Fire Gas Ignition; Brandgasexplosion; Fire gas Explosion; 3D Firefighting; Terminology & Developments 2004

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My research and work over the past 30 years has always been at the cutting edge. As an operational firefighter serving out of some of the world's busiest fire stations I have followed a quest to provide that vital missing link between the excellent approaches being taken by members of the scientific fraternity, to enhance firefighter safety with their complex calculations and lengthy technical papers. It wasn't always easy! To transfer their message into 'firefighter speak' often took a great element of understanding and appreciation of the practical aspects of their thesis.

On occasions I worked tentatively to advance my own theories, gained through my own experiences at fires in London, New York and elsewhere, of things I had seen and done. I would sit and discuss these experiences with scientists who were most keen to put a physical explanation to some situation, or occurrence, never before documented through controlled laboratory research. In particular I worked to develop, since 1980, in the areas of fire-ground operations that I felt particularly uncomfortable with as a firefighter with limited knowledge. Was it correct to vent a roof or window, as I so often did in New York; or keep the fire under-ventilated with an element of 'control', as I was taught to in London? Was it more effective to apply water in direct flowing straight stream patterns as I was so used to doing in the South Bronx tenements in the mid 1970s, or were the emerging Swedish water-fog applications I utilized from 1984 onwards, in the west-end of London, offering a safer approach? Did Positive Pressure Ventilation truly hold the key to smoke clearance? Were there better ways to organize ourselves to fight fires on the upper floors of high-rise buildings? These were all aspects of firefighting that struck me early on, needed a little 'tweaking'!

As my own concepts evolved I invented terminology where it did not exist, and redefined some terms that had been misleadingly translated from Swedish into English, to describe methods and approaches that firefighters might make to improve safety and effectiveness at fires. I presented over 100 technical papers through the world's firefighting journals and as an international conference speaker, along with four books in six languages, between 1979 to 2004 explaining these approaches and definitions. In some cases my views were hotly disputed at the time by scientists and many operational fire officers who saw these approaches as 'new-wave' and against accepted 'tradition'. However, following the loss of several firefighter lives my initial concepts, and associated terminology, of Tactical Ventilation; 3D Firefighting and Rapid Fire Development, began to filter through in operational training texts and scientific research documents around the world. On occasions, some of these terms would become shrouded and somewhat lost in definition and misinterpretation.

In particular I would like to clarify some of these concepts, terms and definitions as they have evolved.

Fire Gas Ignition - It was the 1980s when I originally began to redefine some of the scientific terminology and practical definitions that were in clear conflict with each other. The generic use of the term 'flashover' by firefighters to describe all instances of rapid fire development was a clear indicator that firefighters, and in some situations scientists, were failing to grasp even a basic appreciation of the differences between 'backdraft' and 'flashover'.

In the 1990s it further became obvious that although the reported theories of Rosander & Giselsson presented scientific misinterpretations that caused some confusion when their Swedish terminology and definitions were translated to English, their actual views that there were other related phenomena of rapid fire development that firefighters urgently needed to become tactically aware of were correct.

In 1997 Bengtsson and Karlsson attempted to redefine the Swedish definitions to meet with international concerns over the emergence of conflicting terminology. This resulted in the terms - övertändning (flashover), backdraft (backdraft) and *brandgasexplosion* (translated as '*Smoke Gas Explosion*' but later in

1999 as '*Fire Gas Explosion*'). However, at the same time, in 1999, I published the term *'Fire Gas Ignition'* in six languages to amend Bengtsson and Karlsson's term and incomplete definition of '*brandgasexplosion*'. This became necessary, to group and describe a wide range of related scientific, and pseudo scientific, terms and definitions that had emerged and were being used internationally in scientific research papers and by firefighters worldwide. I had acknowledged and referred to previous documented and established scientific definitions in doing so. My introduction and definition of this term was later (2002) debated with, and agreed by, Dr Martin Thomas in the UK.

From Lund report 1019 Bengtsson states -

Definition of fire gas explosion

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."

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

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. 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 my own term & definition *fire gas ignition* (1999) I have grouped the association with wide-ranging 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;

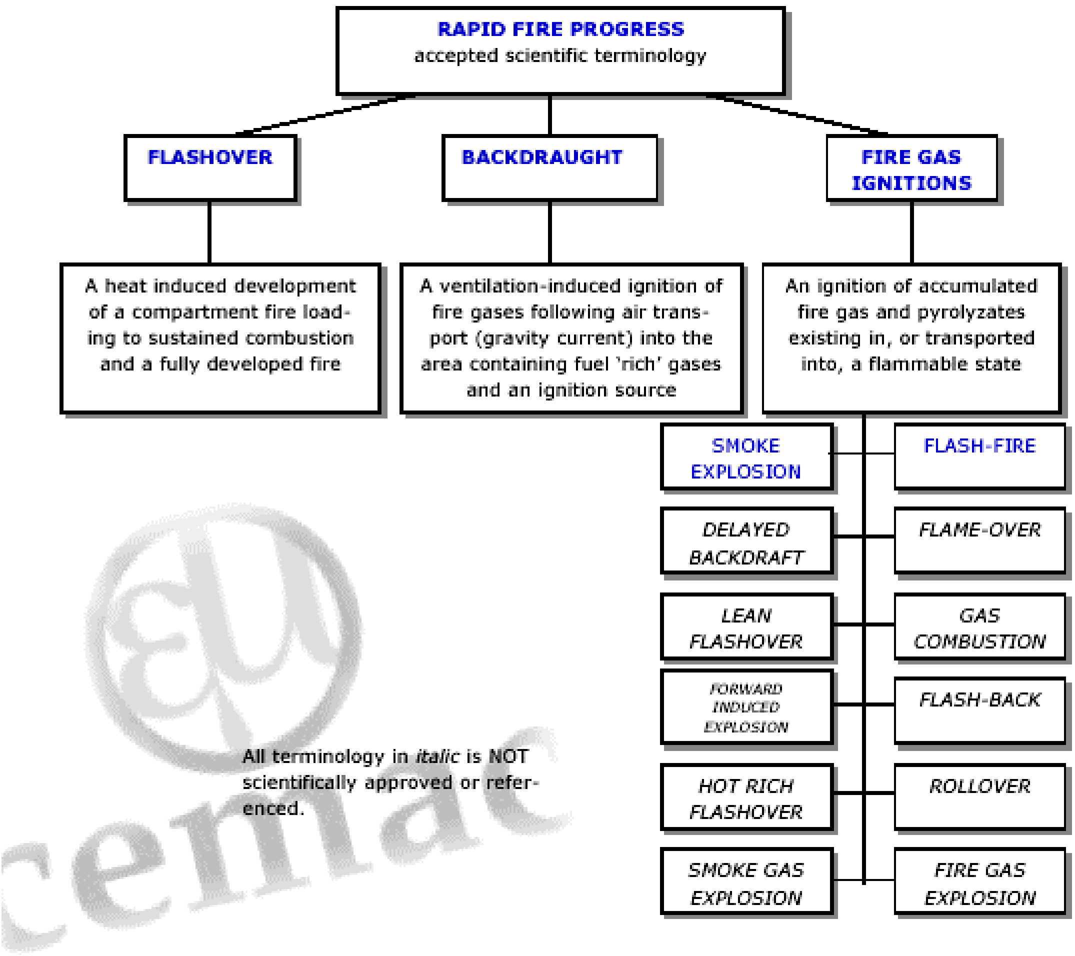

Fig.One - The three groups of Rapid Fire Development - *Tactical Firefighting* (CEMAC Belgium 2003) & *3D Firefighting* (FPP/IFSTA USA 2005)

3D Firefighting - My introduction of the term (3D Firefighting) and its associated definitions were a result of the confusing nature of the original Swedish translation of 'Offensive Firefighting'. Originally I used this term for some years but in during the mid 1990s became uncomfortable with the conflict between the use of this term and that of 'offensive firefighting' as used in the USA, and then increasingly in the UK, to describe *offensive* and *defensive* modes of attack.

I was also (1993 onwards) introducing the concepts of pulsing and bursting water-fog patterns that I had personally worked to develop operationally since 1984 to US firefighters. However, I was encountering much opposition due to their insistence on confusing the tactic with that of *indirect water-fog*, which had caused them some problems throughout the 1970s and 80s, almost to the point where they were opposed to any form of fire attack utilizing water-fog patterns. I therefore redefined the term as *3D Firefighting* (1999) and introduced the teaching concept of a *three-dimensional* approach to applying water-fog (in m3 - into the gaseous-phase combustion) as opposed to two dimensionally (as was normally the case in m2 - onto surface fires etc). This new approach most certainly aided the firefighter's appreciation of not only gaseous-phase firefighting concepts but also that of gaseous-phase combustion (ie; smoke burns)!

The definition of 3D Firefighting was therefore broadened to include not only *pulsing and bursting nozzle* firefighting techniques but also concepts associated with gaseous-phase combustion in the form of flashover, backdrafts and other fire gas ignitions. This teaching approach attempted to broaden a firefighter's tactical vision and coping mechanisms beyond traditionally accepted parameters which in turn, enhanced their views of other tactical practices, such as ventilation, PPV and CAFS when used in compartment fires. My original concepts and terminology associated with *3D Firefighting* have since found their way into NFPA (USA) training texts, dedicated NRC Canada Research reports as well as ODPM and UK fire training documents.

However, there was an enigma attached to 3D Firefighting and pulsing water-fog patterns that evolved from the training arena the Swedish firefighters had introduced. It was most easily conceived that the introduction of gaseous-phase firefighting (3D Firefighting) was initially taught through the steel shipping containers that were easily adapted for live fire training and economical and safe to run. However, firefighters became so adept at dealing with the 1MW 30m3 fire load and at ceiling temperatures around 600degC believed they were now able to utilize the gaseous-phase combustion with ease, sometimes with amazingly low flow-rates. This set a worrying precedent that began to filter through onto the fire-ground! Firefighters were now coming straight from the single 50m3 compartment training ground and tackling fires in larger fully involved compartments but using the same nozzle pulsing tactics! In London (and other parts of the UK) it was reported that firefighters were utilizing primary attack hose-lines against compartment fires with, in excess of, 1000m2 of fire involvement and complaining the nozzle pulsing techniques would not work on 'real fires'!

I was quick to point out that such firefighting tactics *when used offensively* were reserved for the smaller compartments, or situations up to 70m2 of fire involvement. Larger fires in larger enclosures demanded straight stream direct fire attack at two dimensional surface burning. Whilst it was essential that we provided our firefighters with the knowledge, training and equipment that would enable them to deal with three-dimensional gaseous-phase combustion up to its limitation, it was equally important that we didn't deceive ourselves into thinking this approach was the answer to every situation. In this respect, the recent ODPM research into high-rise firefighting have failed to acknowledge the limitations of 3D compartment firefighting tactics.

Tactical Ventilation - In 1984 I presented the first of a series of papers on venting practices by firefighters in the Fire Journals. I had a conflict going on in my mind as to the varied approaches I had experienced in the USA and the UK in terms of *opening up* or *closing down* of fire involved structures. My own experience and intuition told me that there were achievable benefits but also disadvantages in both approaches. In 1990 I introduced and defined my own concept of an internationally integrated approach entitled *Tactical Ventilation* -

> *'tactical venting is the venting or containment action by on-scene firefighters, used to gain tactical advantage during interior structural firefighting operations'.........*

Structural ventilation or fire isolation tactics? - two options that both offer major benefits to the firefighter. The choice in any situation is down to careful risk-assessment by balancing potential risks versus likely gains and applying an 'objectives' test. In some situations an early venting action relies heavily on adequate resources, equipment and manpower on-scene to ensure a safe and effective outcome. To be in a position to operate effectively there must be a pre-plan that is documented by SOPs and firefighters must have early and safe access to roofs, in the form of aerial appliances.

It has been pleasing to note the concepts of *tactical ventilation,* in part, have been adopted by the UK fire service, and several other fire authorities around the world who have followed the ODPM guidelines. However, there is still much to do in terms of ensuring clearer guidance of an integrated approach is produced for firefighters in what remains, a somewhat 'grey' area of firefighting operations.

Firefighting Flow-rates - It was 1989 when I turned my attention to fire-ground flow-rates. Here was an area that demonstrated much conflict and failed to produce what I saw then as reliable estimates of needed fire flows. There were several fire-ground formulae that had evolved but were unsuitable in that they were often derived from engineering design requirements (ie; more suited to fire protection needs) or were based upon fire-flow-rate when used in a specific way, ie; indirect attack (Iowa) or direct attack (NFA). I was searching for a general fire-ground method of estimating water requirements based upon practical experience.

My initial research was based on a 100 fire study, in London, whilst serving as a fire investigator in 1990. The fires were all working fires requiring assistance calls (additional engines) to complete suppression efforts. The study was broadened to include several large fires in the USA where reliable fire-ground flow-rates were derived. There appeared some interesting comparisons!

My research evolved to produce what I termed the *tactical flow-rate* -

....'In theoretical terms of simply meeting a critical rate of flow, Sardqvist (1999) reports that this does not offer the best use of resources, as it requires a more or less infinite time. An increase in the flow-rate above the critical value causes a decrease in the total volume of water required to control the fire. However, there exists an optimum flow giving the smallest total water volume. Above this flow, the total volume of water increases again. In practical terms however, a margin of safety, or error, must be designed into the application of any firefighting tactic and this includes methods of fire suppression and flow-rate. An increase in water flow will generally darken a fire quicker. However, there is an upper limit on flow-rate in terms of what is practical for any given size of fire, inline with the resources available on-scene during the early stages of primary attack. The tactical flow-rate is the target flow (lpm) for a primary attack hose-line/s. It is based upon extensive research and empirical data relating to firefighting flow-rates in several countries, including the USA. The tactical flow-rate in this concept is for fire suppression during the growth phases of development, or in post-flashover steady state enclosure fires before the decay-phase has been reached'....

My basic formula for calculating the tactical flow-rate needed for firefighting is -

A x 4 = LPM

Where A = area in m2 and '4' is based upon ordinary (office) fire load although this may be reduced to 2 for low hazard fire loads or increased to 6 for high hazard loads, or in situations where a fire has spread beyond the original compartment to involve structural elements. The formula is only reliable for estimating the *minimum primary attack hose-line requirements in fires up to 600m2*.

In 2004 I was most pleased that my original research was utilized by NZ Fire Engineer Cliff Barnett to amend previously documented *water efficiency factors* in his SFPE research that culminated in the NZ SFPE TP 1/2004 document into firefighting flow-rates - an internationally accepted project that serves to establish needed firefighting flow-rates.

This has resulted in new design concepts for fire protection and further serves to establish my research work as the most reliable and up-to-date in terms of establishing fire-ground methods of estimating water requirements for structural firefighting.

In Summary - Whilst it has often been frustrating that my demands for action were not met prior to many of my colleagues losing their lives, it has been pleasing that nearly all of my research has eventually benefited firefighters by improving their levels of safety and increasing their effectiveness on the fire-ground in some way or other.

Firetactics.com is now host to a network of tactical firefighting specialists serving several nations. Our work to advance and make knowledge freely available will continue, hopefully for many years to come.

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