Low-pressure, Fixed-gallonage Nozzles:
From The Standpipe to the Preconnect

By Brian Brush and Eric R. Tollund

Fire streams and nozzle selection have become an increasingly popular topic of discussion and research in the American fire service. It is this renewed interest in one of the most basic and traditional elements of fire suppression that prompted a review of West Metro (Colorado) Fire Rescue's equipment and procedures. Our department, like many, has readily accepted the use of low-pressure, fixed-gallonage nozzles for standpipe operations because of the many benefits of their application in the high-rise setting. Unfortunately, until now low pressure fog and smooth bore nozzles have remained a component of high-rise packs and have not been revisited for our more common preconnect operations. The application of these nozzles is nearly undisputed for high-rise operations, yet the task of applying this same logic to the "routine" fireground has met resistance. Operationally, we have had the water system, the apparatus and the equipment to work at higher pressures; and we've done so without questioning why.

There are two main reasons leading to our review of fire streams and nozzles. The first is recent efforts and publications by individuals and the second is from incident case studies and investigations. The fire service has been greatly influenced by a small group of instructors and educators who have dedicated their careers to helping firefighters across the country become better at what they do. One such individual is the late Andrew Fredericks of the Fire Department of New York. Andy is best known for his unparalleled commitment to engine-company operations, his writing for *Fire Engineering* and his involvement with F.D.I.C. Next, Captain David Fornell of Danbury Connecticut Fire Department has become known as a fireground hydraulic "guru" with his publication of *The Fire Stream Management Handbook*. His book is regarded as the foremost text on the subject of nozzles and fireground hydraulics. Lastly, Paul Grimwood of the London Fire Brigade and his extensive research and testing nozzle reaction and its effects has been a catalyst for change in equipment for fire attack on an international level.

Department-initiated studies and equipment reviews have also prompted changes. Following nozzle and hose studies, Boise, Idaho; St. Petersburg, Florida; and Oakland, California recently changed their preconnect equipment and operations to increase fireground flows for modern fuels and decrease the nozzle reaction encountered by firefighters. The studies and changes that resulted in Boise and St. Petersburg were acts of forward thinking and efforts to be progressive in firefighter safety and equipment. Oakland Fire Department made its changes based on the recommendations of a study following a firefighter fatality in which inadequate fire flows were cited as a key contributing factor in the death of one of their own. In September 2004, a nozzle study was initiated at West Metro to see how our 1¾-inch equipment and operations compared to these current trends.

Our department's current nozzle of choice (Elkhart SM-20FG Automatic Fog) is capable of meeting the current 1¾-inch flow rate trend of 150 g.p.m. We found however, that most of our pump operators had developed the habit of “under pumping” the initial deployment of our handlines and gradually increased pressure for greater flow as the interior crews indicated. Their reasoning was to provide a more manageable line during the stretch. In doing so, our pump operators on average are only supplying our firefighters 128 g.p.m. By planning to increase pressures with demand, we are playing catch-up with the fire and compromising safety by putting firefighters behind the ball. This type of pumping will also add to the nozzle firefighter’s workload, in terms of nozzle reaction, with every increase in pump discharge pressure. With these initial findings, we decided to outline specific objectives for our study to move forward. The first was to meet NFPA 1710 by setting a standard fireground flow of 150 g.p.m. from our 1¾-inch handlines. The second was to improve the effectiveness of fire stream application and hoseline management by decreasing nozzle reaction. The third was to simplify fireground hydraulics to ensure we are getting consistent fire flows with every handline deployment.

Why 150 g.p.m.? Nationally, 150 g.p.m. has become the target flow for 1¾-inch handlines. This number comes from NFPA 1710 (Organization and Deployment of Fire Suppression Operations by Career Fire Departments). The standard outlines that the first two handlines in operation at any initial alarm structure fire flow a minimum of 300 g.p.m. combined. Following discussion with other departments and a review of recent publications it was determined that 150 g.p.m. per 1¾-inch handline was the most common way to meet the 300 g.p.m. minimum. The West Metro Operations Division also felt that 150 g.p.m. minimum from all 1¾-inch deployments would be the most appropriate operation. As we mentioned before, our current nozzle choice is capable of supporting this flow rate.

Due to the high nozzle reaction of the Elkhart SM 20-FG, we wanted to evaluate other nozzles that could meet 150 g.p.m. or greater at lower operating pressures in order to decrease our associated reaction forces. Smooth-bore nozzles provide a high g.p.m. flow with a nozzle pressure of 50 p.s.i. We chose to test two smooth bore tips, the 7/8-inch tip with a flow of 161 g.p.m. at 50 p.s.i. and the 15/16-inch tip with a flow of 185 g.p.m. at 50 p.s.i. Another low-pressure option was 50 and 75 p.s.i. low-pressure, fixed-gallonage fog nozzles that provide low-pressure qualities and an adjustable stream. We chose to add the 150 g.p.m. at 50 p.s.i. Elkhart Chief low-pressure, fixed-gallonage fog tip to the study in order to meet the 150 g.p.m. minimum and simplify hydraulics by having a target nozzle pressure that was the same as the smooth bore tips.

Why is nozzle reaction now an issue? Nozzle reaction forces are based on Newton’s first law of motion: for every action there is an equal and opposite reaction. In fire streams, this equal-and-opposite reaction is dictated by the volume of water leaving the nozzle and the pressure at which that water leaves the nozzle. In order to change the reaction force, we must either change our g.p.m. output, the nozzle pressure, or both. The reason this has recently become such a popular consideration is in part thanks to the work by Capt. Dave Fornell of Danbury, Connecticut Fire Department and Firefighter Paul Grimmwood of the London Fire Brigade. Both of these men, through extensive research, have outlined working limits for firefighters in respect to managing nozzle reaction. This is a simple theory: firefighters are not safely fighting fire when their efforts are focused on fighting nozzle reaction. Some of the most common "side effects" of high nozzle reaction are improper stream selection (the change from a straight stream to a fog pattern), gating down the bale to lessen nozzle reaction forces, and excess water damage due to difficulties in stream direction. Paul Grimwood's study outlines the number of firefighters required to safely counter nozzle reaction: one firefighter, 60 lbs./force; two firefighters, 75 lbs./force and three firefighters, 95 lbs,/force. Keep in mind that these working limits are for safely managing the nozzle reaction. This is not how many firefighters should be on the handline for hose advancement or management, but rather how many firefighters should be directly behind the nozzle to support the reaction. During our flow testing we found the Elkhart SM-20FG automatic nozzle (our current choice) had 75 lbs./force of nozzle reaction at 150 g.p.m., the upper limit of two firefighters (our typical staffing for handlines). This presented us with a potential safety issue, because, as we mentioned before, it does not free up one of those firefighters to properly advance and manage the hoseline. The second firefighter would be committed to supporting the nozzle firefighter while flowing water. The flow testing found that, at the same 150 g.p.m. flow rate, the low-pressure, fixed-gallonage fog had a nozzle reaction force of 54 lbs./force. This is 21 lbs./force less than the SM-20 at the same flow. The smooth bores provided even higher flow rates with reaction forces that were also well below that of the SM-20FG. The 7/8-inch tip provides a flow of 161 g.p.m. and a nozzle reaction 57 lbs./force and the 15/16-inch tip a 185 g.p.m. flow and 66 lbs./force.

How are we simplifying hydraulics? It is a rule of thumb to provide a fog nozzle 100 p.s.i. nozzle pressure. Automatic nozzles, because of their compensatory spring and working parts, vary flow to maintain a constant nozzle pressure. With a 100 p.s.i. nozzle pressure, you may be supplying anywhere from 100 to 200 g.p.m.. The g.p.m. output of automatic nozzles is actually determined by pump discharge pressure, not nozzle pressure. The fact that this nozzle is so versatile in its flow range is an attractive option for departments seeking a nozzle with a wide operating range. This same characteristic may also be viewed as a hazard due to the fact that the stream changes very little with the flow rate. This can lead to poor g.p.m. output without recognition by firefighters at the nozzle. Also, as was mentioned before, knowledge of the wide operating ranges can lead to misconceptions of hydraulics and "under pumping." By changing to a nozzle with a single-target nozzle pressure for a single-target g.p.m. output, we can make our pump discharge pressure a single setting dictated by our hose length. This would make a department-wide fire-flow standard easier to implement and eliminate the need for sliding pump charts to assist with varying flow calculations. When we choose a fog nozzle with a 50 p.s.i. operating pressure, the target nozzle pressure now becomes standard for both smooth bores and fogs, simplifying training and department pump charts. Additionally, all those involved know exactly what the flow rate is, from the nozzle firefighter to the incident commander, making operational decisions such as adding lines or changing to bigger lines easy to calculate.

Following a presentation of the aforementioned studies, research and the results of our flow testing, we began a six-month trial period with three engine companies. The test companies are currently operating with the 150 g.p.m. at 50 p.s.i. fog and either the 7/8-

inch or 15/16-inch smooth bore. The operational phase of this study is to evaluate the potential benefits of lower operating pressures on the fireground and the performance of these low-pressure, fixed-gallonage nozzles. The topic of preconnect vs. static and smooth bore vs. fog will continue to be debated. It is not our purpose to say our findings or operations will work for all. We simply aim to share our process and research in equipment and information to make an educated decision and ensure successful initial attack operations.

Please contact us with any questions or for further information at: bbrush@iaff1309.org or ertollund@gmail.com.

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