The 1.75" Nozzle

Introduction:

The fire streams project team recommends a flow rate of 160 GPM minimum, but not exceed the single-firefighter 69 pound nozzle reaction force for 1.75" lines. The fire streams project team focused on the following areas to form this flow rate: response time, flashover time, heat and it's release rate, flow rates, penetration and temperature reduction, droplet size, kink tests, and nozzle reaction. This is summarized below. Please review the references at the end for more details.

Summary of Findings:

The 160 GPM flow meets the NFPA 1710 recommendation that the first two attack lines operating at a residential structure fire (once all first-alarm resources are on scene) should flow a minimum of 300 GPM. Several of the NFPA 1410 standard residential structure fire attack evolutions provide that the first two operating hand lines at a residential structure be 150 GPM each. This is logical, given response and reflex times (NFPA 1221, 1410, 1710 and NIST's Report on Residential Fireground Field Experiments), potential for flashover, nozzle reaction, and responsibilities placed on the first-arriving engine company. When applied to the residential structure referenced in NFPA 1710, a minimum single hand line flow rate of 150 GPM coincides with the NFA Fire Flow Formula and NFPA 1710's 300 GPM first-alarm flow rate, and the heat produced at a residential structure fire of low risk (using a field estimate). The 160 GPM target minimum flow allows for further firefighting capability giving a greater margin for safety that accounts for fireground obstacles and conditions. This will be discussed in further detail below.

Looking at response standards/tests (8-9 minutes) along with fire behavior tests/modeling for compartment fires, first due firefighters should be equipped to handle flashover conditions immediately. Looking at the heat release rates in a residential structure when pre-flashover conditions exist, there is little room for error. The initial attack stream must have the reach, thermal penetration, and droplet size to reach not only the burning fuel base, but also the primary radiant heat sources that lead to flashover—the ceiling-level gaseous products of combustion along with the burning ceiling and wall materials simultaneously. This stream, at a minimum, must be capable of absorbing the maximum potential HRR at the ceiling. At the same time, it also must have enough heat-absorbing capacity and mass so that a significant portion of the stream will not turn to steam. These droplets, if of sufficient mass to avoid evaporation, will then fall to the floor through the thermal column cooling it and creating survivable space. This dual-action of cooling the burning materials and the thermal column suppresses the primary fuel source and prevents the unignited combustible gases from flashing over. As droplet diameter increases, the amount of water that can fall back to the floor onto the burning material also increases because less water is lost in the convective currents through evaporation. Larger droplets place more water where it is needed—the ceiling, walls, and floor—and trap less water in the convection column between the ceiling and the floor. Gases expand as they're heated, and will contract the same volume when cooled. This creates survivable space. A straight or smooth bore stream can achieve this at this minimum flow rate.

One of the largest contributing factors of any well thought out GPM delivery rate is kinks on the fire ground (short stretches, car tires, unsecured doors, narrow hallways, etc...). Looking internally and at external studies, several common themes are found. The solid stream has the ability, at similar initial flows and lower nozzle pressures (50 psi), to maintain a higher average flow when kinks are imposed. As the required nozzle pressure increases for fog nozzles, the ability to maintain a flow decreases when kinks are imposed on the hose line—in other words, as the required operating pressure for a fog nozzle increases, it is more susceptible to flow reduction due to kinks. The 160 GPM rate leaves some room for kinks with the understanding that we keep using a lower psi rated insert for our combination tips.

Our department currently operates with Elkhart fixed-gallonage, combination nozzles with an insert that flows 175 GPM at 75 psi. We have found that this nozzle has a range of 160-168 GPM before it exceeds the industry standard nozzle reaction, for one firefighter, of 69 pounds reaction force.

The fire streams project team matched our current combination tip with a 15/16" solid bore tip. The 15/16" solid bore tip is rated to flow 182 GPM and 50 psi at the tip. This tip size was the largest tip that members could operate while still meeting the nozzle reaction criteria listed above and still provide the necessary flow with kinks imposed (20 GPM drop). This gives our firefighters a greater safety margin when working to extinguish a structure fire with pre- or post-flashover conditions.

The fire streams project team was able to find a balance between both the combination and smooth bore tips. This balance allows the pump operator to keep the same pump discharge pressure (PDP).

(Example: 1.75" Pump Discharge Pressure)

200' of 1.75" with a PDP of 150 psi
15/16" Solid Bore: 182 GPM (69 RF) @ 50 psi tip.
175/75 Combination: 163 GPM (66 RF) @ 65 psi tip.

Note: Our current "match" was selected because we already have the 175/75 combination tip and they (including the 15/16" solid tip) met the above criteria. Another selection that has been proven successful by numerous agencies is the 7/8" solid bore and 150/50 combination tip operating at the same pump discharge pressure.

This concept is already being used by our department on the 2.5”.

(Example: 2.5” Pump Discharge Pressure)

200’ of 2.5” with a PDP of 80 psi
1-1/8” Solid Bore: 265 GPM (99 RF) @ 50 psi tip.
250/50 Combination: 263 GPM (98 RF) @ 55 psi tip.

In Closing:

The information we have presented provides an understanding of how and why our target flow rate was established. Please take the time to read the articles we have listed below. Along with our internal testing, these resources provide the basis for the research we are conducting now. The goal is to make sure our pumping apparatus and hose/nozzle setup meet the standards outlined in the references below and those set by industry experts. This will be an on-going evaluation of our apparatus specifications, hose configuration/specifications and nozzle selection. Our goal is to meet our target flow rate of 160 GPM minimum, but not exceed the single-firefighter 69 pound nozzle reaction force for 1.75” lines on all apparatus in the fleet.

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