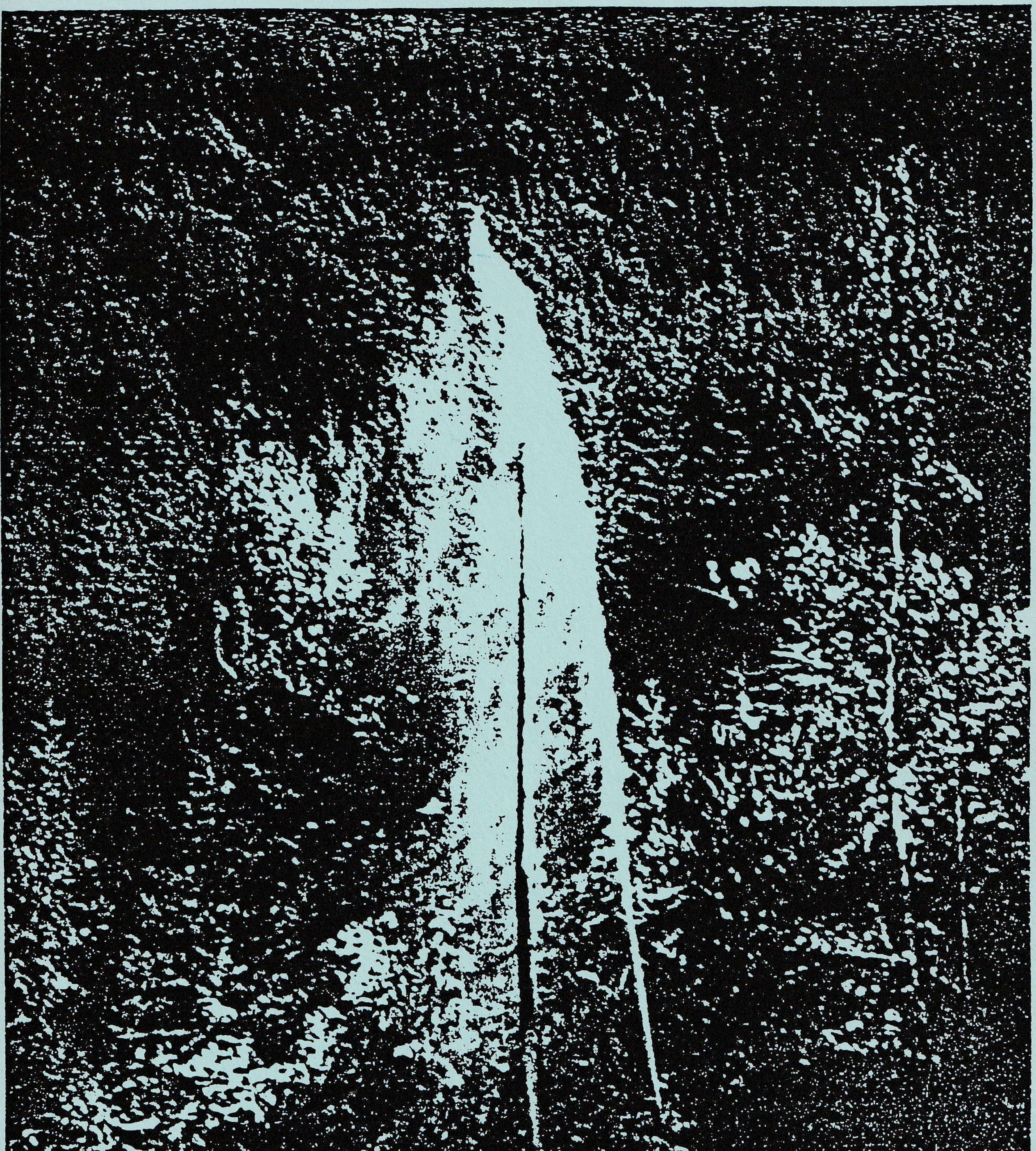

Foam as a Fire Suppressant: an Evaluation

Foam as a Fire Suppressant: an Evaluation[1]

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The ability of fire suppressant foams to improve ground-applied fire control efforts was evaluated. Foaming agents and foam-generating systems were examined. Performance evaluations were made for direct attack, indirect attack, and mop-up. Foam was determined to suppress and repel fire in situations where water would not. Cost comparisons of mop-up work showed straight water to be significantly more expensive than foam. Foam will replace all current water applications and present new suppression opportunities to the fire management community.

The Bureau of Land Management (BLM) is evaluating the effectiveness of foam as a means of controlling fire. The impetus for this study can be described by the reality of current ground-applied fire control efforts. Wildfire suppression capability is limited where water is scarce and real property values are threatened. Prescribed fires are often difficult to contain. Time-consuming mop-up reduces further burning opportunities.

THE CONCEPT OF FOAM

The concept of foam is not new, but the limited use of foam in wildlands warrants a review of its capabilities. Foam extends the life and effectiveness of its water. Foam reduces the surface tension of water molecules enabling greater penetration of the water. Soap-based foam opens the waxy coating of green vegetation, further enhancing wetting ability. Foam inhibits water flow, allowing more of the water applied to be used for cooling. As foam, water becomes a reflective, insulating blanket.[3,4]

FOAMING AGENTS

Foam systems as recent as 1985 relied on foam-making substances not specifically designed for fire suppression. Pine soap or soap skim, popularized by the Texas Snow Job, is a derivative of the paper-making process. Household dishsoap was also used because of its availablility.[5]

Since 1985 foaming agents designed for wildland fire suppression have been available. These products combine relatively stable bubble structure, improved wetting ability, and vapor suppressants. They provide the capability of instantaneous extinquishment, construction of an impenetrable barrier to fire, and reduced mop-up time.

FOAM GENERATING SYSTEMS

Foaming agents can be utilized by a variety of means. Synthetic foaming agents have sparked new interest in the foam generating systems made popular by pine soap. Compressed air foam systems (CAFS) have been modified with centrifugal pumps and metering devices, and enlarged with 40 cubic feet per minute (cfm) or greater air compressors. Air aspirating and conventional water systems also have applications for foam.

Foam is produced in the CAFS by mixing compressed air and solution at equal or nearly equal pressures and pumping the mixture through one of three forms of agitation. Hoselays longer than 50 feet (of 1 inch diameter) provide enough space for air and water to mix into foam. Scrub chambers, tubes filled with obstructions, force air and water into foam in 1-2 feet. Specialized nozzles combine compressed air and atomized solution as they leave the nozzle. Hoselays are the most common agitation method and this discussion will concentrate on their features.

Compressed air systems which pump foam through the hose flow water at less than normal rates. A 1-inch nozzle may flow 12 gallons per minute (gpm) of water as foam at 150 pounds per square inch (psi), with a discharge distance of 85 feet. Water is expanded about 10 times at agent mix ratios of 0.2-0.3 percent. CAFS has the unique ability to change foam consistency by changing water flow rather than mix ratio.

Extra equipment required for the CAFS include an air compressor and full flow ball valves. Compressor size is dependent on need. Generally, 2 cubic feet of air is necessary for every gallon of water to create quality CAFS foam. The ball valves are used as nozzles to shut off the foam flow.

Foaming agents have also initiated the production of a wide range of air aspirating or expansion nozzles. Low- and medium-expansion nozzles produce quality foam. Low-expansion nozzles are most common. They flow 10-30 gpm at 150 psi discharging 30-70 feet. The air aspirating system pumps solution through the hose and creates foam at the nozzle. Air is drawn into the nozzle when the solution is atomized and passed through a pressure gradient. Water is expanded 5-10 times with agent mix ratios between 0.3-0.4 percent.

The third system in which foam agents can be used is as a wetting, extinguishing solute in conventional water systems. Through all apparatus from turbo jet to sprinklers to bladder bags, bubbles will form froth due to low agitation. With the surfactant in the water, wetting and extinguishing will increase over straight water.

Technology offers improvements from conventional equipment for mix methods, hose types, hoselays, and nozzles. The inefficiencies of batch mixing concentrate and water are overcome with eductors or proportioners. Eductors also make possible the use of foam when the sole motive force is a water pump. A portable pump, for example, can draw concentrate into the hose as it pulls water out of a stream. Proportioners, which pump concentrate as desired into the water line, have the accuracy and dependability necessary to be integral engine components.

Hose types are important when foam is pumped through the hose (CAFS). Durable woven rubber hose is used to avoid kinking. Any restriction in a hoselay will breakdown bubbles thus significantly reducing foam quality and discharge capability. Hose which is porous or has an irregular lining will disrupt foam flow and reduce discharge performance (table 1).

Table 1--Hose characteristics important to foam flow.

Hose type	Resistance to Kinks	Resistance to Fire	Porosity w/ Foam	Resistance to Flow
Synthetic	poor	poor	high	high
Cotton	fair	fair	low	medium
Rubber	excellent	excellent	none	low

Hoselays can be different for the CAFS depending on application. Usually, foam barriers are applied with one or two nozzles. Since foam is compressable, hoses are easily clamped and extended. Hoses filled with foam do not exhibit all characteristics of hydraulics. Greatly reduced head pressure enables foam to be pumped significantly farther above the pump than water.[6]

Nozzles vary in performance for aspirated and compressed air systems. Low expansion air aspirated nozzles range in performance for 1.5 inch hose from 7 gpm and 25 feet discharge to 26 gpm and 70 feet discharge at 150 psi. At 35 gpm and 150 psi, a 1 inch CAFS nozzle has a maximum discharge of 70 feet, a sustained discharge of 55 feet; a 1-3/8 inch nozzle: 90 and 70 feet respectively.

APPLICATIONS

The applications phase of the project directly evaluated fire control potential of foam in the field. Where possible, comparisons were made to water performance. Evaluations occurred on prescribed fires and wildfires throughout the West.

Direct Attack

Visual evaluations of foam's extinguishing capability were made. Flames burning in light, flashy, ground fuels, tall snags, pitchy stumps, red slash concentrations, and desert sage were treated. Extinguishment was instantaneous. For example, two light engines worked the flank of a range fire. The engine using air aspirated foam never had to turn around for rekindled flame. This engine's pumping time was 1/3 greater than the water engine's. The engine using water found some of its flank had started burning again.[7]

The compressed air foam system has great extinguishing capability in part because foam can be indefinitely compressed in the hose. The ball valve can be shut off without risk of bursting hose. This creates back pressure in the hose which, when released, produces a fine-bubbled mist and long discharge distances (fig. 1). The fine-bubbled mist is unique to the CAFS. When released the mist puts on a cooling, suffocating performance that has been compared to halon gas. Together with initial discharge distances of up to 85 feet with 1 inch hose, the mist gives the firefighter a deluge initial attack capability. Many prescribed burn spot fires have been extinguished by merely opening and closing the ball valve.

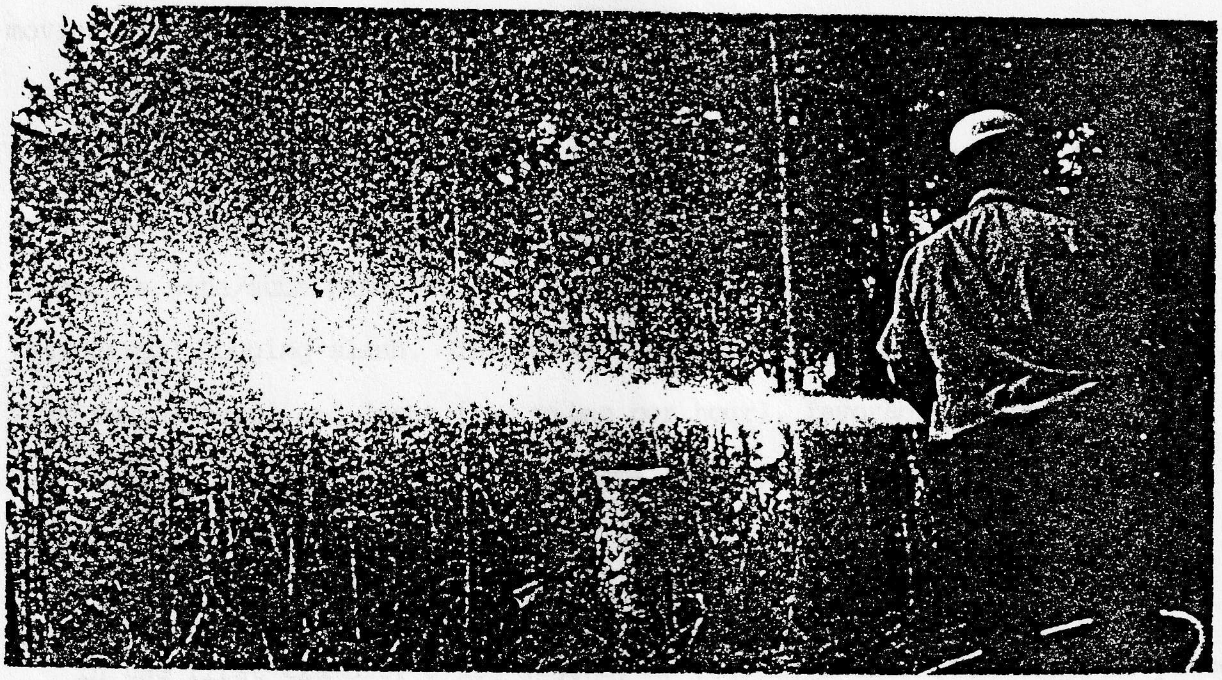

Figure 1--Fine-bubbled mist during initial discharge from the compressed air foam system.

After the initial, fine-bubbled surge, foam produced becomes thicker. It forms large masses of bubbles which cling together. This clinging property is also an important extinguishing feature. Foam can be lofted onto flames, the clinging bubbles forming a vapor suppressing blanket that also separates oxygen from flame. Because it exhibits low head pressures, foam can be injected into the bottom of a burning snag to extinquish fire burning within. The foam will fill any accessible cavity, suffocating fire.

Protective Barrier

Applications of foam for protection include prescribed burn boundaries, fuelwood piles, snags (fig. 2), wildlife trees, and fragile sites, and backfire wetlines . Twenty firelines adjacent to prescribed fire units have been pretreated with foam. The foam-treated areas adjacent to firelines ranged from 300 feet to 1500 feet in length. Width (25-100 feet) and depth (0.25-2 inches) depended on the foam generation system and site conditions. The time between application and ignition ranged from 0-45 minutes. Spotting beyond the foam lines occurred on occasion, but no foam line was crossed by moving fire.

Two examples of foam as a barrier to fire occurred on the Toad Creek unit in western Montana. Fuel loading was 100 tons per acre of fuel model 13 lodgepole pine/subalpine fir (*Pinus contorta var. murrayana* Engelm/*Abies lasiocarpa*) logging slash. The prescription of 40 percent relative humidity, 70°F temperature, and light (1-4 miles per hour), favorable winds was met at 2000 hours. Nevertheless, running flame lengths were 3-20 feet high and the fire crowned to 60 feet.

In the first example, a 150 feet by 10 feet by 1 inch foam line was placed across one 1/2 acre corner of the unit. No tools were used, no fuel removed to construct this line. The unit's test fire was lit in the corner. The fire ran quickly to the poles standing adjacent to the line, crowning and producing firewhirls. When the fire reached the foam line, flames leaned over the line, but the fire's forward progress stopped. Time elapsed from foaming to fire contact was 2 minutes.

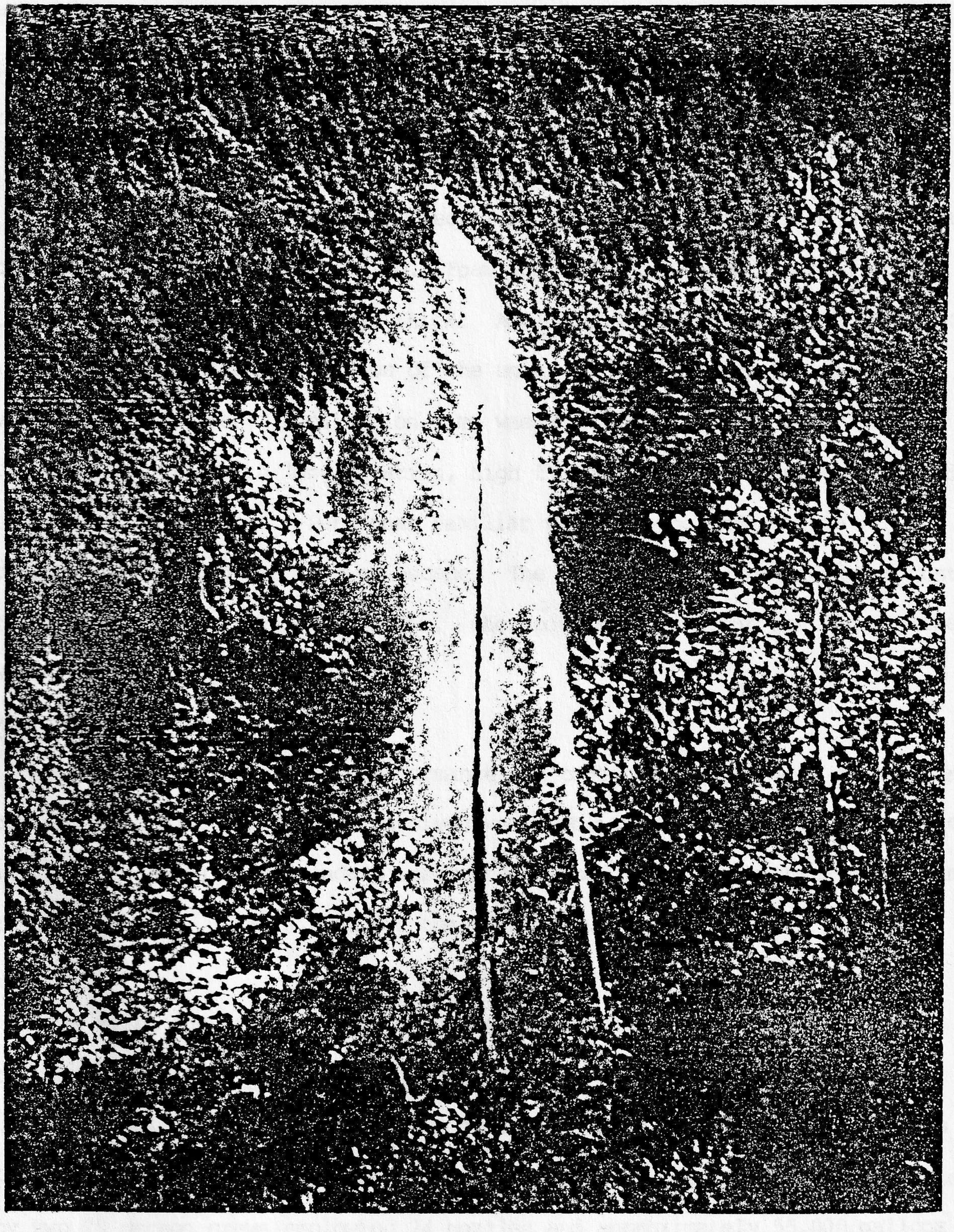

Figure 2--Snag protection capability of the compressed air foam system.

Lighting of the rest of the unit continued across the foam line. The line was exposed to heating on both flanks for about 5 hours. Inspection the following day showed the line intact, with green vegetation and fine fuels throughout. Two logs greater than 8 inches in diameter which had burned through the line from both ends were the exceptions.

In the second example, a 1400 feet foam line was placed outside a cut fire trail in an adjacent timber stand. Foam was applied 100 feet wide, 75 feet into the canopy, and 1-2 inches thick. Application was 5-15 minutes prior to ignition of the adjacent portion of the unit. Two people created this line with one 1 inch hose. Application time was 5-1/2 hours. Fire behavior remained extreme, with long duration, high flamelength fire tossing firebrands into the treated stand. Personnel familiar with burning under these conditions expected the fire to escape. The width of the line prevented most firebrands from starting spot fires. One spot that did occur was extinguished with foam from 60 feet away.

Mop-up

Direct foam versus water performance and cost comparisons were made during mop-up operations. Personnel involved were not informed of the comparison to avoid any changes from standard instructed procedure. In each case, the foam crew was mopping up with foam for the first time.

The first comparison occurred during mop-up of a wildfire in felled and bucked douglas fir (Pseudotsuga menziesii) timber. A 4 person crew using 2 nozzles completed 100 percent mop-up of 5 acres in 3 hours with 7,700 gallons of water. Nearby, on 5 acres of the same fire, this productivity was equalled by two 20 person crews employing 24 nozzles and approximately 55,000 gallons of water.

The foam crew used 15 gallons or $225 of foaming agent based on 0.2 percent mixture and a price of $15 per gallon. Assuming the average salaries for the foam and water crews are $7 and $5.50 per hour, respectively, the foam operation cost $309 for labor and foaming agent; the water operation cost $660 for labor.

The second comparison occurred during mop-up of the Toad Creek unit. A 5 person foam crew mopped up 100,000 square feet in 4 hours. A 25 person water crew mopped up 25,000 square feet in the same time. Both crews had an unlimited water supply. Total water flow for the foam crew was 30 gallons per minute.

Again, 15 gallons of foaming agent was mixed. Using the same wage assumption in the first comparison, the foam operation cost $365; the water operation cost $550.

Foam application technique for both comparisons was designed to let the foam do the work. Foam applied was wetter than the protective foam type. Foam was spread out so that it penetrated and cooled, while the operator moved on. Extra attention to hot spots was given only when heat was well below the surface.

DISCUSSION

Foaming Agents

Of all the types of foaming agents presented, the relatively new synthetic products made specifically for Class A fuels are prefered. The 3.0 percent mix ratios of pine soap are 10 times greater than synthetic. Preliminary laboratory tests have shown pine soap to be an inferior wetting agent. Common dishsoap lacks vapor suppressants and durability. The price of the new agents has continued to drop as the demand for them has increased. Some users have experienced 25 percent reductions in suppression costs despite the $12-15 per gallon prices.[8,9]

The notion that water is free is a fallacy. **The BLM fights most of its** fires where water sources are miles away. Twelve dollars can make 500 gallons of water into 5000 gallons of effective water as foam.

Foam-generating Systems

Purchasing requirements vary significantly with the three generating systems presented. Foaming agent alone will give one an improved wetting agent with conventional apparatus.

As the minimum initial equipment investment, air aspirating nozzles will assure quality foam production, especially for protection and mop-up. Long-term use of this system is appropriate only if the consistent high use of foam is more tolerable than a high initial investment for the compressed air system.

The CAFS generally requires the greatest initial capital outlay, primarily the air compressor, as well as a retrofitting or new engine package. However CAFS can be assembled on-site from inexpensive components such as rented trailer air compressors, readily available plumbing, and an existing water pump. The high initial cost is quickly returned by increased capability and performance, and reduced volume of foaming agent required.

Applications

The success of foam in the examples given of performance can be attributed to two factors. First, the combination of synthetic foaming agents and the compressed air foam system creates a powerful tool for fire suppression.

Second, proper training is necessary to ensure success. Foam can fail and if its properties and uses are not understood, it will. Foam should not be considered a cure for every fire situation. It is simply a very useful tool.

Foam must be of the appropriate consistency: wet, dripping, or dry. It must be applied for the appropriate effect: lofted for intact, clinging, and smothering bubbles; pressure impacted for broken, wetting bubbles.

Foam is designed for short term use when applied as a barrier. Its effective lifetime varies with fuel, weather, and fire conditions. Applications must be adjusted accordingly.

Safety precautions should be understood when using foam. Foaming agents are mildly corrosive to skin and eyes. Protective gear is recommended. The high-pressure lines of the CAFS should be operated with caution. Valves must be opened slowly to prevent nozzle kickback and hose whiplash.

THE FUTURE

Over the past 2 years foam has developed into a tool for the future. The full potential of foam has yet to be realized. In fact, the technology of Class A foam fire fighting is expanding beyond Class A fires. Cost-effective, successful applications have been demonstrated with hydrocarbon fires, vehicle fires, and structure fires. Methods of delivery are also expanding to fit different needs and resources.

The wildland-urban interface fire protection program may have the most to gain from foam development. Research must increase our understanding of foam processes. Training of application techniques must begin. The days of fighting fire with unrefined water are numbered. Water has served us well in fire suppression over the years. As we move into the twenty-first century, water will serve us even better as foam.

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