



Three Lessons from the Fire Behavior Lab

by *Ryan Pennington* On Oct 19, 2012

Today's firefighters are experiencing an old danger that has come full circle to affect everyone. Flashovers are becoming a more common problem due to many factors. Why are we seeing more and more of them when we arrive? I believe that it is due to more energy-efficient homes, higher full loads, more synthetic materials and quicker-developing fires. Fire that doubles in size every 30 seconds can make for a swift-moving catastrophe. Just as you pull the parking brake on your engine, a flashover can be seconds away due to the time it takes to discover the fire, call 911, process, dispatch and respond. It's the perfect storm to get us burned. So how do we combat this problem?

One way is to expose your firefighters to the signs and symptoms of impending flashover. The best way of doing this is to use a flashover simulator. Flashover simulators have been around for years and have been saving firefighter's lives, but often the instructors approach them without understanding the teaching and learning points and objectives.

Melted helmets, burned students,, and equipment damage are not the main objectives. Gone are the days where the cool guys have the melted helmets. Let's take a look at education that can be learned while inside a flashover chamber. Three lessons from the fire behavior lab will give you learning points that you can share with your firefighters to keep them safe.

PPE Use Is Mandatory

I have had the honor of sharing the experience inside the fire behavior lab with many students. One lesson that remains constant is the proper selection and usage of their personal protective equipment (PPE). While operating in a super-heated, toxic environment it is drastically important to select and use all of your personal protective gear. Many times firefighters choose to not wear their proper assembly and this leads to injury. If you do not wear all of your gear into the flashover chamber you will get burned. How is this different than a normal fire? Well, you don't have the prep time that you will have before entry, plus you will also have the stress of a "real-world" situation. Add the problem of a person or persons being trapped inside and the stress level goes through the roof.

A "Wear your gear!" sign should be placed on every jumpseat, front seat and the back of every fire station garage door. You would think that something as simple as complete ensemble wearing should not have to be mentioned in an article, but it remains as a constant problem seen in today's fire service. Everyone is always preaching about "Back to the Basics." We should be removing the back part from this phrase and replacing it with "Never Leave the Basics!" No matter what the drill or skill, the basics should be in place and enforced. I bet if you asked any firefighter who has experienced a near-miss burn injury that this were never be an issue...wear you gear and be proficient at putting it on!



Don't Get Caught Up In the Fire

Often in today's hard-charging fire service, attack crews will come off their truck with their tunnel vision goggles strapped tightly to their head. Ugh, see fire, squirt water. If it was that easy anyone could fight fires. The fact of the matter is that when fighting fires, it's more than just putting the wet stuff on the red stuff. With today's synthetic materials, how often do you even see the flames? Dense, thick, dark smoke can lead you to your death, so why are you not paying attention while you are crawling through unburned fuel? Smoke is a sign of where the fire has been or is going. Have you ever stopped and asked yourself "Is there hidden fire in this thick smoke?" Yes, there could be fire that has reached ceiling level while reaching out across looking for more air. Just because you don't see it, doesn't mean that it's not there.

This is a huge lesson that you can learn from the fire behavior lab. As you instruct your students on fire behavior, you can learn that fire will "Reach" or "Finger" out of the room of origin looking to extend over your head. This sometimes can be seen, but sometimes it cannot. You need to be watching the smoke as it passes over your head for velocity and smoothness. Just because there is a fire on the B-C side and none visible on the D-A side, there still is a danger present. The fire is looking to make its way toward the unburned side. If your attention remains fixed on the self venting fire, you can make some big mistakes in dealing with, or missing, the signs of danger.

Turbulent Smoke Has Fire in It

A lot has been made of reading the smoke to which you are responding while there is hardly any talk about what the smoke looks like that you are crawling under. Thick black smoke that has a "waving" look to it may have fire hidden in it. We can gather a lot of information about the fire by looking at the smoke and its movement along the ceiling. Is there fire above us? Should we cool the ceiling with some short blasts of water? These are two questions you should be asking. By hitting the ceiling with short blast of opening and closing the nozzle, you can reduce the chances of flashover. Fire burning above your head can lead to a disaster, so knowing the signs that it may be present are key learning lessons taught in the fire behavior lab.

While inside the lab, you should be paying attention to the smoke as it begins to build up and push to the floor. The fire will build inside the burn room, filling it with fire before extending into the long hallway of the chamber. The first signs will be small fingers of fire as it searches for air. Flames licking out slowly may or may not be seen. Once the fingers progress, you will reach rollover. If you are experiencing a rollover during a fire, you should knock it down and not let it reach any contents behind you as it will trap you.



Flashover Simulators Provide Life-Saving Training

Firefighters can learn the indicators of flashover in a safe, realistic training environment

By **Charles L. French Jr**

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The first time I heard the words “the Swede,” I was watching a movie called “Heartbreak Ridge” starring Clint Eastwood as a rough and tough Marine Gunnery Sergeant trying to train a group of misfit recon Marines. One of them, a large, muscle-bound guy who’d just got out of the brig, was nicknamed “the Swede.” Eventually, Eastwood’s character faced off with the Swede and knocked him out with one great punch to the chin.

I remembered that scene recently when my department acquired a Swede Survival System flashover trainer. Although these two Swedes are very different, the lesson I learned while watching “Heartbreak Ridge” applies to flashover training as well: Understanding the hazards that you may face and being ready for them is a formula for survivability in almost any situation.

Although my department uses the Swede Survival System, other flashover trainers are available. This article will focus on the broader concepts in flashover training and what a flashover trainer can provide.

Flashover 411

A flashover is a transitional phase that happens between the growth stage and the fully developed stage of a fire (see figure). During a flashover, all the objects within a space are heated to their ignition point due to thermal radiation feedback. Auto ignition of all the contents, including the smoke, occurs in the room almost instantaneously, and the entire space is consumed by fire.

The temperature range in a room when flashover occurs lies somewhere between 900 and 1,200 degrees F. The heat produced by flashover is not survivable for more than a few seconds, even when wearing full PPE and SCBA. If you survive such an event, you’ll likely be severely burned.

We’re faced with the possibility of a flashover at every fire we respond to. With the development of smoke detection systems and traffic-control devices, we’re getting on scene faster than we did years ago, and this means we’re more likely to go into a structure before flashover occurs. Products of incomplete combustion (smoke) are basically fuel; when we enter these structures, we’re “swimming” in that fuel.

Carbon monoxide (CO) is also present at every fire, and it’s a contributing factor to flashover as well. The auto-ignition temperature of CO is 1,128 degrees F, similar to temperatures found during flashover. Therefore, there’s a real possibility that flashover conditions may exist or could rapidly develop during interior operations at any fire. Without an understanding of and ability to recognize flashover conditions, personnel are at great risk of serious injury or death.

Learning from Oklahoma City

On March 8, 1989, at 0809 hrs, three Oklahoma City firefighters died during a routine house fire that involved a small, single-story, two-bedroom home. The cause of all three deaths was attributed to a flashover that occurred within minutes of an interior fire attack being initiated. The effect on the department was devastating, to say the least. At the time, the Oklahoma City Fire Department had not lost a firefighter in the line of duty in 39 years.

During the incident, flashover indicators were present, with high levels of heat and heavy smoke being reported by first-in companies. However, the fire gave a false indication that it had vented itself through the roof. Unknown at the time to the fire crew operating inside was that the house had two additions. The fire they saw outside the structure was between an existing roof and one of the two added-on roof coverings.

The fire crew gained access through the front door while carrying a preconnected hoseline. Once inside, they crawled through a 30’ living room to a doorway toward the rear of the house, where they found what they thought was the seat of the fire in a bedroom. They knocked down the main body of the fire and



thought it was extinguished, so they put down their hoseline and made their way toward the exit for reassignment. That's when the flashover occurred. The additions made to the house held in a tremendous amount of heat, which built up, contributing to the flashover.

One positive outcome of this tragedy: The citizens of Oklahoma City passed a 0.0075 cent sales tax increase, earmarked to help better equip their fire department and to train its members. Needless to say, however, the price that this community paid and the lives that were affected by this event should not be the way to secure fire service funding.

Flashover Indicators

The most effective way for firefighters to minimize their risk of being caught in a flashover is by maintaining an awareness of developing fire conditions and controlling the fire environment with effective water application and ventilation tactics (IFSTA 5th Ed). Flashovers push out of openings, such as doors and windows, faster than a firefighter on their hands and knees can move. When a flashover happens, you may not have enough time to escape, which is why it's so important to practice your firefighting skills and understand the indicators of a flashover.

A flashover can present itself in a variety of ways during a fire incident. The following are indicators that an impending flashover is about to occur:

- *Buildings:* Flashover can happen in any type of structure, but certain building features and contents contribute to how fast a flashover can develop, including fuel load, ventilation profile and thermal properties. The size of the room is also a contributing factor; the smaller the room, the faster flashover conditions can develop. Contents also add to the hazards. The synthetic materials commonly used today have a higher heat release rate than natural products and therefore create flashover conditions much faster than in years past.
- *Smoke:* Smoke build-up, density and pressurized movement are typically strong indicators of an impending flashover. Remember: Smoke is a fuel, and smoke conditions indicating a rapidly developing fire should not be ignored. After making entry, the presence of thick black smoke, hot gases and layered smoke are strong indicators that a flashover is about to occur. Heavy smoke banking down with increased heat, keeping firefighters on their hands and knees, is also a strong predictor.
- *Air flow:* A strong air current in which air is moving inward and smoke is pushing out should also be a flashover indicator to fire personnel. This is when ventilation can be helpful, if performed correctly, in controlling the heat build-up within the structure. Vertical ventilation can help channel the smoke and the hot gases out of the fire area, reducing the possibility of flashover. However, if ventilation isn't performed correctly, it can be a contributing factor in a flashover situation.
- *Heat:* Rapidly increasing temperature or high heat build-up is also a strong indicator of flashover. However, this is usually a late indicator and means that everything in the room is about to ignite.
- *Flames:* The combination of flames traveling out of the hot gas layer and smoke (sometimes referred to as "snaking" or "ghosting") is another indicator to watch out for. This can be confused with rollover, but it precedes rollover behavior and exhibits a snake-like movement pattern that moves more slowly than rollover flames. The problem for firefighters with this indicator is that it may not be visible due to the smoke conditions in the structure. A thermal imaging camera (TIC) can help firefighters see through the smoke and identify this condition.
- *Rollover:* This is an event in which the unburned gases accumulate at the top of a compartment and the smoke ignites, then flames begin to propagate through the hot smoke and gases and roll across the ceiling. Rollover will precede flashover and is a strong indicator that an impending flashover will occur.



Flashover Training

Now that we're aware of the indicators associated with flashovers, how do we train and gain the necessary experience to be able to recognize them? Flashover simulators like the one my department acquired are an excellent way to train firefighters in safe, yet realistic conditions.

A flashover simulator works like a split-level room, with an upper level for the flashover to occur and a lower level in which firefighters can observe the conditions of the upper level. On the top level, plywood panels used for the fire load are inserted on the walls and ceiling. Then a 55-gallon drum stuffed with wood scraps is set up as a burn barrel to help get the fire started. Once everything is set up, the firefighters and instructor(s) crawl into positions on the floor of the lower level. They watch as the smoke builds and banks down to the level of the floor of the upper container. They can observe the conditions of a flashover begin to develop, as "snaking" of flames begins to stream out into the smoke. Then a small air vent on top of the flashover simulator is opened, and almost instantly, the smoke above the firefighters turns to flames.

To control the flames in our simulator, we use a pre-connect with a fog nozzle and apply three straight bursts from one side to the other, then reverse our pattern with three quick medium-sized fog bursts. At this point, we rotate and watch the whole thing again until each member has taken a turn on the hoseline. This gives everyone a chance to watch a flashover take place several times, become familiar with the indicators of flashover and learn how just a little bit of water, with effective nozzle tactics, can cool the atmosphere.

Firefighters get to see how smoke builds and stratifies, and how it banks down and out when it has no place to go inside a compartment. They get to feel a bit of the heat associated with a flashover and see how untenable conditions are in a room that's flashed over, making search-and-rescue operations pointless. Finally, they get to learn how, with just a small amount of water from a hoseline, they can change the conditions and cool down the atmosphere without creating a disruption of the thermal balance in the room.

I'm sure some of you reading this article are thinking, "This sounds great, but my department could never afford one of these props." But grant funding can help, and you may be able to pool resources with regional training centers, community colleges or state training agencies. You can also look into conferences where such classes are offered. Even a few times through a flashover simulator can provide invaluable experience.

Conclusion

Although a flashover simulator does not actually produce a "true" flashover, it can provide an excellent opportunity to teach and recognize the signs of an impending flashover and how to effectively prevent it, thus improving your chances of survival. Training combined with experience allows us to develop the skill sets and knowledge we need when we go to combat, keeping us from becoming another fatality statistic.

If nothing else, I hope you'll gain more knowledge about flashover and study the warning signs so that you know what to do if you ever find yourself in these dangerous conditions during a fire incident.



Instructor Assignments

5 Instructors are ideal for each evolution

Nozzle 1 Instructor;
Positioned at the front of the container operating the nozzle as instructed by the lead instructor

Vent 2 Instructors;
Staged in the container at the side doors to provide ventilation as requested by the Lead instructor

Lead 1 Instructor;
Will be position in the front of the container to address the students including the instructional teaching points.

Outside Safety 1 Instructor;
Will be outside safety, this instructor will address the “on Deck” crew and provide teaching points that will be associated with but not limited to:
-smoke (what this means during size-up)
-25 second drills in a “smoked: outside atmosphere”

Staging material for a total of Approx. 4 burn rotations

Logistics: Water

- Two water sources (hydrants are sufficient due to the low operating pressures)
- One hoseline from each water source to the flashover container (1 ¾)
 - Primary Hoseline
 - Back-up (RIT) Hoseline
- Hoselines will be equipped with low pressure (CFA Flashover) nozzles that will be stored in the CFA Flashover logistics “Box”
- Dumpster Hoseline will be placed on a separate water source for “overhaul” of the debris in the dumpster after each evolution.

Logistics: Material

- Chainsaw and fuel mix
- Two (2) burn barrels will be pre staged with approx. one (1) pallet of material cut to fit into barrel. One barrel will be utilized for each rotation.
- Six (6) sheets of wood-fiber board (found in flashover shed) will be utilized for each burn rotation as such:
 - (2) 1-Sheets per side of Burn Chamber
 - (3) Sheets for the ceiling of Burn Chamber
 - (1) Sheet cut to 51” & 45” for Doors of Burn Chamber
- *Shiny side down facing the fire*
- Numerous “wedge” style 2x4’s will be cut into sections to allow the wood fiber board to fit tight to the container by placing them under the chains. This allows less of a gap to prolong fuel consumption.

Logistics: Fuel

- The propane torch and striker can be found on a cart in the flashover shed
- *Note* the application of the torch usually takes direct contact to the barrel for approx. 3-5 minutes to assure the material has ignited.
- Once ignited the fuel source will be staged away from the flashover container
- Once the material starts to off gas and smoke starts to build the evolution will begin.



PPE & SCBA Inspections

- Structural Firefighting Protective Clothing Inspection will be compliant to NFPA 1581 Standard
- SCBA must PASS Operational Inspection
 - Instructors must ensure the proper Operation of the PASS device
 - SCBA Cylinder must be FULL

Staging PPE / Flashover Helmet Issue

- Explain the purpose of Issuing a Flashover Helmet and when it is to be Donned
 - Issued 1 per Recruit entering the Container
 - To be worn throughout the Skills Training
 - No Fire Department issued Helmet to worn
- Explain and demonstrate to the Recruits the proper method for staging the PPE prior to Practical Skills training.
 - Placing the gear in an organized and logical order will account for all required items / equipment.
 - Staging will help develop the order to which it should be donned.
 - Staging consistently improve donning speed.

Recruit Briefing

- Explain the Skill Station Rotations
 - Posted on Flashover Material Container
 - Or: _____
- Typical Rotation:
 - Squad 1 - Flashover Training
 - Squad 2 – Staging In full PPE)
 - Squad 3 – Clean Out & Reset
 - Recruits IN Box SCBA & Full PPE
 - Recruits OUT of Box Full PPE & Safety Glasses
- Explain the Seating Assignments when in Container
 - Further explanation will be conducted in the Container prior to Ignition
 - Rotating Seating Assignments During Flashover Training in the Box
- Explain the Procedures for an EMERGENCY
 - Follow Instructor(s) Commands
 - If Evacuation from Box
 - Squad Leaders are Responsible for PAR Check
 - PAR report to Lead Instructor
- Post Flashover Training
 - Exit Container and Count Off to Exterior Instructor
 - WITH GLOVED HAND
 - Doff Regulator
 - Allow Time to Cool
 - Doff Helmet & Hood



Teaching Points

The Instructors will start by discussing the progression of the fire through the growth stages as it relates to the building up to and encountering flashover.

The Instructor will discuss the smoke layering, color, velocity and how air flow will effect or hinder operations as it relates to flashover.

The Instructor will emphasize and use ventilation (via side doors) to manipulate the burns and rollover in the observation chamber throughout the evolution.

The Instructor will apply short burst amounts of water to cool down the atmosphere after each flashover to allow the group rotation. * Again very little water is used the fires are mainly controlled by the ventilation practices*

The amount of “flashovers” that will occur during each evolution will vary from weather conditions to material consumption, the Instructor should expect in the area of 3-6 “flashes” per evolution (could be more) the goal is to get as many as possible until the fuel burns out.

Reset and Rehab

Upon completion of the evolution (4) students will remain in full PPE and SCBA to assist in the overhaul of the debris from the container to the dumpster.

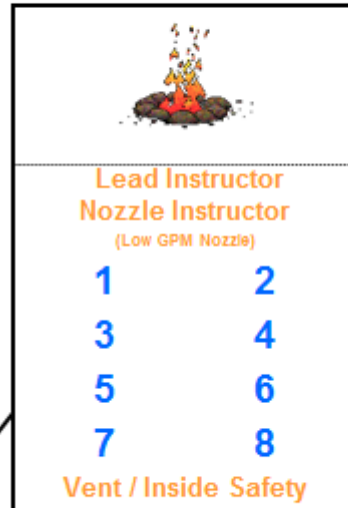
The Nozzle instructor will assure the fire is out by flushing out the burning material to allow other students to reset for the next evolution.

Upon completion of the Flashover training day all “flashover materials will be secured to the Flashover shed, all CFA Recruit materials will be secured in the mezzanine in the CFA firehouse.



Instructor Assignments

- Lead Instructor
- Nozzle Instructor
- Vent Instructor
- Inside Safety
- Outside Safety



Outside Safety



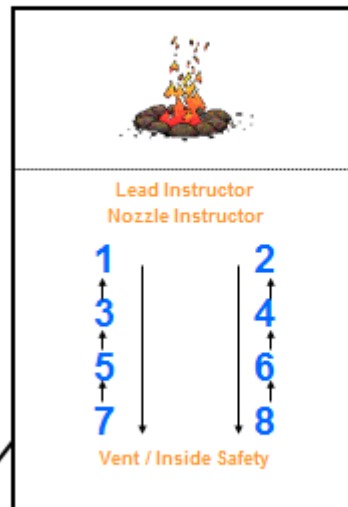
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Inside Seating Assignments

STUDENTS

- Numbers 1 through 8
- 1 & 2 Crawl to Back
- 3 & 4 Slide to Front
- 3 Instructors Inside
- 2 Rear Exit Doors

Rear Doors for Emergency Exit
 and Horizontal Ventilation



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