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"NEW WAVE" 3-D WATER FOG TACTICS:A RESPONSE TO DIRECT ATTACK ADVOCATES

BY **PAUL GRIMWOOD**

Firefighters' use of water fog as a suppression agent for structural fires is a strategy shrouded in controversy that has been debated extensively and openly, particularly over the past decade. Most recently, I read with great interest Andrew A. Fredericks' two-part discussion of water fog applications and the direct form of attack. I noted that generally the U.S approach to compartmental (interior) firefighting currently seems to favor the low-pressure, high-flow, solid stream attack.[1-2] (The results of a recent Internet survey suggested that 54 percent of firefighters preferred smooth bore over the 42 percent who support fog nozzles.) However, these figures are mainly influenced by the direct attack vs. the indirect attack experience.

During my 26 years as a firefighter, I have been fortunate enough to have served on both sides of the Atlantic and am fully aware of the varying approaches made and the differences in construction and cultures that exist between our nations to appreciate why preferences may evolve. Having advanced hoselines alongside Fire Department of New York firefighters into burning South Bronx tenements during the 1970s and having experienced the effects of smooth bore streams directed into heavy fire fronts, I can testify to the reasons such an approach is effective and remains popular.

However, when something good and innovative comes along in this profession, it's only natural to want to share it with others, especially when it is believed that major advances in firefighter safety can be achieved. There are always opportunities to learn from each other, and the concepts of tactical (structural) and positive pressure ventilation are prime examples of how European firefighters are currently advancing techniques adopted from the United States.

Since 1984, I have studied, researched, and employed the "new wave" uses of water fog in compartment fires, originally developed by the Swedish fire service in 1982, and have presented more than 20 published technical papers introducing these innovative techniques. I explained in my book *Fog Attack*[3] (1992) the advances in safety being made by Scandinavian firefighters in relation to compartment firefighting. The work became a much referenced source in later research studies. I am currently linked to a worldwide network[4] of qualified and experienced firefighting instructors who, like me, have practiced these techniques in real fires and have refined them further still over a 16-year period to a level where the concepts are now scientifically approved and are being adopted as part of the national strategic policy in several countries.

U.S. NAVY ADOPTS WATER FOG

The U.S Navy[5] followed this new wave use of water fog closely for several years and in 1994 officially approved and adopted the Swedish principles in its approach to shipboard firefighting. It considered this style of fire attack suited to the seven types of fires likely to be encountered onboard ships, including those in mess halls, lounges, storage areas, galleys, and berthing areas, where surface coverings and furniture are similar in nature to land-based structural fire loads.

The Navy also demonstrated through scientifically monitored tests that (a) firefighting time is greatly reduced, (b) peak body temperatures of firefighters are lowered, and (c) working heart rates are dramatically reduced when using an offensive water fog attack in comparison with the more traditional straight stream direct attack.

NEW WAVE USE OF WATER FOG

The new wave use of water fog is not a reinvention of the indirect water fog tactics that became popular in the 1950s, where the intention was to evaporate water droplets on the heated surfaces (walls, ceilings, and so on) within a fire-involved compartment (room). This effect of producing large amounts of steam to smother the fire to extinction most certainly had its drawbacks. Although the concept generally worked, it definitely wasn't popular with the majority of firefighters. The reports of nozzle operators and building occupants' receiving steam burns and the "pushing" of smoke and fire farther into the structure are well-documented; I won't discuss these negative aspects further here. The aim was to achieve a 10- to 35-percent concentration of water vapor within the fire compartment; the application was measured in gpm/per square foot of surface contact.

The new wave concepts of water fog applications [also termed three-dimensional (3-D) water fog] are aimed essentially at flashover control and may be applied both defensively (preflashover gaseous cooling) and offensively (postflashover suppression of gaseous combustion). In simple terms, the water droplets are placed directly into the fire gas layers that form throughout a fire-involved structure, with the applications being measured three-dimensionally in gpm/cubic foot of compartmental volume. Such gases will exist both in the compartment where the fire is burning and adjacent compartments (rooms, corridors, hallways), although their flammability limits will be dynamic and somewhat unpredictable as the firefighting operation progresses.

The changing ventilation parameters as firefighters "open up" and the development of the fire itself alter the flammability limits of these gases as they form and transport throughout the structure. To counter the hazards of fire gas ignitions, water droplets are applied in short bursts using rapid on/off motions at the nozzle-termed pulsing. This effect ensures that the droplets suspend in the gases for several seconds, not on the walls and ceiling, avoiding the formation of excessive amounts of "wet" steam. Placing fine water droplets into the gas layers cools the gases, taking them below their ignition temperature and outside their limits of flammability. Although there is massive expansion of the water as it turns to steam, this is immediately countered by the effect on the gases, which actually contract as they cool. Where the application is precise, water vapor is seen to be dry and humid (as in a sauna) as opposed to wet and cloudy (as in a Turkish steam bath). The nozzle operator is easily able to recognize when too much water has been applied and adjusts pulses to compensate. The results are a safe and comfortable working environment for firefighters and an effectively maintained thermal balance.

These applications may be applied offensively to deal with burning gas layers (postflashover), but it is important that this approach not be viewed as a replacement for the straight stream direct style of attack. The true qualities of pulsing water fog tactics are realized in their defensive role when approaching a fire through heavy smoke conditions. Placing fine water droplets into the smoke (gases) on the approach route will create a much safer corridor for firefighters to traverse, allowing them to revert to a straight stream pattern as and when flaming combustion is encountered.

I have heard so many ill-informed arguments from firefighters who have "read articles and seen videos" concerning these techniques but who have never actually been trained to apply them or have not experienced their practical effects. Having personally suffered the effects of misapplied indirect water fog applications is no reason to refute the new wave approach.

EVALUATING ARGUMENTS AGAINST WATER FOG APPLICATIONS

Let's address some of the issues raised in opposition to this innovative approach to flashover control.

- The stream from a smooth bore nozzle will cool gases in the overhead more efficiently, if not better, than one from a fog pattern and will not disrupt the thermal balance as a fog pattern may. It is a scientific fact that water droplets will dissipate heat with greater efficiency than a solid stream of water, and I just cannot believe that firefighters constantly resort to this argument. Numerous research studies confirm this simple fact, and the U.S. Navy tests (5) clearly demonstrated, under strict scientific monitoring, that the pulsing of water fog into the overhead cools superheated gases far more effectively in comparison with a straight stream used in continuous or pulsed fashion.

The Navy tests also affirmed that upward spikes on the heat-flux plot graphically displayed how straight streams sufficiently disrupted the thermal balance to impose serious heat and steam threats to firefighters occupying the compartment. These upward spikes and associated effects were not observed at all when water was pulsed in a fog pattern.

A study by the Fairfax County (VA) Fire & Rescue Department in 1985[6] had also reported how temperatures in the overhead were dramatically reduced by water fog applications, which were clearly seen on display monitors to outperform smooth bore streams.

I am told: "No firefighters have ever been caught by a flashover while flowing water onto the fire or at the ceiling of the room involved." Has a firefighter ever been caught in a flashover while actually flowing water from a smooth bore nozzle onto the fire? I know for a fact that firefighters have! However, most firefighters caught in flashovers are caught while not flowing water of any sort. This is where the Swedish concepts place great emphasis on (1) understanding, (2) recognition, (3) dynamic risk assessment, and (4) training. It is not just about using the new wave tactics but more about training firefighters under safe and realistic conditions to understand how fire gases form, behave, and transport in a structure. This cannot be done in a classroom but can be repeatedly demonstrated and experienced under the controlled conditions that occur within a flashover simulator.

With this knowledge, the firefighter can progress safely onto larger training burns in real structures and practice a risk-based approach where conditions are constantly dynamically and reliably assessed. This training provides the firefighter with a greater knowledge and respect for fire gas formation, and the nozzle techniques practiced repeatedly in the simulators allow for greater precision over water fog applications, providing a safer working environment for all.

More firefighters in the United States are being killed by flashovers (ignitions of the fire gases) now than 10 or 20 years ago, with an average of 10 line-of-duty deaths (LODDs) (4) being attributed to flashovers every year. These deaths are preventable! In Sweden, there has been a dramatic decrease in associated LODDs since this new wave approach to compartmental firefighting was adopted 16 years ago.

The applications of new wave water fog techniques require such great precision that the nozzle operators are rarely able to apply them safely or effectively. The term "precision" when used in relation to 3-D water fog refers to many things. A whole range of considerations is relative, such as nozzle design, water droplet diameter, nozzle pressure, flow rate, nozzle technique, positioning, and operator skill. These factors combine to create precision and, as such, prompt an unnecessary belief that such precision requires great effort, is time-consuming, and may be difficult to achieve. However, these factors are all variables within reason, and the key to success is adaptability.

When the United Kingdom adopted such techniques from the Swedish fire service, we needed to adapt the entire concept to suit our initial attack strategy, which was commonly based around low-flow, high-pressure 3/4-inch booster lines. The Swedes had used higher flow rates from low-pressure hoselines to apply the techniques, and this worked well for them. It is perfectly feasible to apply this form of attack using automatic, fixed, or selectable-gallonage combination type nozzles delivering flow rates between 25 and 150 gpm. The nozzle design is particularly important. For optimum effect, the spray pattern should produce fine water droplets that can suspend in air for about four to seven seconds.

In Sweden, the United Kingdom, and Australia, several brands of nozzles have been used effectively for applying 3-D water fog. In terms of nozzle techniques, the operator is trained in precision. Most firefighters require about six to 10 evolutions in the simulator to grasp the approach. The U.S. Navy, however, has reported successful applications from recruits with just 15 minutes of training. (5) With practice, it becomes second nature for the firefighter to assess conditions and pulse droplets into the overhead effectively, maintaining a steady-state, safe, and controlled environment in which to advance/work.

To achieve success, an application of water fog requires a fire compartment that has not been ventilated. Three-dimensional water fog applications may be used with equal effect in ventilated or unventilated compartments or structures. Try to think new wave techniques where the droplets are placed into the overhead to cool and quench the forming gases and not as indirect techniques, where the intention is to smother the fire at its source.

An application of water fog is likely to push fire, heat, and combustion products ahead of the stream into areas that potentially remain occupied by trapped occupants or firefighter search teams. A recent report of a fire in which two Washington, D.C., firefighters were killed by a sudden backdraft stated that the incident commander denied two radio requests from a lieutenant to open his hose stream on the fire.[7] These denials were made in fear of the tactically opposing hoseline streams' vying against each other. I was truly astounded to hear this. Never in my 26 years as a firefighter have I had to request permission to open my nozzle at an escalating fire in front of me. It is the nozzle operator's call. Where a pulsing application is used correctly, there can be no opposing of hoselines or pushing of fire ahead of the stream. Gaseous combustion effectively dealt with by pulsed water droplets in offensive fashion will not create overpressures or pressure waves ahead of the stream, as the burning gases actually contract as they cool. Where a rapidly escalating fire is encountered, the firefighter on the nozzle simply doesn't have time to radio for permission to open the nozzle: The pulsing techniques will ensure that a safe and effective application of water fog can be made instantly.

Proponents of new wave water fog techniques have researched this innovative approach extensively since 1982 and have documented their findings. There is a wealth of scientific research data from Sweden, the United Kingdom, and the United States (for example) that stands in support of new wave tactics. Opponents similarly should base their arguments around qualified research that demonstrates such a strategy is not effective or safe to apply, although I do not believe such data exist.

LITTLE DROPS OF WATER, "PART 3"?

I have enjoyed conversing with Andrew Fredericks in the past and fully respect his views and opinions in relation to compartment firefighting, which are based on many years of sound experience. I certainly do not oppose his viewpoint that the flow from a straight stream attack, at the base of a fire, is the most effective (and safest) application a firefighter can use to control a room-and-contents fire. However, I was sadly disappointed that his extensive analysis of water fog tactics (1,2) devoted almost a third of the lengthy text toward the use of 1950s indirect applications while offering little more than a paragraph to the new wave approach, in which he summarized: "It's time to admit that fog streams are not the answer."

In both situations, he was clearly encouraging the reader to move away from the tactical use of water fog in any form and was quick to reaffirm the disadvantages of indirect applications that have been generally well documented in the past. Unfortunately, he was attempting to condemn, by use of a single paragraph, a tactical approach that has been scientifically researched and proven over an 18-year period and seen to influence a large proportion of the world's firefighters to move toward the safety of new wave water fog applications.

Unlike his well-presented arguments against the indirect use of water fog, he failed to produce an equally convincing case against the use of new wave 3-D techniques. His reasoning was simply this: Despite the reported effectiveness of new wave methods, it is essential to keep handline and nozzle techniques as "simple and straightforward" as possible because of the fact that the modern fire service faces a wide spectrum of distractions such as EMS, haz mat, technical rescue, and so on. I wish to emphasize that we also face such distractions in Europe and Australia but still find time to perfect our nozzle techniques in the professional and volunteer forces.

I was confused at first by Fredericks' references at "directing streams into smoke" in Part 2, when he had condemned this action in Part 1 of the series. In Part 2, he suggests, "The volatile nature of the smoke produced by the contemporary fire environment requires that we rethink this approach." He goes on to say that we may even "justify putting water on smoke." I was overjoyed to finally hear this acknowledgment from an experienced FDNY firefighter. Let's analyze what he is saying.

He certainly did a good job in explaining how modern compartment fires are more likely to develop slowly in the initial stages than they did two decades ago, producing highly toxic (and flammable) fire gases that suspend and transport in the smoke layers. He mentions the high surface spread of flame rates (up to two feet per second) of some surface linings, but did you know fire gas ignitions (flashover) can actually support flame speeds in excess of 20 times that rate? I fail to see how the application of a solid stream of water into smoke (fire gases) can prevent such ignitions, for there is no scientific evidence of which I am aware that will support such a notion.

There is, however, a great deal of research supporting the suspension of fine water droplets in flammable gas layers to prevent/quench such an ignition. Most of this research has been directed at water mist fire suppression systems (WMFSS)[8] and suggests that extremely fine droplets (below 100 microns) are required to prevent ignition (normal firefighting combination nozzles produce droplets three to six times this size when in a fog pattern).

However, it is also known that during an actual ignition of the gases, suppression may be achieved as the parent spray, consisting of larger droplets, breaks down during the propagation to produce tiny droplets capable of quenching the fire's progression. Preventing fire gas ignitions within the smoke layers can only be achieved by the suspension of fine water droplets directly into the gases themselves-a solid bore nozzle is not capable of achieving this. A most recent study consisted of creating backdrafts onboard a U.S. Navy test ship, where it was shown that applying water spray into the fire compartment was an effective mitigating tactic that was able to completely suppress backdrafts primarily by means of diluting the atmosphere and reducing the fuel mass fraction.[9]

Where fire gas layers (in the smoke) have reached and maintained superheated levels, the optimum cooling effect is achieved by placing fine water droplets into the smoke. A solid stream will not suspend water in the overhead as a water fog pattern will, although it will create "wet" steam on contact with hot surfaces, and this will have some cooling effect as it disrupts the thermal balance (as seen in the Navy tests). If you doubt the cooling effects of pulsed water droplets as opposed to solid streams, take note of what Queensland firefighters in Australia have observed. (4) Station Officer Shan Raffel reports that a clear comparison was observed between the effects of a solid stream and a pulsed water fog pattern by using a thermal imaging camera (TIC). After seeing this effect, even the most hardened supporters of solid streams will review their approach. Through this innovative use of a TIC, Raffel is refining the applications of pulsed water fog further still. He has noted, along with Swedish Fire Chief Tommy Torling (one year attachment to QFRA, Australia), that a combination of pulsing and a widening cone angle from 30 to 90 degrees in one swift movement of the nozzle has a tremendous effect on reaching all parts of the gas layer in the overhead of a fire compartment. This advanced nozzle technique is acquired through familiarization and handling sessions prior to live evolutions in the simulator.

Further references by Fredericks in Part 2 to "black fire," high-pressure backdrafts, and theories on closing the door at the entry point to control/reduce the airflow into the fire compartment (anti-ventilation) are all topics I have discussed and documented over the past decade. Additionally, I have constantly warned about the hazards of fiber insulating boards (FIB) (3) and described their role in causing several serious backdrafts that have killed firefighters over the past 20 years. Sadly, much of this advice has failed to register, and I still hear of incidents in which firefighters have died under circumstances I would consider unnecessary and preventable.

TRAINING

It is not my intention to generate confusion among firefighters but rather to offer advice on a "new" approach that has been successfully evaluated, developed, and proven scientifically. These techniques require no special equipment and can be easily adapted to conform to local styles, methods, and procedures. This can be done in several ways, but the major implication is training, and this is obviously limited by financial constraints.

The Queensland Fire & Rescue Authority in Australia may be seen as an ideal role model, having taken on the services of an English-speaking Swedish firefighting specialist for a one-year period. This has enabled the Authority to build and develop a "live fire" training site that conforms to established safety specifications and is now recognized as one of the most advanced and innovative compartment fire training programs in the world.

The Fire Service College at Moreton-in-Marsh, England, has also established itself as a recognized leader in the field of such training and offers residential based courses for international students. It is currently training firefighter-instructors/chiefs from all over the world and has recently been contracted to train London Fire Brigade firefighters in compartment firefighting techniques. Since officially adopting these techniques in 1995, approximately 65 percent of the UK's 35,000 firefighters have received this form of training, and it is estimated that the entire force will be trained within the next two years. There is an ongoing program to update and refresh this form of training every six months.

It is essential to keep an open mind about such an approach to compartment firefighting. The techniques described above are complementary to the more traditional and accepted methods of fire suppression and are not intended as replacements. What is important is that readers stand back from their previous experience and knowledge of water fog applications to reevaluate this innovative new wave approach with a view of not passing professional judgment until such techniques have been seen, tried, and tested firsthand under strict and qualified supervision.

I agree with Fredericks that although our tactics may differ, "our goal remains the same- to keep firefighters alive." However, "our" tactics are now your tactics (U.S. Navy), and it's finally time to admit that the "new wave" water fog approach most certainly deserves a closer look.

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