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# FOAM APPLICATIONS FOR WILDLAND & URBAN FIRE MANAGEMENT

***Prepared by:*** **NWCG Fire Equipment Working Team's Task Group for International/Interagency Foams and Applications Systems**

Canadian Committe on Forest Fire Management

Comité canadien de gestion des feux de forêt

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## ENVIRONMENTAL IMPLICATIONS OF FIREFIGHTING CHEMICALS

*By Susan E. Finger, Acting Chief, Field Research Division, United States Department of the Interior, National Biological Service, Columbia, Missouri*

Fire retardants and suppressants are used extensively in the United States for suppression and control of range and forest fires. Each year, fire control agencies utilize millions of gallons of these mixtures on a wide array of ecosystems. These chemicals are often applied in environmentally sensitive areas which may contain endangered, threatened, or economically significant plant and animal species. Relatively little information is available on the toxicity of these chemicals to aquatic and terrestrial life. Less information is available concerning impacts at the community and ecosystem level.

The extensively used ammonium compounds, essentially dry or liquid fertilizer formulations, have long been considered to have minimal toxicological or ecological impact. Research is mostly confined to effects on aquatic organisms. Several authors have reported on the toxicity of the active ammonium salts found in most fire retardants (Pramanik and Sarkar 1987, Sheehan and Lewis 1987, Ram and Sathyanesan 1986, Singh et. al., 1985). Limited studies concerning nitrate poisoning to aquatic animals (Johnson and Sanders 1977) from fire retardant formulations have been conducted. Even less information is available on foam products. Although the risk associated with firefighting chemicals has generally been accepted as minimal, extensive fish kills have been documented after accidental drops of chemicals directly in a stream. ***(continued on pg. 3)***

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For example, many trout were killed in the Little Firehole River during the major 1988 fire in Yellowstone National Park (Minshall and Brock 1991). Specific concerns over potential fire chemical effects on endangered and threatened fish has underscored the need to define "safe" distances for chemical application in areas supporting aquatic resources.

Based upon the few reported studies concerning fire retardant chemicals and formulations, it was impossible to ascertain their impact without additional research. Moreover, the effects of repeated applications on aquatic and terrestrial ecosystems was unknown. Therefore, the Interior Fire Coordination Committee (National Interagency Fire Center, Boise, ID) funded the National Biological Service to conduct studies to address the toxicity of these chemicals to aquatic and terrestrial organisms in a comprehensive manner.These studies, conducted cooperatively with the Department of the Interior agencies and the USDA Forest Service, included standard laboratory testing of select chemicals followed by two years of field studies to evaluate ecological effects resulting from fire chemical application. It was agreed that these studies would be conducted in a prairie wetland habitat in North Dakota and in an area in the Great Basin region of northern Nevada. Terrestrial and aquatic laboratory studies were initiated in 1992 with field studies to be conducted in 1993 (North Dakota) and 1994 (Nevada).

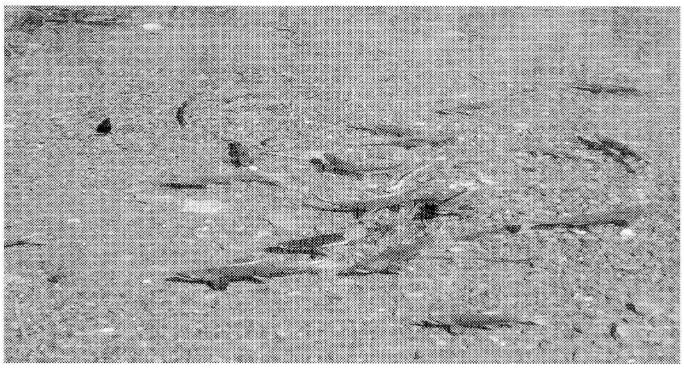
Research in these areas will provide valuable information to fire managers and policy developers to ensure that sound decisions are made concerning firefighting activities on private, state, and federal lands.

### Current Research Summary

In 1992, laboratory studies were initiated at the Midwest Science Center (Dr. Steven Hamilton) and the Patuxent Ecological Science Center (Dr. Nimish Vyas and Dr. Elwood Hill) to determine the toxicity of five commonly used firefighting chemicals (Fire-Trol GTS-R, Phos-Chek D75-F, Fire-Trol LCG-R, Silv-Ex, and Phos-Chek WD-881) to two fish, two aquatic invertebrates, an algae, three birds, a mammal, and a terrestrial invertebrate. In general, all chemicals were of comparatively low order of toxicity to terrestrial species. For all test species, the $LD_{50}$ exceeded the limit criteria for significant acute toxicity.

*Biologist measuring water quality in a limnocorral dosed with Silv-Ex in North Dakota wetland study.*

In contrast, tests with aquatic organisms indicated the two foam suppressants (Silv-Ex and Phos-Chek WD-881) were similar in toxicity and were significantly more toxic than were the three non-foam chemicals. Water quality did not modify toxicity in a consistent manner for all species. In general, the egg life stage of both fish species was more tolerant of chemical exposure than other life stages; swim-up stage was most sensitive for all chemicals. Such results imply that accidental introduction of these chemicals into an aquatic system during the salmonid swim-up period could cause significant mortality and be catastrophic to a local population, especially if that population was threatened or endangered.

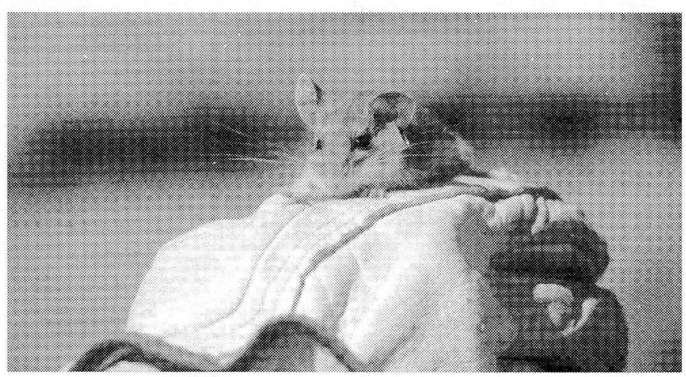


*Salmon in Cordova, Alaska Ranger District stream.*

Based on information from laboratory toxicity tests, field studies were initiated to evaluate the response of the aquatic, terrestrial, and vegetative communities associated with a prairie wetland habitat to several firefighting chemicals in May 1993. The vegetative and terrestrial components were exposed to the retardant, Phos-Chek G75-F, and a foam suppressant, Silv-Ex. In the aquatic ecosystem, two foam suppressants, Silv-Ex and Phos-Chek WD-881, were compared. The purpose of this phase of the study was not only to provide information on aquatic, terrestrial, and vegetative responses to firefighting chemicals in a prairie wetland environment, but also to develop field assessment methods that could be used to determine the effects of these chemicals in a more complex ecological system such as the Great Basin area of Nevada; a study planned and implemented during the summer of 1994.

Results from the vegetative study on a mixed-grass prairie site in North Dakota suggested that fire chemical application may cause changes in growth, including biomass accumulation, and changes in species diversity (Dr. Diane Larson, Northern Prairie Science Center). Fire retardants such as Phos-Chek are primarily fertilizers, and as such stimulate growth. Although the fertilization effect from Phos-Chek produced a pronounced increase in herbaceous biomass, species diversity was depressed. This likely resulted from the strong response of the exotic grass *Poa pratensis* to fertilization, thus allowing it to out-compete other species. Foams such as Silv-Ex did not affect growth, but did depress species diversity. Implications of this research depend on the objectives of the manager. If the objective is to halt an uncontrolled fire, subtle changes caused by Silv-Ex and Phos-Chek may be of little importance. On the other hand, if the objective is to aid in the control of prescribed burns, the potential effect on species diversity should be considered. In particular, if the control of exotic, robust grasses such as *Poa pratensis* is important, these results suggest that use of these chemicals should be minimized or avoided.

Terrestrial field studies indicated no measurable effects on small mammal populations (N.Vyas and E.Hill). Although this is supported by laboratory information, which suggests a relatively low level of acute toxicity for these chemicals, field results are confounded by the extremely low population densities that likely resulted from the unusually cold and wet weather in North Dakota during the summer 1993. Analysis of ant population data also revealed no dose-related effect.



*Small mammals were trapped from both study sites to determine chemical effects on population density.*

Overall, interpretation of this information for management purposes must be guarded due to the unseasonal events of the 1993 summer.

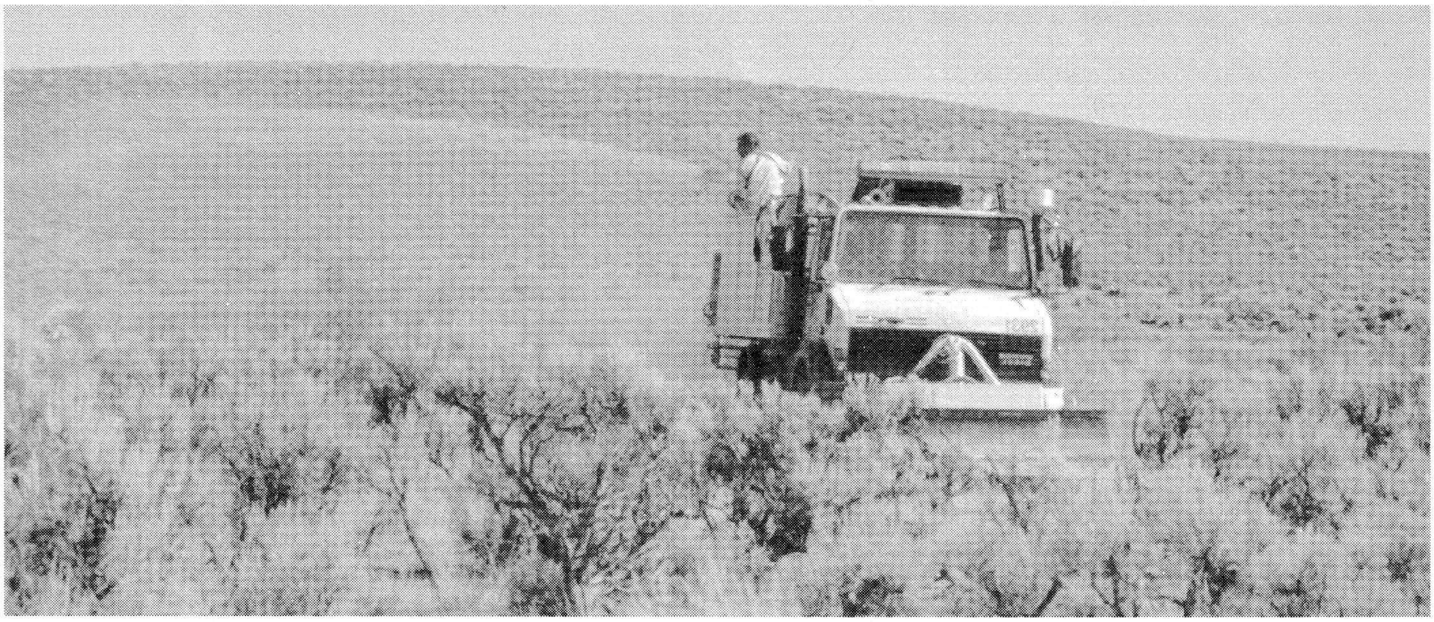
However, development of methods during this study greatly benefitted the experimental design and method selection for the 1994 field season in the Great Basin.

Of the two foams tested in the aquatic environment, Silv-Ex was more toxic than was Phos-Chek WD-881 (Dr. Barry Poulton). Survival of water boatmen (Cenocorixa sp.) was reduced dramatically by exposure to 6 mg/L Silv-Ex, the exposure representing the lowest observable effect concentration for daphnids under laboratory conditions. These invertebrates are dependent on surface tension for mobility. It is likely that the effect of the surfactant associated with Silv-Ex reduced the surface tension and resulted in the observed mortality. The slightly lower concentration of Phos-Chek WD-881 (4.7 mg/L) resulted in no mortality to the water boatmen. However, organisms showed impaired movement that suggested a sublethal response related to chemical exposure. Sensitivity of fathead minnows to Silv-Ex was similar between field and laboratory exposures.

The most dramatic decrease in survival occurred during the first 24 hours. No dose-related fluctuations in pH, conductivity, oxygen, phosphates, sulfates, chlorides, or chlorophyll a were measured during the study. Ammonia never exceeded concentrations known to be acutely toxic to fish and aquatic invertebrates. In addition, no effects on the macroinvertebrate community resulting from either the Silv-Ex or Phos-Chek foams were evident after 96 hours.

A safety factor of 100 is commonly applied to toxicity data to estimate a maximum acceptable toxicant concentration for the protection of aquatic organisms (Rand and Petrocelli 1985). Based on information derived from this field exposure with fathead minnows, a spill of 1% Silv-Ex into a closed aquatic system such as a pond or terminal wetland would require a 41,600-fold dilution. Thus, in a one-acre pond, with an average depth of 10 feet, use of a safety factor of 100 would estimate that about 78 gallons of 1% Silv-Ex spilled directly into the pond would represent no threat to aquatic organisms. Inclusion of a safety factor is essential to provide protection for all trophic levels in an ecosystem. Although aquatic invertebrates do not represent an economical or recreational resource, they represent an essential food source for most fish and are thus, essential to the integrity of the ecosystem. Caution should be exercised when applying foam suppressant chemicals near aquatic ecosystems to reduce the potential for accidental spillage or incidental overspray of the chemicals during application.

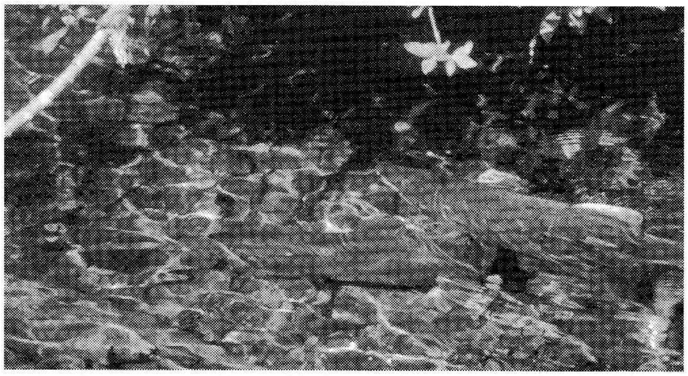
Most recently, field studies have been completed in the Great Basin area of northern Nevada (summer 1994). Effects of Phos-Chek D-75F and Silv-Ex were studied. Analysis of these data is underway. Preliminary information suggests that the chemicals



*Application of Phos-Chek on the Nevada experimental area.*

may have minimal effects on the terrestrial community. However, in-stream exposures with Lahontan cutthroat and rainbow trout confirm that, similar to laboratory testing, Silv-Ex is more toxic than is Phos-Chek D-75F. Research to evaluate the rate of degradation and potential risks associated with mobilization of these chemicals from the terrestrial environment into the aquatic environment is also in progress.

Preliminary results from this extensive research effort confirm that the current policy of exercising caution when applying fire chemicals near streams with threatened or endangered species is appropriate. For protection of fish populations, the time of application, as it coincides with fish development, will be a decisive factor in estimating potential effects.



*Time of application of fire chemicals near streams, as it coincides with fish development, is a decisive factor in estimating potential effects.*

For desired vegetation responses, objectives of the land manager may be most important. Overall, these combined field and laboratory studies will result in information that will clearly define effects expected from chemical application. In addition, this research should provide the capability to delineate, for aquatic systems, the "safe" zones required to protect fish and wildlife resources from chemical-induced mortality. Most importantly, toxicity information from these studies must be combined with existing knowledge of ecological effects of fire on terrestrial and aquatic systems to ensure that the best possible management alternative is exercised.

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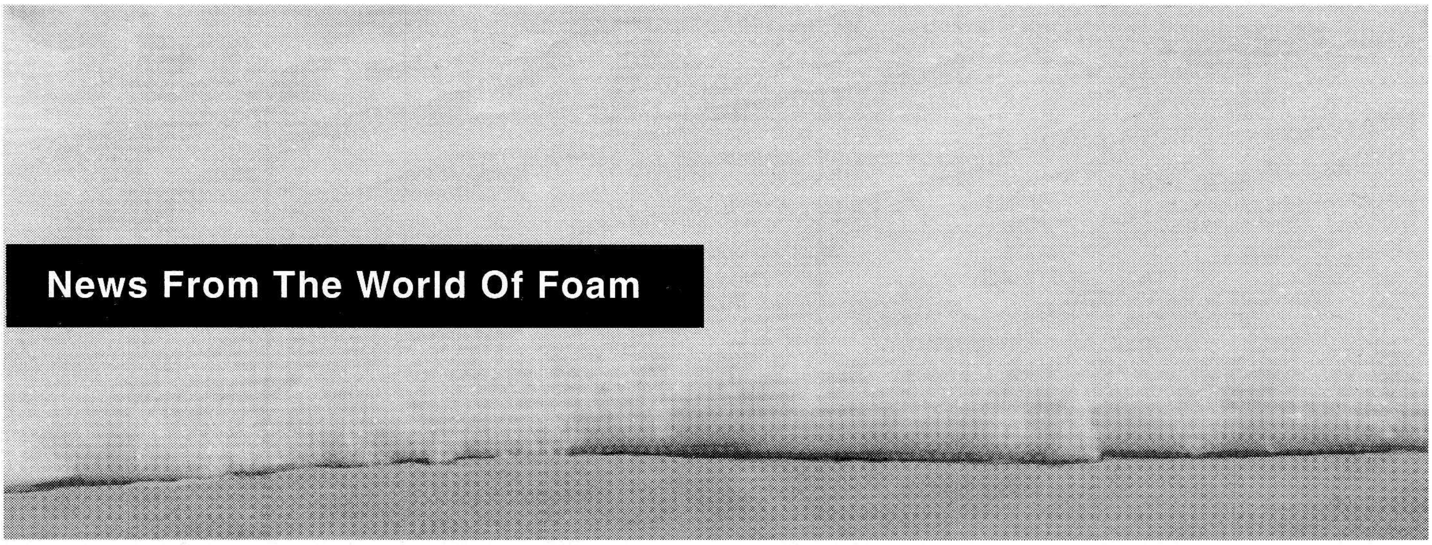


## News From The World Of Foam

• National Fire Protection Association (NFPA) standard 1906, Wildland Fire Apparatus will soon be available. This all-new standard covers the requirements for new fire apparatus designed to support wildland fire suppression. It provides for both on-road and off-road vehicles and requires apparatus to have a pumping capability of between 20 to 250 gpm, at least a 125-gallon water tank, and hose and equipment. There are also requirements for Class A foam systems, compressed air foam systems, electrical systems, and winches when they are included on the apparatus. Order item No. MY-1906—95 (53 pp, 1995), cost is $22.25 (Members of NFPA $20.). NAFP toll-free telephone number is 1-800-344-3555.

• National Fire Protection Association (NFPA) is updating standard 1901, Automotive Fire Apparatus. A draft of this standard will be available for public comment about 1 August, 1995. The updated standard contains requirements for Class A foam proportioners and compressed air foam systems (CAFS) for automative fire apparatus if this equipment is specified. To obtain a copy for review call NFPA at 1-800-344-3555 and ask for Report on Proposals, Annual Meeting 1996. There is no charge for this report.

• The Direct Reading Percent Foam Meter from New Zealand is now available from W. S. Darley and Co. (1-800-323-0244). Darley calls the meter DIGIFOAM.

• Foam vs. Fire—Aerial Application, the third in a series of Foam vs. Fire manuals will soon be available. The Steering Committee met at San Dimas the first week in December to complete the final draft and make arrangements for publication and distribution.

• The USDA Forest Service, Fire Sciences Laboratory, Missoula, Montana, is working on fire-fighting effectiveness of foam products, foam concentrate compatibility, international foam specification, foam characteristics, and effects of temperature and changes on foam proportioning. Progress on these items will be reported in the Foam Applications for Wildland and Urban Fire Management publication.

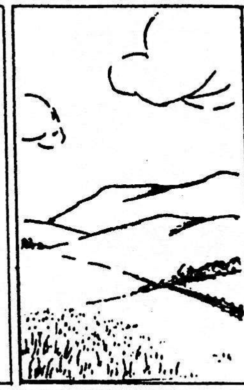
• Ron Rochna has retired from the USDI BLM and can now be reached at Applied Foam Technologies, 10391 Harvester Ct., Boise, ID 83709, 208-322-5004.

• Steve Raybould and Dan McKenzie have both retired from the USDA Forest Service, Technology and Development Center, San Dimas, California. They are both working as reemployed annuitants for the Center.


FOREST RESEARCH NOTES

U.S.DEPARTMENT OF AGRICULTURE
FOREST SERVICE
CALIFORNIA FOREST AND RANGE
EXPERIMENT STATION *

STEPHEN N. WYCKOFF, Director


No. 71 June 27, 1950


*Editors note: This article by Wallace L. Fons appeared in the **June 27, 1950** issue of the publication Forest Research Notes, printed and distributed by the U.S. Department of Agriculture, Forest Service, California Forest and Range Experiment Station maintained at Berkeley, California, in cooperation with the University of California. The 1950 article has been provided from the extensive files of Charles W. George, USDA Forest Service, National Wildfire Suppression Technology, Missoula, Montana.*

[1]Presented at: Annual meeting, Southern California Association of Foresters and Fire Wardens, San Bernardino, CA, April 7, 1950, and Annual meeting, California Rural Fire Association, Merced, CA, April 21, 1950.

# Wet Water For Forest Fire Suppression

BY

*Wallace L. Fons, Mechanical Engineer*

In recent years wetting agents have been recommended by manufacturers and others for increasing the efficiency of water for fire suppression. Many local fire-protection agencies have made tests comparing wetting agent solutions with plain water for flame suppression and mop-up under field conditions. In general, their results and conclusions indicated the need for comprehensive tests to determine the types of wetting agents best suited for suppression and the best technique for application of chemically treated water, called wet water.

Such comprehensive research was begun in 1948 by the Engineering Department at the University of California at Los Angeles.Technical supervision of the research was administered by the Division of Forest Fire Research, California Forest and Range Experiment Station. In 1949 the Station took over all phases of the investigative work.

At the outset it was realized that a great deal of fundamental research would be necessary before specifications on all phases of suppression could be developed. For instance, those physical properties of water and chemicals accounting for the suppression action were not known. The research program was divided into three parts: (1) Determining the physical properties of plain water and wet water; (2) investigating the mechanisms of fire suppression; (3) determining the suppression effectiveness of wet water over plain water.

## Physical Properties

The physical properties thought to be important in suppression are: surface tension, penetration, surface spreading, and foaming. Surface tension is a measure of the force required to hold a liquid drop in a spherical form. For instance, mercury has a high surface tension value (513 dynes/cm); water, a moderate value (72.8 dynes/cm); and alcohol and petroleum, low values (approximately 25 dynes/cm). Most wetting agents in concentration of one percent will reduce surface tension of water to 30 dynes/cm. The more active the wetting agent is, the more rapidly the surface tension of water is decreased. The recommended concentration for firefighting is usually such as to reduce the surface tension of water to about 35 dynes/cm.

When the surface tension of water is reduced, spreading, penetrating, and foaming are increased. Tests of these physical properties were made on water and 14 commercial wetting agents. The tests show that:

1. Surface spreading of wet water on wood is 2 to 8 times greater than water, depending on species of wood.
2. Penetration into wood of wet water is about 8 times greater than water.
3. Penetration of wet water into charcoal is about 2/3 as much as it is for wood.
4. Penetration & surface spreading of water on charcoal is practically nil.
5. All wet water readily forms foam.

Corrosion tests with iron and galvanized iron showed that wetting agent solutions in general, unless they contain an inhibitor, have higher corrosion rates than distilled water. With few exceptions the rate of corrosion was greater for the galvanized iron. The corrosion of metals by wetting agent solutions may be wholly corrected by the addition of small amounts of chemicals, known as corrosion inhibitors, such as potassium dichromate and sodium nitrite. Tests showed that as little as 100 parts per million, or about 2 ounces per 100 gallons of water, of commercial granular potassium dichromate was effective in reducing the corrosion of iron and galvanized iron by wetting agent solutions.

## Suppression Mechanism

Before tests with fires were begun, some important questions arose concerning the suppression action of water. First, what is the behavior of a water droplet when it strikes a burning wood surface? Calculations revealed that water, sprayed on burning wood with its surface reduced to charcoal, will impinge on the charcoal surface having a temperature as high as 1900 degrees F. Second, what is the theoretical minimum volume of water necessary to cool a unit volume of burning wood below the rekindling point? Again, calculations showed that a unit volume of water suddenly applied over the entire surface will cool 300 volumes of burning wood below the kindling point; but if the water is applied only to the frontal area of the burning wood, the amount of water required is doubled. Third, does penetration cooling have an advantage over surface cooling and vice versa? Results of calculations indicated that there was no significant difference between penetration and surface cooling.

## Suppression Effectiveness

Water may be used to an advantage in forest fire suppression for: (1) Flame suppression; that is, application of water on the flame to retard the spread of a given section of fire; (2) mop-up; that is, application of water on a burned area to extinguish small isolated flames and to cool glowing and charred material to a point at which rekindling is unlikely; (3) pretreatment; that is, application of water on unburned fuels in advance of an oncoming fire to retard its rate of spread or in holding a line from which to backfire.
For each of these uses, fire tests were conducted to compare the suppression effectiveness of wet water and plain water.

### Flame Suppression

For flame suppression, a total of 93 model fires were burned on which the effectiveness of 14 commercial wetting agents were tested. Besides these laboratory tests, 66 field-fire tests were made, in which three commercial wetting agents were tested. Each fire was allowed to burn up to its maximum flame intensity before suppression was started. The intensity of each fire was measured with a radiometer. From the radiometer record of each fire, the intensity during suppression was calculated.

The experimental work established the superiority of wet water over plain water in reduction of fire intensity. The superiority is at its maximum when the liquid is first sprayed on the fire. Results indicate that this superiority at the very beginning of spray application on a section of flaming front is from three to four times greater than at the end of application, when only isolated flames remain.

For the period of flame suppression of these experimental fires, the mean superiority values of wet water over plain water are 1.70 for field fires and 2.10 for model fires. Ordinarily, superiority is expressed as a ratio of quantity of plain water used to quantity of chemical solution used. The superiority of wet water based on quantities was 1.25 for field fires and 1.55 for model fires.

However, in recommending wet water for flame suppression, emphasis is given to the superiority based on reduction of flame intensity. The practical importance of this superiority, especially at the beginning of suppression, is that it shows the decided advantage a hose operator has in advancing on a fire front with wet water. This advantage should permit an operator to knock down the flame intensity more quickly to a point where he can move in and hold the spread of a fire.

It is believed, therefore, that the use of wet water in flame suppression should result in controlling a greater number of fires as well as in controlling the fires at an earlier period, thus reducing the size of the mop-up job.

Even where an abundant supply of water is available, use of wet water in some instances may make the difference between success and failure in controlling a forest fire.

In these tests the ratios of volume of burning wood to volume of wet water used for flame suppression were: field fires, 56 to 1; model fires, 117 to 1. For fires suppressed with water the ratios were 45 to 1 for field fires and 76 to 1 for model fires.These ratios, when compared with 300 to 1—the maximum possible, show that there is room for improvement in techniques of application.

Experimental work has not yet advanced sufficiently to specify what pressures and discharge rates to use for most efficient flame suppression. It has been noted, however, that on the experimental fires, sprays were superior to straight streams primarily because of their greater coverage.

Mop-up

To test the effectiveness of wet water in mopping up fires in deep pine litter, a total of 108 test fires were burned. The technique used in mopping up these fires consisted of first spraying the burned area as rapidly as possible, suppressing all glowing, smoking, and burning material; yet not wasting water or wet water by wetting the area unnecessarily. In this first application care was taken to hold the nozzle above the surface of the burning litter at a distance which gave minimum air entrainment and effective spray distribution with maximum coverage. The first application was followed by an intermittent application on those spots where smoke appeared. A quick-opening-and-closing shut-off nozzle permitted closing the nozzle quickly when moving from one smoldering spot to another and opening it only long enough to extinguish the immediate small hot area.

The results of 82 of these fires show that the superiority based on quantity of plain water used compared to quantity of wet water used is about 1.29. Thus, by the addition of wetting agents at appropriate concentration, a saving of 23 percent in the quantity of water can be realized on a given mop-up job. As intermittent application was used part of the time in mopping up these fires, the superiority of wetting agent solutions based on time of mop-up is only 1.15. This means a saving of 13 percent in time in mopping up a given burn. In practice the saving of 23 percent in quantity of water and 13 percent in mop-up time may appear as not being significant; however, on a national scale or even on one large burn, such a saving can amount to a considerable sum of money.

Another factor of practical importance is that wet water in mop-up has a distinct advantage in reducing the rekindling from hot spots and glowing embers. For the mop-up tests in deep pine litter the ratio of rekindled spots on plots suppressed with water to the rekindled spots suppressed with wet water was 1.43 to 1. For comparable fuel types one can expect approximately 30 percent fewer rekindlings on an area mopped up with wet water.

Pretreatment

Pretreatment experiments were made by spraying wet water and plain water on litter fuels to determine whether wet water would increase the length of time that wetting is effective. The results of these experiments indicate that the length of time for sprayed unburned litter fuels to dry is 50 percent longer for wet water than for plain water. This is attributed to the greater surface spreading and penetration of wet water.

## Conclusions

Significant differences were found in physical properties among the wetting agent solutions tested. However, no special meaning can be attached to these differences because these same agents were not significantly different in their effectiveness in the fire suppression test. It appears that the surface spreading, penetrating, and foaming properties of all the wetting agents tested, when the agent is used so as to reduce the surface tension of plain water by one-half, are within that range which does not alter the effectiveness of a wetting agent solution for fire suppression. The results indicate that on the basis of penetration and surface spreading, any one of the hundreds of wetting agents now on the market, if used at the proper concentration, would yield suppression-effectiveness results comparable to those obtained for the wetting agents tested.

Specific conclusions drawn from work performed to date are: (1) Savings up to 23 percent in the volume of water required and 13 percent in time of mop-up can be obtained with wet water if applied with reasonable efficiency; (2) rekindling is reduced as much as 30 percent on fires mopped up with wet water as compared with plain water; (3) foaming appears to be a desirable property of wet water in mop-up because it prevents channeling of the water; (4) wet water is markedly superior to plain water in its ability to knock down flames quickly, thus permitting access to a fire edge not otherwise accessible; (5) dead fuels along the burning edge of a fire or along a backfire line remain wet up to 50 percent longer when sprayed with wet water than when sprayed with plain water; (6) fuels once treated with wet water and allowed to dry may be sprayed later with plain water with results comparable to an original spraying with wet water; (7) most wetting agents increase the corrosive action of water, but this can be wholly corrected by the addition of chemicals known as corrosion inhibitors.

In general, the results to date have been shown that wetting agents have a definite place in forest fire suppression. Certain information on foaming and dermatological effects, however, is still needed to permit the writing of definite specifications for the most desirable type of wetting agents. Some advancement has been made on technique of application for maximum effectiveness; but this knowledge is not yet complete enough to satisfy all field conditions. Experiments are still needed to determine the effect of foam and pattern of spray on fire suppression efficiency, for plain water, wetting agent solutions, and other chemicals.

## USE OF CLASS A FOAM ON A WILDLAND FIRE

*By David Roe*
*Professional Response Organization (PRO), Twin Falls, Idaho*

INCIDENT:
Corral/Blackwell Complex near McCall, Idaho, in Valley County.

LOCATION:
Division "G," western side of Upper Payette Lake.

DATE:
01 October, 1994

TIME:
Day Shift

INCIDENT COMMANDER:
Rich Wands

ENGINE AND CREW:
PRO, INC. #605

ASSIGNMENT:
Provide assistance to dozer operations at a slash disposal site.

DISPOSAL SITE CONDITIONS AND SIZE:
Ninety percent of all fine fuels had been burned, deep seated fire in the stumps and 1000 hour fuels, mixed with large amounts of mineral soil. Estimated disposal area about 160 feet in diameter, varying in heights from 2 feet to over 6 feet. Site was in excess of 700 feet from water source (Upper Payette Lake) and 400 feet from an existing hose lay, provided with water by two Mark III pumps.

ENGINE #605 SPECIFICATIONS:
Navistar 4 x 4 chassis rated at 32,000 pounds gvw. Five person cab—230 hp turbo-diesel engine and 5-speed Allison automatic transmission. Hale CBP hydraulic driven pump, 250 gpm rated, with adjustable relief valve.

Sulaire rotary screw air compressor, hydraulic driven and rated at 150 cfm. FoamPro 2001 *foam* proportioner, dual tank system for either Class A or Class B foam.

This 1992 Model Urban Interface Engine was built by Boise Mobile Equipment, located in the City of Boise, Idaho.

EVENTS OF 01 OCTOBER 1994:
Crew of #605 deployed 400 feet of the 1 1/2 inch-hose that connected engine to existing hose lay. This provided the engine with a continuous water supply using close radio contact with hand crews also using the hose lay for extensive mop-up operations.

Using three 1 1/2 inch pre-connects, #605 provided cooling and dust control as the dozer began to spread the pile and separate the fuels from the rocks and soil. A water stream was projected on both sides of the dozer at all times, as well as cooling over all of the disposal area.

Due to the fact that continuous flow was needed, the FoamPro 2001 was set at its lowest rate of 0.1 percent.

During the shift, engine #605's digital flow meter registered total flows of 17,290 gallons of water and 17.3 gallons of foam concentrate. The only shut- down was a short lunch break. The engine performance was 100 percent. By working with the dozer boss, dozer operator, division supervisor, engine strike team leader, and hand crews using the hose lay for mop-up, the objective of **total cooling** of the disposal site was completed by 1800 hours.

## FOAM ON THE (FIRING) RANGE— CLASS A FOAM IN DEPARTMENT OF THE ARMY

*By Samuel Duncan, Research Associate*
*Department of the Army*
*Tank-Automotive Research, Development and Engineering Center (TARDEC)*
*Mobility Technology Center*
*Belvoir Fire Research and Development*
*Fort Belvoir, Virginia*

The continuing reorganization and downsizing of the Department of the Army has made for unprecedented creativity as the engine of success for the fire research and development mission. This inventive spirit is making visible many issues, resource requirements and the incontrovertible need to continue research and development efforts. The broad and sometimes sticky issue of Class A foam is addressed here.

In May of 1994, Doc Smith, then Chair of the International Foam Working Group, said, "We have foam (Class A) in the corral." I think he was correct but to continue the analogy, we do not have a saddle on Class A foam and nobody's gonna ride it this year. What Doc Smith meant then is, we know more than ever, but it is not enough. What I mean now is, there will be no objective performance standard for Class A foams in this decade.

Class A foam technology has a rather lengthy history in America's fire service but in the Department of the Army Fire and Emergency Service the issue is embryonic. Class A foam has yet to reach the stage of controversy. That is not to say no Army fire department uses Class A foams. Several installations are using one foam or another. When the departments were queried as to what singular performance criteria led them to spend increasingly scarce dollars on proportioners, meters, nozzles, and the chemicals, the response reflects less operational success than marketing hype. Class A foams are curiously without a procurement rationale other than price, despite their 100 year history.

The effect on Department of the Army fire departments, coping with a newly reemphasized and vigorously applied procurement philosophy based on performance is the lack of requisite criteria by which to procure Class A foam at all—we cannot prove it works.

There has never been a policy in the Department of the Army which addresses Class A foams, yet Department of the Army owns or is responsible for 12 million acres of undeveloped land. Some of these undeveloped acres either border state or national parks or wild-life refuges for protected species. Foresters and installation fire departments often have their hands full during the fire season coping with wildland and range fires ignited by weapons training, careless campers, and responding to the myriad of other incidents that occur as well as mutual aid calls from the surrounding community. It seems reasonable that a technology with the potential of Class A foam to heighten firefighter safety, reduce water requirements, reduce runoff thus preventing erosion and provide exposure protection to uninvolved property would be a strong candidate for research.

In the Department of Defense, the U.S. Air Force officially has the lead for conducting fire research. Obviously, Air Force focus is on fixed-wing aircraft, hangers and fixed petroleum facilities. The U.S. Navy conducts research with regard to fires aboard ship—a logical extension. Recently the void in wildland fire research was filled by U.S. Army's Tank-Automotive Research, Development and Engineering Center located at Fort Belvoir, Virginia. In the latter part of this fiscal year a group will meet to write a Department of Defense policy regarding wildland fire suppression operations and develop a memorandum of understanding that will promote and define interagency cooperation to fight these fires. That is a first, very positive step that could result in a coherent, national effort of all agencies involved in the management and protection of the wildlands. It could result in an earnest, objective and funded pursuit of Class A foam performance standards.

Doc, you're right—foam is in the corral. There's no saddle on it yet, but there are a couple of us intending to continue your efforts; we're gonna ride this elusive critter until it performs at its highest level. It will save an acre and a little time, reduce some expenses and it will do one other thing—it will save somebody's life. That's worth a few government dollars, isn't it?

## CLASS A HIGH EXPANSION FOAM

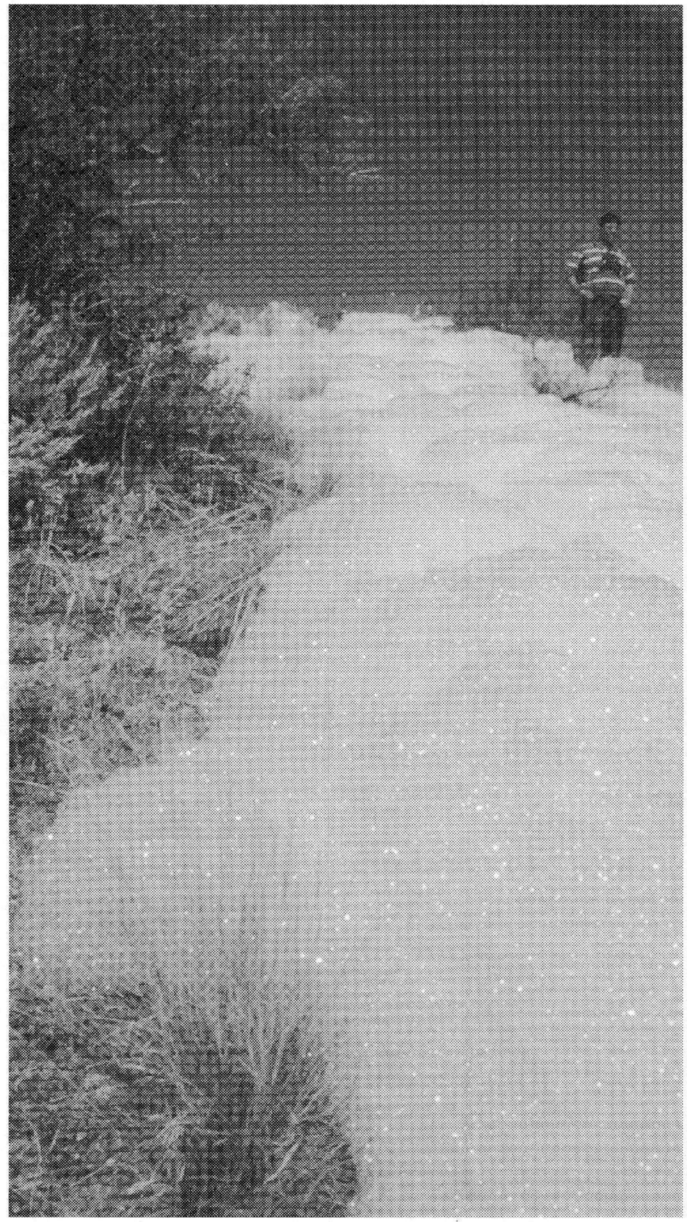
*By Ronald R. Rochna, Fire Equipment Specialist BLM (retired), National Interagency Fire Center, Boise, Idaho*

It is a common belief that High Expansion Foam (Hi-Ex) is not effective on wildland fires. This was due to the larger bubbles (low density) that Hi-Ex foam generators produce. (The definition of High Expansion Foam is any finished foam with expansion ratios above 200 to 1.) When this low density foam is generated in the open, such as a parking lot, it does not take much of a breeze to pick it up and carry it away. The same thing happens when wind blows paper out in a field—it becomes caught up in the brush, trees, fences, just about anything that will act as an anchor.

When Hi-Ex is applied in dense brush or under a timbered canopy, there is little effect from the wind to begin with. However, the brush is the key to holding or anchoring the foam. This is where foam belongs anyway—in and on the fuels to permit wetting.

High Expansion Foam will easily flow down slope without any breaks in the barrier when applied on brushy or timbered slopes. Slopes greater than 35 percent work best. When using a generator with a 750 to 1 expansion ratio, flowing 65 gpm of 0.5 percent foam solution will generate 48,750 gallons of Class A foam per minute. The massive amount of bubbles flowing over a hillside is overwhelming. The bubbles create a straight barrier, without any dips or jogs, ideal for holding or burning out. On one incident, a barrier 2000 feet long, 5 to 10 feet deep, and 100 feet wide was created with just 4000 gallons of water and 20 gallons of foam concentrate. This was in a heavy timber and brush fuel type.

Utilizing gravity to move Hi-Ex foam down a hillside eliminates human errors of not applying enough foam to wet the fuels. This is due to the fact that the foam is hesitant to advance until the surfaces beneath it have become wet. Foam solution penetrates natural fuels 20 times faster than plain water. No long hose lays are needed to create the barrier. Just place the generator on the road bank above the slope, supply with ample water, and a river of foam will slide down slope.



*Five hundred to one foam—does not advance until fuel is wet underneath.*

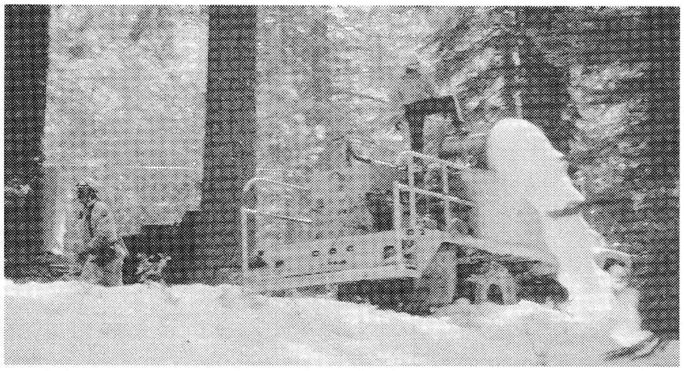
I suggest experimenting under controlled conditions to establish a feel for how and why it works and when it will not. One should check the conditions of the fuel for effective wetting prior to running fire against the line such as in a burn-out operation.

After the fire passes, the next objective is to begin mop-up. The quicker you mop-up, there is less chance of fire becoming deep seated. The foam blanket effectively smothers the residual fire, cutting off secondary smoke production. This also eliminates carbon monoxide, *making the area much safer to work in.* This technique works well with all types of foam; low, medium, or high expansion foam solutions.

The technique of using high expansion foam has been effective in reducing smoke emissions, wind borne embers, firefighter smoke exposure, and mop-up costs. The long throw of CAFS, and also the use of low-expansion aspirated foam, along with the long downhill flows of the medium and high expansion foam, have all helped make the use of foam practical.

Hi-Ex foam is also an excellent mop-up tool. The foam will work many times better on deep seated fires than low or medium expansion foam. Because Hi-Ex is a low density foam, it permits heat beneath it to escape. Low and medium expansion foam is more dense, so it traps heat instead of releasing it. This is why high expansion foam is not suitable for vapor suppression of high vapor pressure fuel such as flammable liquids. Higher density foams (low or medium expansion) is just like dirt when applied over deep seated fires. To achieve extinguishment, the heat from combustion must be released. Usually this is accomplished by mechanically opening up the hot area.

This past summer, Hi-Ex foam was used on a wildfire on the Sierra National Forest. The foam was applied to a steep slope above a large creek that was too dangerous to have personnel work on after dark. A ChemGuard High Expansion foam generator was used. This generator flowed 65 gpm with an expansion ratio of 750 to 1. The foaming agents used were: (1) Fire Foam 103 by Chemonics, and (2) ChemGuard Class A foam.



*ChemGuard Hi-Expansion Foam Generator—
650 to 1 expansion, flowing 55 gallons per minute.*

The foam concentrate was proportioned with a Hale 2001 FoamPro direct injection proportioner. This proportioner meters the concentrate at the desired ratio (0.5 percent) and also totals the consumption of foam concentrate and water used. This operation was started by flowing Hi-Ex off the edge of the road. Personnel were stationed at the bottom of the burn to report to us when the foam blanket reached the bottom of the slope, approximately 1500 feet below.

The generator was then moved up the road 25 feet to start another pass. It took an average of 15 minutes for the foam blanket to reach the burn at the bottom of the slope.

In one shift, 8 firefighters had laid down foam off 2000 feet of road, down the 1500 foot slope. This required 35,850 gallons of water and 175 gallons of foam concentrate. What was left to mop-up for the relief crew (four type I hand crews and a strike team of engines) was smoke. The Hi-Ex foam had extinguished burning logs, duff, and brush with little hand work required other than moving the foam generator.

Other benefits included the total elimination of smoke and dust. Moisture had been uniformly distributed over the entire area with penetration of three to five inches into the ash. The area remained wet for over two days.

High Expansion foam has had little use in wildland incidents. Those who have been using it have experienced overwhelming success with little cost in manpower. *This is where the real cost is.*

How has management received this tool? Until you actually see it work, its effectiveness is hard to grasp. The use of Hi-Ex will have to be shown in action before its use will be accepted. As with any new resource, management must experience its use to understand the potential.

What is the cost of the High Expansion foam generators? Prices start at $1100 for a 20-gpm generator and range up to $6500 for a 150-gpm model. As with most equipment, the greater the flow—the higher the price. *In actual operations, the cost is more than offset by the increased productivity of the firefighter.*

Hi-Ex 650 -1
Blanketing Hillside.

55 x 650 = 35,750
gallons of bubbles per minute.

Using Hi-Ex Foam
on the Huntington Lake fire.

ChemGuard Hi-Ex flowing 65 gallons per minute and producing 42,250 gallons of foam per minute.

Photo shows volume of foam produced in a single minute.

Kern River Breaks in Bakersfield.

With 500 gallons of solution—foam flowed a distance of more than 2000 feet.

Foam depth on slope was 4 feet and 10 feet in canyon bottom.

Do High Expansion generators require a special foaming agent? No! Most all Class A foam concentrates work well with these generators. A good foaming agent will generate an excellent foam with a mix ratio of 0.5 percent.

What sizes do High Expansion generators come in? Just about any flow rate starting at 1 gpm up to 500 gpm. Generators that have flow rates of water over 50 gpm require a fan to supply the needed large volumes of air. Some have an internal water motor, others adapt to exhaust fans, and the larger units have fans driven by 40-hp Volkswagen engines.

High expansion generators with water flow rates above 40 gpm measure the performance by CUBIC FOOT OF AIR OUTPUT PER MINUTE.

Where can High Expansion generators be purchased? What follows is the list of High Expansion foam generator manufacturers that I have personally worked with.

This list is not complete by any means, but should provide you with a source to begin inquiries.

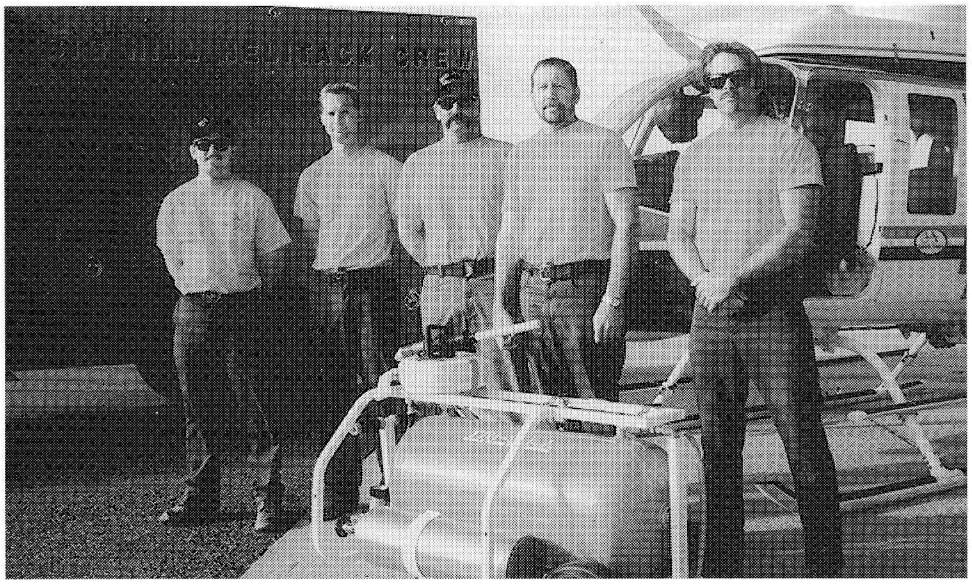
ChemGuard
John McConnell
204 South Sixth Avenue
Mansfield, TX 76063
(817) 473-9964

Ansul Fire Protection
One Stanton Street
Marinette, WI 54143-2542
(715) 735-7411

Angus Fire Armor
Sam Goldwater
P.O. Box Drawer 879
Angier, NC 27501
1-800-334-3156

MSA
Corporate Headquarters
P.O. Box 426
Pittsburgh, PA 15230
1-800-MSA-2222

National Foam
P.O. Box 270
Exton, PA 19341
(610) 363-1400



*Tri-Max CAFS Unit carried by the Big Hill Helitack Crew service vehicle on the El Dorado National Forest, Northern California.*

## PRESSURE TANK, SELF-CONTAINED, 30 GALLON CAFS UNIT NOW AVAILABLE

*By Dave Mahrt, President*
*HFS Defense Systems, Inc.*
*Redding, CA*

The HFS Fire Defense Systems, Inc. of Redding, California, has developed and is now marketing a pressure tank compressed air foam system (CAFS) called a TRI-MAX 30. The TRI-MAX 30 has a 30 gallon tank to hold the foam solution and two 3000 psi, 80 cfm SCBA bottles to furnish the air (or nitrogen) to power the system.

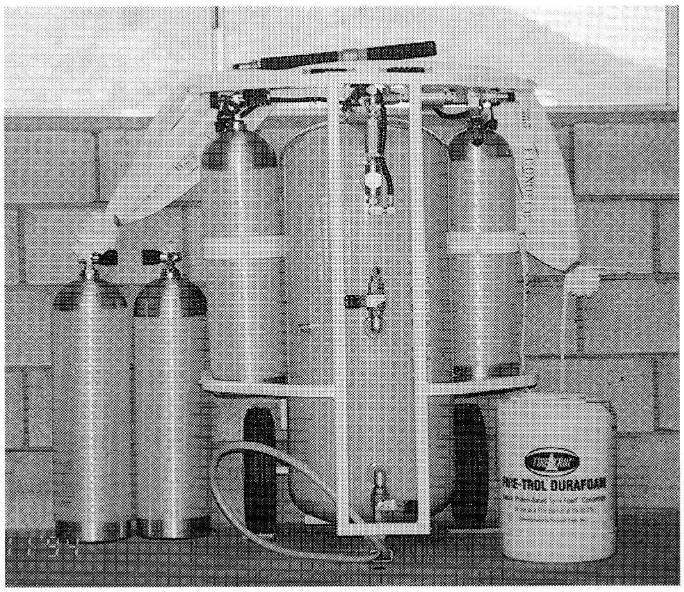
The system can produce 600 gallons of foam using one of the 80 cfm bottles. The unit can than be refilled with 30 gallons of water and foam concentrate added and discharged again using the other SCBA bottle. The TRI-MAX 30 is user friendly and fully self-contained. It has virtually no moving parts (no pump) and is put into operation by turning one lever. The unit can throw foam up to 80 feet and over 200 feet of one-inch hose can be used. The TRI-MAX 30 is 29" high, 33" wide, and 45" long and when charged, weighs 500 pounds.

This is the first CAFS unit available that can be flown-in on light helicopters. It can be flown-in to pioneer helispots for fire protection during crew shuttles or long-lined to accident sites. It is truly an air mobile Compressed Air Foam System.

Other sizes and capacities are available.

The system with Class B, AFFF Foam can be used for heliport protection. The CAFS unit is being used at remote heliports and other locations. The Eldorado National Forest has one unit in operation and Cleveland National Forest is planning on operating three units this summer on half-ton District patrol vehicles (FPT program) under a pay-when-used rental program. This pay-when-used program is available throughout the U.S. Forest Service. If unit is loaded with MC-1 AB foam, it can also be used for cleaning up HAZ-MET spills that are petro-chemical by nature.

For further information contract:
Dave Mahrt, President
HFS Fire Defense Systems, Inc.
2566 Christian Lane
Redding, CA 96002
916-223-6040



*Tri-Max CAFS unit located in a Santa Monica, California home. The homeowner was burnt out during the Bel Air fire and installed a CAFS unit to provide protection from a wildland brush fire or an earthquake-caused fire.*

## CLASS A EFFECTIVENESS DEMONSTRATION AND PROPORTIONER TESTING, BAKERSFIELD, CALIFORNIA, AUGUST 1994

*by: Dan W. McKenzie, Mechanical Engineer, USDA Forest Service, San Dimas Technology & Development Center, CA (retired) and Ronald R. Rochna, Fire Equipment Specialist, BLM (retired), National Interagency Fire Center, Boise, ID, now with Applied Foam Technologies, Boise, ID.*

On August 23, 1994, Ron Rochna (BLM, NIFC) conducted a demonstration on the BLM Bakersfield District to show the effectiveness of Class A foam in firefighting. In the afternoon Ron and Dan McKenzie conducted a test on the Flow-mix proportioner.

The Class A foam demonstration was designed to show the effectiveness of Class A foam and was not necessarily the way one would fight a given fire. The demonstration compared the effectiveness of plain water, foam solution (no aspiration), foam solution using an aspirating nozzle and Compressed Air Foam System (CAFS). The demonstration was conducted on a very dry cured grass field using a backing fire (fire moving into the wind) with 6" to 24" flame lengths.

The results showed that foam solution went about twice as far per gallon of fluid in the production of line than did plain water. When an aspirated nozzle was used with foam, the line production per gallon was about the same as with plain water. When CAFS was used, about four times as much line was produced per gallon of fluid than when using plain water.

Foam solution, aspirated nozzle, and CAFS all resulted in more rapid line production than plain water. Foam solution and CAFS were about 100 percent faster than plain water in line production and when the aspirated nozzle was used it was about 50 percent faster than plain water.

Foam solution only and CAFS did not have any rekindles. Plain water had a rekindling rate of 21 per 100 chains of line and the aspirating nozzle had a rekindling rate of 33 per 100 chains of line. These results were no surprise, as they are typical of results observed in 10 years of development work in foam delivery systems.

### Proportioner Test

The Flow-mix 500 was tested using:

1. Low flow differential pressure valve with low flow metering valve (2-1/2" in x 1-1/2" out)

2. High flow differential pressure valve with low flow metering valve (2-1/2" in x 2-1/2" out)

3. Improved differential pressure valve with low flow metering valve (2-1/2" in x 2-1/2" out)

4. Apollo 2" check valve (61-508) with venturi with .78" throat used in Region 6 (R6) with a low-low flow metering valve which will give .4 % when set on .4 %. With the metering valve used when set on .4 % a higher percentage will be produced as can be seen in the graphs on pages 22 and 23.

The metering valve was set at .4 percent and not changed. Foam percentage was measured with two direct reading Foam Percent Meters from New Zealand which are operated by the conductivity change in water when foam is added. Low water flow was measured by a Hedland flowmeter (2 to 25 gpm) and high flow was measured by a Fire Research Corp. portable digital flowmeter Model MFPD-1 1/2 (20 to 350 gpm). Both had recently been calibrated.

Arrangements number 1 and 2 were very close in performance and fell off in percent foam as flow increased. Arrangement number 3 performed well from 2 gpm to 275 gpm staying very close to the same percentage of foam solution (+ or -10 percent) (from 25 to 276 gpm + or - 7.7 percent). Arrangement number 4 had a marked percent increase at low flows (2 to 15 gpm) but held a steady percent foam from about 25 to 251 gpm (+ or - 6 percent).

Arrangement number 4 is the arrangement now in use on R6's model 75 and 80 engines. This arrangement could be made to perform well at low flows by shorting the spring in the Apollo check valve. However, we would not want to do this when purchasing new equipment because there is now satisfactory equipment at reasonable cost commercially available.

A guideline which is used, and should be used, by the Federal Government in equipment development programs is, if there is satisfactory commercially available equipment at reasonable costs which meets the needs of the Federal Government, that equipment should be procured and used. Following this guideline will generally result in the use of proven mature components, and will reduce or eliminate staff work in design and development, procurement, and maintaining and servicing of equipment all resulting in reduced equipment costs and improved reliability. It will also result in the procurement of the latest upgraded and updated equipment with generally no up front costs to the Federal Government.

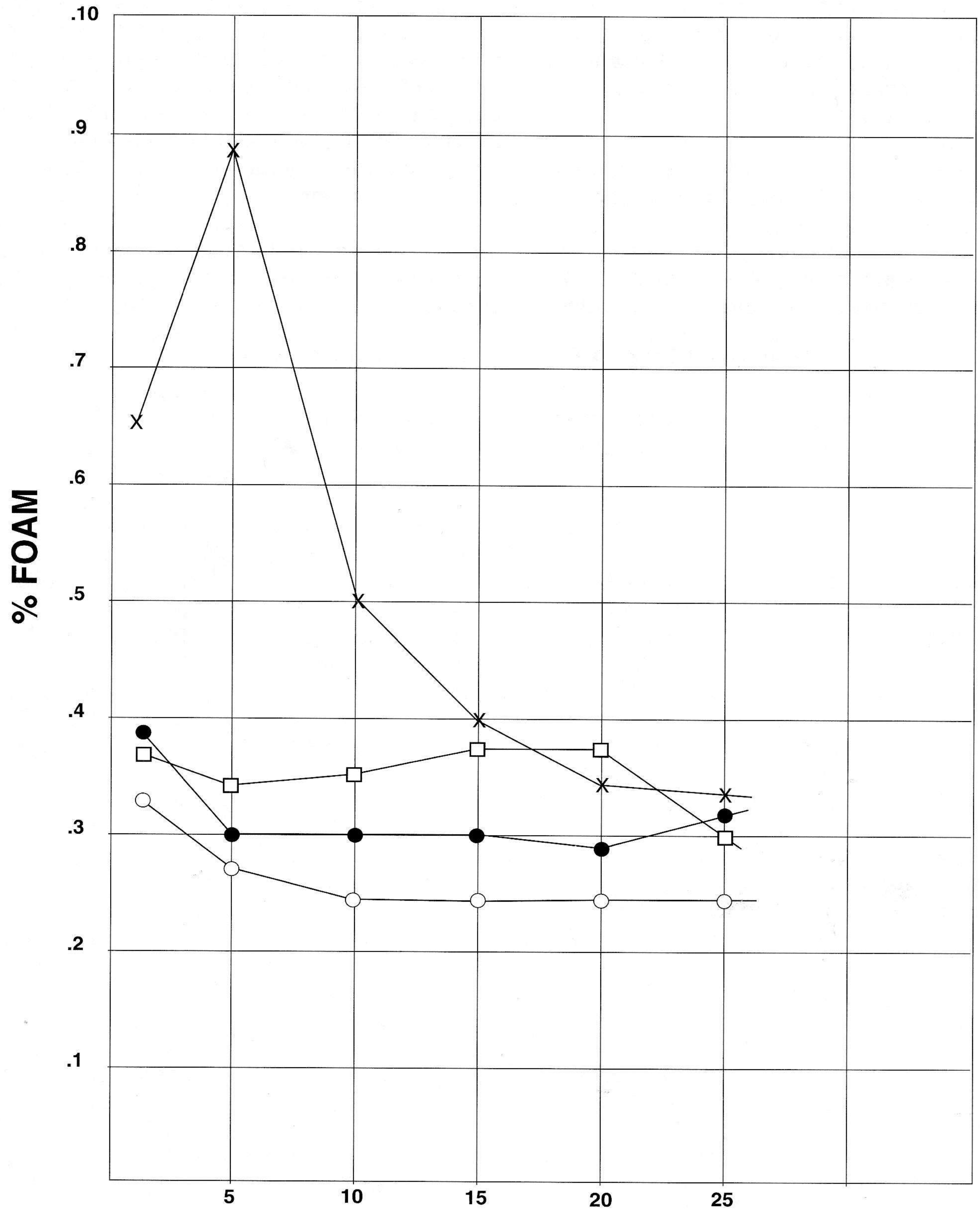
With the better performance of the Flow-mix improved differential pressure valve, this valve should now be used in the R6's engines.

**Bakersfield Class A Foam Tests (August 23, 1994)**

| | Water Only | Foam Solution | Aspirating Nozzle | CAFS | * |
|---|---|---|---|---|---|
| Water Flow (gpm) | 2.7 | 2.7 | 4 | 1 | 1.4 |
| Water used | 50 | 50 | 50 | 5 | 50 |
| Percent Foam | 0 | 0.5 | 0.5 | 0.2 | 0.2 |
| Length | | | | | |
| Chains | 20 | 36 | 18 | 8 | 76 |
| Feet | 1320 | 2380 | 1190 | 530 | 5020 |
| Rekindles | 4 | 0 | 6 | 0 | 0 |
| Rekindles per 100 chains | 21 | 0 | 33 | 0 | 0 |
| Time (minutes) | 18.5 | 18.2 | 12.2 | 5 | 36 |
| Time/chain (min/chain) | 0.93 | 0.51 | 0.68 | 0.62 | 0.47 |
| Ratio (water 1) | 1 | 0.55 | 0.73 | 0.68 | 0.51 |
| Gallon water per chain | 2.5 | 1.39 | 2.8 | 0.62 | 0.66 |
| Ratio (water 1) | 1 | 0.56 | 1.11 | 0.25 | 0.26 |
| Chains per gal water | 0.40 | 0.72 | 0.36 | 1.6 | 1.52 |
| Ratio (water 1) | 1 | 1.8 | 0.90 | 4.0 | 3.8 |

* Data taken on August 25, 1994

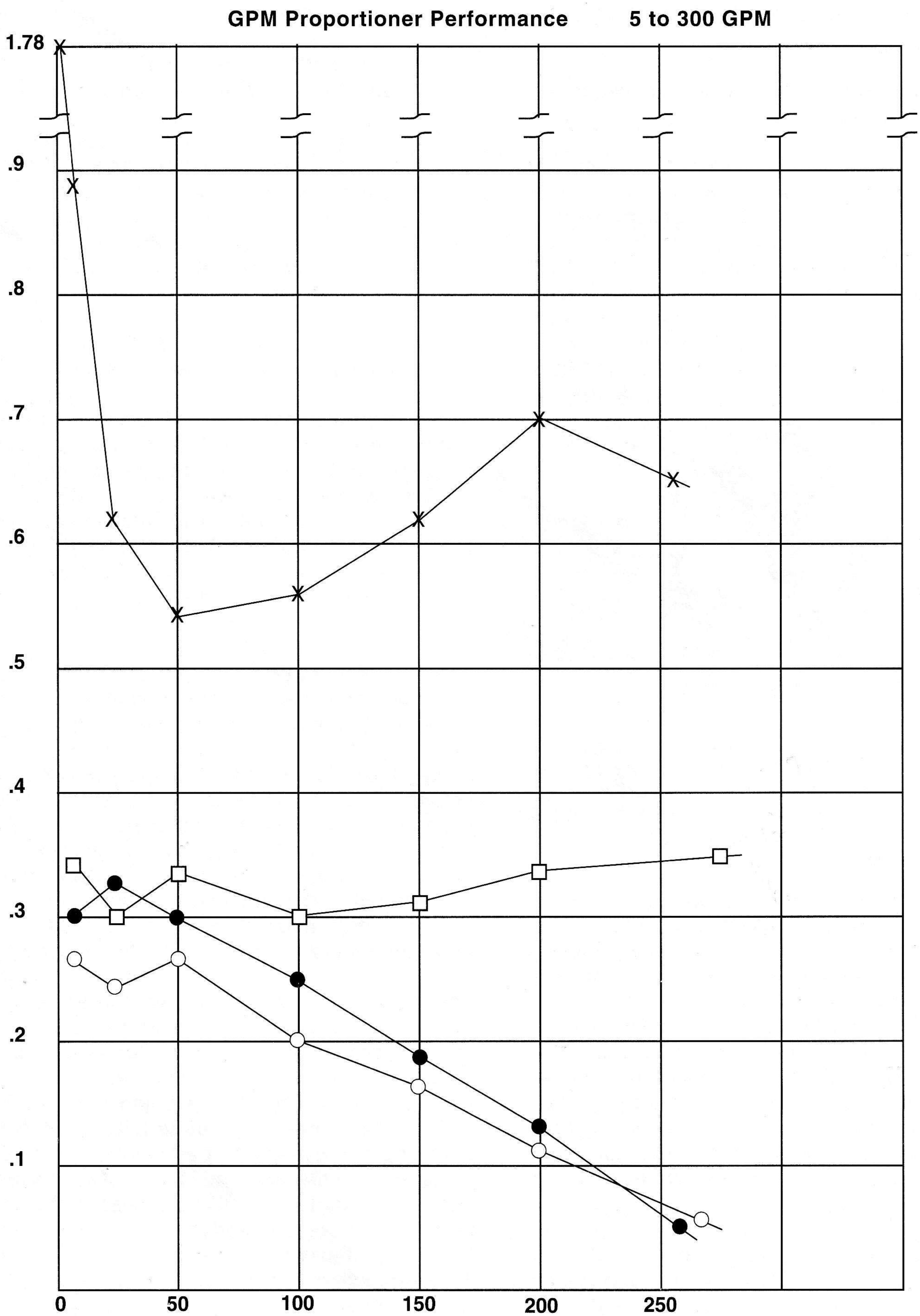
GPM Proportioner Performance 0 to 25 GPM




**GMP**

PROPORTION PROFORMANCE
2-25 GMP

1. ● LOW FLOW / LOW FLOW METERING
2. ○ HIGH FLOW / LOW FLOW METERING
3. □ VENTURI / LOW FLOW METERING
4. X 2" CHECK VALVE WITH VENTURI
(NO. 4 is twice % foam on 0 to 25 GPM and actual on 5 to 300 GPM)


GPM Proportioner Performance 5 to 300 GPM
1.78
.9
.8
.7
.6
.5
.4
.3
.2
.1
0
50
100
150
200
250

## CLASS A FOAM IN THE STRUCTURAL FIRE SERVICE

*By John Liebson, Western Regional Director ISFSI, Santa Fe, New Mexico*

Based on the pioneering work of such people as Ron Rochna and Paul Schlobohm of the BLM, Dan McKenzie of the USFS, and Clarence Grady, formerly of Chemeketa Community College, Salem, OR and now with Pneumax, Peoria, AZ. ISFSI has undertaken, over the past few years, a transfer of Class A foam technology from the wildland fire service to the structural fire service[1]. Just as wildland fires are different from structural fires, the applications of Class A foam are different.

*A crew protects a structure using aspirated Class A foam during a working fire. Please note that the crew members are wearing protective gear except for self-contained breathing aparatus. The fire is in the building to the right of the firefighters, who are outside the actual "hot zone."*

The first direct result of the cooperation between the wildland fire service people and ISFSI was the publication of the first book to cover Class A foam applications in the structural fire service, *Introduction to Class A Foams and Compressed Air Foam Systems for the Structural Fire Service,* written by the author of this article. The book was published by ISFSI in 1991[2]. This is an illustrated primer which covers some of the history of Class A foam, and talks about how the technology can be applied to the suppression of structural fires and use of foam for structural exposure protection.

Following publication of the book, ISFSI undertook a series of classes on Class A foam which were presented to several structural fire departments and accompanied by demonstration burns.

The purposes of the live fire drills were multiple:

1. To gain working knowledge of the uses of Class A foam in various structural fire scenarios

2. To teach people how to conduct *safe* live fire drills (a skill which is sadly being forgotten by the structural fire service, to its own detriment)

3. To acquire specific data on the improvements shown by foam over plain water in fire extinguishment

4. To amass high-quality video footage of fires being attacked with Class A foam.

As the series of classes and live fire drills continued, it became evident to ISFSI that Class A foam technology offers great advantages to the structural fire service. However, as with nearly any new technology, there are also problems inherent in the adoption of Class A foam. Some of these problems are inherent in foam technology itself, while others lie more in the realm of the fire service.

The first product produced by ISFSI, based on the material it had accumulated during these tests, is a 14-minute VHS videotape, available for purchase.The videotape gives an overview of the advantages of Class A foam in the structural fire setting[3]. The tape is basically aimed at people, such as city councils and country commissions, to show non-fire people why their local fire services ought to consider the adoption of Class A foam. Nonetheless, the tape is valuable for fire departments that have heard about Class A foam and want a quick introduction to the technology.

The author of this article then turned to the development of a structural fire service course on the adoption of Class A foam. During the early stages of developing the course, it became apparent, based on reports being received by ISFSI, that there were underlying problems inhibiting the wide-spread adoption of foam by the structural fire service. These problems, not well understood at the time, indicated that the thrust of the course needed to be moved away from the traditional "hands-on" training scenario. The redirection can best be described as the "people problem."

A further study was made of why departments were not adopting foam and of why others that tried to adopt it were returning to the use of untreated water. It became evident that the real problem lay not with the hardware or the foam chemical, but rather, with the assumptions being made by all too many departments that foam could simply be considered as "just another tool."

In reality, however, it has been found that in order for most structural departments to move into the world of Class A foam, they must *first* make fundamental changes in the very nature of how their departments operate. Such things as management from the chief down have to be replaced by techniques of modern business management, including total empowerment of everyone in the fire department. This, of course, is a radical proposal and one that has already created controversy. ISFSI has not, in the past, shied away from controversy on issues where the organization has firmly-held positions. This is very true in the area of Class A foam.

ISFSI believes strongly in the benefits to firefighter health and safety, the environmental benefits that foam—by reducing water, smoke, and particulate pollution—provides, and in the inherent improvement in fire suppression and prevention efforts that Class A foam can provide.

ISFSI does hold these positions so strongly that it has now published "Implementation and Utilization of Class A Foam Technology in the Structural Fire Service," a two-day classroom course[4]. Unlike the traditional hands-on approach, this course deals in depth with the need for the fire service to realize why water itself is not a good fire suppression agent, and where the barriers to foam adoption lie. The course shows that the barriers lie within both the people and the policies of the institution, the fire department, and offers a methodology to overcome these hindrances to foam adoption. This part of the course occupies the entire first day and understandably generates the most confusion and distress among the students. The second day, the course delves into the technology of Class A foam, in both the aspirated and compressed air formats. It shows how the adoption of foam can be used not only as a weapon against fire, but also as a tool to reposition the fire service politically within its community and ties the new technology to the new methodologies learned during day one.

The course consists of a student manual, an instructor manual, a glossary, resource guide, a set of 35-mm slides and a course-specific videotape. The entire package can be purchased, and ISFSI can provide an instructor under contract to teach the course. In fact, because of the nature of the course, which presents not only new firefighting materials, but also new philosophies of fire department management, ISFSI encourages local agencies to have an ISFSI-approved instructor teach it the first time. This way the local instructors may better understand the very nature of the course and, thus, be adequately prepared to teach it themselves.

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[1] Since the time that this work was started, ISFSI has formed a wholly-owned subsidiary, The Alliance for Fire and Emergency Management, under whose aegis continuing work on Class A foam for the structural fire service is being conducted.

Information about The Alliance may be found on the World Wide Web at <URL http://afem.org/afem/>.

[2] John Liebson, *Introduction to Class A Foam and Compressed Air Foam Systems for the Structural Fire Service.* ISFSI, Ashland, MA, 1991. Publications of ISFSI are now sold by The Resource Center, a part of The Alliance. The Resource Center may be reached at 800-435-0005 or 508-881-5800, or by FAX at 508-881-6829. Information about The Resource Center may also be obtained at The Alliance's World Wide Web site.

[3] ISFSI, "Class A Foam Videotape." Ashland, MA, 1992.

[4] ISFSI, "Implementation and Utilization of Class A Foam Technology in the Structural Fire Service." Ashland, MA, 1993.

For further information, contact John Liebson, 7 Frasco Court, Santa Fe, NM 87505; 505-466-1871, via E-Mail jliebson@roadrunner.com, or through The Alliance, 30 Main Street, Ashland, MA 01721; 508-881-5800.

## MORE CLASS A FOAM ON THE SHELF

*By Paul Schlobohm, Forester/*
*Fire Management Specialist, BLM,*
*National Interagency Fire Center,*
*Boise, Idaho*

If you have a need for practical information or equipment for use of Class A foam, you may be able to find it on the shelf of your nearest fire cache. A videotape series introduces the basic principles of foam chemicals, explains the function of mixing and foam generating equipment, and demonstrates suppressive and protective applications. Videotapes and publications listed here are now available through the National Wildfire Coordinating Group (NWCG) Publications Management System (PMS).

### Ordering

Copies of each of these items may be ordered from the National Interagency Fire Center (NIFC). To order, mail or fax a purchase order or requisition to:

National Interagency Fire Center
Attn: Supply
3833 S. Development Avenue
Boise, ID 83705
FAX 208-387-5573

Orders must be from agencies or organizations, not private individuals. Use the "NFES" number for the item(s) you are ordering. Do not send money, checks, or money orders with the order. Phone orders are not accepted. You will be billed the cost of the item(s) after the items are sent.

Orders from other than Federal wildland fire agencies or State land protection agencies will receive an 18 percent surcharge on the bill. Transportation charges, other than mail, will also appear on the bill. Questions regarding ordering procedures can be addressed to the NIFC Supply Office, 208-387-5542. Questions regarding billing procedures can be addressed to the NIFC Finance Office, 208-387-5533.

### Videotapes

***Introduction To Class A Foam***
A brief introduction to Class A foam technology discussing chemistry, generating equipment, and examples of application. 1989, 13 minutes, VHS only, NFES #2073, $2.34.

***The Properties Of Foam***
Explains how Class A foam enhances the abilities of water to extinguish fire and to prevent fuel ignition. Basic foam concepts including drain time, expansion, and foam type are presented. 1992, 15 minutes, VHS only, NFES #2219, $2.36.

***Class A Foam Proportioners***
Explains how common mixing systems, including eductors and direct injection devices, add a measured amount of foam concentrate into a known volume of water. Advantages and disadvantages also discussed. 1992, 23 minutes and 10 seconds, VHS only, NFES #2245, $2.41.

***Aspirating Nozzles***
Explains how aspirating nozzles work and introduces the variety of nozzles available. 1992, 10 minutes, VHS only, NFES #2272, $1.82.

***Compressed Air Foam Systems***
Explains the basics of compressed air foam systems; discusses options for water pumps, air compressors, and power sources; demonstrates safe and basic operation; discusses advantages and limitations. 1993, 20 minutes, VHS only, NFES #2161, $2.28.

***Tactical Applications With Class A Foam***
Presents the objectives and techniques of applying Class A foam during wildland fires. Explains four basic considerations for application and emphasizes techniques for direct attack, indirect attack, and structure protection tactics. An introduction to the many ways foam is used on wildland fires. 1994, 8 minutes, VHS only, NFES #2404, $1.70.

**Publications**
A basic user guide series presents introductory and detailed explanations of foam properties, equipment, ground applications, and aerial applications. User guides now available through the Publications Management System include:

***Foam vs. Fire, Class A Foam For Wildland Fires.*** This 28-page publication explains how to get the most firefighting punch from water by converting water to Class A foam.

Discusses how and why foam works. Explains drain time, expansion ratio, foam type, proportioning, aspirating nozzles, and compressed air foam systems.

Also covers application for direct attack, indirect attack, mop-up, structure protection, and safety considerations. NFES #2246, 33 cents.

***Foam vs. Fire, Primer.*** This 9-page publication covers the basics of using Class A foams and discusses their adaptability to present application equipment. NFES #2270, 44 cents.

A third user guide will address aerial delivery of Class A foam including properties and equipment for helicopter and fixed-wing applications. This publication will be available soon.

**Equipment**
Foam concentrate, proportioners, and aspirating nozzles are available through Regional fire caches. To order foam concentrate:

(1) NFES #3400 concentrate, liquid/dry 4 oz. For use with backpack pump, NFES #1149. $1.25 per bottle, R3, R6, NIFC.

(2) NFES #1554, Chemonics Fire-Trol, 5-gal pail, R3, R9, NIFC.

(3) NFES #1145, Monsanto Phos-Chek WD 861, 5-gal pail, R1, R3, R6, R8, NIFC.

(4) NFES #1360, Silv-Ex, 5-gal pail, R1, R6, R9, NIFC.

(5) NFES #0360, Silv-Ex, 30-gal drum, NIFC.

To order proportioner kits and aspirating nozzles:

(6) NFES #0626, Foam Proportioner Kit, R1, R6, R9.

(7) NFES #0627, Fire Foam Nozzle (Aspirated) 3/4 inch NH, 8 gpm, plastic, $10.24 each, R3, R6, R9, NIFC.

(8) NFES #0628, Fire Foam Nozzle (Aspirated) 1-1/2 inch NH, 16 gpm, plastic, $30.19 each, R1, R3, R9, NIFC.

(9) NFES #0629, Fire Foam Nozzle (Aspirated) 1-1/2 inch NH, 32 gpm, plastic, $36.07 each, R3, R6, NIFC.

## THE ALLISON MD SERIES AS A PUMP SYSTEM DRIVER

*Clarence Grady*
*Canyon State Emergency Products/Pneumax*
*Peoria, Arizona*

The MD Series Allison automatic transmission has been used quite successfully as the prime drive for fire pumps. It has two power takeoff (pto) ports that are capable of operating pumps of up to 1250 gallons per minute (gpm) rating. These pto's are engine driven, meaning that, if engaged, they operate at engine speed at all times. The earlier Allison transmissions had converter driven pto's which stopped if the vehicle was in a drive range and not moving.

The most promising use of the MD series transmissions is that of driving an air compressor and a water pump for use as a compressed air foam system (CAFS). There are several rotary air compressors that are designed to be driven by pto from a vehicle transmission. Both single and two-stage pumps may be used to supply the water for such applications.

The most promising application involves the use of a two-stage series parallel pump. Waterous offers the CP-3 while Darley offers the JPM for this application. A two-stage pump allows the operator to select series for operations involving " pump and roll." By selecting series, the operator will gain usable pressures and moderate volumes at very low ground speeds. The available air compressors will develop adequate volumes at the low ground speeds when the proper pto and gear box ratios are chosen.

When the pump is operated in parallel, the operator has both moderate pressures and high volumes of water available. Also, the air compressor will have high volumes of air available.

A chart of operating characteristics is printed below:

Waterous CP-3K
2.45 pump ratio
1.29 pto ratio

**Two-Stage Pump Operating In Series**

| Engine Speed | Pump Pressure |
|---|---|
| 950 | 100 |
| 1100 | 140 |
| 1250 | 175 |
| 1450 | 225 |
| 1550 | 250 |
| 1750 | 325 |
| 1900 | 375 |

Pressure may be limited by setting a pump relief valve to 150 psi when making moving attacks.

The CP-3K, 275 gpm will deliver up to 100 gpm in the series mode.

**Two-Stage Pump Operating In Parallel**

| Engine Speed | Pump Pressure |
|---|---|
| 950 | 40 |
| 1100 | 55 |
| 1250 | 80 |
| 1450 | 115 |
| 1550 | 125 |
| 1750 | 160 |
| 1900 | 190 |

Pressure may be limited by setting a pump relief valve to 150 psi when making attacks.

The CP-3K, 275 gallons per minute (gpm) will deliver up to 275 gpm in the parallel mode.

The Waterous CP-3 has similar pumping characteristics to the Darley JMP, which is a 500 gpm pump that was used on the latest version of the Region 5 Model 62. The Waterous is available with 150, 275, and 500 gpm ratings.

The air compressors used for such applications are rotary screw units such as the Bauer B101. The B101 would be developing air volumes of 75 to 140 cfm when operated at the speeds shown in the pump chart.

A key component of such an arrangement is the automatic air pressure regulating system that controls the air compressor's pressure.

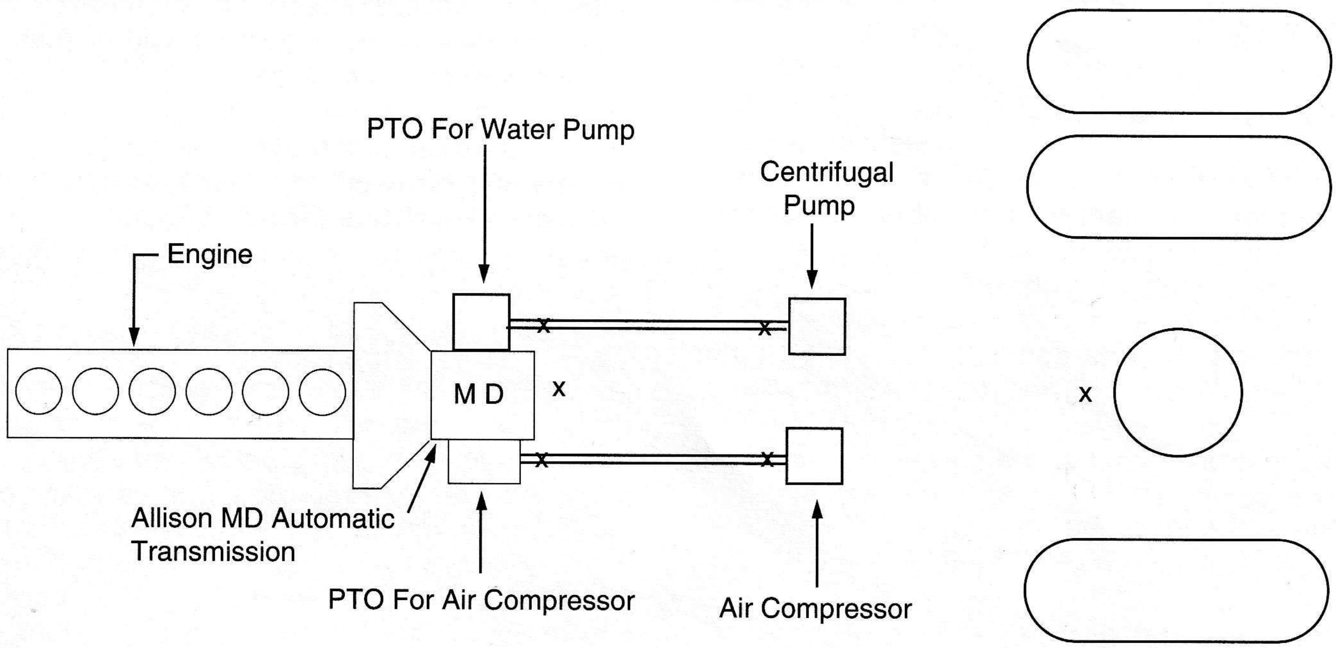
Such a unit makes the output pressure of the compressor follow and match the water pump's pressure. Dan McKenzie and I developed the system over a period of two years. It is now in service on about 100 air compressors and is performing with few problems. This control system's ability to synchronize the outputs is the reason that such an arrangement of pump and compressor is possible.

Several units are already in service with single-stage pumps. These include units at Sonoita, AZ, which has a 1000 gpm single-stage pump and Apache Junction, AZ, which has a 350 gpm pump.

The single-stage pump applications are very successful. However, the mobility characteristics of some units with the single-stage pumps, are barely acceptable . The single-stage pump on the Apache Junction engine does have similar characteristics to those of the Waterous units in the parallel mode.

It is possible to use the proper pto and pump ratios to gain good mobile attack characteristics with a single-stage pump. However, due to efficiency considerations, the two-stage pump is a better choice.

**Layout of Drive System For CAFS Using Allison MD Automatic Transmission**




— PTO's direct engine driven with hot shift clutch
— Air pressure controlled by pump pressure
— Maximum water pressure limited by pressure relief valve

## CHEMICALS USED IN WILDLAND FIRE SUPPRESSION—A RISK ASSESSMENT

Labat-Anderson, Incorporated of Arlington, Virginia, has prepared a risk assessment of chemicals used in wildland fire suppression for the USDA Forest Service, Fire and Aviation Management. The assessment report includes three primary sections:

- Human Health Risk Assessment
- Ecological Risk Assessment
- Risk Comparison of Uncontrolled Wildfires.

Included in this article are summaries of the first two parts and the conclusions of the last part. For a complete copy of the report, contact Charles W. George at the USDA Forest Service, Fire Sciences Laboratory, National Wildfire Suppression Program, P.O. Box 8089, Missoula, MT 59807. Telephone 406-329-4815.

### Human Health Risk Assessment

***Summary:***

This report summarizes a quantitative assessment of the risks to human health as a result of exposure to four types of chemicals approved by the U.S. Forest Service for wildland fire suppression: long-term retardants, foams, short-term retardants, and wetting agents. A hazard analysis was conducted for each chemical to determine an acceptable dose level, and this level was compared to the estimated doses to both workers and members of the public from both average and upper end exposure scenarios.

The results show a potential for risk from some, but not all, of the formulations currently approved. However, there is significant uncertainty in this analysis, primarily due to the limited toxicity database. The use history of these chemicals reveals only incidents of skin and eye irritation, and no cases of systemic toxicity.

### Ecological Risk Assessment Wildland Fire Suppression

***Abstract:***

The risk assessment analyzes the effects of commonly used fire suppression chemicals on ecological components throughout the United States. The assessment examined seven different regions and corresponding ecosystems to assess the impacts of long-term fire retardants and fire-fighting foams. Representative soil and stream data were collected or estimated, and fate and transport modeling was performed to estimate the impacts of typical and upper level fire suppression chemical applications.

The risk estimates indicate minimal effects to terrestrial species. Risk estimates for aquatic species show probable risks to aquatic species from both types of fire suppression chemicals under accident scenarios. Firefighting foams are generally more toxic to aquatic species than long-term retardants.

Risks estimates from typical scenarios indicate that site-specific characteristics greatly affect the potential for adverse effects. These characteristics include soil type, slope, stream pH, soil permeability, and types of species present.

Modeling results contain a large degree of uncertainty; many of the important physical and chemical parameters for the formulations being modeled were unavailable and were therefore estimated.

## CONCLUSIONS

The relatively low risks of the chemicals to humans estimated by the risk assessment, and the fact that no links between exposure and toxicity in humans have been reported in the past 50 plus years of use, appear to justify their use. Neither the risk assessment nor the literature review identified any potential areas of concern for human health associated with the use of the fire suppression chemicals.

Risks to terrestrial species are similarly unlikely. A potential risk exists for a few species if sufficient portion of their diet is contaminated; however, populations of these species is not likely to be affected. The use of fire suppression chemicals is not likely to have a lasting effect on terrestrial ecosystems.

Aquatic species are more at risk from fire suppression chemicals than are terrestrial species;

however, these risks are not easily quantified. Salmonids as a group are more sensitive to firefighting foams and long-term retardants than other fish species. Aquatic invertebrates are more sensitive to firefighting foams than to long-term retardants. Firefighting foams are generally more toxic than long-term retardants; however, long-term retardants are typically applied in much greater amounts. The toxicity of long-term retardants to aquatic species is determined by the temperature and pH of the receiving stream.

Soil types, watershed slope, and stream size have a greater impact on risks to aquatic species than does the quality of chemicals involved. Actual risks from fire suppression chemicals must be addressed on a site by site basis, depending on local characteristics. Many of the potential risks may be mitigated by careful mixing and application practices, and through local restrictions on their use if conditions in a sensitive ecosystem warrant, such as the presence of endangered or threatened aquatic species. Some risks may not be eliminated, but these risks must be weighed against the necessity of firefighting activities.

Some of the uncertainties involved in the assessment of risks to humans and ecosystems from fire suppression chemicals may be reduced through research activities. For example, the only toxicity data available on the chemical fire suppression formulations as a whole were acute $LD_{50}$s. The use of this value in the risk assessment requires extremely conservative assumptions to extrapolate an acceptable exposure level for humans. Sub-chronic or chronic laboratory toxicity studies to determine no-observed-effect levels would greatly reduce the uncertainty in the human health risk assessment. In addition, data on the rates of dermal absorption of the fire suppression formulations would significantly strengthen the conclusion of the risk assessment.

Some potentially useful areas of research for the ecological risk assessment include measurements of $K_{oc}$ and water solubility for firefighting foams, and field studies on the fate and half-lives of fire suppression chemicals on vegetation and in water. Data from these types of studies will help to further assess potential ecological risks from these chemicals.

## OBTAINING COPIES OF THIS PUBLICATION SERIES

Are you reading your own copy of this document, or a hand-me-down copy? Do you wish to obtain back issues and get on the mailing list for future issues? Do you even know who put this together and what the objectives are? Read on!

The National Wildfire Coordinating Group (NWCG)—which is sponsored by the United States Departments of Agriculture and the Interior and the National Association of State Foresters—in cooperation with the Petawawa National Forestry Institute and Forestry Canada, has been issuing documents jam-packed with information on "Foam Applications for Wildland & Urban Fire Management."

This publication series contains articles presenting background, historical, health and safety, use, equipment, and suggested reading data on foams and applications systems. The series of publications represents a complete compendium on everything you ever wanted to know about foam but perhaps didn't know enough about to ask.

Authors from numerous agencies, worldwide, have been contributing to the issues in the series. Publications group personnel at the USDA Forest Service San Dimas Technology and Development Center (SDTDC) have been taking the original inputs and performing editorial and graphic functions to produce each issue in the series. So far, the following have been published: Vol. 1, No's 1 to 3 (1988); Vol. 2, No's 1 to 3 (1989); Vol. 3, No's 1 and 2 (1990); Vol. 4, No. 1 (1991) and 2 (1992); Vol. 5, Nos. 1 and 2 (1993); Vol. 6, No. 1 (1994) and now this present issue, Vol. 7, No. 1.

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## FIRE CHEMICALS

(Qualified of Approved and commercially available)

| Chemical | Mix Ratio | Status | Qualified/Approved Applications[1] | | | |
|---|---|---|---|---|---|---|
| | | | Fixed-Wing Airtanker | Fixed-Tank Helicopter | Helicopter Bucket | Ground Engine |
| WILDLAND FIRE FOAM (Administrative approval using Interim Requirements for Wildland Fire Foam) | | | | | | |
| Ansul Silv-Ex | .1-1% | Adm. Approval | | | ● | ● |
| Fire-Trol FireFoam 103 | .1-1% | Adm. Approval[2] | | o | ● | ● |
| Phos-Check WD 881 | .1-1% | Adm. Approval[2] | | o | ● | ● |
| Fire-Trol FireFoam 104 | .1-1% | Adm. Approval | | | ● | ● |
| Angus ForExpan S | .1-1% | Adm. Approval | | | ● | ● |
| Pyrocap B-136 | .1-1% | Adm. Approval | | | ● | ● |
| TCI Fire Quench | .1-1% | Adm. Approval | | ● | ● | ● |

[1] Administrative approval given when interim requirements are met.

- ● Administrative Approved
- o Temporary administrative approval

[2] Temporary administrative approval for use from fixed-tank helicopters until a new or modified formulation meeting magnesium corrosion requirements is commercially available (GSA).

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