A REPORT ON GROUND APPLIED FOAM

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EXECUTIVE SUMMARY

We have made many advances in ground-applied foam; some of which are quite controversial at this time. We have generated worldwide interest on use of foam in fire suppression.

The most important step we can take to further the development and use of foam would be to proclaim the inefficiencies of water, and remove all ties the Bureau has to pure water use for fire suppression in the wildland environment as well as the urban/rural interface. We must continue research efforts with the Fire Growth and Extinguishment Department, Center for Fire Research, National Bureau of Standards. We must continue to work with the Federal Emergency Management Agency and the U.S. Fire Administration.

Future efforts must quickly be concentrated in the following areas: education; research, evaluation, and documentation; equipment development; worldwide information distribution; and program priority.

INTRODUCTION

In 1987, we learned far more about foam and water than could be recorded in this summary. Each answer brought several more questions and this fact is indicative of the current development stage of foam technology. We have a long way to go. Our experience in the field and in the library tells us that the most important step the fire community can take for the development of foam is to proclaim the inefficiencies of water and remove all ties the Bureau has to pure water use for fire fighting. No evidence exists that water by itself is the best way to extinguish fire. In fact, much has been documented to show that reducing water's surface tension with a surfactant, such as a foaming agent, is far superior to plain water for extinguishing fire.

Water has been perceived for years to be cheap, or free. This is not true. Hydrants are not free. Time and equipment spent hauling water is not free. The public has been misled for years to believe that a fire that cannot be put out with water is more fire than man can handle. That is not true, and we should not continue to support this misunderstanding.

Selling the concept of foam will not be successful if we merely praise the glories of foam. Others, such as Fireout and slippery water, have died by this tactic. One cannot understand how foam works without knowing how water fails.

In early April, we concluded this year's testing of foaming agents with the flame test at Chemeketa Community College. We were pleased to find that all synthetic foaming agents (i.e., Angus Forexpan - then Surefire - Foam, Ansul Silv-ex, Chemonics 103, and Monsanto WD861) were at a performance level for insulation/reflection acceptable to us. Since all products were not at this level in June of 1986, we consider the test to be a success. Furthermore, by their apparent acceptance of the test, the foam industry has indicated that we, the users, have the lead with the development of the technology.

Insulation/reflection is not the only characteristic by which we can now judge foaming agents. In their foam standard due later this year, the NFPA will be requiring that concentrates have no change in viscosity above freezing. This characteristic is necessary because the future of the technology is in proportioning systems which require flow through small orifices at low temperatures. At this time, Silv-ex and Forexpan are the only products which do not change adversely in viscosity at temperatures below 40° F and above 32° F. We recommend a full-scale survey of all concentrate containers at above freezing storage temperatures for crystallization and thickening.

The use of proportioners is vital for accurate and variable mix ratios, but also because it is important to keep the water supply clean. We discovered that residual foaming agent left in a water supply may promote the formation of noxious hydrogen sulfide. Naturally occurring anaerobic bacteria found in well water throughout the country will convert sulfate in the water to H_2S. Foaming agents with bacteriacides may not be sympathetic to this reaction; however, because the bacteria can "hide" in tank sediments, a clean tank is the ultimate solution. Ansul's Silv-ex was the product which experienced the H_2S formation.

We would like to share with you our experiences during a recent trip to Washington, D.C., and Maryland. The reasons for the trip were (1) to observe and review the progress made by National Bureau of Standards on their radiant panel test and (2) to meet with the U.S. Fire Administration and show them the merits of compressed air foam.

February 7. We met with Dave Evans, Fire Growth and Extinguishment Department Head, Center for Fire Research, National Bureau of Standards. Dave is conducting the radiant panel ignition resistance test for us.

February 8. We toured the Center for Fire Research at NBS, Gaithersburg, MD, and met with Evans' staff. We watched a repetition of the panel test. The test shows that 9 grams of low expansion compressed air foam (¼" x 6" x 6") is twice as effective at delaying ignition of T 1 11 as 9 grams of plain water. A complete report by NBS is forthcoming.

We raised questions about the test concerning the foam bubble size. The test apparatus made foam at low velocities in order to control output. Bubble sizes were, therefore, more variable and generally larger than bubbles we typically generate at higher discharge velocities. We felt smaller, more uniform bubbles would improve this 2:1 ratio.

Evans explained that combined performance ratios of insulation, wetting, and extinguishment would more closely describe the difference between water and foam we were expecting. He hoped we could stimulate more interest in foam to provide funding for the wetting and extinguishing tests.

February 9. At the National Bureau of Standards, we attended the symposium entitled: Revolutions in Solving Fire Safety Problems: Materials, Tests, Suppression, and Measurements.

At the conference, we met with Tom Smith and Roger Lanahan, both from the U.S. Fire Administration, Emmitsburg, MD. They suggested that we go to Emmitsburg and present our information to Ed Wall and Clyde A. Bragdon, Jr.

Information we brought about surface active agents was useful to Evans' studies of reduced water droplet sizes from overhead sprinklers.

February 10. We traveled to Emmitsburg, MD, home of the Federal Emergency Management Agency and the U.S. Fire Administration.

We met with Edward Wall, Deputy Chief; Roger Lanahan, Firefighter Health and Safety; Bob McCarthy, Firefighter Health & Safety; Gary Bassett, National Fire Academy Wildland/Urban Interface Program; and John Ottoson, U.S. Fire Admininstration.

We gave them a quick overview of our work with compressed air foam on wildlands, structures, and hydrocarbons. Using a small air pressure tank, we gave a simple demonstration of what this foam is. We answered questions for 2 hours. They were inquisitive and supportive.

They asked us to return and present our material to the U.S. Fire Academy in the future. They suggested we take part in a fire protection conference occurring the following week to be attended by the Department of Defense, as well as local and State fire agencies.

We went back to Gaithersburg to conduct a radiant panel test with foam bubbles made at higher discharge velocities. Results indicated no significant difference at that foam depth and relative bubble diameter between the test method and our apparatus. The significance of this is that a stringent requirement of foam bubble structure will not be necessary to ensure performance. Application parameters can remain simple.

February 11. In Washington, D.C., we visited the USDA Forest Service Fire and Aviation. With Francis Russ, manager of Fire Management Notes, we discussed publishing: how and what. We decided to give Russ our latest paper, Relationships of Water, Wet Water, and Foam to Wildland-urban Interface Fire Suppression, for publication in "Notes" later this year. He suggested a call for other material about foam to accompany this article. The use of National Wildfire Coordinating Group (NWCG) newsletter space was also discussed with Russ and Bill Shenk.

We discussed the merits of compressed air foam, aspirated foam, eductors, and surfactants with John Chambers.

We traveled across town to the USDI Bureau of Land Management Fire and Aviation group and met with Gardner Ferry. The intent of this visit was to inform the Washington Office of the results of our visit to NBS and to give them an update on our project. We briefed Ferry on our activities and showed some of the staff short video sequences. In response, they asked if we would (1) return to present our information to the entire staff and (2) keep them posted on our progress and our project needs.

Due to the financial nature of our visit to Washington and the inquisitive receptions from our audiences, a summary of our project's accomplishments and future directions is in order:

<u>Accomplishments</u>

1. Realized, studied and demonstrated the single most important and most basic element of foam use: the ineffectiveness of water.

2. Measured the effectiveness of foam in lab and field:

   A. Developed a still recognized foam performance test.

   B. Demonstrated and documented that compressed air foam (CAFS) is more effective than water in all fire work.

   C. Compared CAFS with other foam on wildland vegetation and structures.

   D. Raised questions about what is occurring during the extinguishment phase when using a surfactant.

   E. Developed joint BLM-Forest Service Foam Evaluation Form.

3. Hosted the first international foam symposium, sparking interest and involvement by NFPA, NWCG, U.S. Forest Service, and National Park Service.

4. Convinced the National Bureau of Standards to become involved with testing and promoting this concept of foam.

5. Designed and evaluated foam generating hardware, including inexpensive foam metering systems.

6. Developed a foam training package in response to field users requests to gain our understanding of foam.

7. Presented material at over 30 demonstrations, training sessions, or conferences, each received with positive comments and requests for more information.

8. Wrote two papers about our work and presented them at symposia.

9. Compiled the largest known wildland foam bibliography.

10. Compiled a foam information catalog which is being distributed internationally.

11. Produced a 7-minute introductory video to wildland foam.

12. Became the focal point in the world on wildland foam use.

Based on these accomplishments, our experiences, and user comments, we believe the direction of this program should focus on five major goals.

1. Training - actually education
   - develop foam use education course
   - increase staff training capability

2. Evaluation and documentation
   - field evaluation form
   - specific tests of apparatus (i.e., nozzles) or capability (structure)
   - priority video coverage

3. Equipment development
   - State-of-the-art engine
   - motionless mixers
   - rotary engine
   - concentrate injector systems
   - other

4. Information distribution
   - publication of material
   - quality, official duplication
   - availability of personal contact

5. Program priority expansion
   - personnel
   - computer that is compatible with other agencies

Throughout the evaluations on the following pages, the bottom line is the effectiveness of plain water versus water treated with a surfactant:

1. A straight stream of water is only 5-10% effective at direct attack (Haessler).

2. In Montana, mop-up with compressed air foam was 10-20 times more effective than mop-up with water.

3. Evaluations from others in the field note a 30-70% reduction in mop-up costs with foam.

4. Compressed air foam offers increased capability over water for direct attack because of greater discharge distance and a more useful form of water.

5. Davis noted in 1952 that wet water was 3 times more effective than wate on wood fires.

6. Godwin stated in 1936 that his chemical foam pretreated lines were 8 times more effective than water.

April

Hydrocarbon/liquid fuel pit fire demonstration, in cooperation with the Portland City Fire Bureau.

Location: Portland, OR

Accomplishments: A burning, 600 square foot fuel pit filled with diesel and gas was attacked with wildland foam. The compressed air foam system was used with Silv-ex at 0.3%. Two attacks were made with two 1" foam lines. Their extinguishment times were 44 and 60 seconds; water usage was 18 and 24 gallons, respectively. A third attack made with one 1.5" line required 24 seconds and 13 gallons of water for extinguishment.

Analysis of film footage of an attack using 3% AFFF and a 1.5" line on a similar fire showed that 32 seconds was necessary with a water use of 52 gallons (100 gpm flow).

Very successful attacks were also made with two 1" CAFS foam lines on a burning oil transfer platform and a burning fuel truck.

This event made it clear that CAFS and wildland foams together offer a versatile extinguishing tool for today's urban-rural fire fighters.

June 25 - July 1, FOAM PROJECT SUMMARY

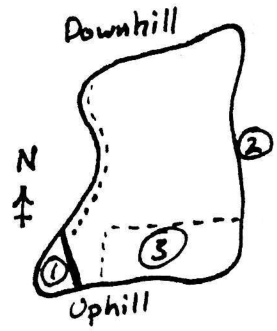
June 25-27

Demonstration of the merits and techniques of foam applications during a burn-boss certification program.

Location: St. Mary, Blackfeet Indian Reservation, Montana

Accomplishments: Toad Creek Unit. 14 acres. Fuel Type: Lodgepole pine/Alpine Fir. Fuel Model No. 13. Fuel load: 100 tons/ac.; Duff Depth 1-3"; Aspect: North; Slope > 10%; Temp. 70° F; Humidity 40%; Wind speed 1-4 mph; Behavior: Running, Crowning; Flame Length 3' - 20', crowning to 60 feet.

1. We placed 150' X 10' X 5" of foam across one tip of the unit. No tools were used, no fuel removed to make this foam line. See 1 on map.



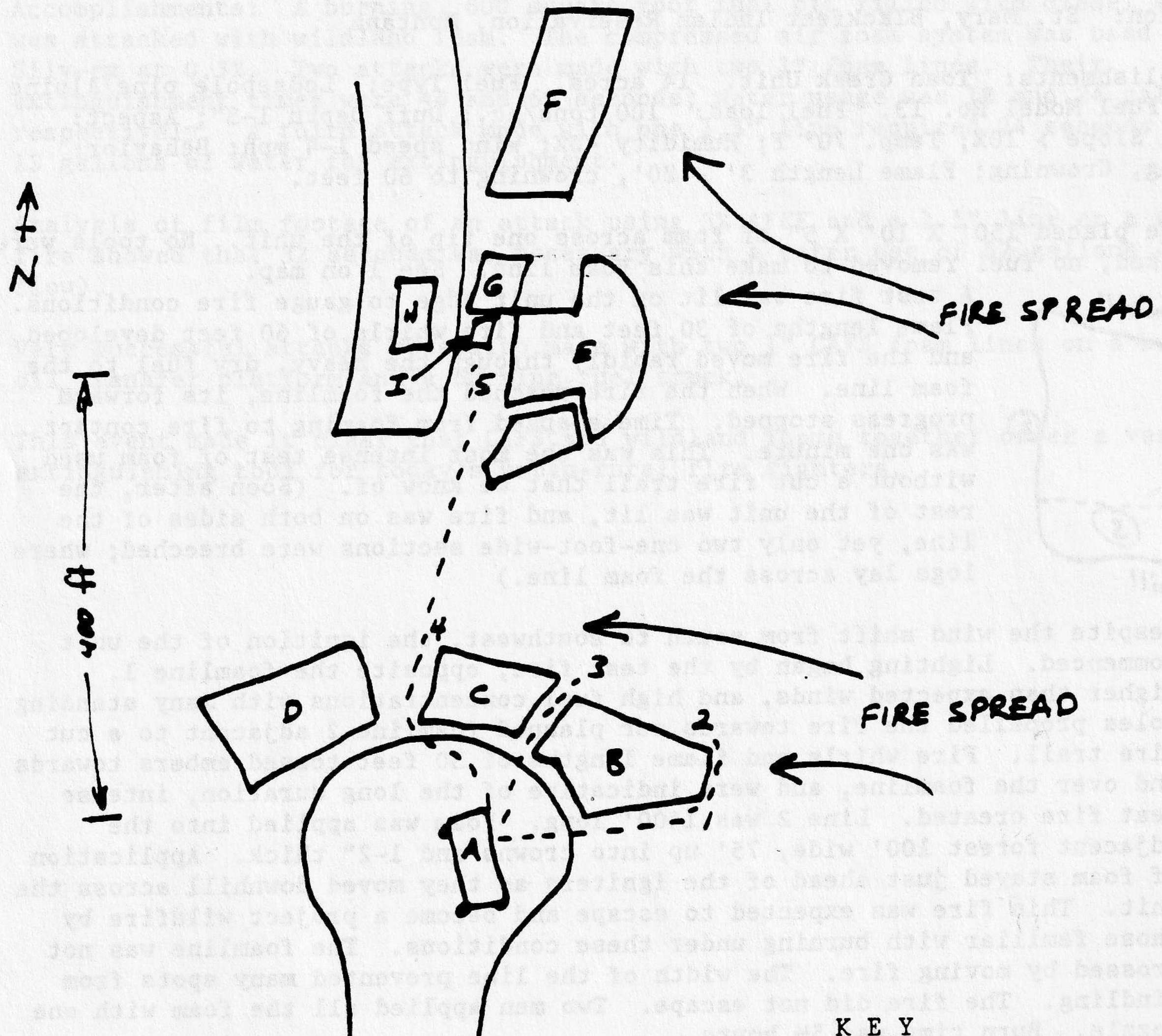
A test fire was lit on the unit edge to gauge fire conditions. Flame lengths of 30 feet and fire whirls of 60 feet developed and the fire moved rapidly through the heavy, dry fuel to the foam line. When the fire reached the foamline, its forward progress stopped. Time elapsed from foaming to fire contact was one minute. This was the most intense test of foam used without a cut fire trail that we know of. (Soon after, the rest of the unit was lit, and fire was on both sides of the line, yet only two one-foot-wide sections were breeched; where logs lay across the foam line.)

2. Despite the wind shift from south to southwest, the ignition of the unit commenced. Lighting began by the test fire, opposite the foamline 1. Higher than expected winds, and high fuel concentrations with many standing poles propelled the fire towards our planned foamline 2 adjacent to a cut fire trail. Fire whirls and flame lengths of 30 feet tossed embers towards and over the foamline, and were indicative of the long duration, intense heat fire created. Line 2 was 1400' long. Foam was applied into the adjacent forest 100' wide, 75' up into crowns and 1-2" thick. Application of foam stayed just ahead of the igniters as they moved downhill across the unit. This fire was expected to escape and become a project wildfire by those familiar with burning under these conditions. The foamline was not crossed by moving fire. The width of the line prevented many spots from kindling. The fire did not escape. Two men applied all the foam with one nozzle. Burn time was 5½ hours.

3. Mop-up the following day. Area 3 indicates the 100,000 sq.ft. mopped up by 5 people using compressed air foam versus the 24,000 sq.ft. worked by 25 people using straight water. No one knew such a comparison was taking place. Those using foam were trained that day and had never used it before. Work time was about four hours. Water availability was not a factor. Combined water flow was 30 GPM.

In summary, all in attendance (the Blackfeet tribe, the USFS, BIA, BLM) were impressed with foam's performance. They wished to know how they can use it on existing equipment. They felt our efforts had averted a catastrophe. They wanted us to come back in the fall of 1987.

SCENE
OF BOISE STRUCTURE PROTECTION
JUNE 29, 1987



KEY

1-5	Attack sequence
A	Engine 854
- - -	Hose Lays
B,C,D,E	Homes saved
F	Home destroyed
G	Garage destroyed
H	Municipal fire engine
I	Pickup truck

NOT DRAWN TO SCALE

June 29

Wildfire Suppression

Location: Boise, ID

Accomplishments: We noticed a brush/grass fire burning in hills above and north of the city of Boise. Homes appeared to be threatened. We offered our services, knowing foam is well-suited to structure protection. We were dispatched to the fire by the Boise BLM District. The fire had been burning for at least an hour above town before we were dispatched. We were the first engine of any kind to reach the top of Horizon Drive where a cul-de-sac was surrounded by five homes. Three of these homes were actively threatened by fire as we arrived. We quickly deployed our 1" Angus booster line flowing 12 gallons/minute and knocked down the most immediate fire, burning in the rubble of a woodpile, grass cuttings, and decking. The fire swept around the house opposite from the truck. We deployed our 1½" line for greater reach and discharge capability. Now with 60 gallons/minute of water as foam (far less than conventional urban fire trucks) we attacked and extinguished fire on the far side of the homes. This all occurred in 10 to 15 minutes. Then we noticed that fire had continued ahead of us up the hill towards two more homes. We added 150 feet of hose and reached the first. Its garage, with a pickup inside, and front face were on fire. Here, we were joined in attack with a city fire truck. Its turret and our nozzle worked on the garage and saved the house. The second house went up in flames as we ran out of water. It was the only house destroyed. We were able to pump extinguishant (foam) for approximately 30 minutes because water was expanded. Since sprinklers down the hill in town removed all water pressure from nearby hydrants, our pumping time (and effectiveness) would have been much less without foam.

June 30

We spent the day with Boise District personnel training and exposing them to mop-up with foam. On Bennett Mountain, an area of approximately ¼ acre was mopped-up with foam in 1½ hours by their people. They assured us that this was a two-day job for them normally. (Fire had started at 7,000 feet in Douglas-fir timber with heavy fuels and duff layers.)

July 1

Lightning strike

Location: Brothers, OR.

Accomplishments: Extinguishment of a western juniper, approximately 12" dbh. The tree was fully involved upon arrival. We used an 0.3% mix ratio of CAFS foam delivered through a mop-up wand. The rich mixture created a thick foam blanket to suffocate the volatile juniper pitch. The mop-up wand and reduced tip provided enough pressure to (1) strip bark off the tree at low water flows and (2) push foam into hidden or vertical spaces where pitchy fire persisted. Complete extinguishment occurred in 5 minutes with 70 gallons of water.

Crew: Foam Project: Ron Rochna
Paul Schlobohm
Clarence Grady
Salem Dist. Sam Caliva

July 18-19

Bland Mountain Fire

Location: Canyonville, OR

Accomplishments: Mop-up of deep-seated fire in understory of Douglas-fir forest. We showed workers with limited or no experience with foam some of our techniques for mop-up. These included: (1) filling vertical and horizontal cavities with foam for extinguishment, (2) applying the appropriate amount of water, as foam, to a warm area and the letting the foam cool and suffocate while the applicator moves on. In the instance of item (2), a foam must not be so dry that it holds all its water. A foam blanket should be wet enough to penetrate duff and soils during mop-up. Dry foams merely act as a lid on a pot of boiling water.

We used one 1½ trunk line feeding five 1" laterals. Pumping distance was 1500 feet.

July 26

Pearl Fire

Location: Emmett, ID

Accomplishments: We participated in initial attack of sagebrush-grass type fire. We used the 1600-gallon foam engine in pump and roll attack of grass fire flanks of two-foot flame length. Hot temperature (+100^{o}) and low humidity were indicators of a situation where a relatively dry foam barrier is not going to be successful preventing fire spread. Foam had to be wet enough to drain moisture into vegetation. And adequate moisture had to be available to completely wet these very dry fuels. Flame knockdown will be instantaneous, but, unless the water necessary for wetting is provided, foam will not be effective. The fire will rekindle and continue on its way.

Water is still the extinguishing tool. It is important to realize that the water in the foam is doing the work required, not the foam itself. Foam is created to (1) hold the water in place long enough for it to be used and (2) make the water more usable. Many direct attack and mop-up applications require a delivery of wet, frothy water rather than thick, durable foam.

August 26

Structure Fire Demonstration, in cooperation with the Boise City Fire Dept.

Location: Boise, ID

Accomplishments: This was a demonstration for the Boise Fire Department. We showed what a low water flow as foam can do on interior and exterior structure attack. A two-story, three-bedroom home of approximately 900 ft^2 was ignited. When the first floor was fully involved, Clarence Grady began to instruct the attack. Using 1.5" hose, the flow was 35 gpm of water. The nozzleman moved slowly compared to high-water flow, conventional tactics, but as foam was applied, fire extinguished and stayed out. Total attack time on the first floor was approximately 2.5 minutes.

During post-analysis, we realized the method of attack more closely resembled today's present water techniques of direct application. This was not the technique used on attacks made in Jefferson in 1985 and elsewhere. These attacks were similar to indirect attack tactics developed by Lloyd Layman in the 1950's. The concept then was to project a small water flow in the more usable fog droplet form into the superheated space of a burning compartment. The water would then expand, forcing air out of the space, extinguishing the fire. We experienced immediate success with indirect attack and CAFS.

August 27

Hydrocarbon/Liquid Fuel Pit Fire Demonstration, in cooperation with the Boise City Fire Department and the United States Air Force

Location: Boise, International Airport

Accomplishments: This was the second demonstration for the city fire department. Two attacks were made on hydrocarbon fires burning in a 2,000 ft^2 fuel pit with 600 gallon JP 4 fuel. Attacks began when flame lengths reached 40 ft.

The first attack was made with a 1.5" hose using a 1.5" waterway. Wildland foam (Silv-ex) was mixed at 0.2%. The 40 cfm compressed air system flowed 35 gpm. Extinguishment was rapid with the type 3 foam. However, knockdown time was lengthened when heat of radiation prevented the nozzleman from reaching the fire. By reducing the tip size to 1¼", the discharge distance (45-70' into the wind) was long enough to complete the attack.

The second attack was made with a 2.5" hose using a 2" i.d. full flow ball valve as a nozzle. Air was supplied by a 100 cfm trailer air compressor taken from the airport. Water flow was 80 gpm at 0.2% mixing. The attack began on 60-ft. flame lengths encompassing half the surface area of the pit. Very quickly, gaps in the fire appeared as the foam began building and spreading on the fuel surface. The fire was out within one minute.

These attacks, although not directly compared to AFFF or other systems, were impressive to all people involved. Questions as to why the foam has such success with these fires are numerous. A vapor seal appears to form on the liquid fuel, but is there more to the picture than we can see? Why is such a low water flow capable of reaching the fuel surface rather than vaporizing when projected into the midst of a 40-foot flame length liquid fuel fire? Is the chemical compound of the foaming agent aiding extinguishment by some other means, such as disrupting the chemical reaction that is fire?

September

Longwood Complex Fire

Location: Cave Junction, OR

Accomplishments: We began the process of foam education. This included an introduction to foam use for all those who worked with us and an introduction to the blind tradition of water use for us. At an individual level we were able to communicate and demonstrate the values of foam over water.

9/1-9/2: We demonstrated the use of foam for structure protection during burn-out around an interface community. We applied foam to and around many homes prior to backlighting to reduce the potential for uncontrolled fire in the area.

9/3: We worked initial attack above the rapidly moving fire on a mid-slope road. Two people laid and worked a 1,600 ft. 1.5" foam line uphill to cut off the fire head where it had already crossed the road from below. This line was fed by the 1,600 gallon foam engine. Then, in an adjacent draw, the fire roared up from below the road. The engine broke away from the uphill line and proceeded to the point where the fire was crowning with 50 feet flame lengths from below the road to above. Two people on the crew knocked down the fire with 1" handlines flowing 20 gpm each in a matter of seconds. Foam was wet and frothy. Burn area above the road was held to 400 ft^2.

This was a phenomenal sequence of events. Because foam makes hoses light and very manageable, the first two workers could rapidly create a long uphill hose lay along the flank. Elevation rise of about 400 feet did not affect foam performance. The crowning fire that moved across the road would probably never have been attacked with water alone. The common firefighter's concept of water's effectiveness tells him that the water pumping systems in use at the fire would not have been successful. Therefore, the normal reaction would have been to pull back and let the fire go. This notion was supported by several hydroseeder operators contracted for water support at the fire. Their equipment has large water flow capability, but did not feel comfortable in high intensity situations with their machines until they began adding a foaming agent to the tank. Before the complex was under control, they, too, instantly knocked down running crown fires as the fire moved across mid-slope roads.

This begins a series of extinguishment events which lead us to ask questions about what is happening at the fire interface during extinguishment with a foaming agent.

9/6-9/13: We continue the success we experienced in Montana with multiple lines, low water flow, and high pressure during mop-up. Much time is spent demonstrating to and educating other workers. The mop-up wand becomes the preferred tool for deep-seated fire. Most importantly, we realize that the best tactics are no different than those using plain water. Digging and probing are still valid. A layer of foam will not magically put out fire. We know that less water will be used to put out fire if it is better able to spread or penetrate or remain in one place. What foam provides is less water in a more usable form.

September 14-19

Silver Complex Fire

Location: Agness, OR

Accomplishments: We worked side by side with a BLM 700-gallon water engine for 4 days doing mop-up and indirect attack from a foam line. Direct comparisons could be made between the performance of CAFS and water and between CAFS and aspirated foam. CAFS provided longer discharge distance at given water flows than water or aspirated foam. CAFS operating time per gallon of water was about 3 times greater. CAFS more readily provided the type of foam necessary for different tasks than aspirated foam. Applications were made with CAFS which would not have been attempted with aspirated foam or water, such as protecting massive slash piles. Water pumping crews immediately noticed a benefit to foam-filled hose during an up-hill hose lay. When members of the foam crew had to work with water, a reduction in efficiency was observed.

February 1988

Structure Fire Demonstration

Location: On a farm outside St. Paul, OR

The Chemeketa Community College Fire Protection School, in cooperation with the St. Paul Rural Fire Protection District, held a fire attack training session. The purpose was to demonstrate and train firemen for attacks on large structures, specifically a house and a 144,000 cubic foot barn. The procedure was to make the initial attack with wildland compressed air foam to see what would happen. The second attack or back-up would be made with straight water.

Compressed air foam was applied to the barn fire after the barn became completely engulfed in flame. The barn dimensions were 60'x80'x30'. According to the Iowa formula for water attack requirements, 144,000 ÷ 100 = 1,440 gallons per minute (gpm) would be required to extinguish this fire with conventional water methods.

The compressed air foam was made with a 40 cubic foot per minute (cfm) air compressor mixing air with 0.5% Silv-ex foam solution. The concentrate was injected into the water line. Water flow as foam was 70-100 gpm through one 1.5" woven rubber hose. The nozzle had a 1.25" bore.

The attack began on the ground level. With applications to the upper air space, the ceiling and the walls. Application continued to the upper loft. Exactly what processes were occurring is not clear.

However, black out was achieved in 50 seconds. Thus, less than 100 gallons of water from one 1.5" line was necessary to extinguish this fire.