INFORMATION GUIDE

SOG4242/2006/11
3D WATER-FOG v STRAIGHT STREAM

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Warning: It should be made clear that the techniques and methods used to improve fire conditions presented throughout this 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

INFORMATION GUIDE

3D Firefighting offers a safe and effective means of securing the overhead during the entry & approach to a compartment fire—However it requires training by qualified & approved instructors

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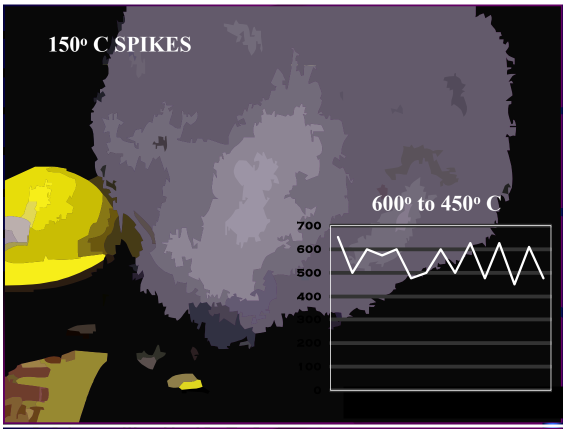
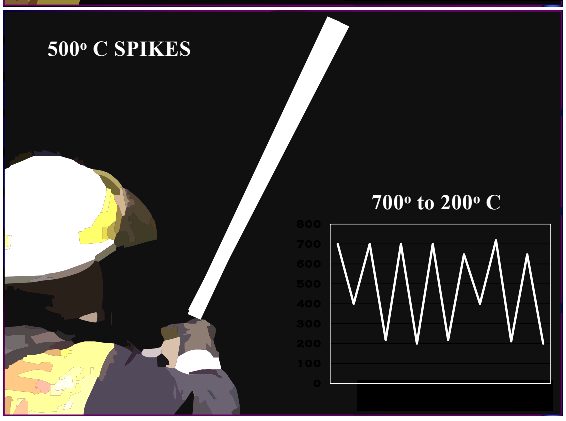
Bursting straight stream patterns into the overhead has been said to offer an effective tactic in controlling flashover conditions. However, is this approach as effective as bursting a 3D fog-pattern into the overhead? Not if you want to be sure that overhead is effectively secured!





- *3D water-fog will outperform a bursting straight stream in cooling the overhead*
- *The basis of these tactics can easily be taught in 15 minutes!*
- *3D water-fog tactics are not training intensive*
- *Steam expands at 1600-1 low down in the room but near the ceiling the expansion ratio may be as high as 5000-1*
- *Fire gases actually contract as they are cooled and this contraction will serve to counter the expansion of water vapour*
- *The humid environment created by a series of 3D nozzle bursts serves to 'inert' the overhead just prior to any venting action*

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3D FIREFIGHTING

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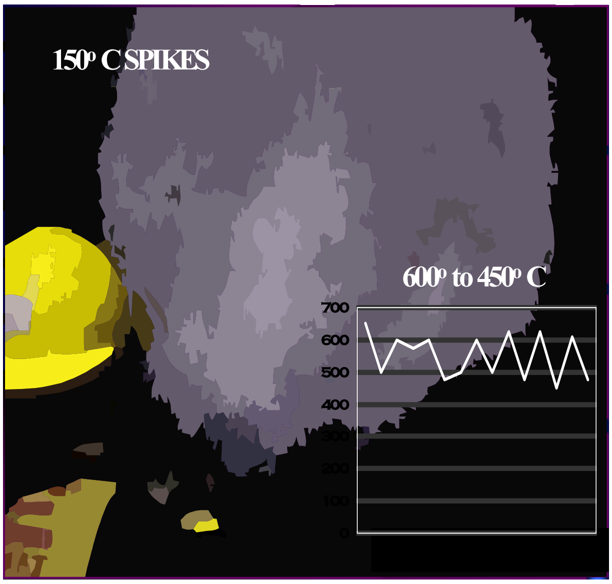
3D Water-Fog Tactics

3D Water-Fog versus Straight Stream Cooling

There is a common misconception that a series of short nozzle bursts from a straight stream pattern will cool super-heated fire gases in the overhead just as effectively as bursting or pulsing fog pattern.

It is a fact that this is not the case at all! Several scientific research projects have produced evidence to suggest that 3D pulsing fog patterns offer the most practical method of cooling gases in the overhead, whilst still maintaining the thermal balance in the compartment.



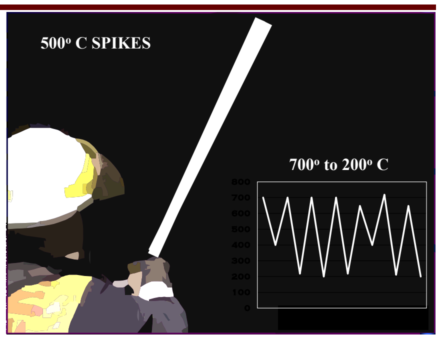
The computer aided graphic (right) of actual bursts of 3D water-fog show temperature spikes of 150° C as each one second burst at 360 LPM reaches the gases. The ceiling temperature in the overhead drops from 600 to 450° C on each burst and immediately rises again to the 600° C level. When compared to the spikes produced by one second bursts from a 360 LPM straight stream pattern (below) it can be seen that a larger series of 500° C spikes sees the temperature bouncing backwards and forwards between 700° C and 200° C.

Surely then the straight stream performs better? Read on!

Straight Stream Nozzle Bursts Create 500° C Spikes and Force Steam down on the Operator

Superheated Steam

Even though the straight stream pattern offers surprisingly greater cooling effects than the fog pattern above, the massive 500° C spikes force excessive amounts of super-heated steam down onto the nozzle operator. Greater control is needed in placing the water where it will have a more uniform effect in the overhead, producing a better cooling gradient. This is only possible with a pulsing 3D fog pattern.



Learning Outcomes:

1	Straight stream versus 3D Fog in cooling
2	Gaseous phase versus Fuel phase cooling
3	Avoiding Superheated Steam
4	Steam expansion versus fire gas contraction
5	Compartment cooling gradients
6	Typical temperatures in the overhead
7	How the spikes can upset thermal balance

Special points of interest:

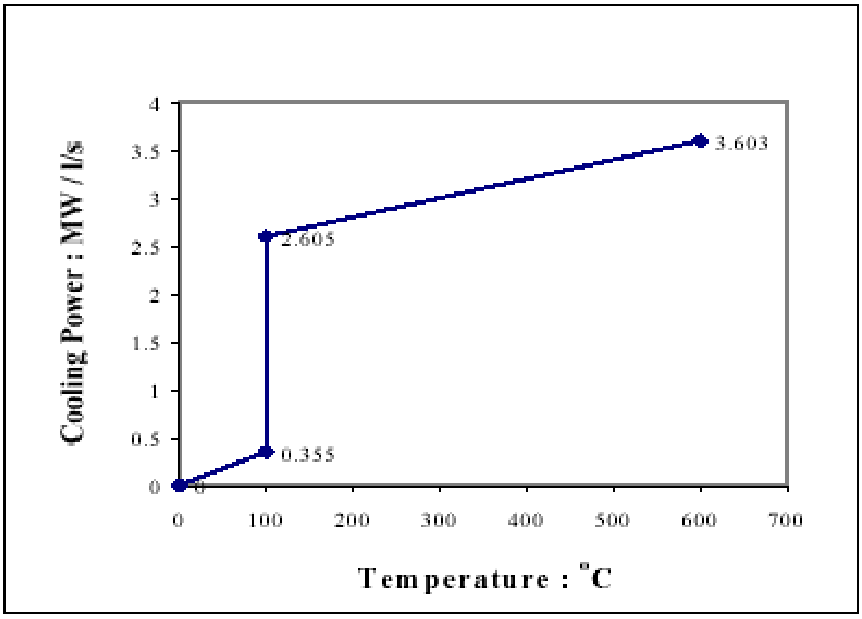
- *3D water-fog is NOT an alternative to direct attack using straight streams*
- *Appreciate at all times the objectives and limitations of 3D water-fog tactics*
- *Whilst the basics of nozzle pulsing can be taught to firefighters in just 15 minutes, more advanced compartment entry and approach tactics will take several hours training.*
- *3D Fog outperforms a straight stream when cooling the overhead.*

The Greatest Cooling Power of Water Exists at 100°C where Liquid turns to Vapour - Will it Cause problems?

The cooling power of water is approximately the same per degree in both a liquid or vapour state at around 4kJ/kg°C. In the diagram (right) it can be seen that 0.34MJ of heat is absorbed by water being heated from 18°C to 100°C. In it's vapour (gaseous) state approximately 0.8MJ of heat is absorbed from 100°C to 300°C. However, the massive cooling power of water during its transition from liquid to vapour phase at 100°C is around 2.3MJ.

As water strikes a hot surface it will absorb heat two dimensionally. If the heat is sufficient the water will turn to vapour at 100°C. However, any cooling after this stage occurs mainly in the gaseous phase (hot gases) as the water itself is three-dimensional, in its vapour phase.

Any problems associated with super-heated water vapour flashing down into the lower regions of a room depends on the amount of water used and the temperature of the gases.



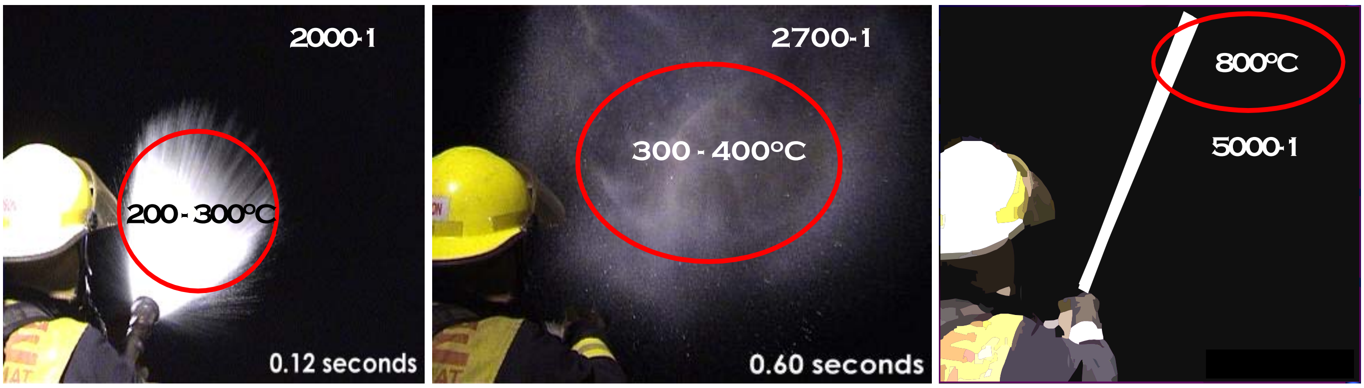
3D Water-fog Evaporates in the 300° C to 400° C Range as opposed to Straight Streams which Evaporate at the Ceiling!

- The greatest evaporation of a burst of water-fog droplets begins just after it leaves the nozzle
- The evaporation of a burst from a straight stream occurs nearest the ceiling as water in a solid cone is not easily evaporated until it strikes a surface and breaks down into smaller particles.
- If water droplets are too fine they will evaporate immediately on leaving the nozzle and this effect may be most uncomfortable for the nozzle operator!
- Where water droplets are too large, or are extreme in their velocity, they will penetrate higher in the compartment before evaporating fully at higher temperature

'Evaporation ratios at the ceiling are often in excess of 5000-1 causing super-heated steam to flash down'

- The ideal evaporation occurs with medium sized droplets in the 300-400° C range where steam expansion is around 2700-1 and easily countered by fire gas contraction.

Fine droplets evaporate too near the operator; Straight streams evaporate at the ceiling; Medium droplets evaporate at 350° C

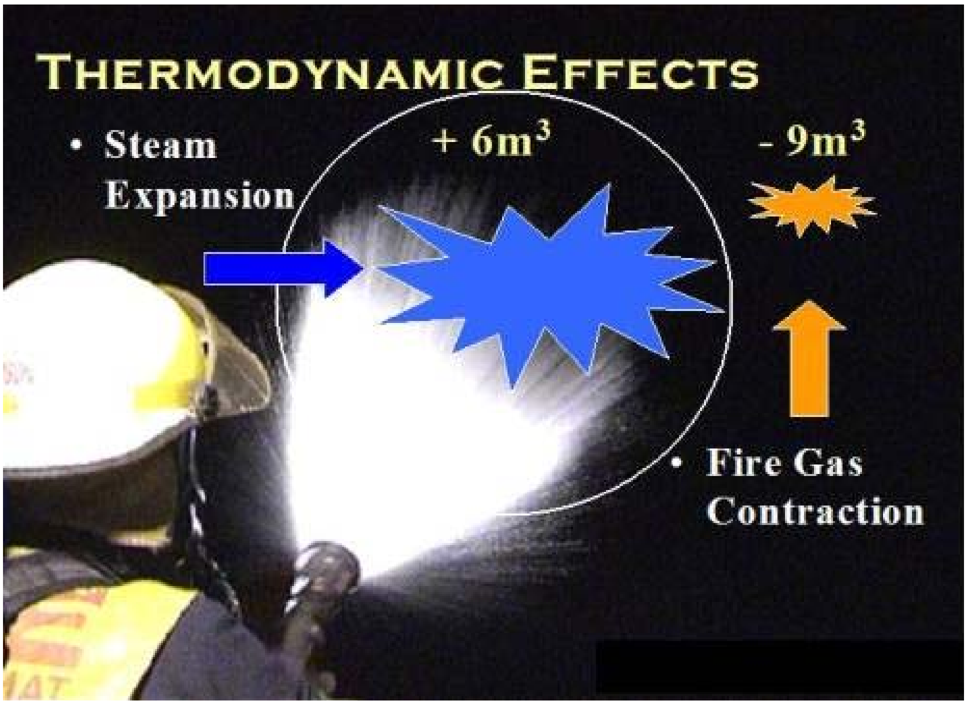


As Steam Expands within the 3-400° C Range the Contraction of Fire Gases is even Greater in the Overhead.

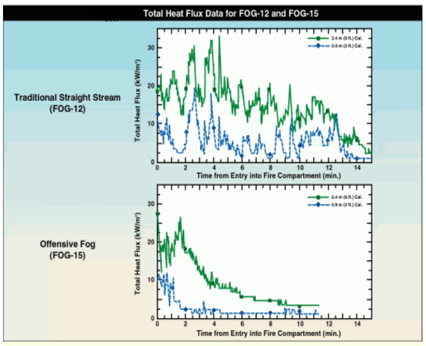
The water from a fire stream evaporating in the overhead will cause water vapour (steam) to expand. The amount of steam depends on where the evaporation occurs with the greatest expansion occurring as water reaches the upper portions of the room, due to the highest heat conditions existing there.

The effect of evaporation occurring lower down in the room (at temperatures around the 3-400° C range, means that the contraction of the gas layer is GREATER than the steam expansion. Of 2700-1.

Therefore the actual room pressure is lowered and the steam expansion is countered. What is left is cooled 'humidity', which also has the added effect of 'inerting' the overhead gas layers.



Compartment Cooling Gradients are More Gradual with Fog



The temperature read outs (left) are typical comparisons between bursting straight streams and fog patterns at a flow of 360 LPM (100 GPM).

'These temperature gradients from US Navy research in 1994 compare straight stream bursts (top) to 3D water-fog bursts (below) showing a more uniform cooling'

It can be seen that the lower graph of the 3D fog bursts presents a more uniform and gradual cooling effect without major pressure spikes or temperature inversions that serve to make the environment harsh and dangerous for the firefighters manning the nozzle.

These graphs are from US Navy research in 1994 where firefighters were given just 15 minutes instruction in the 3D application techniques prior to the trials.

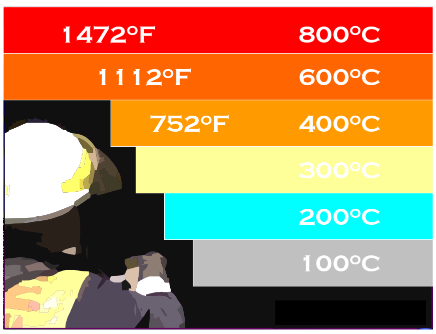
3D Fogging Creates an Inert Atmosphere for Safer Venting ahead of the Hose-line - Reducing the Likelihood of Flashover

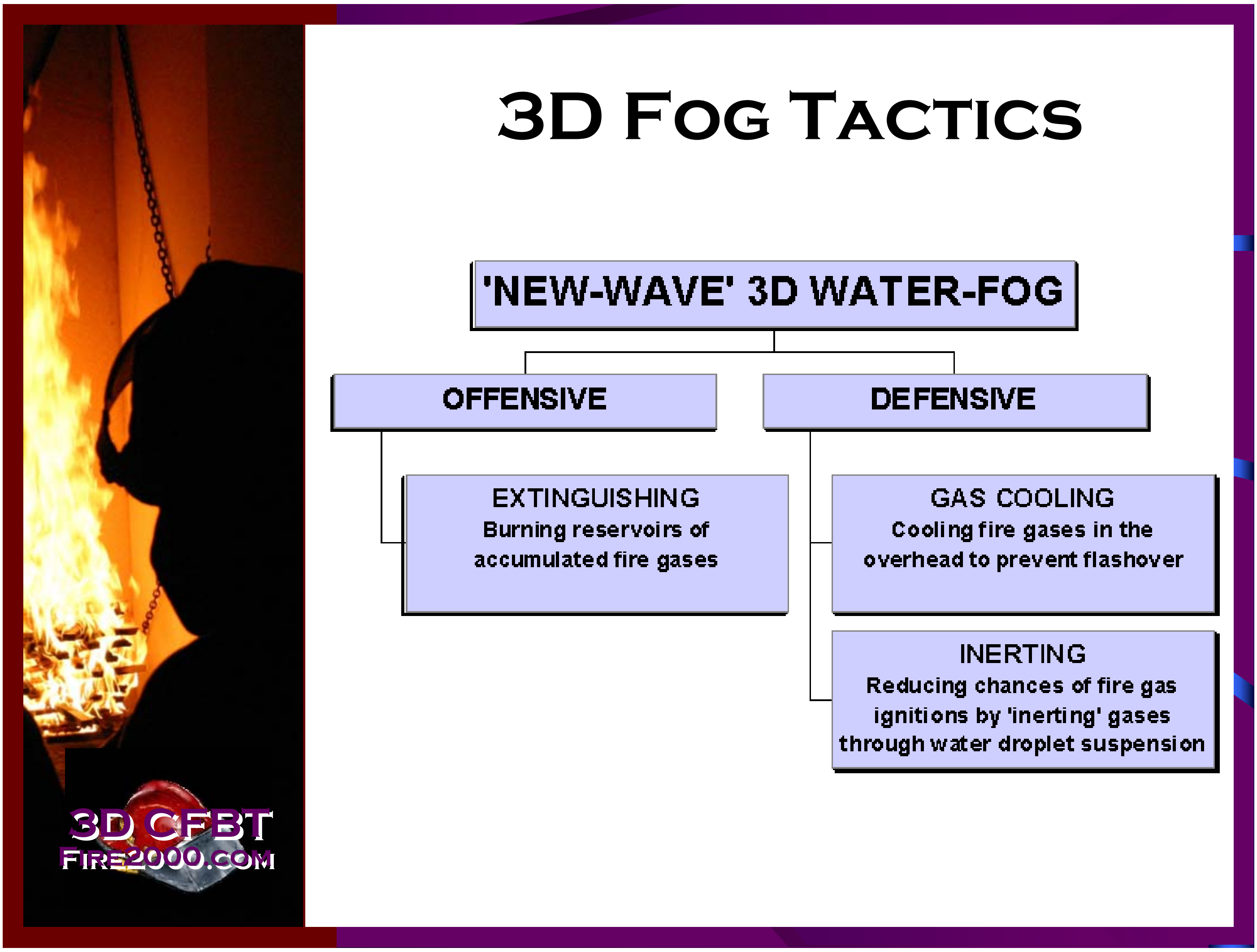
Temperatures at the lowest levels of a room fire are generally within acceptable parameters for advancing firefighters. However, temperatures around one metre from the floor demonstrate severe conditions with 400° C sometimes touching helmet tips of kneeling firefighters.

In these conditions firefighters must either vacate the compartment or take evasive actions to control conditions.

A venting action may provide some temporary relief until the fire intensifies, feeding on the additional air supply. A venting action may also serve to bring air into a rich gas mix, diluting it sufficiently for a sudden event of rapid fire phenomena to occur.

3D water-fog can be used to inert the gas layers with controlled humid water vapour, just prior to venting.





How the ‘spikes’ can Upset Thermal Balance & Lower the Smoke

It can be seen how repeated bursts from a straight stream will serve to upset thermal balance and lower the smoke layer in a room fire. The massive 500º C spikes (top right) where water evaporates at the ceiling from a straight stream causes 5000-1 super-heated steam expansion to push the smoke down.

The 150º C spikes produced by a 3D fog-pattern are less likely to force steam or smoke levels downwards. At this level of evaporation the contraction of the fire gases actually creates a negative pressure and lifts the smoke layer (lower right).

What happens in practice is the straight stream operator will burst one or two times and believe the effect is sufficient, being unable to add more bursts due to the steam and smoke layer descending.

The 3D water-fog operator will continue to add bursts in series and with greater effect. The smoke stays high, the temperature in the overhead gradually reduces and the effect is one of controlled humidity rather than severe and scalding steam.

This humidity serves to ‘inert’ the overhead and makes subsequent venting actions safer to undertake. The cooling effect with 3D fog is more gradual but effective.

Arguments such as ‘obtaining the right droplet size is difficult’; or ‘changing from straight to fog and back is difficult to teach’; or ‘training in 3D tactics is time restrictive’ are not viable.

The simple basics of 3D nozzle pulsing can be taught in 15 minutes and they serve to complement straight stream attack, not replace it. Several hours are needed for more advanced applications