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RETURN OF THE SOLID STREAM

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A growing number of fire departments large and small are returning to the use of solid-stream nozzles (also called "smooth-bore" or "solid-bore" nozzles) for interior structure firefighting. They are realizing success in directly attacking interior fires using the long reach afforded by the compact solid stream and fire-quenching power of its high-volume flow. This article is intended to describe some of the many benefits provided by solid streams and to contrast the safety and efficiency of the direct method of fire attack with both the indirect method and the so-called "combination" attack. 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 demonstrated the supposed efficiency of using 30- and 60-degree 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 solid stream inside the fire building.

Whereas the indirect method of attack, if employed properly at fires involving unoccupied enclosed spaces such as attics and cocklofts, can be a valuable tactical tool, the same cannot be said about the combination method. In my opinion and that of a growing number of firefighters and fire officers, the combination attack should be permanently retired to the scrap heap of tried and failed firefighting techniques. In almost all cases, an aggressive, interior, direct attack will provide for rapid and efficient fire control while minimizing the potential of burn injury to civilians and firefighters.

PRINCIPLES OF DIRECT EXTINGUISHMENT

The direct method of attack involves applying water directly on the burning fuel to cool it below its ignition temperature and suppress production of volatile vapors. If the fire is small and localized, a fire stream, such as that from a pressurized water extinguisher, may be aimed directly at the base of the flames; in short order, the fire will be extinguished. Even in the case of a mattress burning in a bedroom or rubbish burning in a hallway, a stream from a handline can be applied directly on the burning materials. In the case of larger fires--those approaching flashover and those already in the fully developed phase--it may not be possible or safe to immediately apply a stream of water directly on the burning fuel. Due to burning fire gases rolling across the ceiling, high heat conditions, and/or partitions and obstructions interfering with the direct application of water, the stream first must be deflected off the ceiling and upper walls until the nozzle team can get close enough to permit direct cooling of the fuel.

Some members of the fire service confuse the deflection of a straight stream or solid stream off the ceiling and walls with "indirect" extinguishment. The purpose of directing the stream upward at a 60- or 70-degree angle is not to cause rapid cooling of the effluent fire gases (which will create large amounts of steam, as in the indirect and combination methods of attack) but to allow droplets of water from the stream to rebound off the ceiling and walls, penetrate thermal currents produced by the fire, and start cooling the burning fuel--all while the nozzle team operates from a safe distance. Once the rolling flame front at the ceiling has been repulsed due to a reduction in fire gas development, the nozzle team can make a close approach to the seat of the fire and complete the extinguishment process.

CRITICAL FACTORS

Four critical factors affect the safe and efficient extinguishment of fires using the direct method:

-Volume or flow sufficient to overcome the heat being produced by the fire. Many fire attack operations have been doomed to failure simply because the size of hose was too small to deliver the proper flow or the nozzle was designed with a flow range too limited for the job at hand.

-Form or shape of the water as it leaves the nozzle (commonly called the "pattern") and as it reaches the burning fuel. The goal is to get water on the fuel-flame interface without premature vaporization of the water and excess steam production.

-Reach and penetration of the stream, enabling the nozzle crew to initiate operations from a safe distance and allowing "the water to do the work." I am not saying to open the nozzle on smoke, but the nozzle team does not have to be so close as to risk severe burn injury. In addition, the hydraulic force of the stream should be sufficient to allow penetration of tightly packed or baled materials.

-Ventilation. This critical factor must be timely and adequate. Ventilation is essential to remove combustion gases, smoke, and unwanted steam and permit an unhindered advance to the seat of the fire. We learned in basic firefighter training that when water converts from liquid to vapor at 212°F, it expands some 1,700 times its volume. Most of us were never taught, however, that at 1,000°F, a ceiling temperature easily attained at interior fires, water expands some 4,000 times! Without a large channel or opening through which to remove this superheated steam safely to the outside, suppression crews will be enveloped in the expanding steam and subjected to extreme discomfort and often painful burns.

Regardless of the type of stream--fog, straight, or solid--whenever a nozzle is opened in the fire building, conditions for the nozzle team immediately worsen. Most visibility is lost, and it can become uncomfortably hot and humid even near the floor. There is no magic fire stream, but a direct attack with straight or solid streams coupled with proper ventilation wins hands down over the combination method in maintaining more tolerable interior conditions.

SOLID STREAMS VS. STRAIGHT STREAMS

Although their use in direct attack is similar, straight and solid streams have distinct differences. A straight stream is, in essence, a very narrow fog stream. It is produced by a combination nozzle and is composed of millions of tiny water droplets separated by air entrained within the stream. One text identifies the narrow stream produced by a fog nozzle as a "solid" stream, but this is not correct. A solid stream is produced by a smooth-bore orifice and is a compact, solid cylinder of water as it leaves the nozzle. With proper tip pressure, a solid stream will remain compact for a considerable distance before friction with the air, gravity, and other factors degrade the quality of the stream.
One important reason solid streams are more effective than straight streams in interior fire attack concerns water droplets. When a solid stream is deflected off the ceiling and walls, it produces droplets of sufficient size and mass to reach the burning fuel without being carried away by thermal currents or vaporized prematurely by the heat of the fire. Straight streams--created by fog nozzles and therefore the result of changing the direction of water travel within the nozzle by striking the stream against a deflector (most fire service nozzles are of this type, called periphery jet)--consist of countless small droplets that are made even smaller in colliding with the ceiling and upper walls. These smaller droplets, with their low mass, are drawn into and propelled out of the thermal column of the fire, never reaching the burning fuel--producing excess steam and wasting water.

MISCONCEPTIONS ABOUT SOLID STREAMS

Misconceptions about solid streams abound within the fire service community. I will address some of the most common ones. The first and most commonly held misconception is that a solid stream, unlike a fog stream, does not offer the nozzle team protection when operating inside the fire building. I`m sure you`ve heard that the fog pattern will protect you should fire roll over your head or flashover occur or a gas pipe suddenly fail and create a jet of burning natural gas. It is simply not true! Using fog inside the fire building does not protect you; it burns you. The combination attack has been largely discredited because of its injury-causing potential, inefficiency, and the lack of evidence to prove otherwise.

I`ve encountered fire rolling over my head and failed gas piping, and the solid stream always offered ample protection. This misconception has it beginnings in "war stories" told to probies by "senior men" who remember the days when fog--especially high-pressure fog--was all the rage. In those days, the few self-contained breathing masks available were so bulky, heavy, and time-consuming to don that crews on the first attack line often opted not to use them. The "johnies" were amazed by stories of nozzlemen who had to "breath the air from the fog pattern" just to stay in the fire building--leaving yet another false impression that fog is a lifesaver. In reality, it is the volume and reach of the stream (in conjunction with your protective clothing and SCBA, of course) that protect you--nothing else.

The next most common misconception concerns water damage. You`ve heard it, and I`ve heard it: Solid streams cause more water damage than fog streams. Again, it is not true. William Clark in Firefighting Principles and Practices describes several tests conducted to determine the amount of water runoff from fires extinguished by solid streams and fog streams. In trial after trial, runoff from the fires extinguished by solid streams was consistently less than that from fires extinguished by fog streams at the same flow. I believe the reason is that a solid stream, used in a direct attack on the burning fuel, will knock down the fire much more quickly than a fog stream. If the nozzleman shuts down almost immediately after darkening down the main body of fire, water damage will be minimized and overall fire attack effectiveness and safety will be enhanced. These test results aside, firefighter safety and prompt control of a serious fire are absolutely more important than any concerns about water damage. If they are not, you should carefully reevaluate your tactical priorities.

A related misconception concerns water conservation. For years, many rural fire departments--and even some suburban ones--believed that, by using low-flow fog nozzles at structural fires, the water supplies carried on board their apparatus could be extended until the fire was extinguished. Problematically, unless the gpm flow being discharged was sufficient to overcome the heat produced by the fire, it continued to grow. Eventually the on-board water supplies were exhausted and by the time drafting operations, tanker shuttles, or relay operations were established, all that remained of the fire building was smoldering rubble. The key, as reflected in most modern rural fire attack operations, is to hit the fire hard and fast with ample volume to quickly knock down the fire and limit extension.

Another misconception concerns nozzle reaction. I`ve heard line officers at training sessions state that solid streams produce more nozzle reaction than straight streams. False! Solid-stream nozzles require lower operating pressures than standard fog nozzles, producing significantly less nozzle reaction and making hoselines less stiff and easier to move around corners and newel posts. In general, at equal flows, a 100-psi combination nozzle in straight-stream position will generate one-third more nozzle reaction force than a solid-stream nozzle operated at 50 psi. In an effort to control the straight stream and its higher reaction force, the nozzleman may change to a fog pattern (lessening nozzle reaction but also reducing reach) or the shutoff may be partially closed, breaking up the stream and/or reducing the flow. Any of these actions will compromise the safety of the nozzle team, and firefighting efficiency will be lost.

Misconceptions also exist about why lower pump discharge pressures resulting from the use of solid streams are better and safer than higher pressures needed to supply straight streams. Several recent articles decry those who call for lower operating pressures. One such article (purported to separate fire stream "facts" from "fantasies") points out that today`s fire hose is designed to resist pressures of at least 300 psi and that our modern pumping apparatus is designed to pump higher volume and higher pressure. This article states that since our equipment can handle the higher pressures, reducing the workload on our personnel is the key issue.

But, if this is such an important concern, why should fire departments employ fog nozzles that produce more nozzle reaction (in straight-stream position) than solid-stream tips at the same flow and make the hoseline steel hard and extremely difficult to bend and advance? In addition, higher pump pressure is a serious safety issue. Although present-day pumping apparatus is designed to operate efficiently over a wide range of discharge pressures, higher pressures are dangerous. In the real world, hose lengths burst and injure firefighters (pump operators most often) and damage apparatus and equipment. This danger is especially great when pressures greater than 250 psi are needed to supply standpipe systems in conjunction with the use of combination nozzles.

Another misconception is that solid streams degrade rapidly after leaving the nozzle whereas straight streams hold together better due to the design of the combination nozzle, which produces a more uniform "exit" velocity across the stream. In most cases, the reason some solid streams appear to break apart so rapidly is that they are over-pressurized. Most texts state that a solid-stream tip should be operated at 50 psi. In reality, lower tip pressures are better, and engine company chauffeurs in the City of New York (NY) Fire Department (FDNY) commonly supply 40 psi to the tip, producing a better, more compact fire stream. "Old timers" in the FDNY state that even lower tip pressures may be advantageous--especially when using 2 1/2-inch hose. Supplying only 30 to 35 psi to a 1 1/8-inch tip attached to 2 1/2-inch hose produces a fire stream with considerable reach, adequate volume (about 210 to 230 gpm), and reduced nozzle reaction.

STANDPIPE FIREFIGHTING OPERATIONS

One of the areas in which fire departments continually demonstrate tactical deficiency is standpipe firefighting operations. NFPA 14, Standard for the Installation of Standpipe and Hose Systems (1993 edition) states that Class I and III standpipe systems need only supply 100 psi at the most remote floor outlet. The 100 psi represents required tip pressure when using combination nozzles, but what about friction loss, which is at least 20 to 25 psi per 50-foot length of 1 3/4-inch hose at approximately 200 gpm? Older standpipe systems may only supply 65 psi at the most remote floor outlet, and a pressure this low can be safely used only in conjunction with three lengths (150 feet) of 2 1/2-inch hose and a 1 1/8-inch solid-stream tip. Critics will say that pressures can be increased sufficiently to properly supply combination nozzles once fire department pumpers begin augmenting the system. This is true in some cases; but as the Philadelphia Fire Department found out at the One Meridian Plaza high-rise fire in 1991, permanently affixed pressure-reducing hose outlet valves installed on standpipe outlets in very tall buildings will defeat any attempt to effectively augment pressures. Standpipes may also suffer from inadequate maintenance, vandalism, and clogging of the system`s piping by debris--all of which reduce outlet pressures and prevent effective augmentation. Even when higher pressures can be supplied to the floor outlets, there is a danger the system riser and/or fittings may fail due to improper design or the use of pump pressures that exceed the system`s rated pressure.

Another lesson learned from the One Meridian Plaza fire is that some types of automatic fog nozzles require a minimum pressure of 40 to 50 psi at the tip to actuate the pressure-control mechanism and produce a stream. Other departments have reported similar problems, some narrowly averting tragedy when nozzle teams were unable to flow water or suddenly lost pressure and could only dribble a stream in the direction of the fire as they beat a hasty retreat. Appendix A of NFPA 14 states the following in regard to this potentially dangerous situation: "Constant pressure (automatic) type spray nozzles (See NFPA 1964) should not be used for standpipe operations because many of this type require a minimum of 100 psi at the nozzle inlet to produce a reasonably effective fire stream." The potential to flow 200 to 250 gpm at extremely low pressures is the single most important reason solid-stream tips must be used during standpipe firefighting.

I believe it is necessary to discuss a related issue concerning standpipe operations--hoseline diameter. The FDNY uses 2 1/2-inch hose for all standpipe operations, and with good reason. The heat output of fires in high-rise office buildings requires a large volume flow to achieve successful extinguishment. Fires in high-rise residential buildings of concrete construction also demand the use of the "big line" to help overcome the oven-like conditions usually encountered. Multiple 1 3/4 or two-inch lines simply cannot provide the volume of flow that one or two properly placed 2 1/2-inch lines can. Sadly, as long as fires in high-rise buildings continue to be fought with nozzles of inappropriate design and handlines of insufficient diameter, more tragedies await America`s fire departments.

THE PROOF IS IN THE PERFORMANCE

Many fire departments have returned to the use of solid streams and many others are considering doing so. Not just large departments, but many small ones, have discovered the numerous benefits in using solid-stream nozzles for interior fire attack. I have helped train several fire departments in the proper use of these nozzles, and the response of firefighters and fire officers has been overwhelmingly positive. As a matter of fact, one fire chief told me that, since he placed solid-stream nozzles in service alongside his department`s automatic fog nozzles, the fog nozzles have been virtually forgotten. The bottom line is this: Fog nozzles are suitable for use in direct fire attack, provided they are used in straight-stream position and proper tip pressures are supplied by the pump operator. (This last point is especially important to ensure an adequate flow with automatic fog nozzles.) Solid streams are designed for efficient direct fire attack with less nozzle reaction and fewer operating variables, making them the better, safer choice in almost all situations. Maybe your department should consider a return to the solid stream.