NOZZLE TESTS PROVE FIREGROUND REALITIES

BY JERRY KNAPP, TIM PILLSWORTH, AND SEAN P. WHITE

A NUMBER OF CRITICAL FACTORS AFFECT THE OUTcome of an aggressive interior fire attack at a structure fire. The most important of them is the nozzleman's understanding of what actually happens to the fire conditions in the room or building where firefighters make the push with the hoseline to extinguish the fire.

When operating the line inside, we often don't see the effects caused by the nozzle, the stream pattern, and associated air movement on the fire environment because our vision is obscured by dense smoke and steam. Consequently, we have limited quality opportunities to witness, experience, and learn from conditions caused by our application of water during an aggressive interior fire attack.

The purpose of this article is to help you improve your next aggressive interior fire attack operation by providing observations and measurements from nozzle tests conducted at the Rockland County Fire Training Center in Pomona, New York. Test results will be linked to fireground experience, existing information, and research.

TEST APPARATUS

The purpose of our testing was to measure the amount of air moved by the solid/smooth-bore nozzle and the combination nozzle set in the straight-stream and fog patterns. They were operated in typical fireground methods in a simulated fire environment. The test apparatus was designed to capture as much of the air moved by the nozzle as possible while providing ventilation behind and in front of the nozzle. This configuration was selected to simulate the open door through which firefighters enter the fire area and an open window across the room simulating the horizontal ventilation conducted by an exterior firefighter (see Figure 1).

A shipping container 6.5 feet wide; 8 feet, 10 inches high; and 22

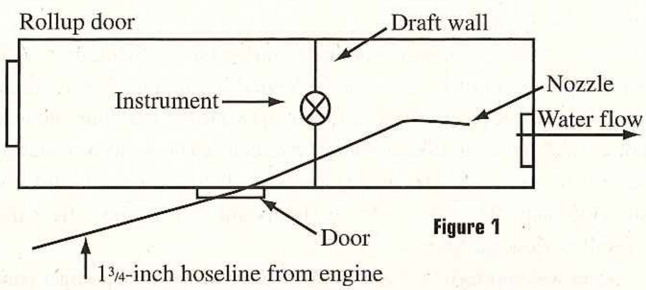
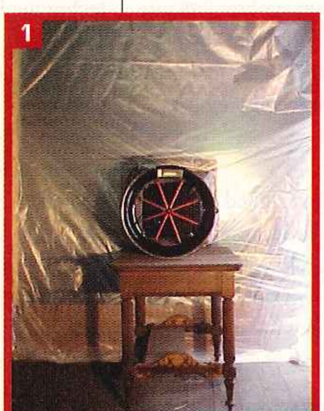
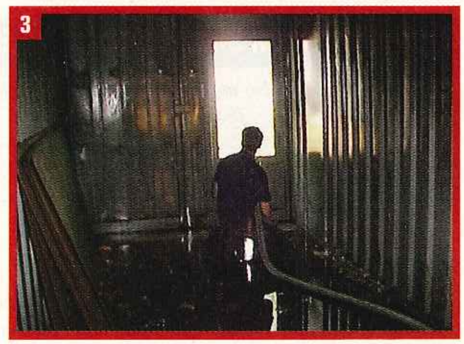


Figure 1





(1) Interior view of the draft wall with an air-measuring instrument in place on the table. A hoseline was passed through the draft wall in the lower right corner of the wall. The line was not in place at the time this photo was taken. (Photos by Jerry Knapp.) (2) Exterior view of the fog stream being directed out the window of the shipping container. (3) Overall view of the shipping container from the inside. The draft wall is behind the photographer.

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feet long (exterior wall to draft wall) was used for testing and taking airflow measurements. A draft wall (2 × 4s and plastic sheeting) was installed prior to testing and sealed against the floor, ceiling, and sides of the container. A 2-foot × 2-foot opening was made to provide a source of air for the test area (simulating the door through which firefighters would have entered) and to provide a means for instrumentation specifically designed to measure the flow of air through the opening. The airflow-measuring device, a velocity/volume meter, typically is used to measure airflow from ceiling vents to balance HVAC systems. The instrument reads positive and negative directions in cubic feet per minute (cfm) of air.

Hose streams were operated from three points: at the window, four feet from the window, and 10 feet from the window. Nozzles were operated in as realistic a manner as possible; extreme care was taken to maintain similar positions and limit variables. Turnout gear was not worn because the weather was extremely hot. No live fire or smoke was used.

Five repetitive tests were conducted on each trial; the figures were averaged to minimize false values created by unique or unrealistic data. Wind during the tests was less than two miles per hour and was not considered a significant factor. Ambient airflows were checked several times during the testing process. Test instruments did not show ambient flows of air to be significant and did not affect the overall airflow readings.

Water was supplied by 100 feet of 1¾-inch hose from a pumper connected to the hydrant supplied by the municipal water system. Pressure gauges added to the nozzles for test purposes and a digital flowmeter on the discharge side of the engine monitored proper flows and pressures. All nozzles were operated at their design flows and pressures.

AIR MOVED BY SMOOTH BORE

The test involving the smooth-bore nozzle was designed to measure the airflow caused by a solid-bore nozzle. A solid-bore 15⁄16-inch nozzle was operated at 50 psi, flowing approximately 180 gpm with the results shown in the chart below. The nozzle was operated without being moved and then was moved in clockwise/side-to-side motion out the window.

AIRFLOW FROM SOLID-BORE NOZZLE

	No movement	*Clockwise movement*	*% increase*
0 feet from window	250 cfm	250	0
4 feet from window	350 cfm	500	43
10 feet from window	510 cfm	725	42

ANALYSIS

The data collected verified that, when compared with fog streams, solid-bore nozzles move relatively little air into the fire area. This information supports what we have long been told: The solid-bore nozzle will not disturb the thermal balance of the room. The moving of minimal air into the fire room benefits firefighters by keeping the hot air at the ceiling and the cool air at the floor. Inside the fire building, this means that using a solid-stream nozzle will most likely allow firefighters to move through the fire room and continue to advance to additional rooms to complete extinguishment.

Additionally, because the solid-bore stream produces very little steam, firefighters' turnout gear protects them enough to allow them to move through the fire area. The steam produced can easily exit through the horizontal or vertical ventilation openings made as an integral part of the attack. We must remember, when discussing the effects of our hoselines and nozzles, to factor in the other phases of the fire attack process, such as ventilation and search and rescue. These critical operations are influencing or being influenced by the fire attack operation.

The fact that solid-bore nozzles do not move significant quantities of air into the fire area has additional benefits:

- The potential for pushing fire into rooms that are not involved is greatly reduced. This may save the lives of firefighters conducting searches or on other missions. It also greatly increases the chances of survival for civilians who may be trapped in adjoining areas.
- It is well-documented that the oxygen content of the fire environment is the controlling factor in fire growth and spread. This may be especially important in buildings with energy-efficient windows. It seems reasonable to conclude that not driving large quantities of air into the fire area will have a positive influence on the fire attack by not stimulating fire growth in areas not being reached by the water.
- Oxygen is prevented from entering an adjoining room that has been collecting flammable products of combustion, and heat from the fire room and may be ready to light up if oxygen is added.

MOVE THE NOZZLE!

A common technique taught during engine company training is to operate the nozzle in a clockwise/side-to-side motion. We used this technique in Part 2 of the test, directing the stream out the window. *In all tests, using smooth-bore nozzles, we were able to document a 42 to 43 percent increase in the amount of air moved by the fire stream.*

These data are consistent with our fireground experiences and were documented in a Fire Department of New York 1989 engine company operations manual.[1] In the section describing how to operate the nozzle while advancing, the manual states the following in part: "He (nozzleman) should then set himself in position so he can hit the fire and operate the stream forward and upward, hitting the ceiling in a whipping (side-to-side) or clockwise action."

After many experiments, the following was concluded: When rotating the nozzle in a clockwise manner,

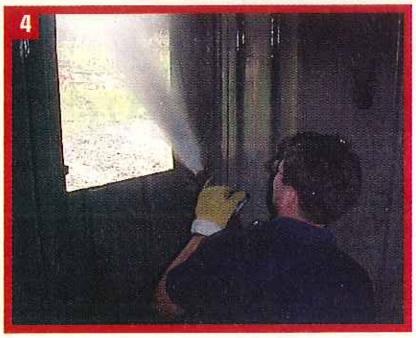
- most of the heated gases and smoke was driven away from the nozzleman;
- any flame close to the nozzleman was driven away from him;
- the steam formed by the application had a particularly violent rolling action;
- the fire knockdown, by many timed experiments, was faster and the efficiency of the water was increased; and
- rotating the nozzle in a counterclockwise action will produce opposite effects.

It is reasonable to conclude that rotating a solid-bore nozzle clockwise for interior fire attack removes the optimum amount of air for safe and aggressive operations.

SOLID BORES CAN'T VENTILATE

"Solid bores can't ventilate" is another fire service "truism" to which we sought to apply a numerical measurement. Many firefighters claim they must have a fog nozzle so they can direct a fog pattern out a window for ventilation purposes after fire extinguishment.

Although we don't understand why you would choose a nozzle based on its ventilation abilities and performance, we repeatedly hear this argu-



(4) A 15⁄16-inch solid bore with the bail open 50 percent is creating a broken stream, 50 psi and 160 gpm.

ment. It's akin to choosing a ventilation saw for its suitability to flow water or a hook to beat out the fire.

When we created a "broken stream" by closing the nozzle by 50 percent and directing this pattern out a window, we achieved airflows of 1,150 cfm. Nozzle pressure was 50 psi, and the flow was reduced to 160 gpm.

This airflow is not nearly as much as that created by a fog nozzle, but consider the following: A 12- × 16- × 8-foot room is 1,536 cubic feet. This solid-bore tip will provide one complete air exchange in 1 minute, 20 seconds (1,150 cfm) if operated as described above. A broken stream from a solid bore will provide ventilation, but it is not as effective a ventilation tool as a fog stream.

AIRFLOW FROM BROKEN STREAMS

	No movement	*Clockwise movement*	*% increase*
0 feet from window	300 cfm	550	83
4 feet from window	625 cfm	650	4
10 feet from window	950 cfm	1,150	21

The second goal of our testing was to compare the amount of air moved by straight streams generated by fog nozzles.

As you can see from this table, straight streams generated by fog nozzles moved a volume of air similar to that moved by solid bores.

AIRFLOW FROM STRAIGHT STREAMS

	No movement	*Clockwise movement*	*% increase*
0 feet from window	200 cfm	250	25
4 feet from window	325 cfm	550	69
10 feet from window	225 cfm	650	188

Moving the nozzle in a circular motion causes a dramatic increase in air movement away from the nozzle. Data were collected from three separate fog nozzles, all flowing at designed pressures and volumes. The airflows caused by each of these nozzles are summarized in the above chart.

In terms of air movement, it is reasonable to conclude that straight streams generated by fog nozzles perform very similarly to solid-bore nozzles for interior fire attack. We did not attempt to evaluate variations in reach, nozzle reaction, or stream integrity.

Fireground experience is our best teacher. In a 1995 article titled "Choosing a Nozzle," District Chief Andrew O'Donnell shared and summarized his years of very valuable experiences from his early days "on the busiest engine companies in Chicago."[2] He stated: "I have been involved in many comparison tests of nozzles without the help of sales people or other biased interference and conclude that, first, all nozzles vary from manufacturer to manufacturer (depending on quality of design and workmanship in eliminating water turbulence within the device); and, second, in the real world of interior structure firefighting, the difference between smooth bore and straight stream in terms of direct attack effectiveness is negligible."

In the remainder of the article, Chief O'Donnell makes the following points about the advantage of using a combination nozzle:

- The straight stream is available for interior firefighting.
- The fog pattern is available to ventilate if necessary.
- Fog patterns may be necessary for flammable liquid fires or flammable gases such as propane. Foam (nonaerated) can be discharged through it if necessary. Too much nozzle pressure can be overcome simply by throttling down the nozzle (and maintaining an effective stream).
- A low-pressure fog nozzle has reduced nozzle reaction for low-staffing situations.

FOG NOZZLES AS PROTECTION DURING FIRE ATTACK

Many firefighters choose a combination nozzle for interior fire attack so they can use the fog pattern to ventilate. They further profess a burning need for the fog pattern for "protection" during an aggressive interior fire attack. The bases for these thoughts/opinions are the airflow patterns, air-movement volumes, and velocities they experience while operating the nozzle *outside* a structure during a training evolution without the realistic heat or confinements of a fire condition. Let's take a closer look at that interior air movement to examine the volume of air moved and then the pattern of movement *inside* a fire area.

The following chart summarizes numerous tests with three different fog nozzles in the configuration previously described. Nozzles tested were a low-pressure, constant-gallonage fog tip and two automatic nozzles.

As you can see and as we know from experience, you get the most airflow from four to 10 feet back from the window when using the fog pattern for ventilation. However, some additional explanation of these numbers is critical to these results.

AIRFLOW FROM FOG NOZZLES

	30° Fog	*Wide Fog*
0 feet from window	500	1,000 cfm
4 feet from window	1,500-2,000+	2,000+
10 feet from window	2,000+	2,000+

The instrument we used had a maximum upper limit of 2,000 cfm. We were able to accurately measure and, therefore, prove that at least this much air is moved. While flowing the fog nozzles as described, two interesting things happened. First, the test instrument was violently sucked out of the draft wall and thrown onto the floor by the huge volumes of air moved by the fog nozzle. During testing of fog streams, we had to position a firefighter at the draft wall to hold the instrument in place.

Second, as photo 5 shows, the fog pattern moved so much air that water was being sucked up through a

(5) Water is being sucked up through the floor while the fog line is flowing out the window. Air movements from the fog stream caused a massive amount of negative pressure.

hole in the floor of the shipping container. Water from previous tests had run under the box and was being lifted off the ground, six inches below the container, and drawn up in a geyser-like fashion through the floor and into the box.

These observations, combined with the rapid maximum readings obtained from the instrument, demonstrated that air flows from the fog nozzles we tested were easily three to five times what was measured. *This leads to estimates of 6,000 to 10,000 cfm of total air movement in the fire area when using fog patterns (at flows and pressures noted) for interior fire attack.*

Let's relate this airflow volume to our experience. According to advertising data, state-of-the-art electric smoke ejectors with ½- to 1½-hp motors move between 3,200 to 4,500 cfm, depending on the strength of the motor used. Even if the low-end estimate of 6,000 cfm of air moved by a fog nozzle were used, would you conduct an interior fire attack by simultaneously advancing a nozzle team and a smoke ejector team into the fire building? Of course, this sounds ridiculous; but if you use a fog nozzle inside a fire building, the airflows would be very similar.

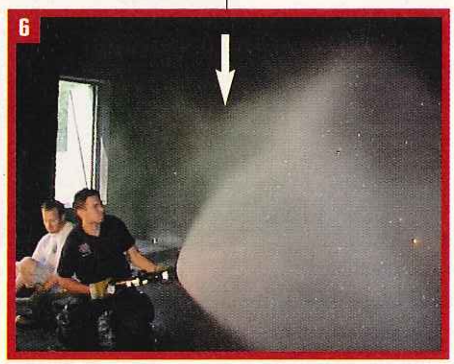
The quantities of air moved by fog lines has been well known for many years. William E. Clark, in *Firefighting Principles and Practices*,[3] states: "The effects of mechanical ventilation by fog nozzles were first studied by Fitzgerald in New York in 1957." Clark reported air movements as high as 144,000 cfm.

Later in the chapter, Clark notes: "His measurements showed that a fog nozzle on a 2½-inch hoseline operating at a nozzle pressure of 100 psi will cause air movement with a velocity of 1,000 feet per minute and discharge about 30,000 cfm through an opening measuring 30 square feet."

Our test facility had a four-square-foot intake area and an eight-square-foot discharge window.

Clarke also states in his book, originally published in 1974: "Comparisons with currently available smoke ejectors show that a fog nozzle operating at 100 psi and a discharge of 60 gpm can move 20 percent more air than a 10,000-cfm fan" (20 percent greater than 10,000 = 12,000 cfm).

Clearly, we have proven that fog nozzles can and do move large amounts of air into the fire area. Many firefighters see this as a good tool that will help drive fire, heat, and steam away from the nozzleman. As previously mentioned, firefighters make this ob-servation from experience with the nozzle outside the fire building and then assume incorrectly that the same thing happens inside a building or room under fire conditions. This, however, is not true. We must understand exactly what effect the nozzle is having on the air movement inside the fire rooms.



(6) Fog is injected into a nonventilated fire room, resulting in dangerous ricochet of superheated air and steam onto the nozzle team, as indicated by the arrow.

Using estimated air flows from fog nozzles, consider this example: You are making an aggressive interior attack on a room-and-contents fire in a living room 12 feet × 16 feet × 8 feet. The volume of this room is 1,536 cubic feet. You enter the room to extinguish the fire; open the nozzle to a 30° or 45° fog; and then whip the nozzle around in large, rapid clockwise circles for 20 seconds. The fog pattern will introduce approximately 6,000 cfm of air into that room. In about 20 seconds, you would have introduced about 2,000 cfm, thereby more than doubling the volume of air that room is capable of holding.

This air (2,000 cubic feet) has to go somewhere, and it does. Firefighters who support the use of fog for interior firefighting assume that all of that air is being driven out the horizontal ventilation hole (door or window). They make this assumption because they feel the air currents move away from them while operating the nozzle outside a fire building. Outside, there is no limit to the size of the ventilation/discharge opening, as there is inside a building.

Actually only *some of the air* will go out the window (that the outside vent firefighter has taken for you). The remainder of that air will enter the 2,000°F upper atmosphere of the room (this temperature figure was well-documented by the National Institute of Standards and Technology[4]) and return to you as steam (converted from the small drops of water you injected into the superheated area) to burn the backup firefighter and the nozzleman. This will happen because the fog nozzle overpressurizes the room even if there is a good-size vent opening.

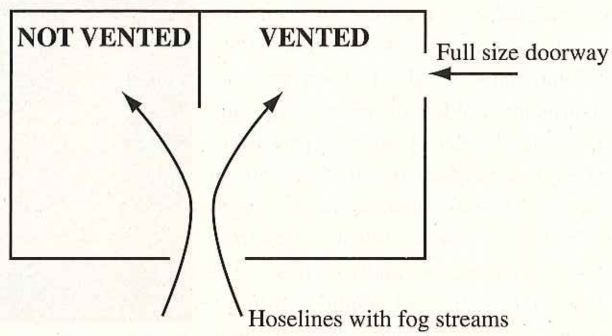


Figure 2. Floor plan of test building for fog streams.

We were able to demonstrate this fact with the following experiment. A fog line was operated as shown in Figure 2.

First, a fog stream was directed into a room that was not ventilated in front of the stream (see photo 6). As expected, the stream injected large amounts of air into the fire area. Because of overpressurization, water entrained in the air was driven back onto the nozzle team from the ceiling level. In a real-fire environment, the temperatures at the ceiling could have been near 2,000°F.

Note that in photo 6 the arrow indicates water being rapidly directed back at the nozzle team. This water was moving at great velocity. During our testing, the backup firefighter said that he could feel the impact of the water on his shoulders through his T-shirt. We did not have live fire and did not wear turnouts because of the 100°F August temperatures and humidity.

To support those who profess to use fog as protection, we directed the same fog stream toward a fire room that had a full-size doorway in the far corner, in front of the nozzle. To our surprise, the air currents were the same as those described above. At first, this seems impossible. However, if you remember how much air is being moved by the line and the negative pressures created by the fast-moving water away from the nozzle, it makes perfect sense. We coined the term *fog nozzle ricochet* to describe these dangerous effects.

Photos 7 and 8 show fog nozzle ricochet from a fog stream inside a building with the stream directed toward an open doorway. Note that these air currents are very different from those we experienced with the fog line operating outside a building. Inside air currents are not the same as the outside air currents created by fog streams. Again, it is important to note that the still photo cannot show that fog pattern ricochet is actually a continuous stream of superheated air, steam, and products of combustion being driven back onto the nozzle team.

Returning to our fog attack example, we have examined only the first 20 seconds of the attack. Each additional 20 seconds of fog flowed into that room adds 130 percent to the room air volume. What this means is that any air, now superheated by water expansion to steam and heated by the fire, that does not go out the window will remain in the room with you. The fog has caused violent and continuous air movements, essentially stirring up the air, heat, and products of combustion into a uniformly hot, steamy, and dangerous area. The fire attack team, using what we in Rockland County refer to as the "Spray and Pray" method, has now created in the fire area "Fireman's Soup," and firefighters are the main (painful) ingredient.

THE FIRE ATTACK TEAM, USING WHAT WE CALL THE "SPRAY AND PRAY" METHOD, HAS NOW CREATED IN THE FIRE AREA "FIREMAN'S SOUP," AND FIREFIGHTERS ARE THE MAIN (PAINFUL) INGREDIENT.

The fortunate or unfortunate thing about the fire I just described is that one-room fires can be successfully extinguished using this Spray and Pray technique. Then again, almost anything works on fires limited to one room. A number of years ago, we witnessed a fire department extinguish a fully involved kitchen fire from the outside with a booster line. The technique worked because the fire was contained to one room and firefighters made entry immediately after this dangerous nozzle technique.

The concept that all fires are like one-room fires kept ineffective fire attack operations such as high-pressure fog and the indirect attack alive for so many years. Sure, high-pressure fog works for a one-room fire, but, as we said, almost anything works for a one-room fire!

Without a doubt, once the fog line has disturbed the thermal balance of the room (hot air up, cool air down) and the small drops of water have converted to massive amounts of steam, the fire attack team will not be able to move through that atmosphere farther into the fire building to continue the attack. The building will die a slow death, creating another parking lot, and firefighters will profess later that it was way too hot to get inside.

(7, 8) A stream being directed toward an open door; an open doorway and an opened window are behind the nozzle team. Note the excessive ricochet that would carry superheated steam back to the nozzle team.

SOLID AND STRAIGHT STREAMS

Compare the volume of air introduced by the fog line with that introduced by the straight or solid-bore stream. From our test data, we know the $^{15}/_{16}$-inch solid bores will move a maximum of 750 cfm if operated in a clockwise motion. In the first 20 seconds, approximately 250 cfm will be introduced into the room along with 60 gallons of water to quench the fire. The introduced air is only 16 percent of the room volume. The vented window will easily allow that much air to escape, maintaining tolerable conditions in the room for firefighters to advance. Because of this low airflow and air movement, the thermal balance is maintained. Dangerous temperatures at the high levels of the room will remain until complete ventilation takes place.

Additionally, because most of the water fell in large drops onto the fuel, the fire was rapidly, successfully, and *permanently* extinguished with only minimal steam production. Conditions created by this method will allow firefighters to move through this room and extinguish fire in other rooms.

The late Andrew A. Fredericks, a frequent contributor to and advisory board member of *Fire Engineering* and a passionate supporter of solid-bore streams, stated in "Return of the Solid Stream"[5] the following:

> When I first entered the fire service in the late 1970s, many of my instructors taught both the indirect and combination methods of fire attack with little or no mention of the direct method. Training films of the period demonstrate the supposed efficiency of using 30° and 60° fog patterns for interior fire attack, and live fire drills often involved tolerating extremely debilitating heat conditions brought about by inappropriate use of fog streams. As recently as 1987, while engaged in a training exercise as a member of a career fire department in Virginia, I received a second-degree steam burn on my face due to improper use of fog within the training building—even while wearing a protective hood.
>
> Although my instructors preached the gospel of fog, the most experienced nozzlemen I fought fires with consistently used straight streams and the direct method of extinguishment. I, too, adopted this method of aggressive interior fire attack; and, in my 16 years as a career and volunteer firefighter, I have never used anything but a straight stream or a solid stream inside the fire building.

FOG ... MISINTERPRETED

Given all the facts presented above, why is anyone STILL using a fog stream inside a fire building? Some of the reasons are experiences with one-room fires and, even more so, the misinterpretation of the indirect method of attack as developed and presented by Lloyd Layman in *Attacking and Extinguishing Interior Fires*.[6]

As young firefighters, we were taught to "get inside, put it on fog, and whip it around," and the fire will go out. This is the "spray and pray" method of fire attack. For many years, the fire service may have misinterpreted the indirect theory of fire attack.

Chief Layman's techniques were developed from 1943 to 1951 for use on shipboard firefighting. Layman never suggested using fog lines inside a fire building. Here are a few highlighted excerpts from his book that make this point.

• On how and where the testing and technique were developed:

"This being a full-scale experimental project for the purpose of developing effective and practical methods for controlling and extinguishing fires involved in baled cotton within the holds of cargo vessels."

• Photos that depict the indirect attack show firefighters outside the building injecting fog inside; the opposing page reads in part: "An indirect attack should always be made from positions that will enable personnel to avoid injuries from super-heated smoke and live steam. If possible and practical, an indirect attack should be made from positions outside the involved building."

• Regarding the use of fog from inside the building: "Where the area of major involvement is on upper floors, it may be possible and practical to attack from an interior stairway below the involved floor. The nozzleman may have to discontinue the attack temporarily to avoid the downward movement of heated smoke and steam."

• On positioning the attack line: "A doorway is an undesirable type of opening due to the size, and usually the nozzleman will have to discontinue the attack and retreat to avoid envelopment by heated smoke and steam."

• Today, rapid and aggressive ventilation always accompanies our interior fire attacks. In 1955, Chief Layman wrote, "Conventional methods of ventilation are practical only where a fire is in its first phase or has entered the second phase but has not developed sufficient volume and flame production to generate excessive atmospheric temperature within the involved area."

• William E. Clark, a friend of Layman, described in September 1995[7] how the indirect attack may work well for cargo holds of ships that can be sealed up and remain that way but may be inappropriate for modern aggressive interior structure fire attack:

"The principle is very simple: Aim the fog stream through a window toward the ceiling. The water will expand about 1,700 times as it turns to steam, and the steam will smother the fire, even in places remote from the point of application.

"Rules for success. Several rules must be met to obtain success; however, Layman told me the first three, namely:

"1. The water must be in spray (fog) form.

"2. The ceiling temperature at the site at which the water is applied must be at least 1,000°F.

"3. Confinement of the steam within the building is essential to utilize the smothering effect, although cooling will extinguish the fire in the areas where the water is applied.

"Based on my own observations at several full-scale test fires, I offer these two additional rules:

"4. The effectiveness of the steam smother is in inverse proportion to the amount of ventilation. Even a small opening through which steam can escape will lower effectiveness considerably.

"5. The effect of steam smothering is permanent on liquid fires but transitory on solid fuels because they hold heat longer and will reignite as the steam dissipates and is replaced by air. In one of our tests, the remote fire darkened by steam rising through a shaft was burning briskly again two minutes later."

• • •

Layman deserves great credit for his advances in shipboard firefighting and the use of fog as another tool for the fire service toolbox. More than 15,000 copies of his book were distributed in the 1950s. Maybe it is time for all firefighters to read and understand Layman's methods. It is important to understand that times and conditions have changed since 1943, when Layman published his book. At that time, some apparatus had hard rubber tires, aerial ladders were made of wood, coats were made of rubber, some helmets were made of aluminum, there was no SCBA, and ventilation was completely lacking. Times and conditions have changed since 1943. It is just not the way we do business today.

Fire departments that are conducting successful, safe, and efficient aggressive interior fire attack operations use rapid ventilation, excellent protective clothing for firefighters, SCBA, and solid-bore or straight streams for direct fire attack. These components achieve the safest, most expedient fire extinguishment.

The fog/solid-bore debate has entertained us for years in discussions around the fire station kitchen table, at seminars, and at training sessions. These test procedures were developed as a result of our engine company operations classes at the Rockland County Fire Training Center. We urge you to try some of these experiments yourself, without live fire, to make your own observations and draw your own conclusions. ■

Thanks to the following for their assistance: Captain Troy Spong and Driver/Operator Jason Spong, West Haverstraw (NY) Fire Department; Tom Bierds, New York State fire instructor, Walter Morris, training supervisor, and Gordon Wren, Rockland County fire coordinator, Rockland County Fire Training Center, Pomona, New York; Gordie Harris, Elkhart Brass; Joseph Poptanich and Phil Traver, Wallkill (NY) Ambulance Corps.

This article is dedicated to Lieutenant Andrew A. Fredericks, of Fire Department of New York Squad 18, who was killed during the World Trade Center attacks on September 11, 2001. He lives in our hearts as a friend, a firefighter, and an ever-present enthusiastic supporter of solid-bore nozzles.

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