NOZZLE TESTS PROVE FIREGROUND REALITIES, PART 3

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CONDUCTING AN EFFECTIVE AND EFFICIENT AGGRESSIVE interior fire attack is the engine company's most critical mission. Extinguishing the fire quickly minimizes all other problems and increases firefighter and civilian safety on the fireground. If the fire is not getting smaller, it is getting bigger (more dangerous). The nozzleman is the tip of the spear in this attack and can use a variety of nozzles, nozzle patterns, and nozzle movement techniques to accomplish the job. Further complicating this critical operation is that a variety of inaccurate and unsubstantiated myths have evolved involving interior fire attack. These myths are passed down by well-meaning people as facts.

In phase 3 of our nozzle testing program conducted at the Rockland County Fire Training Center in Pomona, New York, we examined critical factors relative to the effect of moving a fire stream in the fire environment during an aggressive interior fire attack.

Most of us have been taught nozzle techniques by the "old timers" and the senior members in the company. Many favorite techniques exist and are passed on with vigor and enthusiasm: "This is the only way to put out a fire, kid." A popular method taught to us was to set the nozzle for 30° fog, whip the nozzle around, and the fire goes out. If it were only that simple! Of course, we now know (and can demonstrate clearly and repeatedly) how dangerous this "spray and pray" method is for interior firefighters. It creates the painful "fireman soup," for which we are the main ingredient.

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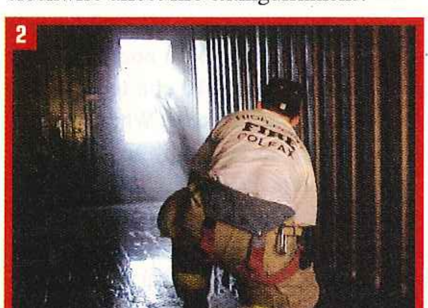
(1) Firefighters must understand the effect their fire stream will have on the interior fire environment. Nozzle movement and stream selection are critical to a successful fire attack. (Photo by Brian Duddy.)

Fireground experience is a critically valuable asset. But studying and drawing reasonable conclusions about the effect of your nozzle during a fire attack operation is nearly impossible. At that point, the pressing need is to put out the fire. Further complicating the issue is that each fire attack situation has a number of variables. Uncontrolled variables such as fire conditions, fuel type, ventilation (size and placement), water volume, pressure, and nozzle pattern are serious impediments to reliable/repeatable conclusions relative to fire attack methods. Unfortunately, the myths that develop over time are often based on single experiences and are not often supported by cold hard facts or scientific and repeatable tests. The long-standing nozzle techniques examined here include the following:

- How does moving a solid bore nozzle clockwise or counterclockwise affect fire extinguishment?



(2) A view of the test apparatus looking out toward the vent opening. The air measurement instrument is to the photographer's back. (Photo by Christopher Flatley.)

• How does moving a fog nozzle clockwise or counterclockwise affect fire extinguishment?

• Does the fog nozzle design affect the air's movement into the fire area?

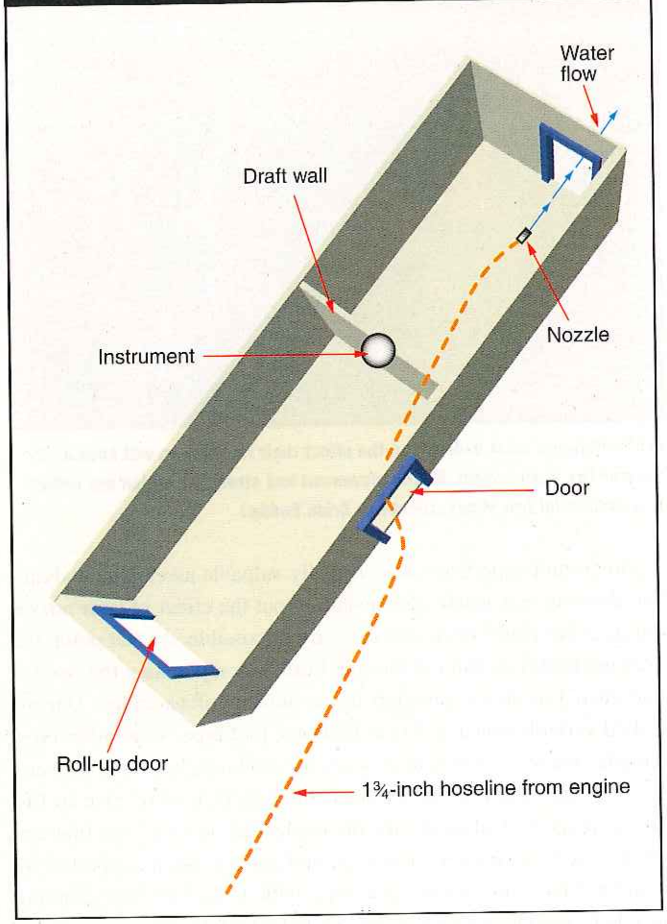
The purpose of our nozzle-testing project was to provide real-world practical insight, based on facts and realistic tests, into current fire attack methods, hardware, and specifically engine company nozzle techniques. Our findings are described below.

PHASE 1 TEST RESULTS

In phase 1 of our testing program, we designed and set up a test apparatus to capture and measure the airflow caused by the direction of a fire stream into a fire room. A single air balancer for an HVAC system measured airflow. The plan view of the apparatus is shown below.

As a result of our testing, we were able to measure an air flow into

Figure 1. Plan View of Apparatus



the fire area from both solid bore and combination nozzles (set on straight stream) on 1¾-inch attack lines flowing approximately 180 gallons per minute (gpm). From this testing, we concluded the following:

• A 15⁄16-inch solid bore nozzle operated at 50-psi nozzle pressure and flowing 180 gpm caused approximately 510 cfm to be moved into the fire area to which the stream was directed. When this nozzle was rotated clockwise, the airflow increased by approximately 40 percent, to 725 cubic feet per minute (cfm).

• The straight streams produced by fog nozzles using test methods similar to those described above generated almost exactly the same airflow data. After numerous tests, we concluded that the air movement by straight streams (from combination nozzles) and air movement into the fire area from solid bore nozzles was very similar, if not exactly the same.

• Combination nozzles used in the fog position cause massive air movements into the fire area. Although the quantity of air moved exceeded the measurement capability (2,000 cfm) of our instrument, through testing and researching the literature, we believe that a typical 1¾-inch fog line flowing 150 to 180 gpm will move 6,000 to 10,000 cfm of air into the fire area. Recall that a typical electric fire service fan will move 10,000 cfm.

From this test, it appears that the airflow generated by a solid bore nozzle stream has played a critical and beneficial role for successful interior fire attack. Such a stream combines the optimum amount of air movement (combined with adequate and proper ventilation) and the large flow and water droplet size. The modest airflow drives fire and products of combustion from the nozzle team. Standard ventilation tactics provide an adequate size opening for this volume of air to be safely vented out of the building. Further, the thermal balance of the room is maintained. The superheated air (2,000°F) near the ceiling is not stirred up by injection of huge volumes of air forced in by a fog stream. This provides for the engine company's safe and rapid advance. Another benefit of this stream is the lower nozzle reaction. The less fatigued firefighters are, the less air they will consume from their SCBA and the longer they will be able to continue the aggressive fight.

In addition to the large volume of water this nozzle provides, the maintaining of the thermal balance, and the proper volume of air movement, this nozzle offers the advantage of large-size droplets, which are bounced off the ceiling, penetrate the thermal layers, and land on the fuel to permanently extinguish that area of fire.

PHASE 2: THE OPTIMUM COMBINATION

Phase 2 of our nozzle test program was designed to more realistically test and demonstrate the airflow into a room caused by fire streams under different but realistic ventilation conditions. Using airflow indicators hung from a grid system inside our burn building, we realistically operated solid, straight, and fog patterns into a room under three ventilation conditions: no ventilation, a window-size opening, and a full door-size vent opening.

Results of these tests showed that solid and straight streams operated realistically into the fire room under *all three ventilation conditions* did not cause any air to move out of the fire area back toward the nozzle team. When fog patterns were selected, huge movements of air injected into the fire area caused an overpressurization and resulted in superheated air being driven back toward the nozzle team. In a real interior fire attack, this most likely would cause burns to the members and, therefore, effectively stop the fire attack and allow the fire to continue to grow.

It is critical to note that the fog nozzle caused the air currents to be driven back toward the nozzle team even when there was a large properly placed ventilation opening (full-size door opening—8 feet × 31 inches) ahead of the nozzle. Supporters of using fog nozzles for an interior fire attack profess that the fog will drive *all the heat and smoke* away from the nozzleman and out the vent opening. This test proved that this is not the case when the nozzle is used inside a building. This is a great theory, much like positive-pressure ventilation; but if the ventilation is not adequate, not accomplished, or not big enough, you will quickly drive heat and smoke and likely spread fire with deadly results.

(3) Airflow indicators clearly show actual air movement inside the fire area. We call this "fog nozzle ricochet." Even in this properly ventilated demonstration, massive quantities of air driven into the fire room by the fog pattern cause superheated gases and steam to be forced back on the nozzle team. (Photo by Jerry Knapp.)

(4) A 15/16-inch solid bore is operated into a simulated fire area. Airflow indicators show no movement of superheated gases or steam back toward the nozzle team, thus allowing the aggressive interior fire attack to continue. The ventilation opening permits discharge of the small amount of air (700 cfm) this fire stream adds to the fire environment. (Photo by Jerry Knapp.)

The single experience in the parking lot, with the air moving from behind and then past the nozzleman and away, is not what happens when the fog stream is used inside a building. This is a classic example of one single experience morphing into a false training technique. Parking lots are not the same as the interior of a fire building. Don't expect the air currents to be the same.

It is important to note that this technique—even spray and pray, for that matter—will extinguish a one-room fire. But a one-room fire is not every fire, and one size fire attack does not fit all.

MOVE THE NOZZLE!

Nozzlemen have been taught for years to move the nozzle in a clockwise or side-to-side motion while conducting an aggressive interior attack. There are two main reasons for this technique. The first is to provide a good distribution of water into the fire area. As the stream is deflected off the ceiling and walls, it causes it to be broken up into large drops. These drops penetrate the thermal updraft of the fire and fall onto the burning fuel, extinguishing that area of fire. These large drops also are not turned to steam very readily by the heat of the fire and, consequently, do not produce volumes of debilitating steam in the fire area. Continuing this clockwise motion to its full circle, down onto the burning fuel such as furniture, stock, and so on, puts volumes of water directly on what is burning, rapidly and permanently extinguishing the fire. Sweeping the stream across the floor allows the rushing water to sweep away dangerous debris on the floor in front of the attack team. Debris can be dangerous and may contain discarded hypodermic needles, hot plaster, burning floor coverings, flammable liquids, and so on. As the stream sweeps across the floor, you can easily differentiate between the sound of the stream's hitting a solid floor and disappearing in silence into a firefighter-killing hole in the floor.

Much has been written about the clockwise motion of the nozzle's driving the fire away from the nozzle team. However, as far as we know, there has been no scientific reason or quantitative measurements to prove this observation.

As we reported in Part 2, the Fire Department of New York engine company manual (1989) recommends clockwise movements of the nozzle to drive heat and products of combustion away from the nozzleman. It clearly states that numerous experiments have shown that rotating the nozzle clockwise resulted in faster knockdown. It then says that counterclockwise nozzle movement draws the heat and products of combustion toward the nozzle team.

In this phase of the tests, we measured and compared the airflow caused by a solid bore nozzle's being moved in a clockwise and counterclockwise motion under three ventilation conditions. The nozzle was a 15/16-inch smooth bore flowing 180 gpm measured by an engine-mounted flowmeter. An experienced nozzleman operated the nozzle, as would be the case during an aggressive interior fire attack.

The stream was directed out the following openings from a position 10 feet away from the opening: a 2- × 4-foot (8-square-foot) window opening, a 48- × 102-inch (34-square-foot) full-size door opening, and both doors open at the rear of the 92- × 10-inch box, resulting in a 65-square-foot-size opening.

There was no significant difference in airflow volume or direction. Clockwise movement airflows averaged 710 cfm and counterclockwise approximately 695 to 700 cfm. Actually, the differences in airflow we recorded may be attributed to ambient air movement outside the test device or the margin of error of our measurements and test method.

The data we collected speaks for itself: The direction of the rotation of the smooth bore nozzle on a 1¾-inch line during an interior aggressive fire attack does not affect the volume or direction of air movement into the fire area by a smooth bore nozzle. It is reasonable to assume that if air movement is the same, the ability of the stream to push fire and products of combustion away from the nozzleman is the same. Therefore, according to these tests, which way the nozzleman rotates the nozzle makes no difference.

It is likely that the circular nozzle movement pattern, not the direction, is the critical factor that results in the significantly more effective stream. The sweeping, almost violent, movement provides excellent distribution of water in only a few seconds in the fire area. Try it yourself (without fire or smoke) in a burn building or acquired structure. Note the excellent distribution of water throughout the room. The nozzleman repeats the circular pattern of the nozzle several times. Each rotation is a bit different from the previous rotation and causes excellent widespread and repeated distribution of the high volume of water. This distribution method has the following advantages:

- It provides good coverage onto the burning fuel.
- The large drops minimize steam production.
- The large drops permanently extinguish the fire.
- It infuses the right amount of air to drive away fire but not overpressurize the room.
- The thermal balance is maintained: The hottest air remains up, the coolest air down.

It is important to note that this conclusion is based on one very important assumption: that only the air movement caused by the stream's movement affects the fire and drives it away. We could not conceive of another reason, although it may certainly exist.

Up until our tests, quantitative data did not exist to support the emotional claims that rotating the nozzle clockwise pushes fire away better and results in better fire control. Although we designed what we believe is an unbiased test, it is very apparent to us that there may be something very significant that these tests did not consider or detect. In an effort to further investigate this clockwise-counterclockwise phenomenon, we conducted two more tests with two additional nozzles.

ADDITIONAL TESTS

Santa Rosa Nozzles

Many firefighters believe the clockwise motion should be used because of the direction of spin of the engine's centrifugal pump. The rationale is that the water is spinning in a particular direction as it comes out of the solid bore nozzle and this spinning is the reason for "better fire control with the clockwise motion." Although we do not believe this is true, our second test of this phase was an attempt to dispel this long-standing myth. It seems logical that if this were true, nozzles with flow straighteners would not "push fire" as well as those without. This test also provided another verification of our first results.

(5) This model of an old-style periphery jet nozzle flows only 85 gpm. (Photo by Jerry Knapp.)

The nozzle used was an old-style periphery jet nozzle, known to us as a "Santa Rosa" nozzle. This nozzle had a limited (85-gpm) flow. The water that exits these nozzles is directed against a baffle and then to the peripheral ring of the nozzle, resulting in a spray or fog pattern. If the water were in fact in a centrifugal pump-induced swirling flow, these two rapid directional changes would cause it to finally exit the nozzle in a straight line. Visual observation shows the water exiting the nozzle and traveling straight away from the tip with no apparent swirl, curve, or the like. Selection of this nozzle was also based on its age. We thought that the clockwise-counterclockwise issue may be related to some unknown factor of a nozzle of this era. Results from this test were the same as for the first: no significant difference in airflow or direction.

Spinning Teeth

Another reason commonly given for why the clockwise rotation works better to drive fire away from the nozzle team is the spinning teeth on a combination nozzle. We conducted a third series of tests using a nozzle with spinning teeth. Again, we saw no significant measurable reason to support the theory that clockwise rotation of the nozzle is more effective. When the nozzles were set on 30° fog and rotated clockwise or counterclockwise, the same air volume and direction were noted.

(6) This modern combination nozzle, flowing approximately 150 gpm, is being rotated counterclockwise and directed out a window of the test facility. Air movement direction and volume were exactly the same for each rotational direction. (Photo by Tim Pillsworth.)

TEST CONCLUSIONS

There is a large body of very technical research pertaining to fire control and extinguishment with water. Much of it is extremely theoretical, and street firefighters cannot apply it to their current operations. An equal number of volumes of research argue for one method or another of fire attack. There is a significant need to combine the practical fireground experience with the theoretical knowledge so we can improve and understand our current fire attack methods. Our nozzle testing program was not as controlled and as precise as we would have liked it. It is, however, rooted in real, world-class fireground practicality.

This series of articles provides the fire service with realistic test results of a variety of nozzle-movement techniques. Firefighters can use the field tests and demonstrations we developed to eliminate some of the long-standing myths that have developed over the years and to formulate better, safer, and more realistic and appropriate fire attack training, methods, and operations.

In the end, the engine company's successful aggressive interior attack will protect the lives of everyone on the fireground. Make sure that whatever method and nozzle you choose, your members will be able to execute it flawlessly on time, every time. ■

This article is dedicated to Lt. Andy Fredericks, Squad 18, Fire Department of New York, who was killed while saving others during the World Trade Center attack on 9-11-01.