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FIRE GROWTH & FLOW-RATE

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Issue 1

What is different about 3D Firefighting as opposed to traditional structural firefighting strategies? Quite simply it involves a 'culture change'. It demands greater attention is paid to the three-dimensional risk - the 'hidden dangers of smoke as it transports throughout a structure to lay in wait for firefighters. The real danger may exist in what you cannot see as opposed to what you can! The hazards of ‘flashover’; ‘backdraft’ and ‘smoke explosions’ are generally known but little understood by firefighters. The way a fire grows, develops and on occasions spreads so rapidly that firefighters become trapped or killed, is often taken for granted.

There is clear evidence that some fire commanders do not fully appreciate the practical aspects of fire behavior or understand the counter measures of tactical ventilation; or anti-ventilation (a strategy rarely documented in training manuals); 3D water-fog pulsing; or the safe deployment of firefighters under risk-based guidelines and principles.

Fire-ground commanders and company officers should adopt a greater appreciation of the when; how; why; and where to deploy; attack; ventilate or isolate fires and gain a more in-depth and practical understanding of what 'coordinating' fire attack with ventilation actually means.

- Power Laws
- Flow-rates
- Fire Intensity

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3D FIRE

3D FIREFIGHTING

This is a draft safety bulletin for discussion and peer review only

3D FIREFIGHTING SAFETY BULLETIN 4/2007

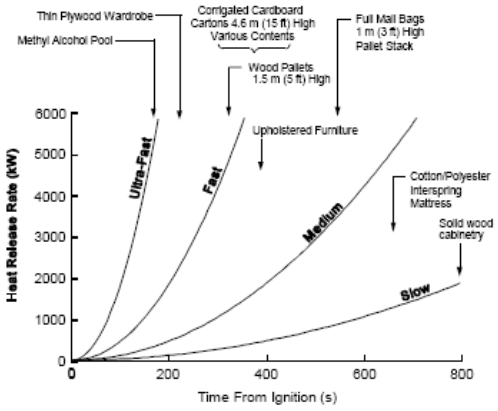
Fire Growth & Flow-rate

Fast Developing Fires; Flow-rate & Ventilation

If we take a look at the Power Laws related to fire growth and development we become aware that even average fires, of medium fire loads (offices and residential occupancies for example) existing between normal ventilation parameters within the confines of a compartmented space, are expected to double in size every 60 seconds where there is adequate amounts of fuel and air. In areas with higher fire loads or high velocity winds feeding in, the growth rate may well develop on a faster time/area gradient (doubling in size every 30 seconds) or even ultra-fast gradient (doubling every 16 seconds).

- Slow developing fires – Double in size every 120 seconds
- **Medium developing fires – Double in size every 60 seconds**
- Fast developing fires – Double in size every 30 seconds
- Ultra-fast developing fires – Double in size every 15 seconds

Placing these guidelines into a fire-ground perspective, where the fire load is excessive and the supply of air is plentiful, a large non-compartmented area involved in fire can **double in size every 15 seconds**. If this particular area is, for example, open-plan to 20,000 ft^2 (1,860 m2) and filled with 'fast burning' upholstered furniture, we might expect a fire involving 500 ft^2 (47m^2) to double in size every 30 seconds. Within a minute of committing firefighters inside the building, this average sized fire may have developed rapidly in area and intensity to involve over 1000ft^2 (nearly 100m2) of floor space! This fire may have developed so fast that it was already beyond the control and capability of a single 150 gpm (567 lpm) hose-line within 30 seconds of entry, or even two hose-lines in less than a minute!



Special points of interest:

- *Not every situation will benefit through the creation of ventilation openings*
- *A well-vented average fire load will approximately double in size every 60 seconds where adequate amounts of fuel and oxygen (air) become available*
- *The flow-rate in use must therefore far exceed that needed to deal with the potential fire load that might become involved before venting takes place*

Fire Development in Large Floor-space Buildings

Chief Vincent Dunn of the New York City Fire Department (FDNY) once said a single 2.5-inch (63mm) hose-line, flowing 300gpm (1,134lpm) through a 1.25-inch (32mm) nozzle could handle up to 2,500 ft2 (232 m2) of office space fire involvement.

- **Chief Dunn suggests 300gpm (1,134lpm) will deal with up to 2,500ft2 (232 m2) of fire**

Another interesting suggestion, based on research in the USA, by Chief Bill Peterson of the Plano Fire Department stated that when a compartment fire reaches 925 ft2 (86 m2) in size the interior fire attack stood a 50 percent chance of failing. Statistics demonstrate that only a very small number of fires progress to 1,000 ft2 (100 m2) or beyond.

- **Chief Peterson suggests 50% failure rate to control fire from the interior after fire size exceeds 925ft2 (86 m2)**

Paul Grimwood has undertaken his own extensive research into firefighting flow-rates over a twenty-year period and with the assistance of Cliff Barnett, a leading fire protection engineer with SFPE, compared firefighting flow-rates derived from various international research.

As an example, according to the **NFA flow formula**, a fire involving a floor area of 1000 ft2 would require two hose-lines (primary and back-up) each flowing at least 165gpm (1000/3 = 333gpm shared between two hose-lines).

The same example using the author's **metric formula** would approximate to a fire involving 100 m2 of floor area which would require an attack flow of 100 x 6 = 600lpm (a back-up hose-line of equal or higher flow is additionally recommended).

- **NFA Fire-flow Formula – Area ft2/3 = GPM**
- **Grimwood's Metric Formula – Area m2 x 6 = LPM**

The NFA method of calculating needed flow-rate is based upon an interior aggressive fire attack and the formula may become increasingly inaccurate where fire involvement percentages above 50% of large floor spaces might not offer any opportunity for such an approach. The accuracy of the NFA formula may therefore be questionable in compartments larger than 6000ft2 (560m2), demonstrating in excess of 50% fire involvement. The NFA approach to fire-ground flow-rate calculation is designed upon direct attack (fuel surface) applications in commercial structures, where the upper flow-rate does not exceed 1000gpm (3,780lpm) and the property is not over-sized. It is acknowledged by those who produced the formula, in its fire-ground format, that the NFA calculation provides more water for suppression than would be necessary if the building were to remain un-vented and tightly closed.

- **The NFA formula recognises that an aggressive interior attack has a probable upper limit in flow-rate of 1000gpm, or 50 percent involvement, before structural integrity is dangerously compromised (rule of thumb)**
- **However, large open-plan floor areas normally have roof trusses that may fail much earlier than where 50 percent structural involvement is reached.**
- **Where the fire is developing so fast that it outpaces the flow available at the nozzle then firefighter safety is clearly compromised.**