspectives. The truths of firefighting are that the first interior hose line saves more lives than anything else we can deploy on 90% of building fires, and the variables are endless when considering fighting fire in occupied buildings. So, beware of "new truths" as they are not wise without aged experiences that have proven them to be so. I insist we maintain our profession to be result based *and* value driven service that is centered on our people who we swore to protect.

References and Acknowledgements:

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