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Flashover - The Answers to Firetactics.com Quiz!

What is 'flashover'? There are so many different forms of 'flashover' related phenomena it can become confusing for the firefighter. We have grouped the various phenomena under the single heading - Rapid Fire Progress (RFP). These are all events that are **known KILLERS of firefighters!** It is essential for firefighters to know -

- What actions might CAUSE an event of RFP?
- What actions might PREVENT an event of RFP?

The types of RFP discussed here are all forms of Fire Gas Ignition (FGI)

- Hot Rich Flashover (Auto-ignition)
- Smoke Explosion
- Flash-fire
- Backdraft
- Progressive Flashover

What firefighting actions might lead to an event of RFP?

- Incorrect location of vent opening
- Mistimed vent opening
- Inappropriate vent opening
- Inappropriate entry point/procedure for gaining access to structure
- Creating vent openings without confining the fire or laying a charged primary attack hose-line
- Delay in getting water on the fire or into the gas layers

The actions that can be taken by Firefighters to counter or prevent RFP are;

- 3D Tactical Door Entry Procedure
- Confine the fire to room of origin (close doors)
- Get sufficient water on the fire as quickly as possible
- Get water into the gas layers as quickly as possible
- Tactical Ventilation (under strict protocols)
- Anti-ventilation

Answers below [or in PDF format HERE](#) 

1. THE DOOR ENTRY

When a fire is enclosed it often produces large amounts of heat and combustion products in smoke, through the pyrolysis process. That is, all fuel surfaces, walls and ceilings are giving off highly flammable gases that accumulate in smoke. As firefighters gain entry, the fire can be seen igniting just outside the door in the first picture as the superheated smoke is mixed with air. This event is termed

The Firefighter

“It is not the critic who counts, not the man who points out how the strong man stumbled, or where the doer of deeds could have done them better. The credit belongs to the man who is actually in the arena;

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'auto-ignition'. The fire then burns back into the point of entry and under the right conditions there may be sustained burning. This rapid fire development is likened to that of a 'flashover'. However, it is not an interior heat induced development of fire, but rather an event that initiates outside the fire compartment itself - it falls under the heading of 'Fire Gas Ignition'.

How can we prevent this situation? A 3D door entry procedure that entails pulsing water droplets in through the door crack, prior to opening the door fully. This takes a few short seconds but often prevents such ignitions from occurring.

2. THE WINDOW ENTRY



Again, what we have here is generally auto-ignition of superheated fire gases as they exit from the window opening. However, if this is delayed due to insufficient heat in the smoke, an inflow of air into the window may occur with an exchange of hot black smoke (top of window) for air (lower part of window).

This may result in a situation where the fire is developing faster than heat can be released from the opening. We call this 'thermal runaway'. In effect, a 'flashover' will occur as the build up of fire gases within the room ignite.



3. THE SMOKE LAYER

What we are seeing here is actually two events. As the air flows into the door as it is opened, we see either some auto-ignition or a minor backdraft from the room itself. This causes the layer of smoke existing at the ceiling to ignite in a 'flash fire'. This is a smoke 'explosion' but without severe pressure. It will not damage structural elements and will not likely sustain its burning. If were to place an ignition source of sufficient energy, possibly a burning ember, into the smoke layer above our heads prior to opening the door we might possibly get the same result under the right conditions, although in a simulator it is not likely. These events are all forms of Fire Gas Ignition and not flashover.



4. THE 'HIDDEN' FIRE

The lifting of the mattress, or the cutting into a smoldering sofa, allows air to mix with the rich fire gases inside/under the furniture. This may bring a sudden ignition of the gases as



they mix with air as they enter the flammable range.

What might be worse is if the fire gases have smoldered into a flammable pre-mix in the room itself. The conditions may be light, hazy and cool but the pre-mix may be ideal! As the initial fire development in the furniture occurs it reaches the room's pre-mixed gases and Whoompf!



The ignition may be brief, in the form of a flash-fire; or destructive, in the form of a smoke explosion, depending on the levels of pre-mix. You are bringing hidden fire into the pre-mix itself.

Pre-ventilation before revealing hidden fire is needed in this case.

4a - A recent (August 2007) quote by a County Fire Marshal investigating the LODD of two California firefighters

"A smoke explosion happens when a large buildup of smoke becomes very hot inside a room, and the whole cloud ignites all at one time," said the County Fire Marshal. "A flashover is pretty much the same thing without smoke."

But is this statement true? Well not exactly. The fact it was made as a way of explaining to the media, in simple terms, the differences between 'flashover' and 'smoke explosion' is acknowledged, but from a firefighter's point of view here are some important points to be aware of

- A 'smoke explosion' can also involve **cold smoke**
- A smoke explosion involves a contained layer of flammable smoke already existing within its limits of flammability
- *All that is needed is an **ignition source***
- A rich-mix of superheated fire gases in smoke may **'auto-ignite'**
- *All that is needed in this case is **air** - this is not truly reflective of a smoke explosion*
- A smoke 'explosion' usually causes structural damage caused by pressure waves whereas the lesser event, termed 'flash-fire' does not
- When a flashover occurs, there is generally plenty of smoke accompanying it

What is the relevancy? Well it is relevant to **firefighting actions** because if firefighters are creating openings that allows air in to feed the fire at the time of the rapid fire development, then it is the venting action that might initiate the RFP. If however the action of firefighters was to a) uncover an ignition source by disturbing debris; or b) 'push' a flaming ember up into a flammable smoke layer through inappropriate use of a fog nozzle (for example) or a PPV fan (another example), then a smoke explosion or flash-fire may result.

The countering actions to avoid each event are -

- A super-heated fuel rich smoke layer needs cooling before venting
- A heavy pre-mix layer of smoke with a suppressed fire needs removing (tactical venting) before overhaul, or disturbing hot spots

5. UNPLANNED VENTILATION

Firefighters arrive to see smoke issuing from the upper floor bedroom window. They attempt to advance a hose-line into the structure from this vantage point using ladder access, but fail to notice the heavily stained black windows on the first (ground) floor level.

Suddenly, the windows on the first (ground) floor break through the heat and smoke turns instantly into flame what occurred? How can we prevent this?



It is always important to check windows around a structure during the 360 deg. size-up. Look for signs of blackening; crazing in the glass; are they hot to touch? So much valuable information can be gained here. We must apply correct and safe **3D door entry procedure** at the fire floor (as 1 above) to counter such an ignition. The windows break air flows in most probably an auto-ignition Fire Gas Ignition (FGI) as the hot rich fire gases ignite and burn back into the compartment for sustained burning.

6. LARGE VOLUME STRUCTURES

Firefighters arrive on-scene to a commercial or large volume industrial or storage building showing fire in the rear. They make entry through the front but the fire has access to an abundance of fuel and air, and the fire continues to develop in size so rapidly that it escalates beyond the flow-rate available at the nozzle/s and chases them out of the structure just a few short minutes after gaining entry.



What might cause this sudden development of fire? Can flashover occur in such a large volume area?

The fire dynamics associated with normally accepted definitions of 'flashover' preclude such an event from occurring in high-ceiling, large volume structures. What normally occurs here is an accumulation of flammable combustion products and fire gases in the smoke at ceiling level. This smoke may be collecting in a flammable reservoir and may be visible or hidden in a ceiling attic space.

When this layer of smoke enters the flammable range, either from the lean side or the rich side, and sufficient fire or heat energy reaches the smoke layer, a fast developing escalation of flaming combustion will spread across the ceiling. The heat flux radiating downwards will eventually ignite fuel sources at the lower level. This ignition of high level fire gases will most likely occur very quickly, possibly faster than a firefighter can run, and will be preceded by a layer of thick black smoke hitting the floor and reducing visibility to zero. The most intense areas of burning may be at walls as the gases deflect downwards with some high velocity and force, similar to a flame thrower effect. Some have referred to this form of event as a 'progressive' flashover. It can equally be argued that this is a form of flash-fire, as described at 3 above, where the smoke layer is igniting - a Fire Gas Ignition.

7. BACKDRAFT OR SMOKE EXPLOSION?

Again, using images from a 3D Firefighting CFBT simulator (below), what event occurs here when the fire is allowed to smolder for several minutes inside the simulator, before opening a window hatch to allow air to enter and smoke to escape. Is this a backdraft? A smoke explosion? What is the difference between this and the door entry at 1 above?



How can we prevent or reduce the chances of such an event from occurring?

The ignition you see above is a backdraft. It clearly demonstrates an ignition that originates inside the fire compartment several seconds after creating an opening. In some cases the ignition is delayed and several minutes might actually pass before the backdraft occurs. The ignition inside the compartment forces a large volume of unburned gases outside where they instantly ignite on meeting and mixing with air. This type of ignition may occur under varying proportions of gaseous pre-mix with air. The percentages in the pre-mix will affect the likelihood of severe structural damage.

Unlike the backdraft, a smoke explosion occurs where heat or flame energy is introduced into an ideal pre-mix of combustion products and fire gases, whereas the backdraft is initiated by air being admitted into a non-ideal pre-mix of gases and combustion products, but bringing it within the ideal range of flammability.

In both cases, recognition of the hazards and effective tactical ventilation procedures may assist. Effective zoning of compartments is another strategy used by firefighters trained in 3D tactics in an attempt to deal with such situations.



8. ROLLOVER

Here (above) our students are observing fire development in a training simulator. At this stage they are witnessing tongues of flame detaching themselves from the fire plume as it deflects off the ceiling and heads off along ceiling, over their heads. This detachment of flames in the overhead, also known as fire 'snakes' or 'dancing angels' is typical of the Rollover effect and heralds the onset of 'flashover'. It is at this stage that firefighters need to be taking countering, defensive actions or considering moving quickly out of the compartment to a place of safety.

If the fire is unshielded a direct hit at the base of the flames will gain some knock-down. The gaseous phase at the ceiling may still remain

dormant and should also be dealt with. If the fire's base is shielded then the gaseous fire development should be approached directly, using 3D water-fog applications, penciling and surface 'painting' to cool the wall linings.

9. THE OSCEOLA 'FLASHOVER'

Two firefighters were killed in this training burn in an acquired structure in Florida when an event of RFP occurred. Subsequent investigations by NIST, which included computer fire modeling and full-scale test burns, suggested that amongst several influencing factors, the most relevant to the 'Flashover' that occurred was potentially the venting of a window (shown below).



As the window was vented the attack team were reportedly just beginning to apply water into the fire room from a position located in the hallway outside. Inside the fire room were two firefighters carrying out search and rescue tasks, ahead of the hose-line. As the window was taken, white smoke quickly turned to gray smoke and within ten seconds there appeared dark black smoke issuing under heavy volume and increasing in velocity. At 29 seconds after venting, a flame can be seen at the lower right of the window, initiating from inside the room. The picture above is taken at 30 seconds following the venting action.

The RFP event seemed to manifest itself from an interior rich mix of fire gases being brought into their flammable range by large amounts of air entering the window. The ignition may have initiated from the original fire that reportedly had most likely subsided into an 'under-ventilated' state. It may also have been an auto-ignition within the room itself. The term (hot-rich) 'flashover' might be used to describe this event although 'thermal runaway' must also be considered a possibility, where the fire was creating energy (heat) faster than the heat could be released from the window. Interior conditions prior to venting were reported as extremely hot with near zero visibility at the hallway outside the room.

[See the VIDEO of the Osceola Training Burn **HERE**](#)

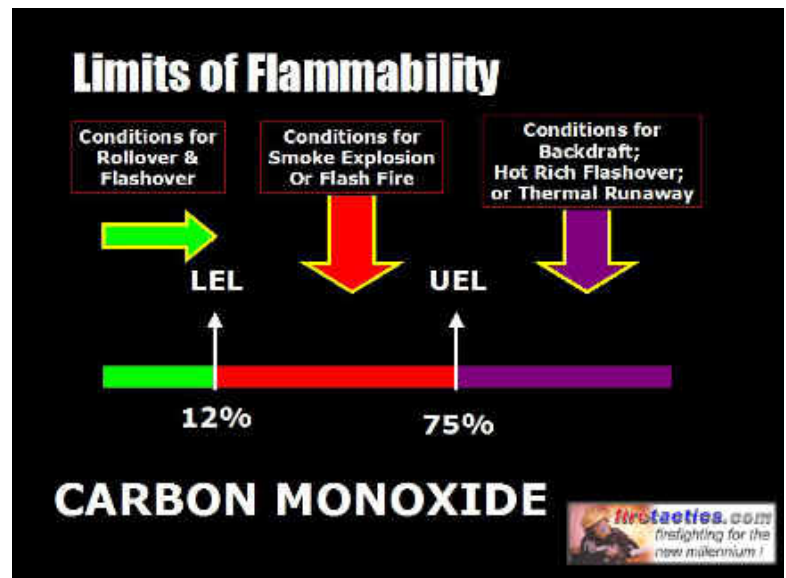
10. 'SEA OF FLAMES'

It moves lazily as if in slow motion hanging just a few feet above your head what is it? What are the dangers here? This is rich-mix gas layer that is igniting along the smoke interface where the air meets the smoke. The smoke is dark and hot and hanging at the ceiling. The air is feeding in from behind you, where the entry point is. As the gases ignite the flaming combustion appears as if in slow-motion to roll gently across the ceiling.



This event is rarely seen and looks almost harmless, but beware! Above that glistening 'sea of flames' lay a deep rich mixed super-heated gas layer. Anything that might disrupt it, such as a sudden gust of wind, a misplaced fog stream, or a PPV air-flow, might serve to stir the gas/air mix up and cause a sudden escalation in the gaseous-phase fire. A couple of brief bursts of a well-placed 3D fog pattern will knock this burning gas layer back and maintain the thermal balance.

Example of how the 'Limits of Flammability' of fire gases (CO is used just as an example of many) may influence the Fire Gas Ignition (FGI) - an event of Rapid Fire Progress (RFP) (Below) (Note: at fire temperatures, the LEL (Lower Explosive Limits) and UEL (Upper Explosive Limits) widen further still!).



- Flashover Information [HERE](#)
- Flashover - A Firefighter's Nightmare [HERE](#)
- Fire Gas Ignitions [HERE](#)
- Forced Draft (Draught) Fires [HERE](#)
- Flashover 'Pathways' [HERE](#)
- Smoke Explosions [HERE](#)
- Backdraft [HERE](#)
- Rapid Fire Progress [HERE](#)
- Tactical Objectives [HERE](#)
- Exterior/Interior Temperature Differences [HERE](#)
- 'Confusing' Definitions of Flashover [HERE](#)
- Flashover - Kennedy (Excellent Review) [HERE](#)



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