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LESSONS LEARNED:

Enhancing Fire Streams for Wildland and Structural Firefighting

By **Timothy Herrick, Wildland Program Director, Maui Fire Department; and Jack Smith, Chairman, R&D, Maui Fire Department**

Recent shifts in fire behavior—particularly the emergence of large-scale, destructive wildfires—require that fire agencies continuously evaluate and update their equipment and tactics. The Maui Fire Department conducted a series of live fire tests to compare combination fog nozzles (hereafter "Fog") to combination blade nozzles (hereafter "Blade") under conditions designed to replicate both wildland and structural fires. These tests, supplemented by real-world use at an incident in Mahinahina, underscore valuable lessons that can guide fire departments seeking more effective fire suppression with simpler operational controls.

In these tests, a Fog nozzle with a nominal flow of about 60 gallons per minute (gpm) was compared against two Blade models that delivered approximately 45 gpm and 20 gpm, respectively. Firefighters assessed nozzle reaction, operator mobility, knockdown power, ease of pattern adjustment, and overall performance in both grass fires and pallet fires. Thermal imaging cameras were employed to detect hidden hot spots, providing a more complete perspective on extinguishment effectiveness.

Lessons from Grass Fire Scenarios

In the wildland setting, rapid movement and the ability to pivot quickly are critical. The Fog nozzle tested flowed more water—about 66 gpm measured under 100 pounds per square inch (psi)—yet the Blade-45 consistently produced comparable or better knockdown with a measured flow of about 41 gpm.

Maui Fire Department testing. *(Photo courtesy of the Maui Fire Department.)*

Firefighters noticed that the manageable reaction force of the Blade-45 helped them move confidently over uneven terrain. They also reported less fatigue because they did not have to fight as much nozzle reaction, allowing more agility and coverage per pass.

In these scenarios, a lower flow does not necessarily equal a weaker fire attack. The Blade-45's stream soaked the ground thoroughly, as evidenced by the distinctive quenching sound when it contacted light fuels. Observers noted that the water penetrated the grass more effectively than the Fog nozzle's wider pattern. Another advantage was that the Blade's patterns can be switched with a simple quarter-turn, eliminating the multiple turns sometimes required by certain fog nozzles. With less guesswork or delay, firefighters could transition rapidly from a focused stream to a blade (fan) stream, which is critical when the wind changes or when the fire spreads unpredictably.

A 20-gpm Blade nozzle, also tested, showed some benefits for conserving water and for mop-up tasks but did not match the Blade-45's knockdown power against moving fire fronts. Smaller brush fires or containment edges might be an ideal niche for the Blade-20, but the Blade-45 appeared more effective when flames were more intense or spread was faster.

Lessons from Pallet Fire Scenarios

The Maui Fire Department also replicated structural fuel loads by igniting stacks of pallets. These tests highlighted a second set of benefits for the Blade-45. Observers noted that its stream reduced heat and smoke more quickly, cooling the pallets rapidly in both direct (solid stream) and wide (blade) modes. Stream adjustability again proved critical: Switching from a strong, penetrating stream to a wider coverage pattern for smoke reduction was as simple as turning the nozzle a quarter turn.

By contrast, the Fog nozzle tested has multiple rotation points, including wide fog, flush, and straight stream. While a seasoned operator can learn these settings, the relatively simpler mechanism of the Blade-45 left less room for error. Under high-stress conditions, any delay or confusion in pattern selection can hinder suppression efforts. Firefighters involved in these tests indicated that the Blade-45 was the "go-to" choice when facing significant Class A fuel loads, while the Blade-20 was more of a specialty nozzle for smaller tasks.

Real-World Validation in Mahinahina

A significant lesson comes from the Mahinahina wildland fire on November 4, 2023. Firefighters who had not previously used the Blade-45 worked with it for the first time under operational pressure. They praised its straightforward quarter-turn design and its steady suppression power. A single pass with the Blade-45 along the fire line cooled the ground thoroughly and contained the flames, lending real-world support to the conclusions drawn from the controlled grass fire and pallet fire tests. This level of effectiveness

A comparison of a solid stream and a Blade stream. *(Photo courtesy of HEN Nozzles.)*

often depends on the balance of enough flow for swift knockdown and a manageable reaction force that does not exhaust firefighters. The Mahinahina incident showed the Blade-45 excelled at both.

Integrating Thermal Imaging

A vital component of the lessons learned is that nozzle performance goes hand-in-hand with accurate detection of hot spots. During the tests and the Mahinahina mop-up, a FirePro 300 thermal imaging camera (TIC) by SEEK Thermal was used to identify lingering pockets of heat. Firefighters found that the TIC gave them a clear view of where water needed to be applied, preventing rekindles and saving time that might otherwise be spent guessing or manually probing for smoldering areas.

By combining a high-performing nozzle with thermal imaging, the fire attack became more targeted. When operators saw a hotspot on the TIC, they could rotate the Blade-45 to a penetrating stream for a quick knockdown of hidden embers and then switch to a blade stream to cool the area or control smoke. This technology-driven strategy offers a higher level of confidence when declaring a fire fully contained, ensuring that it does not reignite.

Operational Simplicity and Training

The lessons learned also extend to firefighting culture and training. Transitioning to the Blade-45 requires minimal extra instruction because its quarter-turn design is easier to grasp than fog nozzles that rotate through multiple settings. In a profession where new recruits and seasoned veterans alike must routinely adapt to new tools, gear that is straightforward can shorten the learning curve. This simplicity reduces confusion in stressful conditions where every second counts.

Implementing simpler nozzles across an entire department can streamline training and minimize misapplication. Repetition and muscle memory are critical in fire suppression. With fewer settings, there is less chance of unintentionally choosing the wrong stream in the urgency of a live fire. Since mental load correlates directly with safety, any reduction in complexity can have real-world benefits.

Balancing Flow Rate and Fatigue

One of the most prominent lessons involves the balance between flow volume and reaction force. Higher gpm, on paper, sounds advantageous, but it can come with a higher nozzle reaction that may slow operator movement and cause fatigue. While a 20-gpm nozzle might seem too small for large-scale incidents, a 45-gpm flow rate offers enough water for robust knockdown while still allowing operators to maneuver quickly. That balance is especially helpful in wildland scenarios where terrain is uneven and speed is crucial for containing a fire line.

Cost-Benefit Analysis for Departments

Departments considering changes to their nozzles should recognize the cost-benefit ratio highlighted by these results. A nozzle like the Blade-45 effectively fights fire at a slightly lower flow rate, which can extend the water supply. That is an advantage in rural or remote areas where hydrants are scarce. Fewer refills mean more continuous suppression, and less frequent water shuttles can free up personnel for other tasks.

Simplicity of design also tends to reduce maintenance concerns. Although routine checks remain necessary, having fewer internal components or separate settings can result in fewer mechanical failures. Departments that place heavy demands on their equipment—especially in a variety of wildland and structural contexts—stand to benefit from any gear that is both rugged and user-friendly.

Looking Ahead

Based on these experiences, several forward-looking recommendations emerged. Fire agencies should conduct localized field trials of the Blade-45 to confirm performance under their specific conditions, such as different types of vegetation, wind patterns, or structural materials. Incorporating thermal imaging into both the initial attack and mop-up phases remains a sound strategy, as it has proven successful in pinpointing hidden embers that might otherwise go unnoticed.

Continued research could examine the performance of this nozzle design in extended, large-scale incidents. It would be beneficial to explore how it compares to other modern nozzles under conditions like steep terrain or heavier brush loads. Expanding the scope of testing would help refine best practices and train firefighters to adapt quickly to a variety of fire environments.

The Maui Fire Department's comprehensive tests of combination fog nozzles and combination blade nozzles—especially the Blade-45—provided clear lessons in balancing flow rate, nozzle reaction, and operational simplicity. Field and real-world data showed that a modest flow of approximately 41 gpm, combined with an easy quarter-turn pattern adjustment, can achieve significant knockdown power in both grass and pallet fires. This setup also maintains mobility in uneven wildland terrain and reduces operator fatigue, critical factors in improving overall fireground efficiency.

Thermal imaging played a pivotal role in post-fire hot spot detection, reinforcing the principle that water application is most effective when guided by accurate situational awareness. Implementing simpler nozzle mechanisms alongside reliable thermal imaging tools can simultaneously elevate firefighter safety, reduce rekindle risks, and maximize the effective use of limited water supplies. Departments that adopt these lessons stand to enhance their readiness in an era of increasingly complex fire behavior, ensuring that both wildland and structural incidents are met with the best tactics and technology available.