An Operational and Tactical Guide to Ground-applied Foam Applications

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and Tactical Guide to
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Preface:

The purpose of this operational guide is to promote and support the proper use of foam as a fire suppressant tool. However, the guide does not pretend to have all the secrets to effective foam use. As more information becomes available, these pages will be updated and supplemented.

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PART 1. FOAM-GENERATING SYSTEMS

Detergent Foams

The advantages of using a detergent-based foaming agent designed for natural fuel applications are many. These agents are specifically developed to enable water to expand, penetrate, protect, and extinguish.

The key process which these agents perform is to reduce the surface tension of the water molecule. When foaming agent concentrate is mixed into water, water molecules are spread apart by surfactant molecules. When air is added, surgactants in the foaming agent allow the water molecules to remain in the more planar arrangement of a bubble. Depending on the foaming agent and the foam generation method, this bubble may last for hours. The ability of foam to hold water to a surface and, thus, lengthen its availability, is an important characteristic.

Foam's state of reduced molecular tension also provides an easy pathway for water into vegetation. Detergent foams made for wildland use break down water resistant plant cuticles just as dishsoap breaks down grease. With less tension from neighboring molecules, water from around the bubbles penetrates faster than plain water.

Foaming Agent Solution

Foaming agents are produced as liquid concentrates designed to be diluted to, for example, 0.3%. There are three methods of mixing the concentrate with the water supply.

The basic method is to add concentrate to the water supply by hand. This method, called batching, is convenient for conventional water pumping systems, because no additional appliance is needed to produce agent solution. The simplicity of this method also makes it the most wasteful. Agent concentrate is wated when: 1) the amount of water added to the working solution is estimated, or 2) the percent solution of the supply is estimated. Also the solution should be used within 24 hours for optimum performance.

Perhaps the simplist method of adding concentrate stored separately is by eduction with an in-line tee. The tee is equipped with a regulating valve for concentrate flow and is located on the suction side of the pump. Systems which use this method are able to draw concentrate from the common 5 gallon containers. This method is especially useful when foam is generated from a portable pumping system. Calibrations must be accurate and understood to avoid concentrate waste.

The most expensive and reliable method of induction is the injection of concentrate on the suction or discharge side of the pump with a mechanical foam proportioner. Concentrate is moved from a storage tank and into the water stream by a small pump. The pump is governed by a microprocessor connected to an inline water flow meter. This system allows the concentrate to be pumped on demand at variable rates according to work desired.

Nozzle Aspirating Foam Systems

A nozzle aspirating foam system produces foam by educting air into the solution stream through a specially designed nozzle. Figure 1 is a schematic drawing of a typical aspirating nozzle. As the solution enters the nozzle, it is constricted and broken into multiple streams. Immediately following the constriction are holes radially placed in the nozzle. From here the nozzle bore increases to form the expansion chamber. Air is drawn into the nozzle by the water pressure change due to constriction. Air mixes with the solution during agitation caused by the multiple streams and produces bubbles. Foam continues to develop as the bubbles move through the expansion chamber.

The sole motive force is a water pump. All systems are hydraulic.

Compressed Air Foam Systems (CAFS)

A compressed air foam system produces foam by injecting air (or other pressurized gas) into water that contains a foaming agent. Foam is generated by a combination of air-solution mixing, agitation, and expansion. Schematic drawings of three compressed air foam-generating manifolds are shown in Figures 2,3, and 4. CAFS use a brute force method of producing foam; therefore almost any foaming agent will make foam. With CAFS, signficantly less concentrate than other foam systems is required to produce an effective firefighting foam.

The primary components of this system are the water pump and the air compressor. Pumps may be integral or portable, centrifugal or positive displacement. Compressors of various sizes may be integral or portable, such as rented trailer units. Recommended specifications will be discussed in Part 2.

Essential components are flow valves and check valves for air and water. The flow valves control inputs to the mixing chamber where air and water meet. The check valves prevent water from flowing into the air compressor and air form flowing into the water pump.

Pressure gauges for air and water are necessary for proper foam production. Static pressures of air and water should be nearly equal.

A water flow meter is recommended because it indicates to the operator how wet or dry the foam quality is at the nozzle. For example, 30-40 gallons per minute (gpm) of 0.2% solution and 40 cubic feet per minute (cfm) or air will produce good quality foam from a 1.5 inch hose. See Part 2. for more performance information. The water flow meter should be located before the check valves. Flow meters require specific lengths of straight bore flow for proper measurement.

Pump recirculation should occur prior to the water check valve. This configuration accomodates any of the three foaming agent mixing methods described on page 2.

After the flow valves the solution and air mix and produce bubbles. Most CAFS rely on the length of hose to generate the agitation necessary for desirable foam. As the bubbles travel through the hose they cling to the hose linings and to themselves. This friction further agitates the foam. If the hose is long enough, the foam is agitated to a point where all the bubbles are tiny and uniform in size and water content. These bubbles create a foam plug against which oncoming foam backs up as it too forms into tiny, uniform bubbles. This process is called scrubbing.

Figure 1

NOZZLE ASPIRATING FOAM SYSTEMS

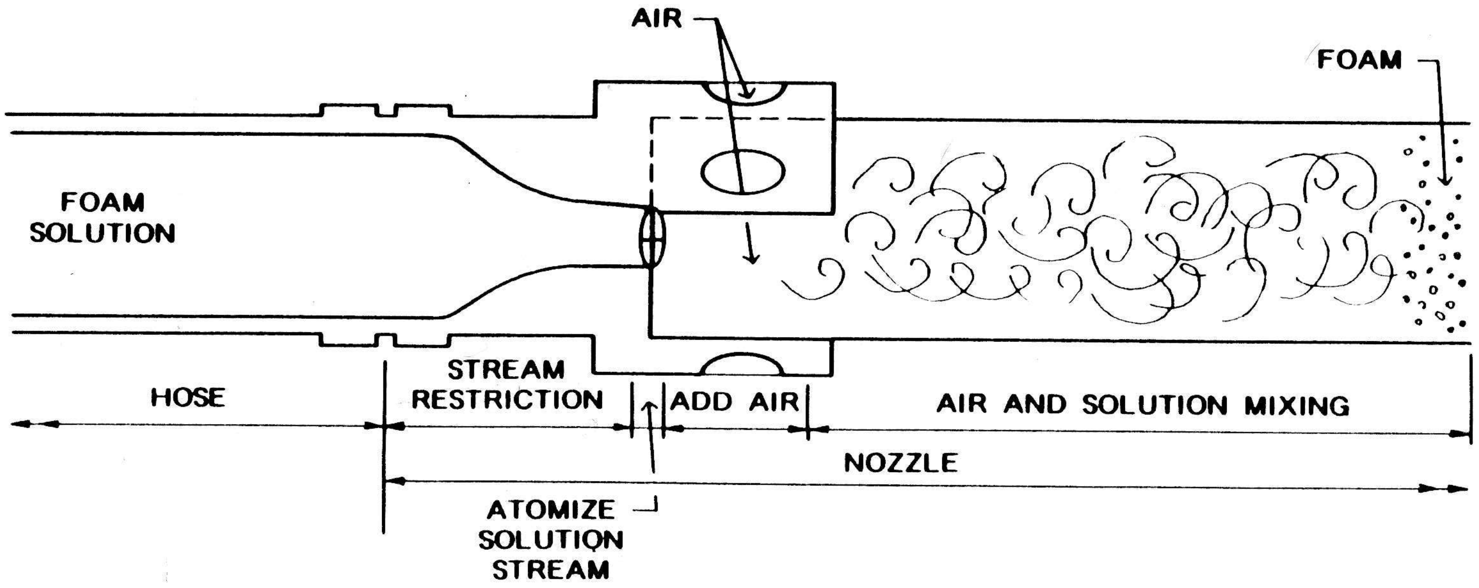


Figure 2

COMPRESSED AIR FOAM SYSTEMS (1)

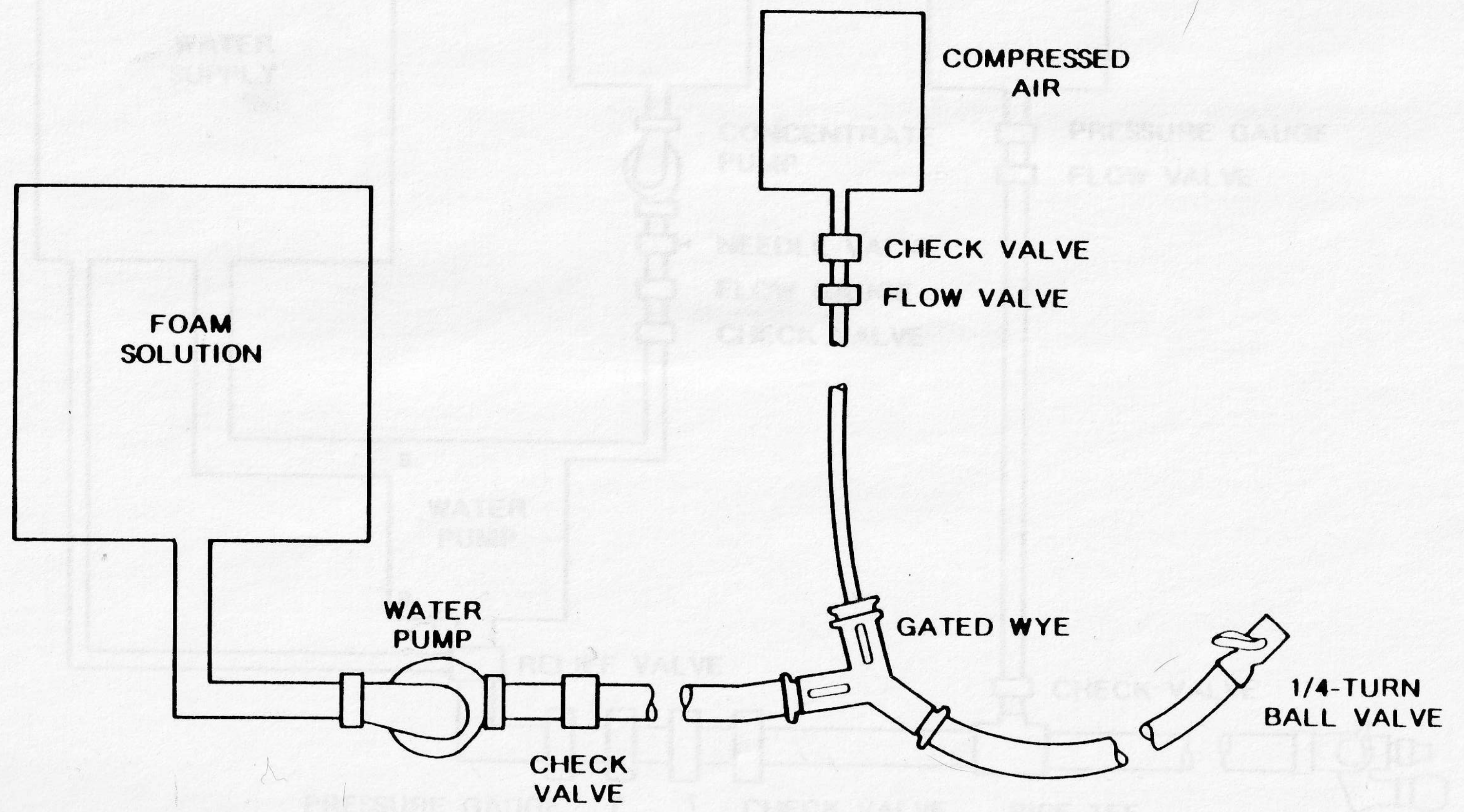


Figure 3

COMPRESSED AIR FOAM SYSTEMS (2)

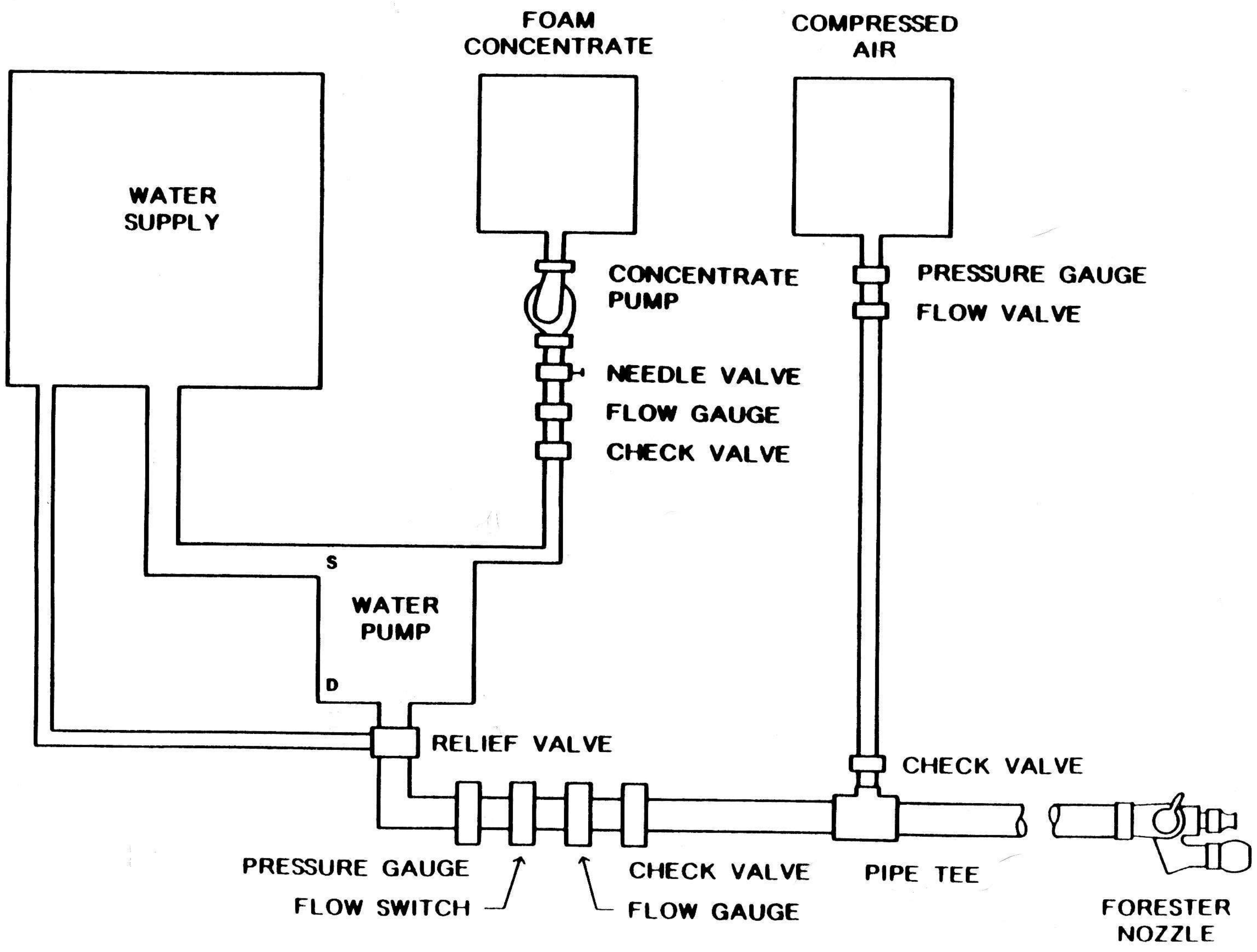
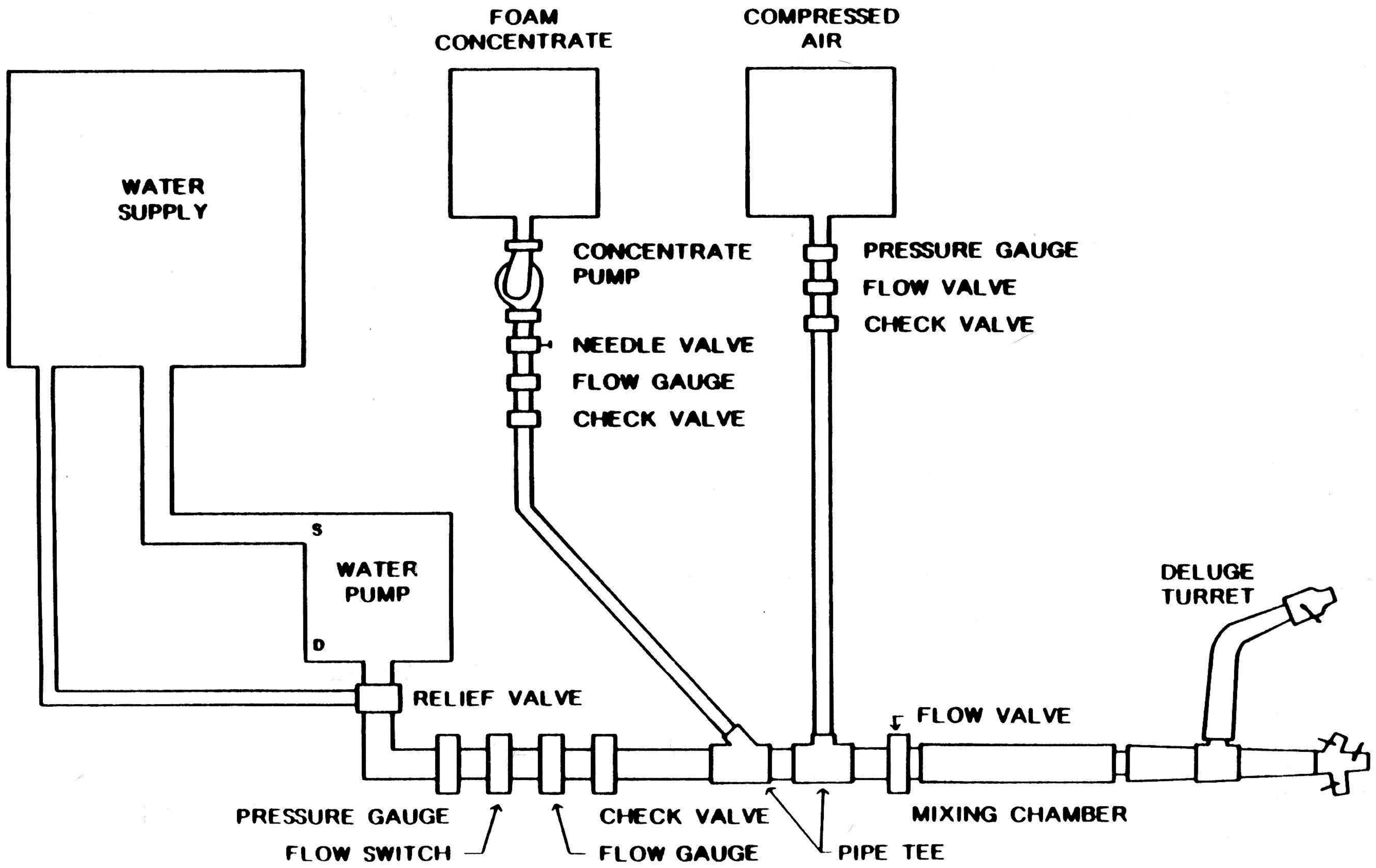


Figure 4

COMPRESSED AIR FOAM SYSTEMS (3)



The length of hose required for scrubbing depends at least upon type and diameter of hose and percent solution. For example, scrubbing of 0.2% solution foam in 1 inch rubber-lined cotton jacket hose occurs within 100 feet at 65+°F; 0.2% foam in 1.5 inch woven rubber hose requires up to 150 feet.

Some CAFS, however, do not need long hoselays to make foam. These use mixing chambers which bring water, concentrate, and air together in a short space. Various designs exist which produce foam with little or no loss in pressure. These mixing chambers may be especially usefull for engine-mounted foam monitors and applicators which have no need for long lengths of hose.

The last parts of the compressed air foam-generating system are the discharge appliances. Almost any nozzle with an unobstructed waterway, such as a forester nozzle, is compatable with a CAFS. The bigger the waterway the greater the flow. A $^{1}/_{4}$-turn ball valve that has a waterway equal to the hose inside diameter will provide the greatest foam flow. Any restriction of foam flow will mechanically break down the bubble structure creating a wetter foam.

Continuous, unimpeded foam flow requires the use of hose resistant to kinking. Woven rubber hose such as Angus Chief is very kink resistant. Rubber-lined cotton jacket is fairly resistant. Synthetic hose kinks readily when filled with foam.

Because a CAFS works by a combination of both hydraulics and pneumatics it is difficult to calculate friction loss, head loss, and other pumping properties. However, at a pressure above 125 psi, horizontal pumping distance of foam is not significantly different than water, and vertical pumping distance is much farther.

Operation of a Compressed Air Foam System

In this example, a $^{1}/_{4}$-turn ball valve is used as a nozzle.

Step 1. Prepare foaming agent solution:
1) add concentrate to water tank,
or 2) prepare and adjust eductor system,
or 3) prepare and adjust foam proportioner.

Step 2. Shut off water and air flow valves (see figure 2)

Step 3. Turn on air compressor. Set pressure as desired, from 50 to 150 psi.

> For example: Air pressure setting is dependent on work desired. A normal pressure for a 40 cfm compressor working one 1.5 inch hose line is between 125 and 150 psi.

Step 4. Turn on water pump. Set water pressure to equal air pressure. Note: static pressures are equal, but discharge pressures may not be.

Step 5. Open air flow valve and desired discharge valve. Ball valve may be open or closed. The air flow valve should remain completely open.

Step 6. Open water flow valve. Open ball valve. Adjust the water flow valve to achieve the desired water flow according to the flow meter. See System Capabilities for reccomeded and maximum water flows. The ball valve should remain wide open for optimum quality and quantity.

> For the above example, set water flow between 35-40 gpm.

System Capabilities

The following table describes performance characteristics of CAFS and nozzle aspirating foam systems. The information is mostly observed rather than thoroughly tested, but all of it is useful.

Data in Table 1 of water flow and discharge distance refer to three systems containing an air compressor and a centrifugal water pump supplying 0.2% solution as foam through various hose diameters and styles. Discharge distance depends on the diameter of the opening at the end of the hose. Maximum water flow for nozzle aspirating systems depends on pump capability, hose length and diameter, and nozzle flow rate. Number of nozzles to use for each CAFS depends on the same factors influencing nozzles on a plain water system (ie. nozzle tip size, pump pressure).

Relative data in Table 2, unless otherwise noted, refers to any CAFS (such as one of the three below) and a comparable solution-pumping, nozzle aspirating system.

TABLE 1

WORK	PERFORMANCE OF CAFS		
	20 cfm 150 psi	40 cfm 150 psi	100 cfm 150 psi
MAXIMUM WATER FLOW (GPM)			
1" cjrl	20	20	20
1.5" cjrl		40	40
2.5" cjrl			80
DISCHARGE DISTANCE (FEET)			
1" cjrl w/ 1" tip	80	80	80
1.5" cjrl w/ 1" tip		100	100
2.5" cjrl w/ $1^7/_8$" tip			180

TABLE 2

WORK	PERFORMANCE	
	CAFS	NOZZLE ASPIRATING
Recommended percent solution		
for fuel protection, direct attack and early mop-up	0.2-0.3%	0.3-0.4%
Pumping height	much greater than normal water systems	same as normal water systems
Foam strength: ability to cling to a vertical surface	very good	poor
Foam durability: length of effectiveness (hrs)		
hot weather	2-4	1-2
cool weather	5-12	4-6
System flexibility (wet or dry foam with given solution)	flexible	predetermined by nozzle and % solution
Hose weight	hose floats on water	same as water

Almost any pump and compressor can be used for foam generation. Centrifugal pumps are recommended because of their greater water flow efficiencies. The most important capability of a pump is delivery pressure. The pump must be capable of matching the pressures of the air compressor.

Compressors can be 1) a standard shop unit, or 2) a portable, trailer-mounted unit whcih can be rented by the day, or 3) one of a variety of models capable of becoming part of an integral compressed air foam system. The compressor must be large enough to provide air to the size of hoselays desired. For example, quality foam can be produced from the following compressor and hose sizes:

20 cfm	one 1-inch hose
40 cfm	one 1.5-inch hose, or two 1-inch hoses
100 cfm	one 2.5-inch hose, or two 1.5-inch hoses, or five 1-inch hoses.

NOTE: These figures are based on hoses equipped with full flow ball valves. More hoselines can be used by adding smaller diameter tips to the ball valve opening.

In order to design a compressed air foam system with matched water pump and air compressor, the following rules of thumb are advised:

(1 hp electric = 1.7 hp gasoline) per 4 cubic feet of air pumped,

1 gallon of water to 2 cubic feet of air for quality CAFS foam.

Foam Capabilities

There are different needs for foam, and, thus, a wide variety of capabilities desired. This section will discuss some characteristics you should expect from foam to aid any of your suppression efforts and some problems with foams you may encounter.

Foam produced by either generation system should quickly penetrate live and dead fuels, charred fuels, and litter and duff material.

Foam should immediately knock down and extinguish flames and eliminate smoke when applied at the base of the flames.

Foam made by a compressed air foam system should form a long-lasting foam layer greater than 0.5" on trees, snags, roofs, walls, eaves, and vehicles.

Hoses carrying CAFS foam should float on water, and be easier to handle when charged than when empty.

Foam durability depends on the weather. Bubbles collapse when their water evaporates, causing the foam to break down. In general, foam will be visible in exposed areas for at least an hour in hot weather; for at least 4 hours in cool weather. Foam in shaded areas will be visible even longer. CAFS foam can be seen for one or more days of cool temperatures. CAFS foam will generally last longer than nozzle aspirated foam because of its stronger, more uniform bubble structure.

A foam's effectiveness as a barrier should not be judged by visibility alone. Much of a foam's water penetrates into adjacent fuels. The exact amount of water absorbed depends on amount of water as foam applied, amount of water evaporated, the foam stability, and the fuel type.

A thick, heavy blanket of foam does not guarantee that fire will not burn through the treated fuels. For example, a thick CAFS foam blanket was applied over 31,000 square feet (700 feet long, 45 feet wide) in 30 minutes using only 1000 gallons of water. Most of the visible foam is air, which is holding the small amount of water in suspension. If the foam is so dry that water is not released to wet fuels, the foam may not stop an advancing fire. Even if wetting occurs, if the advancing fire requires more water to prevent ignition than what was applied as foam, then the fire will burn through the foam. Foam should be applied according to the amount of water and rate of drainage necessary to accomplish the task.

If you are unable to generate a foam which has the capabilities discussed here, you are either 1) not using a quality foaming agent or 2) not producing the foam properly (see our troubleshooting section for more information), or 3) not applying the foam properly.

If agent concentrate is applied directly to the water supply, agitation or circulation of the solution is necessary to insure complete mixing. If eduction or injection is used to place agent concentrate in solution mixing will be completed by water turbulance in the plumbing.

Concentrate separation will negatively affect performance of eductors and proportioners. Check with your product's manufacturer concerning product separation.

All foaming agents have a detergent base. Therefore, expect some corrosion of pipe fittings: minor for those exposed to solution; major for those exposed to concentrate.

When the concentrate is poured directly into the water supply the ability of the solution to weaken water molecule surface tension enough to produce foam may be reduced over a period of days. Water hardness, exposure to air, and other factors may contribute to this effect. A normal operation with day-old solution should alert you to this problem.

Storage of solution overnight or longer may result in the formation of hydrogen sulfide. This compound results from the natural biodegredation processes of high salt content water and some foam products when the oxygen supply is limited. A "rotten egg" smell and blackish water are signs of this toxic, undesirable reaction. For this reason we do not recommend storage of solution. Short-term mixing prior to use or metered mixing within the plumbing will not have this problem.

Safety

Safety considerations should be understood for 4 aspects of foam use:

1) operation of the ball valve under pressure
2) charging a hoselay
3) handling the concentrate, and
4) product safety.

A charged, static compressed air foam hose has high pressure built up against the ball valve. Opening the ball valve too quickly or standing without proper leverage against the discharge force could result in being knocked to the ground and/or struck by an uncontrolled fitting. When opening the ball valve, plant feet wide apart with one foot ahead of the other, bend knees for low center of gravity, and open the valve slowly. This is especially important for 1.5" and 2.5" ball valves. Two people should always be on the 2.5" ball valve while opening. Always use $^{1}/_{4}$-turn ball valves which open toward and close away from the body. It the forces at the ball valve are too great, they can push the operator's hand forward, thus shutting off the valve.

Once the ball valve is wide open and static pressures have been released, the valve and hose become easy to handle. CAFS units can be developed which regulate the motive forces to reduce static pressure build-ups.

Due to the same pressures found at a closed ball valve, caution must be taken when opening a gate to charge a new lateral or extend a mainline. Operators or others holding the hose being charged may be thrown to the ground or struck by the hose or fitting if the hose is charged suddenly. The new hose should be charged slowly.

Like soap, foaming agent concentrate can be mildly irritating to the skin. Excessive exposure may result in chapped fingers and hands. Remove concentrate by rinsing with water. Goggles and rubber gloves are recommended for those handling concentrate. Foam of a normal dilute solution generally is not caustic to the skin.

Foaming agents approved for use by the Bureau of Land Management and the United States Forest Service have been shown to meet standards for skin and eye toxicity, lethal dosage counts for fish, and metals corrosion. All are completely biodegradable. Exposure to foam has not been shown to be harmful to plants. Product manufacturers or distributors can provide Material Safety Data Sheets and other health and safety information.

PART 3. APPLICATION TECHNIQUES

The techniques employed with a CAFS generated foam are basicly the same as when using a water stream. However, a CAFS generated foam stream is up to 9 times more efficient when compared by gallons per minute to a straight water stream.

Rates of application depend primarily upon wind, temperature, fuel moisture, and fuel loading. For most uses manufacturers recommend 0.3% agent solution for the compressed air and nozzle aspirating systems. The width and depth of foam application that is necessary for the task changes with the above variables. In general, enough foam is required to provide adequate water to the fuels. One important feature of foam is that the applicator can see when enough has been applied because it is visible; it stays where it is applied; it extinguishes fire instantly. Also, since foam is mostly air; the hoses filled with foam are easy to clamp or shut off.

Direct Attack

Use 0.2-0.3% agent solution for CAFS, 0.3-0.5% for nozzle aspirating systems. Apply foam to the base of a linear flame front. On wide hotspots secure the edge and move toward the center. While attacking the edge, direct a portion of the foam stream onto immediately adjacent unburned fuels. With the CAFS, use the longer initial discharge to reach very hot and inaccessable flames.

Engine-mounted monitors can be used for pump and roll.

Apply foam stream as you would a water stream for best penetration into burning material. Apply long enough to ensure extinguishment, but realize this will not take very long. As soon as steam is visible move on. Vapor suppression, cooling and wetting have occurred. Leave a foam blanket over the hot fuels to smother and continue to wet the fuel.

The ability of foam to continue wetting and cooling fuels long after the applicator has left the area is a key to foam use strategies. It will be important for all applications of foam. Greater efficiency is achieved when the applicator can move on to a new flame or smoldering stump because he/she knows the foam will continue to work where it was applied.

Once the extinguishing capabilities of foam become familiar, do not be surprised to find foam putting out fires whose extinguishment would not have been considered with just water. Fire inside and at the top of snags, and fire within harvested area log decks can all be extinguished with foam.

Indirect Attack

Use 0.2-0.3% agent solution for CAFS, 0.3-0.5% for nozzle aspirating systems. Apply foam as a wet line adjacent to a back fire. Apply immediately ahead of the lighters. The foam line should be at least two and a half times as wide as flame lengths. Coat all sides of fuel when possible. Apply foam directly at close range as water would be applied for penetration to ground and surface fuels. Then apply foam softly by lofting onto brush and tree trunks and canopies to add an insulating barrier.

Mop-up

Foam's extinguishing, penetrating, and discharge distance capabilities enable earlier use of water for mop-up. Rather than waiting until fires become deep-seeded and time-consuming to extinguish, foam can be used soon after burn completion to extinguish fire before it burns underground to eliminate residual smoke, to reduce reburn potential, and to reduce soil erosion.

Use 0.2-0.3% solution for CAFS, 0.3-5% for nozzle aspirating systems. The greater discharge distance of the CAFS lends itself better than nozzle aspirating systems to attacking burned areas before all heat has left. Begin applying foam on the burn edge and work in, concentrating on hot spots. Direct attack all remaining flames.

Apply foam as you would a water stream into burning material for best penetration. Partially close the valve to strip air from the foam and create a high pressure wet water mist for in-close mop-up.

This tactic allows the frothy foam to do work usually done with water fog and a tool. The fire has not yet burned deep. The frothy foam quickly penetrates the fuel and ground where it lays, and as a blanket separates oxygen from any remaining smoldering fuel. This strategy works extremely well on pitchy and punky material, duff and litter material.

Before leaving the area check for steam rising from the foam. Steam plumes indicate pockets of heat which need more attention.

For deep-seeded fires in stumps, landings, and log decks install a mop-up wand on the nozzle or ball valve. Forester nozzles are also excellent mop-up nozzles with foam or solution. Again, application technique is not different than old water methods, but the water used is able to work harder.

Fuel and Vegetation Protection

The abilities of foam to penetrate dead and live fuels quickly, to form an insulating blanket, to cling to vertical surfaces, and to reach great distances from the nozzle have brought new meaning to fuel protection. Foam can prevent fire spread. It can protect stands of timber, areas of brush and grass, wildlife trees, snags, fuel jackpots, endangered plants, and log decks. And it accomplishes these feats after less applicaton time, with less manpower, and less water used than conventional methods.

The rate of foam application for fuel protection depends on air temperature, relative humidity, and fuel loading and moisture content. Foam is a short-term treatment in hot temperatures. It can not be applied a day or two ahead of use. It is most effective when applied immediately prior to ignition because treated fuels are being wetted and that moisture is being trapped by the foam blanket.

Regardless of the conditions, compressed air foam will remain longer than air aspirated foam. In general, adverse conditions (low relative humidity, high temperature) warrant foam application as close to ignition time as possible. Extra application techniques may also be necessary. Under moderate conditions where foam can be expected to effectively remain for more than a couple hours, application time may be well before ignition time.

Foam characteristics important to fuel protection are wetting ability and durability. The foam must break down to wet the fuels and remain stable to maintain a protective barrier. Foam expansion ratios can be guides to how you are influencing this apparent contradiction:

20:1	very little wetting, too dry
10:1	good for wetting and blanket
5:1	weak blanket, too wet.

Use 0.2-0.3% solution for CAFS, 0.3-0.5% for nozzle aspirating systems. Apply the foam directly from a short distance at high pressure, as water might be applied, for penetration of foam mass to ground and surface fuels. This boring breaks the foam into a froth, releasing the water and wetting surface and subsurface fuels.

Then apply the foam from a distance and with a trajectory to allow the flakes of bubbles to settle gently upon the fuel. This technique provides greater coverage of fuel surface and reduces bubble breakdown on impact. An insulating, reflecting water barrier is formed.

On fireline applications most work can be accomplished from the fireline. Foam width depends on fuel and fire behavior conditions. In Western Oregon slash burn fuels, 20-40 feet wide foam lines were used successfully. Apply foam to all sides of the fuel when possible. Apply foam to ladder fuels and crown fuels above the foam line. Apply as long as it is necessary to coat all fuels with the desired amount of foam. Be sure to direct the high pressure stream directly into the fuels where the fireline meets the foamline.

To provide adquate water for wetting below the insulative foam blanket, foam solution can also be used. Without adding air, run foam solution through forester nozzles and wet the area entirely. Because foam agents wet living, dead, charred, and uncharred fuels, they are recommended for this treatment over standard wetting agents which wet charred fuels only.

For applications to seed trees, wildlife trees, snags, log decks, telephone poles, and other large resource values, it will be necessary to use a foam that clings to vertical, up-side-down, slippery surfaces. More time may be required than for fireline applications to adequately supply enough water through the foam to these fuel masses. Use the initial discharge to reach treetops. Be sure to apply foam 25 to 50 feet out from the base of standing objects. Time of application before ignition is the same as foam line application.

Applications can also be made to protect soils and low vegetation within or adjacent to burn areas. Apply foam to headwalls to prevent soil instability due to removal of ground vegetation and baking of soil surface. Apply foam to stream protection zones to prevent increased stream sedimentation due to the loss of riparian vegetation. Apply foam to rare and endangered plant species to prevent destruction during prescribed burn operations. Applications can be made in the same manner as foam line treatments.

A taller than normal foam can be produced by both foam-generating systems for fuel protection applications requiring barriers of 6 inches or more. Compressed air foam can be thickened by adjusting operating pressures, adding more foam concentrate, or reducing the water flow. Thicker, drier foams have less water per bubble than normally wetter foams. Nozzle aspirated systems can use a medium expansion foam nozzle to produce even larger bubble sizes and a foam blanket more than 12 inches thick.

Structure Protection

The ability of foam to adhere to vertical, sloped, upside-down, and slippery surfaces is the key to structure protection. Without this ability no barrier could be produced and wetting may not be complete. Use 0.2-0.3% agent solution for CAFS, 0.3-0.4% for nozzle aspirating systems. Apply foam to outside walls, eaves, roofs, columns, or other threatened surfaces. Loft foam from a great enough distance to avoid foam breakdown. Durability is consistent with that discussed earlier: it is dependent on weather and fire behavior conditions. In general, CAFS foam should last for an hour in hot weather, nozzle aspirated foam for 30 minutes. Quality foaming agents will leave at least one half inch of foam on all surfaces, even if excess sloughs off.

Foam can be successful preventing wildland and structure fires from igniting other structures. If, however, a structure becomes involved, foam-treated walls alone may not save it because the water requirement for preventing combustion may be greater than the water applied as foam.

Vehicle and Equipment Protection

Vehicles and equipment can be outfitted with small, ready-to-use expanded foam fire extinguisher units for personnel safety and property protection. The Texas State Forestry Department has developed an air pressure unit just large enough to completely cover the bulldozer to which it is mounted. Vehicles and heavy equipment possessing pnuematic systems for brakes or other uses may be easily adapted to produce foam on demand.

Hazardous Materials

Today's awareness of hazardous materials forces us to consider the possibility of our involvement in a hazardous materials incident/accident.

Because of the various hazards involved such as flammability, toxicity, or corrosiveness, the containment or confinement of the hazardous material is mandatory. One mode of confinement is to cover the hazardous material with a blanket of foam.

Foams have been used with great success to extinguish fires but their property to blanket a hazardous material is also a very valuable one. Foams can suppress various vapors produced by a hazardous material. These vapors may be produced when the product is involved with fire or simply spilled from a container.

Foams applied through a compressed air system onto a spill or fire should be done in a uniform manner. Lets consider both direct and indirect application.

Direct application should start by gently lofting the foam onto the spill/fire from a location that is both upwind and uphill of the spill area. Blanketing techniques for spills as well as fires should be handled in the same manner. Apply the foam to the area of the base of the fire or the top of the spill, doing so not to stir or splash the liquid involved. The foam should be applied from the front of the spill area to the rear in an even side to side sweeping motion. The foam blanket should not be disturbed or broken by applying any additional foam or water spray. As the foam blanket "thins out" simply apply foam again in the same manner as mentioned. If the spill/fire involves a storage tank it is important to cool the tank involved with water before applying foam. Foam will seal against the tank walls if the tank is cooled first. This allows the best application of the foam to take place. Caution should always be used when applying foams as not to allow the blanketing effect to be broken Do not allow the application hose to be dragged through the foam blanket. Do not allow personnel to walk through the foam blanket needlessly. If this must be done remember that a CAFS foam will mechanically reseal itself.

Indirect application involves flowing the foam down a structure or wall on to the hazardous material. The foam blanket will form and flow from the rear of the area to the front as it is applied. This technique works equally as well as the direct method on both fires and spills involving hazardous materials. Foam can be re-applied as needed by using the same technique.

The properties of compressed air foam prove to be valuable in the areas of use and efficiency. CAFS foam can be dried to allow application of a thick foam blanket. The bubbles will retain the water content for a longer time allowing the foam to remain thick and stable. The application ratio of 0.2-0.3% allows the foam to be an economical approach to handling a hazardous materials spill/fire. The ability of the foam to be applied as a thick blanket allows for its use on products with a high vapor pressure. The blanket is dense and heavy meaning that vapors will not easily pass through it nor will the wind blow it away.

PART 4: TROUBLESHOOTING

Compressed Air Foam Systems

PROBLEM	CAUSE	SOLUTION
Air in water pump	Lack of or faulty check valve protecting water pump	Install or replace check valve positioned as in Figure 2
Water in air compressor	Lack of or faulty check valve protecting air compressor	Install or replace check valve positioned as in Figure 2
Rapid pulsation at the nozzle, very little foam discharge, or very dry intermittant discharge	Air pressure far exceeds water pressure	Adjust static air and water pressures to their proper levels
		Increase running water pressure by 10 psi until desired foam is achieved
	Water flow valve not open far enough	Open water flow valve slowly until pulsing stops or until water flow meter shows recommended flow according to System Capabilities
Discharge very wet, frothy, almost all water	Air and water pressures are not properly adjusted	Adjust static pressure settings
	Air pressure is too low for current water flow	Adjust static air pressure or water flow valve
	Air flow valve closed or partially closed	Open air flow valve completely
	Too many hose lines for foam pumping system	Reduce number of laterals or increase pumping capability
	Hose diameter too large	Increase pumping capability or reduce hose diameters

PROBLEM	CAUSE	SOLUTION
Discharge very wet, frothy, almost all water, continued	Breakdown of foam in tank over 24+ hour period	Add more concentrate to the water supply
	Not enough concentrate in solution	Add more concentrate by adding to water tank or proportioning into water line
	Discharge hose is kinked	Straighten hose. Any restrictions in flow will break down the foam
	Discharge valves are only partially open	Open all discharge valves completely. Any restrictions in flow will break down the foam
	Hose lay is too long	Hose length limits depend on system size and are being further researched
	Hose lay is not long enough	Add hose in 50 foot lengths. Different types and diameters of hose require differing lengths for scrubbing
Discharge very dry, mostly air	Low water flow	Increase water flow
Poor output volume at end of hose	Hose diameter too large	Use hose diameter matched to the system (see Systems and Applications sections)
Poor discharge distance	Pump pressures too low for work demanded	Increase pump and compressor pressures according to work demanded
	Pressure loss from concentrate eduction not compensated for	Increase water pressure
	Air pressure far exceeds water pressure	Adjust air and water pressures to their proper levels

Nozzle Aspirating System

PROBLEM	CAUSE	SOLUTION
Discharge very dry	Too much concentrate in solution	Add water to dilute solution in water tank or adjust proportioning system
Discharge very wet, frothy, almost all water	Not enough concentrate in solution	Add concentrate to the water supply
	Breakdown of foam in tank over 24+ hour period	Add more concentrate to the water supply
Poor discharge distance	Water pressure too low	Increase water pressure
	Pressure loss from concentrate eduction not compensated for	Increase water pressure
	Poor nozzle design	Change nozzle

PART 5: GLOSSARY

Agent Concentrate	The manufactured product which when diluted with Water becomes Agent Solution
Agent Solution	The dilute, working form of Agent Concentrate
Aspirate	To draw in air. The Nozzle Aspirating System draws air into the nozzle to mix with Agent Solution
Bubble	The building block of Foam. Bubble characteristics of water content and durability influence Foam performance
Concentrate	See Agent Concentrate
Foam	A cohesive body of Bubbles produced from the agitation of Agent Solution
Foam Blanket	A body of Foam which forms an insulating and reflective layer from heat and is used for fuel protection
Foam Generation	The foam production process of solution agitation in a hose, mix chamber, or nozzle
Foaming Agent	The product line or trade name of a foam-producing substance, usually distributed in liquid concentrate form
Foam Line	A body of Foam placed along areas to be protected from fire. Also made as the anchor for indirect attack. Also used in place of hand-made fire trail
Foam Monitor	A turret-type nozzle usually mounted on an engine
Foam System	The apparatus and techniques which mix Concentrate with Water to make Solution, pump and mix air and Solution to make Foam, and transport and eject Foam. Systems discussed here are the Compressed Air Foam System and the Nozzle Aspirating System.
Mixing Chamber	A tube filled with deflectors or baffles which produces tiny, uniform Bubbles in a short distance (1 to 2 feet)
Scrubbing	The process of Solution and air agitation within a confined space (usually a hose) which produces tiny, uniform Bubbles. Length and type of hose influence amount of scrubbing and thus foam quality
Solution	See Agent Solution
Water	Fresh, salt, brackish, hard or soft water