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LITTLE DROPS OF WATER: 50 YEARS LATER, PART 1

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As we approach the new millennium (remember, the new millennium begins January 1, 2001), a debate still rages over the use of water fog in interior fire attack. This debate has become more lively in recent years because of the proliferation of on-line computer users in the fire service and the ever expanding role of the internet as a forum in which to present new ideas or support old ones. This article begins with a brief history of the use of fog streams in structure fire attack. I obtained much of this information by studying the original articles, books, and papers written by three men generally considered to be the fathers of fog firefighting in America-Lloyd Layman, Keith Royer, and Floyd W. "Bill" Nelson.

FOG NOZZLE HISTORY

Fog nozzles and spray streams have been around for almost 150 years. The first United States patent for a fog nozzle was granted to Dr. John Oyston in 1863. During the late 1800s and continuing through the turn of the century, various articles appeared in fire service literature extolling the merits of spray streams. One of the earliest such articles, entitled "Extinguishing Fires," was written by Oyston himself. It was originally published in Oyston's local newspaper but was reprinted in the March 16, 1878, edition of the National Fireman's Journal (known today as Fire Engineering). Significant research in fire behavior and the use of spray streams for interior fire attack began in the United Kingdom and several western European countries during the 1920s-research that continues to this day. In the mid-1930s, Elkhart Brass introduced the first production periphery jet fog nozzle to the American fire service. Known as the "Mystery" nozzle, it was based on a nozzle designed by the Mystery Nozzle Company in Hamburg, Germany, some years before. The United States Navy and Coast Guard used a combination fog/solid-stream nozzle during World War II, although its exact date of issue may predate the war by several years. Manufactured by the Rockwood Sprinkler Company, and known as an "all-purpose" nozzle, it was available for both 1 1/2-inch and 2 1/2-inch hose and had a three-position shutoff that could produce both an impinging jet fog stream and a solid fire stream. It could also be fitted with a variety of extension applicators. It is still in limited use today by the Navy as well as several fire departments.

Despite their long history, fog nozzles were virtually unknown through the first half of the 20th century. The solid fire stream stood for decades as the unchallenged weapon of choice for structure fire attack by America's fire departments. Then, in 1950, it all changed. In the February 1945 issue of Fire Engineering, an article described the results of experimental shipboard fires conducted at the U.S. Coast Guard Firefighting School at Fort McHenry in Baltimore, Maryland. Entitled "Coast Guard Conducts Tests on Ship Engine Room Fires," it explained both the testing process and various

techniques developed for combating fuel oil fires in the confined machinery spaces of large ships using water fog (a decommissioned Liberty ship was used as the test vessel). While the article is interesting, its impact on structure firefighting tactics is not considered significant. It wasn't until five years later that the importance of the Coast Guard tests would begin to be understood. What happened in 1950 that so radically changed fire suppression tactics? The late Chief Lloyd Layman of Parkersburg, West Virginia, presented a paper entitled "Little Drops of Water" at the Fire Department Instructors Conference (FDIC) in Memphis, Tennessee, and in the process stood the fire service on its collective head. In his paper, Layman introduced what he termed the indirect method of attack to suppress interior building fires using the tremendous heat-absorbing properties of expanding and condensing steam, produced in great quantities by fog (spray) streams. Most of the theory and methodology of indirect fire attack was based on the Coast Guard experiments (Layman was in charge of the Coast Guard's wartime firefighting school at Fort McHenry), as well as additional testing conducted jointly by the U.S. Navy and other agencies in San Francisco under the project name "Operation Phobos." Layman continued his experiments after he returned to his position as fire chief in Parkersburg, where he began in earnest applying the indirect method of attack to building fires. Layman explained his theories and methodologies in great detail in two books published by the National Fire Protection Association (NFPA): Attacking and Extinguishing Interior Fires (1952) and Fire Fighting Tactics (1953).

To objectively evaluate Layman's approach, we must be familiar with both the underlying theories and the specific techniques advanced in his books and other writings. First and foremost, the "indirect method of attack" is not an interior fire attack operation. Rather, Layman's methodology emphasizes that the fog stream should be remotely injected into the fire compartment at the highest possible level with the nozzle held in a fixed position. The following quote from Attacking and Extinguishing Interior Fires could not be any more explicit in warning of the dangers personnel face from the large quantities of steam created during an indirect attack: "An indirect attack should always be made from positions that will enable personnel to avoid injuries from super-heated smoke and live steam." Layman continued by stating that "if possible and practical, an indirect attack should be made from positions outside the involved building." In other words, he advocated that fog streams be directed through window openings because of the voluminous quantities of steam created within the fire building. Layman went so far as to discourage the use of doorways for fog application, as the outflow of scalding steam would be extremely debilitating to the nozzleman. In addition to remote injection of the water fog, there are two other requirements for success when using the indirect method. First, the ceiling temperature within the fire compartment must be at least 1,000°F to ensure ready and efficient conversion of the fog spray to steam. When a fire is in the first or early second phase of development, the direct method of attack with timely and adequate ventilation is preferred. Second, the fire compartment (building) must be well sealed to prevent premature leakage of valuable steam to the outside. A well ventilated fire building on the fire department's arrival warrants a direct attack, since the indirect method is only effective if the fire building remains sealed with doors and windows intact. Layman also stated that "where the major area of involvement is on upper floors, it may be possible and practical to attack

from an interior stairway below the involved floor." He continued by warning that "the nozzleman may have to discontinue the attack temporarily to avoid the downward movement of heated smoke and steam."

THE NATIONAL EXPLORATORY COMMITTEE

Shortly after "Little Drops of Water" was published, the Exploratory Committee on the Application of Water was formed to evaluate fire extinguishment techniques using fog and spray streams. Perhaps better known as the National Exploratory Committee or, more simply, the National Committee, it was comprised of fire chiefs, training officers, and members of fire insurance rating organizations and was created "to bring some badly needed light to a very foggy subject." Beginning in 1951, the National Committee began conducting instrumented live fire tests to collect hard data on the growth and behavior of interior fires and the most effective methods of attacking these fires using water or, more specifically, water fog. Throughout the 1950s, tests were conducted under the auspices of the National Committee and independently by various fire departments, as well as the National Board of Fire Underwriters (NBFU), Underwriters Laboratories, and other research institutions. It was the research work of two individuals, however, that has had the most long-standing impact on the fire service.

Beginning in 1951 and continuing for more than three decades, Keith Royer and the late Floyd W. "Bill" Nelson headed the firemanship training program at Iowa State University's Engineering Extension. With the resources available to them at Iowa State, as well as through their membership on the National Committee, they helped collect and analyze data from literally hundreds of experimental fires. Their efforts provided the nation's fire service with a much better understanding of interior fire behavior and the mechanisms of fire extinguishment using water. Among their many contributions, Royer and Nelson developed a formula for estimating, with a high degree of accuracy, the amount of water required to control an interior fire based on the following: a) the amount of heat liberated by common fuel materials burning in ordinary air within a compartment, b) the extinguishing (heat absorbing) capacity of water, and c) the cubic foot volume of the fire compartment. In the "critical rate of flow" formula, as it came to be known, Royer and Nelson determined that the amount of water (expressed in gallons per minute) needed to control (not completely extinguish) a fire in the largest open space within a structure can be determined by dividing the cubic foot volume of the space by 100. Royer and Nelson explained the formula and its scientific basis in Engineering Extension Service Pamphlet #18 "Water for Fire Fighting-Rate of- Flow Formula" (1959, Iowa State University). They also introduced the fire service to a fire extinguishment technique they called the "combination method of attack."

THE COMBINATION ATTACK

Several factors must be considered to execute a successful combination attack. Chief among them is that, like the indirect method of attack, the combination attack was designed primarily for exterior application of the water. Remember, turnout clothing in use during the 1950s and 1960s lacked the thermal protective qualities of modern fabrics. In addition, many fire departments had few, if any, self-contained breathing masks available. These facts, coupled with the large amounts of steam produced during

a combination attack, necessitated an exterior application of water fog whenever possible. If a fire had to be attacked from an adjoining room or hallway, or if multiple rooms were involved in fire and exterior application of the stream were impractical, Royer and Nelson cautioned that a very narrow fog stream should be used to begin the attack. The narrowest fog stream is, of course, a straight stream, which would cause the least disruption to the thermal balance.

In addition to Engineering Extension Service Pamphlet #18, Royer and Nelson's discoveries were published in two Fire Engineering articles. "Water for Fog Fire Fighting-How Much and How to Apply It!" (August 1959) described the combination attack but did not specifically identify it. "Using Water as an Extinguishing Agent: Part 2-Utilizing Heat" (November 1962) contrasted and explained in some detail the various methods of structure fire attack-direct, indirect, and combination. But three films produced by Iowa State University-The Nozzleman (1959); Coordinated Fire Attack (1960); and, to a lesser extent, Where's the Water? (1971) introduced the vast majority of firefighters to the combination method of attack. To initiate a combination attack, first select an opening(s) for stream application. Adjust the size of the fog pattern (discharge cone) based on the approximate dimensions of the fire compartment. Next, thrust the nozzle about an arm's length through the opening into the fire compartment and rotate it as violently as possible with a clockwise motion.

Speaking to the lack of personal protective equipment during the 1950s and 1960s, Royer and Nelson noted that "to do this the nozzleman must have glove, helmet and protective coat." During their many experimental fires, Royer and Nelson discovered that a clockwise rotation of the fog nozzle was required to drive heat, smoke, and flame away from the nozzleman. The objective of the combination attack is to "roll" the stream around the perimeter of the room, cooling the walls, ceiling, and floor with the outer edge of the stream while the inner portion of the stream cools hot gases being produced by the fire. Striking the heated ceiling, walls, and fuel materials produces the maximum amount of steam within the shortest period of time. If the rate of flow is sufficient and the water distribution is efficient, the main body of fire should be "blacked out" after no more than 15 to 30 seconds of stream application. By shutting the nozzle down promptly after the fire darkens, enough heat will remain within the fire area to permit the smoke to lift and afford the overhaul crews improved visibility and lower humidity. Royer and Nelson were very emphatic in their writings when discussing the importance of avoiding "overcooling" and managing the thermal balance to aid in ventilation and overhaul.

MISAPPLICATION AND CONFUSION

Misapplication of Royer and Nelson's methods began almost immediately. For example, the concept of managing heat-using the thermal balance within the fire area to advantage-was quickly lost on many practitioners of the combination attack. In a telephone conversation I had with Royer a few years ago, he said he was very surprised when he first learned how commonly firefighters attempting a combination attack were beset with poor visibility and often suffered steam burns. I believe the misapplication and confusion is attributable to several causes. One involves improvements in firefighter protective clothing and SCBA during the 1960s and 1970s, prompting more and more

fire departments to attempt interior fire attack operations. David Fornell, author of Fire Stream Management Handbook, believes that since the tactics depicted in the The Nozzleman and Coordinated Fire Attack utilized fog streams exclusively, many in the fire service became convinced this was now the only type of stream suitable for structure fire attack. Fornell described what he terms the "interior, indirect attack." Like the misunderstanding surrounding the combination attack, Layman's indirect attack was also widely misunderstood and improperly applied. Layman, himself, contributed to the confusion by including a single paragraph in Attacking and Extinguishing Interior Fires that stated a "direct" attack with fog nozzles may sometimes be indicated and that a 30-degree fog pattern directed at an upward angle is the preferred method. Unfortunately, he made no mention of the role of ventilation when employing this technique; and warnings about the dangers of steam burns to the nozzle crew, prominent earlier in his book, are conspicuously absent here. Fornell sums it up best in Fire Stream Management Handbook: "The interior indirect, or combination, attack as practiced by a large percentage of the fire service today was invented by the fire service itself to compensate for problems encountered employing techniques based on earlier self invented principles. Nowhere in his writing did Chief Layman present scientific arguments that advocated spraying water over firefighters' heads in a fire situation in order to create steam bath conditions. On the contrary, he said firefighters would be enveloped in a hurricane of water converting to steam."

WATER FOG AND LIFE SAFETY

While many an interior fire attack has failed when the nozzle team had to quickly retreat because of steam burns, the full impact of live steam on civilians trapped within the fire building remains uncertain. Studies indicate that when heated air becomes saturated with moisture, the opportunity for and severity of burn injuries rise dramatically. The Fire Protection Handbook (17th Edition), in discussing the impact of heat on life safety, states that "the effects of exposure to heated air are greatly augmented by the presence of moisture in the fire atmosphere." Studies by the National Research Council of Canada indicate that 149 degrees celsius (300.2 degrees fahrenheit) is the maximum survivable breathing air temperature and that "a temperature this high can be endured for only a short period and not at all in the presence of moisture." Insofar as Royer and Nelson's writings are concerned, there is no mention of the impact of steam on trapped occupants. In Fire Stream Management Handbook, Fornell writes in reference to the articles and films of Royer and Nelson: "In viewing the films and reading the results of their research, it must be noted that their tactics advocated application of water from outside the fire building. Though they did discuss interior application, the first priority in the Iowa method was to knock down visible fire before making entry. Mr. Royer says their testing did not address the problem of fire spread caused by applying streams from the outside of the building. The subject of life safety or the effects of steam on trapped victims was never addressed in the three films." In Attacking and Extinguishing Interior Fires, Layman states: "In answer to the question regarding the effect on occupants of steam from fog application, we can only state that we have not heard of any adverse effects." Layman continues: "Contrariwise, the much more rapid flame suppression with indirect application makes it possible to reach endangered persons more quickly so as to be able to remove them to safety and render aid as necessary." This statement,

which appears in the third paragraph on the third to last page of a 148-page book, does not specifically address the impact of steam exposure on trapped occupants. It simply implies that indirect attack may knock down the fire faster than other methods and allow quicker removal of any victims.

LAYMAN BEFORE FOG

Few members of the fire service know that long before "fog mania" swept the nation and confused a generation of firefighters as to proper structure fire attack methods, Layman wrote a book emphasizing the importance of the direct method of fire attack. Published in 1940, Fundamentals of Fire Fighting Tactics examines eight basic fireground functions that together comprise a tactical plan for the successful attack, control, and extinguishment of fires in buildings. I will limit this discussion to Chapter VI, simply called, "Extinguish Fire." Layman stated that "the most important factors in extinguishing a fire within a building are first-to locate the main body of fire, second-to apply [the] necessary amount of water or other extinguishing agent on the BASE OF THE FIRE." (The capitalization is Layman's emphasis.) Layman continued by providing a list of nine "principles and suggestions" for extinguishing interior fires. In examining this list, numbers three through seven are particularly interesting, especially in light of Layman's later writings. They are reprinted below:

-If possible, attack the main body of fire so as not to drive heat and flames into uninvolved sections of the building.

-Use streams of sufficient size to provide necessary volume of water, but avoid using a one inch stream where a quarter-inch stream would be sufficient.

-Direct the stream to the base of the fire.

-As soon as all visible flames have been killed, close nozzle; if the fire flares up, open nozzle again, but close it when visible flames have been killed.

-Don't direct streams into smoke-filled rooms. Wait until the fire has been located and the stream can be directed into the burning material.

These five principles are so sound and basic; they are as true today as they were when they were written 60 years ago.

THE DEBATE CONTINUES

In the past 15 years or so, we have witnessed a resurgence in the use of solid streams, or at least straight streams, as many firefighters and fire officers have realized that using fog streams inside the fire building is rarely a wise and productive action. The fire service has taken many years and detoured down many dead-end paths (remember high-pressure fog?) in reaching this conclusion. Many within our ranks still lack a complete understanding of the tactics and techniques developed by Layman and the Iowa State researchers. Others are just plain stubborn and refuse to face the truth. Sadly, unnecessary firefighter burn injuries and excessive property damage will continue as net results of this situation. Recently, researchers in the United Kingdom and Sweden introduced the American fire service to the idea of "offensive" water fog application. This has generated still more confusion, and the debate over "fog" vs. "solid" shows no signs of abating. Part 2 of this article will analyze offensive fog techniques as well as Class A foams and other "advancements" in our ability to control and extinguish interior fires.