SMOKE EXPLOSION

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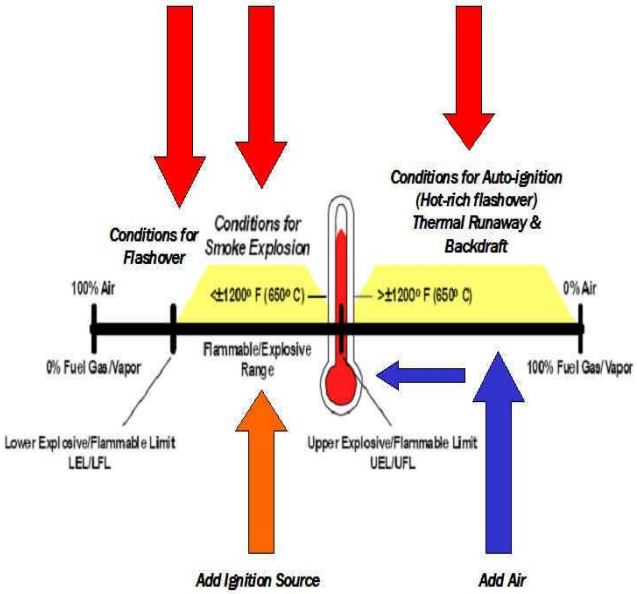
INTRODUCTION

The fire gas explosion concept is not defined in any ISO standard. This concept is, however, used in many countries and those definitions that exist are largely similar. One possible definition is given below: "When fire gases leak into an area adjacent to a burning compartment they can become well mixed with the air in that adjacent compartment. This mixture can fill all or part of the available volume and may be within appropriate flammable limits. If the mixture is ignited this may cause a large increase in pressure. This is called a fire gas explosion."



1. RAPID FIRE PROGRES

A fire gas explosion occurs without changing the status of any opening in the compartment. In order for backdraft to occur the ventilation conditions in the compartment must change during the development of the fire. Naturally, the boundary between the two concepts can at times be hazy.

Here are some important points to consider...

- 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
- Smoke explosions usually occur with smoke/gas/air pre-mix below 650^{o}C for if the temperature is higher than this (see chart) the gases will most likely auto ignite.

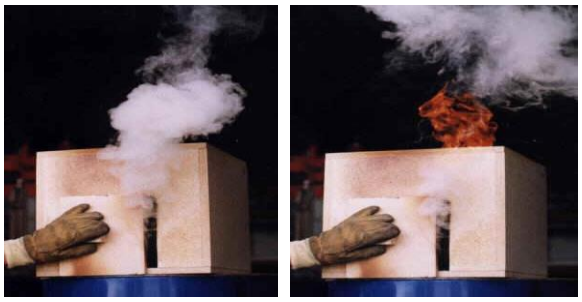
What is the relevancy? Well it is relevant to **firefighting actions** because if firefighters are creating openings that allows air in to feed the fire at the time of the rapid fire development, then it is the venting action that might initiate the Rapid Fire Progress. If however the action of firefighters 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 Positive Pressure Ventilation 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

John McDonough writes in "*3D Firefighting*" [1]- "When the temperature is too low to support flaming combustion, or when oxygen levels drop below 15%, the fuel package breaks down (pyrolysis) with out active flaming and most of the carbon remains on the material. This produces a lighter colored smoke. It is important to realise that as the fire develops, heat will be transferred to neighboring compartments, which can result in pyrolysis of the contents and an accumulating of white smoke, which contains a very high percentage of unburnt fuel. As a general guide; Lighter colored smoke often indicates that there is an accumulation of pyrolysis products due to increasing

compartment temperatures. This is often seen in rooms or spaces adjacent to the fire compartment…"



Photos courtesy of Wayne Atkins (Australia) - '3D Firefighting' (FPP/IFSTA) 2005

In his paper "*Smoke explosions*" [2], Sutherland reports how white/grey smoke was seen to precede experimental smoke explosions following a period of smouldering. He states on p.47 how grey smoke turns white during the transition period towards unstable conditions. "Smouldering is seen externally as the production of thick white smoke…" (p50) (refer to fig. 6.15). He also describes how grey smoke signalled stage 2 and white smoke stage 3 in the gradual progression to stage 4 (smoke explosion).

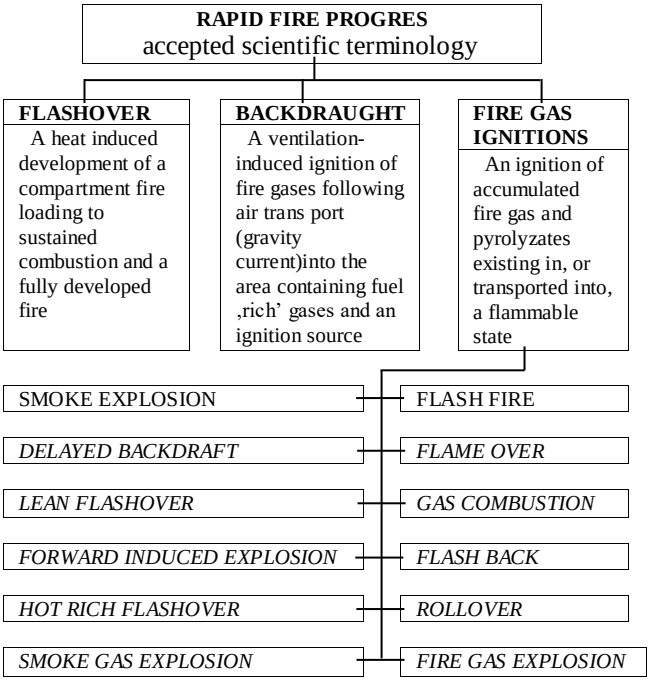
2. BRANDGASEXPLOSION

The term brandgasexplosion (Fire Gas Explosion) and it's associated definition does not account for the fact that 'smoke explosion' has existed for many years in the English language and has been used both practically by firefighters in the UK and USA and documented by scientists from 1975 at least. It is difficult to find the exact origin of the term, but is clear to see it is almost 100 years old and was originally used to describe an ignition of combustion products under circumstances similar to backdraft.

More recent scientific research has defined this term [3]. The most detailed paper by Sutherland (1999) clearly described the phenomenon of fire gases igniting with 'explosive' force. However, this paper also described other events where smoke (fire gases) may ignite without explosive force. There are references to earlier work by Croft (1980) and Wiekema (1984) who inform that high-pressure waves associated with ignitions of the gases (in excess of 5 kPa) may be termed 'explosions' and other such ignitions with minor pressure waves should be termed 'flash-fires'. Then there are auto-ignitions of the gases where they meet additional oxygen supplies at exit points etc. These cannot be termed 'explosions' but are more suited to 'ignitions' as a description of the stated event.

It is essential to differentiate the various phenomena here so that firefighters are able to gain a wider appreciation of slow rolling flame ignitions (more controllable) as opposed to the more dangerous and explosive situations associated with smoke explosion (take fire gas explosion).

In his own terms [1] and from the definition of fire gas ignition (1999) he associatively grouped a wide range of terms in use in recognized firefighting training texts under this heading, conveniently ensuring all such terminology is grouped under one of three headings as follows;



The three groups of Rapid Fire Development – *Tactical Firefighting* (CEMAC Belgium 2003) & *3D Firefighting* (FPP/IFSTA USA 2005)

Note: All terminology in *italic* is not scientifically approved or referenced.

Bibliography

1. Paul Grimwood, Ed Hartin, John McDonough and Shan Raffel. *3D Fire Fighting, First Edition, Fire Protection Publications (FPP), Oklahoma State University, 04/11/2005*

2. Sutherland BJ. *Smoke explosions. Fire Engineering Research Report 99/55, University of Canterbury NZ, 1999*

3. Grimwood P., Desmet K. *Tactical Firefighting, Version 1.1., Crisis & Emergency Management Centre, Belgium 2003, www.cemac.org, www.firetactics.com*

Recomandat spre publicare: 14.03.2008.