STANDARD OPERATING GUIDELINE

SOG4242/2006/10
EXTREME FIRE BEHAVIOR

Date: 31 March 2006

Issue 1

Warning: It should be made clear that the techniques and methods used to improve critical tasking capability presented throughout the SOG4242/2006 document require extensive practical training by qualified Fire2000 instructors and any attempt to follow this style of firefighting without such training may be ineffective and potentially dangerous

The UK has around 112,000 structure fires every year and approximately 50 of these demonstrate 'backdrafts'. However, around 600 of these fires demonstrate other unknown events associated with abnormal rapid fire development; that's once every 187 fires!

In the USA over 50 firefighters were killed by rapid fire progress between 1990 and 2000. A further 50 died through related phenomena. The death rate is increasing annually.

The purpose of SOG4242/2006 is to provide a series of tactical operating guidelines that will enable limited staffed crews to deal with small scale structural fires (up to two storeys) safely and effectively. Identifying and managing risk are the key aims of this ten document SOG. 'Rapid Response'; 'Quick Hit' & 'Fast Attack' strategies are encouraged.

The tactical approaches are based upon the Critical Task Performance Index (CTPI) and recognise that at least 12-14 firefighters are required on-scene to achieve an optimum grading in the CTPI. Targeted training may increase performance & safety of limited staffed crews.

- SOG4242/1 Incident Action Guide (IAG)
- SOG4242/2 Critical Tasking & Decision Making
- SOG4242/3 Fast Attack (Quick Hit) Tactics
- SOG4242/4 Primary Attack Line Tactical Applications
- SOG4242/5 Tactical Ventilation Methods & PPV
- SOG4242/6 Exterior Fire Attacks
- SOG4242/7 'Take the Fire First' - Snatch Rescues without Water
- SOG4242/8 OSHA; NFPA & Other Local Standards & Their Interpretations
- SOG4242/9 Zone Control Concepts
- SOG4242/10 Flashover & other Extreme Fire Phenomena

Fire2000

STANDARD OPERATING GUIDELINE

STANDARD OPERATING GUIDELINES (SOG) FOR LIMITED STAFFED STRUCTURAL FIRE RESPONSE

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3D FIREFIGHTING

Rapid Response
Fast Attack Tactics

STANDARD OPERATING GUIDELINE SOG4242/2006

Extreme Fire Behavior

Flashover, Backdraft & Fire Gas Ignitions

There are many conflicts between internationally accepted definitions of the various events associated with rapid fire phenomena. According to scientific definitions it is arguable that the various events can be attributed to either flashover; backdraft or a range of differing ignitions of the fire gases.

It is confusing for firefighters to attempt to differentiate between the various events. Whilst it is useful to have a basic understanding of each event, the firefighter should concentrate more on event causes, outcomes and counters (actions to prevent or suppress rapid fire development).

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Rapid Fire Phenomena - Three Basic Types

Flashover

Flashover is generally a heat induced development of a compartment fire although added ventilation may also speed up the flashover process. The breaking of a window or the opening of a door can initiate a flashover.

Backdraft

Backdraft is an event that may occur where a fire has been under ventilated for some period and is not receiving enough air to develop naturally. Any sudden inflow of air may initiate the event.

Fire Gas Ignition

The term 'Fire Gas Ignition' covers a wide range of rapid fire phenomena where accumulations of fire gases and smoke are transported towards an ignition source, or where high energy heat is added to a gas pre-mix.

Learning Outcomes:

1	Extreme Fire Phenomena - Types of Event
2	Hazard Recognition & Warning Indicators
3	Possible Effects of Tactical Venting Actions
4	Countering Actions used to Reduce Risks
5	What might Happen?
6	What Tactical Actions might Cause an Event?
7	What can be Done to Prevent or Alleviate Events

Special points of interest:

- *Scientific definitions of events demonstrate there may be confusing crossovers from a practical firefighting viewpoint*
- *It is important to appreciate the wide range of events that may occur*
- *However, the firefighter needs to know basics - What might happen? - What actions might cause an event? - What can be done to prevent or alleviate an event?*

Hazard Recognition & Warning Indicators

It is a stark fact that firefighters may be taught about the hazard warning signs and fire behavior indicators of potential events associated with rapid development, but rarely do they observe or act on these warnings at real fires! This failing has often cost multiple firefighters their lives.

It is common for compartment & structural fires to demonstrate 'classic warning' signs for the potential of an event but rarely do they actually progress to flashover, backdraft or some form of fire gas ignition.

This makes firefighters somewhat complacent and rarely do they communicate what they have seen to the Incident Commander.

It is absolutely essential that any such warning signs or fire behavior indicators are immediately communicated to the IC and where possible, an immediate action/s should be taken to alleviate conditions whilst the building is evacuated. Rapid Intervention Teams on standby and sector/safety officers should also be made aware of such indicators.

If classic warning signs are observed and any immediate tactical action taken to counter such a situation are ineffective, a defensive firefighting approach should be implemented until conditions improve and warning signs disappear.

It should be noted at this point that in some instances, there may be no warning signs whatsoever of an impending event of rapid fire development. Some events simply just happen without warning! Further still, some events may occur some way into the firefighting operation, even when general fire conditions appear to be improving.

The above 'gravity current' where smoke is seen to be exiting a doorway at high velocity can be taken as a clear warning of a fire that may be heading towards an event of uncontrolled rapid fire development. Entry into such an incident is highly dangerous.

Classic Warning Signs of an Impending Event

- High velocity smoke exiting a doorway or window
- A sudden change in colour of smoke, particularly darkening
- A sudden change in heat conditions, forcing crews to crouch low
- A sudden lowering of the smoke layer
- A repeated rising & lowering cycle in the smoke layer
- Pulsing smoke or smoke seen pushing out of openings, appearing under pressure
- Heavily smoke stained or cracked window glass
- Blue flames seen at the fire's bas, in the overhead or at exit points
- Flames seen in the overhead, possibly as fire'snakes' detaching themselves from the main fire
- Brief bursts of flame seen in the gases

The feeling or sound of air rushing in to feed the fire, or the reversal of smoke , causing it to head back into an opening

Flashover or Backdraft?

The basic scientific definitions of flashover or backdraft suggest that flashover is primarily 'heat induced' whilst backdraft is 'ventilation induced'. However, it is also scientifically documented that an inflow of air/oxygen into an under ventilated fire compartment can cause a situation leading to 'thermal runaway'.

This is where ventilation (intentional or as a result of fire development) causes an increase in the burning rate but allows the temperature to increase in the compartment as the vent opening is not large enough to allow sufficient heat to escape. As more heat is being generated by the air inflow feeding the fire than can escape from the opening, a flashover may result.

Therefore it can be seen that it is sometimes very hard to differentiate between a flashover or a backdraft.

Smoke Explosion, Backdraft or Fire Gas Ignition?

It can be seen that there are several types of event that might lead to an ignition of the fire gases accumulating in different parts of the structure. These ignitions may sometimes be explosive but in other instances any such ignition might result in a slow rolling flame front or brief burst of flame pockets where the gas air mix is not uniform throughout the entire smoke layer.

A fire may cause smoke accumulations to build up in the fire compartment, in adjacent compartments and possibly in compartments or voids sited quite some way from the fire itself. If these gases are heated sufficiently they could auto-ignite on reaching air. If they are cool but already existing in a pre mixed state with air, any introduction to a flame source could ignite the gas accumulation, possibly explosively.

If a fire smoulders in a sofa, or underneath a mattress or rubbish bag, or perhaps down the back of a pile of foam backed carpet rolled up in a cupboard, the room or space containing the fire may become filled with highly flammable smoke. If the fire is uncovered, or disturbed, prior to clearing the smoke from the compartment, a violent explosion may occur. This type of event has resulted in the deaths and serious injuries of multiples of firefighters.

On occasions a flammable smoke layer will accumulate at high level in a large volume structure, or within a suspended ceiling. It's presence may not even be noticed by firefighters dealing with the base fire. If a burning ember floats on convection into the gas layer above, again an ignition of the smoke may occur.

If a fuel rich smoke layer exists at high level it can be forced to move in the direction of an air supply and fire source at a lower level. This could occur where a constant flow fog pattern is used that might push the gases around in the fire compartment. Or a ceiling might collapse, causing a large movement of gases to transport towards an ignition source. In either situation the gases may ignite.

In some instances it is arguable that an inflow of air is needed before a fire gas accumulation becomes ignitable and this might be defined as a backdraft. The major consideration in defining an event is to look at the **final** movement that caused the ignition - either air to fire; air to smoke; fire to smoke; smoke to fire; smoke to air.

Tactics used to Prevent or Counter Rapid Fire Development

The three main approaches that are commonly used to prevent or counter any potential for rapid fire development are -

- Tactical Ventilation & PPV
- Fire Confinement
- 3D Water-fog tactics

It is important to realise that although the first of these three options often assists our aims, it sometimes serves as the catalyst for such an event. If not applied correctly at the right location and at the right time, a tactical venting action may actually cause a fire to flashover or backdraft.

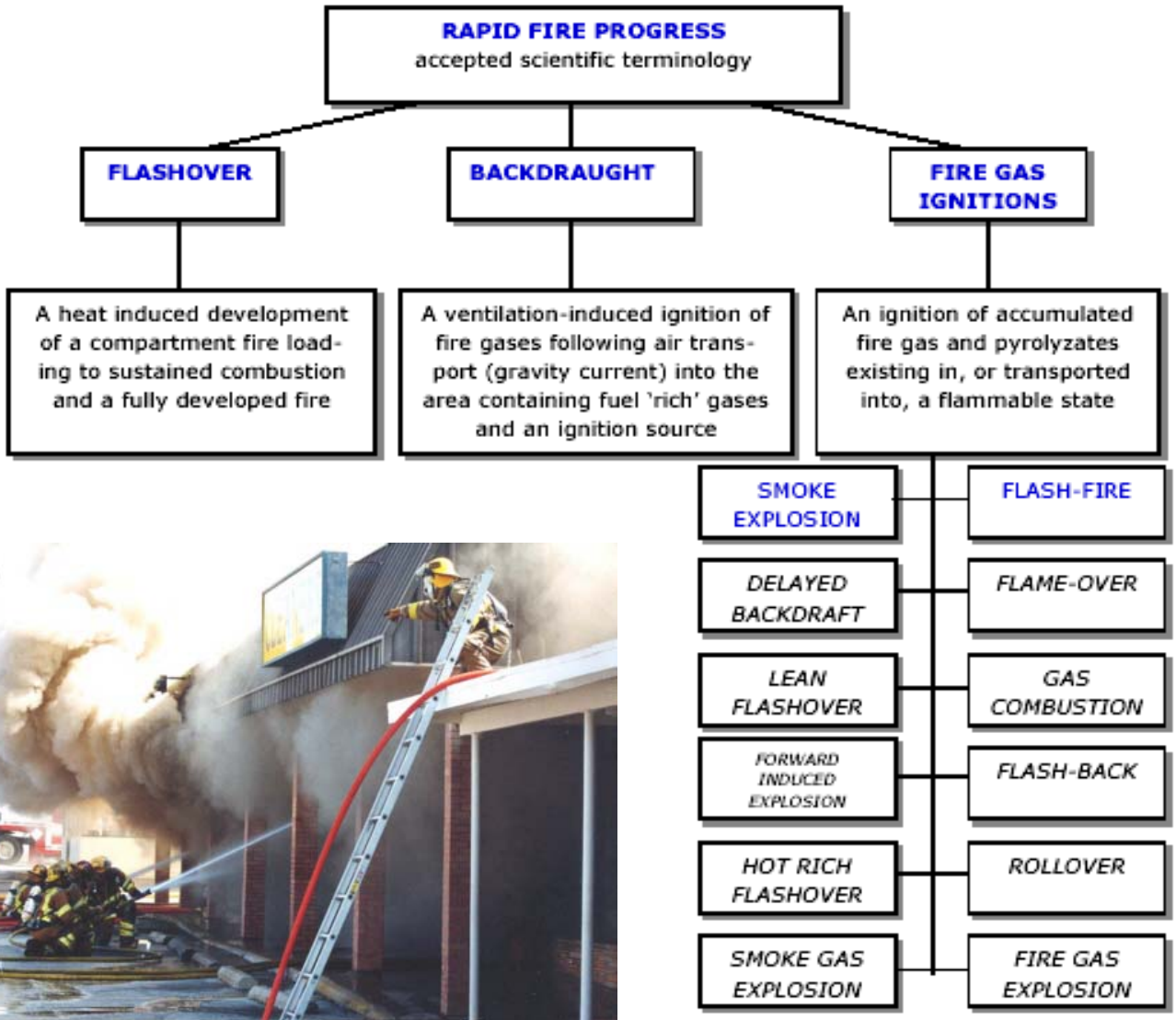
'Recognise the 3D hazard and use techniques that are effective on the 3D risk without upsetting thermal balance'

A constant-flow fog pattern may also serve to push fire gases around and upset thermal balance. Arguably, the most effective approach is normally to confine the fire wherever possible and practical and apply 'pulses' or 'bursts' of water fog into the 3D gas layers in a controlled manner, observing the effects after each application and adjusting the bursts to suit conditions.

White Smoke Explosions

A review of previous fire reports and experiences suggests that although smoke colour is often misleading as an indicator of an impending event of rapid fire development or extreme fire behavior, the existence of white smoke in any great amount may be taken as an additional indicator or warning sign.

There have been several fires where large quantities of white smoke were observed just prior to an event that killed multiples of firefighters. It is certain that wood products or wall panels will give off white smoke when heated and this smoke is highly flammable. If allowed to accumulate in a compartment the hazards of entering that compartment should be fully appreciated and addressed in the risk versus gain assessment.



'High Pressure' Backdrafts & Blowtorching Fires

Severe instances of rapid fire development are common in situations where an exterior wind is blowing into a fire compartment opening. It might be that smoke and heat is prevented from exiting a fire compartment by an external wind and this then accumulates inside the structure. This build-up of exterior air, smoke and fire gases actually causes internal pressures within the fire compartment to far exceed normally expected values.

A sudden decompression and resulting ignition may occur where an internal door is opened by firefighters making their approach on the fire. This ignition may be devastating and is termed 'high pressure backdraft'.

A slightly different effect may occur where a fire is subjected to a constant or gusting wind. Just as blowing on a barbecue increase the burning rate, an exterior wind will raise the heat release of a room fire. Such effects are particularly common in high rise buildings. If a window should fail whilst firefighters are occupying a compartment then the exterior wind blowing in might create a 'blowtorching' effect as the flames increase dramatically.

The dynamic pressures sometimes existing in stairshafts (natural stack effects) may actually cause windows to be 'sucked' inwards or 'blown' outwards within a few seconds of entering a compartment, allowing an exterior wind to create havoc on the fire floor! It is essential that Incident Commanders take the wind strength and direction into account when doing a 360° and selecting an entry point. If the wind is likely to create difficulties during advancement then always have it on tour back wherever possible. If it is not possible to select an entry point with the wind to your back then serious consideration might be given to a defensive attack on any particular fire.