United States
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**Technology &
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Program**

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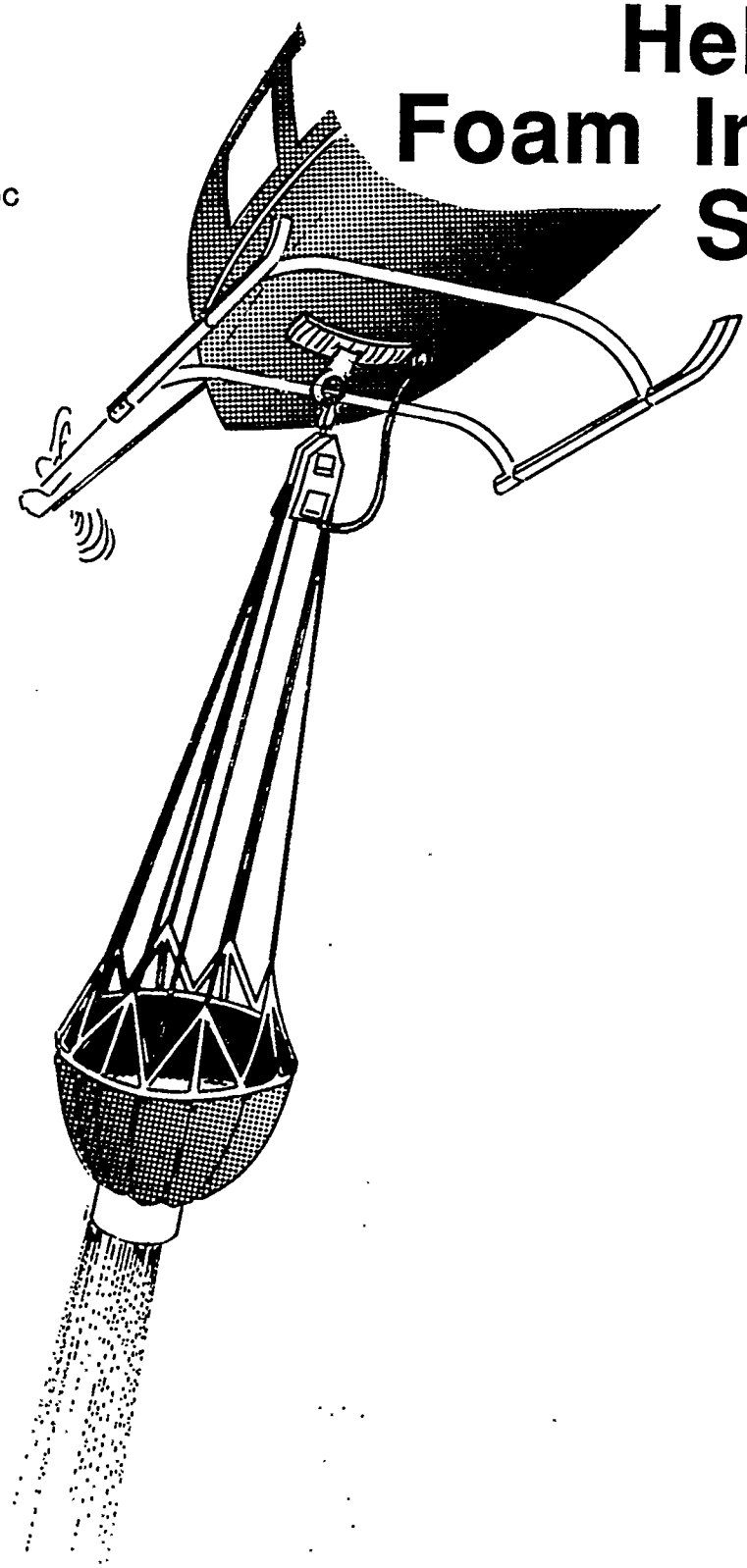
Field Survey of Helicopter Foam Injection Systems



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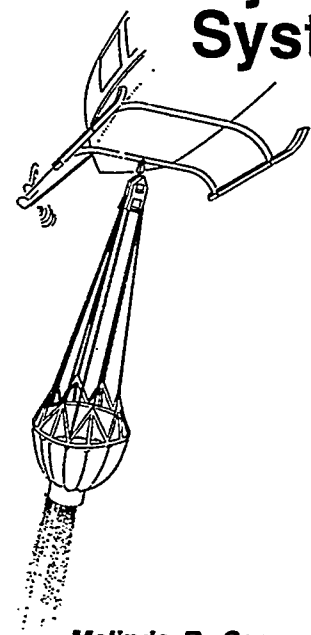

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San Dimas, California

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INTRODUCTION

The use of helicopter on-board foam injection systems has increased dramatically in recent fire seasons. To document the effectiveness of field equipment and discover areas for improvements, the San Dimas Technology and Development Center conducted a survey of operators' experience with helicopter foam injection systems. Topics discussed in the survey included what systems had been used, any operational or equipment problems encountered, and general comments regarding what constitutes an effective system.

A total of 43 responses were received from late summer 1990 through the spring of 1991. Some additional information was gathered after the 1991 fire season. The exact number of surveys distributed is not known, because many surveys were copied and passed on between agencies and helicopter operators after the original mailing. There was a multiagency response from personnel with the U.S. Department of Interior's National Park Service, Fish & Wildlife Service, Office of Aircraft Services, and Bureau of Land Management (BLM); some Canadian organizations; all USDA Forest Service Regions except the Pacific Northwest (R-6) and Eastern (R-9); and State and local agencies including Alabama, California, Florida, Maine, Minnesota, Montana, North Carolina, Oregon, Virginia, and Los Angeles County.

A copy of the survey questions is seen in appendix A. Information gathered from responses to all of the questions are addressed in this report either directly or indirectly, with the exception of questions 4 and 6. Questions 4 and 6 were essentially redundant questions, and were answered elsewhere in the survey by respondents.

HELICOPTER FOAM INJECTION SYSTEMS

The three units most widely used by survey respondents were the various systems from Chemonics Industries and the California Department of Forestry and Fire Protection (CDF), plus the SEI Industries "Sacksafoam." A brief description of each of these is included in this Project Report. In the responses, Chemonics systems (various models, U.S. and Canadian made) were cited 26 times, CDF systems (three different models) 13 times, and SEI systems 8 times. Due to some overlapping of responses, the actual number of systems in use by the respondents may differ slightly from tabulated values.

In addition to the three primary systems mentioned, many other systems exist in the field. These are listed in table 1 in order of quantity cited in the responses.

System manufacturer	Organizations using system	Indicated quantity
Rogers Helicopters (modified Chemonics)	USDA Forest Service Pacific Southwest (R-5)	6
Northern Mtn. Helicopters (B.C.)	Northern Mtn. Helicopters	6
Virginia Dept. of Forestry	Virginia Dept. of Forestry	4
L.A. County Fire Department	L.A. County Fire Department	3
Florida Division of Forestry	Florida Division of Forestry	3
N. Carolina Div. of Forest Resources	N. Carolina Div. of Forest Resources	3
USDA Forest Service Seminole District, FL	USDA Forest Service Seminole District, FL	2
Hawkins & Powers	BLM - Las Vegas, NV	2
ERA Helicopters	USDA Forest Service R-5, Chantry Flat Helibase	1
El Aero Services	BLM - Ely, NV	1
State of Maine Forest Service	State of Maine Forest Service	1

Table 1. Additional systems cited in responses.

It is also known that two other foam systems exist. One is the EGOR Fire Systems EAFFS system (typically used with the Sikorsky S-58 helicopter), and a system manufactured and used by Columbia Helicopters. Exact numbers of these systems in the field is not known.

Nine of the survey respondents had never used foam injection systems.

Helicopters used with the various systems included the Bell 205, 206-L3 & -B3, 212, and 412, Hughes 500, Sikorski S-58T, Aerospatiale SA315B Lama and SA316B Alouette III, and Boeing Vertol BV-107-II.

Foam concentrates used by the respondents are listed in table 2 in order of frequency cited in the survey. Seventeen respondents listed the Chemonics concentrate among the foams they used, making it the most frequent. Fire Quench

was only used by one agency surveyed. These counts are approximate, given that not all respondents answered the question and there were different responses within agencies.

Type of foam	Number of respondents using foam type
Chemonics Fire-Trol FireFoam 103	17
Ansul Silv-Ex	12
Monsanto Phos-Chek WD 881	5
Monsanto Phos-Chek WD 861	3
Texas Correctional Institute Fire Quench	1

Table 2. Foam concentrates reported used

BUCKETS VERSUS FIXED TANKS

When asked if they use buckets, 93 percent of the respondents said that they use buckets for their firefighting operations, 5 percent have not used buckets, and 2 percent did not answer the question.

Due to the widespread use of buckets, the majority of the foam injection systems are used in conjunction with buckets. Some foam injection systems are employed with fixed tanks. Although not directly related to the subject of helicopter foam injection systems, the respondents were asked for their thoughts regarding the use of fixed tanks versus buckets. The breakdown of responses was that 38 percent preferred buckets, 17 percent preferred tanks, 26 percent had no preference (pointed out the pros and cons of each), and 19 percent did not answer the question. Preferences depend upon forest fuel, topography, ground crews and equipment available, water availability, and other helicopter uses (such as sling load work).

A primary reason cited for preferring buckets was the versatility offered by buckets; this is particularly attractive to operators who are doing sling work. Other reasons for preferring buckets included better water penetration of dense canopies, concerns about ground clearance problems encountered with fixed tanks, easy removal of buckets, less weight than tanks, dipping is easier than pumping from trucks, less manpower and equipment required, and more rapid turnaround times.

Those who preferred fixed tanks were typically located in more metropolitan areas with limited water access and plentiful support equipment. Fixed tanks were also preferred by those who felt that using fixed tanks is less fatiguing for the pilot and is an easier technique for pilots to learn. Other reasons for fixed tanks were that the tanks have higher capacity than buckets, enable more accurate drops, are more effective on light fuels and moving fires, and presented fewer safety concerns regarding dropping a bucket or "hanging up on wires."

FOAM CONCENTRATE STORAGE

Of those surveyed, 64 percent stated that they preferred the foam concentrate storage container to be located outside of the helicopter, 17 percent preferred it to be located onboard the helicopter, 17 percent did not answer the question, and 2 percent stated no preference. Of those who preferred the storage tank exterior to the aircraft, 37 percent specifically explained that this was due to concerns over possible spillage and resulting corrosion. One reply went further to state keep the concentrate tank "as far from the aircraft as possible," and several others emphatically added "definitely" exterior for the concentrate tank location.

System Problems

In response to question 9 of the survey, regarding system problems, 42.5 percent of the respondents stated that they had encountered some problems with the systems they had used. Of these problems, 5 percent were operational in nature—such as a system was slow to fill, had a tendency toward "gumming" up with concentrate, or had difficulties with the bucket not dipping properly when a foam concentrate tank in the bucket was empty. The remaining 37.5 percent of the problems entailed either a mechanical or electrical component malfunction.

Also, 32.5 percent stated that they had never experienced any problems with the systems they had used, and 25 percent did not answer the question.

Foam Mixing

Of the respondents that had used helicopter foam injection systems, everyone indicated that sufficient mixing of the foam concentrate and water occurred from either the drop alone and/or from the flight vibration, if foam was injected to the water at least a couple minutes before the drop. More specifically, one replied that it was better if the drop was made at 50 feet above ground level at 10 to 20 kts airspeed, and another stated that it was better to be about 60 feet AGL for optimal mixing.

Concentrate Carrying Capacity and Number of Drops

Questions 11 and 12 addressed whether the present concentrate volume carrying capacity and the number of drops made per concentrate load used was satisfactory. Regardless of specific numbers per system, the general response was that refueling is usually necessary before the foam concentrate supply is completely used.

Concentrate Tank Filling Methods

Question 13 of the survey asked how users refill the concentrate reservoirs, and whether they would prefer another method. The majority of the respondents who explained how they presently refill the concentrate tank stated that they simply pour to refill (usually using a funnel). The next most common

method was to change out the empty concentrate container, stored inside the helicopter, and replace it with a full container. Others use a pump system. At least one pumping system simply refilled through the discharge hose by reversing the system pump. This was claimed to be extremely clean.

Although some users are satisfied with their current method of refilling, many stated that spillage does occur. None of the crews that said they were using a pump system claimed any spillage or problems. However, many of those that either pour or change out containers said that spillage sometimes happens. Several who pour with a funnel stated that it can be messy, and sometimes the funnel had to be stored in the helicopter afterward. Many of those who change out the containers, stated that spillage sometimes occurs when disconnecting and reconnecting. Some systems employ spill trays in the helicopters to prevent contact of foam concentrate with any of the ship.

Several of the respondents admitted that the present method is less than desirable but knew of no better way. One respondent summed up the most important consideration by simply responding, "Neatly!"

GENERAL COMMENTS

The responses were very positive toward the use of helicopter foam injection systems. However, three points were brought up repeatedly that merit concern and consideration. Many commented that the potential for corrosion of helicopter components and equipment due to exposure to foam was of significant concern. Others stated that foam injection systems need to meet established standards and be inspected. And finally, many pointed out there is a need for guidelines regarding the use of foam injection systems.

Of the many positive comments, this one was particularly notable: "I'm a strong believer in foam. It really helps when you are on the ground. If we're going to use helicopter time to drop water on a fire we might as well invest in a good foam unit and do the best job we can for our money. Any person that has worked on a fire with foam would rather see foam than just plain water."

SYSTEM DESCRIPTIONS

Chemonics Industries Systems

Chemonics Industries, Inc. manufactures the Helijector 5- and 10- gallon units and the Helijector 30-gallon units. In addition, the 'Jector Jr. and 'Jector Sr. models are manufactured and marketed exclusively in Canada. The 'Jector Sr. unit is shown in figure 1.

The Helijector 5- and 10-gallon units are located inside the helicopter. Figure 2 shows a Helijector 5 unit without the foam concentrate container installed. The systems include a Sureflo diaphragm pump with a 11-gpm capacity, a 3.5-amp electric motor and a timer to control the foam injection amount. The pilot is only required to operate a single control to activate the system. The entire system connects to an existing electrical outlet.

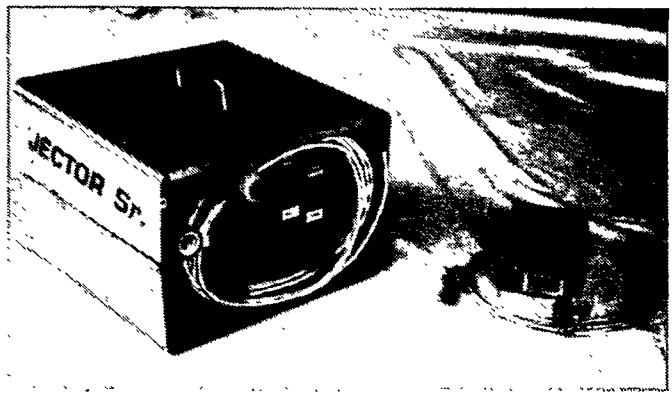

Figure 1. Chemonics Industries 'Jector Sr. unit.

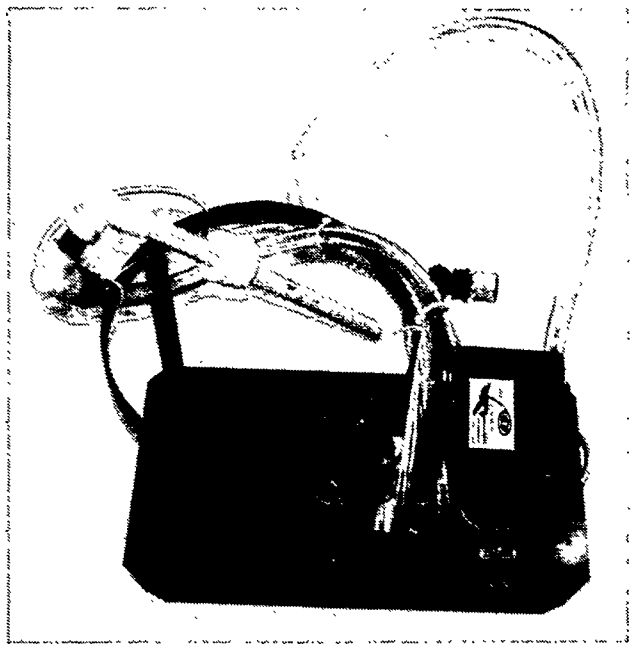

Figure 2. Helijector 5 without foam concentrate container installed.

Without the foam concentrate, the approximate system empty weight is 22 pounds. It is constructed with nylon fittings, spring-reinforced suction hose, antisiphon tube and quick-connect couplings. Metal brackets are used to restrain the 5-gallon concentrate container. An additional bracket is added to hold the second 5-gallon container for use as a 10-gallon unit. Containment units are available for the Chemonics systems.

Helijector 30-gallon units contain the same components as the 5- and 10-gallon units, with the exception of a 30-gallon polyethylene concentrate tank with metal bracket mount, and an empty weight of 46 pounds.

Survey Comments Regarding Chemonics Systems

Of the 11 respondents who had used a Chemonics system, three stated that they were extremely happy with their systems, and had never had any problems. These included at least one H/J-5, H/J-10, and H/J-30 model.

Four complained that they had experienced some type of failure or problem with the functioning of the system. These complaints stated that the H/J-5 system worked OK, but should have been made better—one respondent used the expression "garden hose" quality components for their 'Jector Sr units—and that the system makes a mess in the helicopter. Another complained that whenever the H/J-5 unit got wet from either rain or just being washed, the timer would run on its own without being triggered. A 'Jector Sr unit was said to need a new impellor for the Jabsco pump after about every 100 gallons pumped, the quick disconnects needed to be carefully locked, and the O-rings should be inspected for wear.

Six of the Chemonics system users stated concerns for spillage (and experiences with it occurring) due to the system being onboard the helicopters.

CDF Systems

CDF has used three variants of a foam injection system which they developed and fabricated. The basic system is the same for all three versions. The significant differences are that one is used with a bucket and a 15-gallon externally mounted concentrate tank; the second is also used with a bucket, but with a 10-gallon capacity external tank called "foam steps;" and the third is used with the 15-gallon externally mounted tank and a fixed water tank.

1. External foam tank with Bambi Bucket:

This system is primarily used with Bell 204 helicopters and 324-gallon Bambi Buckets. A 15-gallon capacity commercial polystyrene (high impact) agricultural tank is mounted on an aluminum platform that is attached to the hard points on the Bell 204. A Shurflo model 2173 or equivalent 28-v pump transfers the concentrate to the bucket via a plastic hose. Clear plastic tubing is used to connect the pump to the foam reservoir. Quick disconnect fittings are on all plumbing connections to facilitate installation and removal of the system.

The system also has a 28-v solenoid activated antisiphon valve mounted on the pressure side of the pump, and a 28-v relay switch. A timer mounted on the instrument panel is electrically connected to the pump, solenoid valve, and relay. The timer activates the pump for a predetermined period of time, which determines the amount of concentrate added to the water. The pilot activates the system by pressing a control button on the cyclic. All of the system equipment is on the outside of the aircraft adjacent to the foam reservoir.

2. Passenger compartment external steps that carry foam ("foam steps"):

CDF has developed and manufactured essentially the same system as described above, but with 10-gallon capacity passenger compartment external steps in place of the 15-gallon tank. An aluminum step is attached on each side of the helicopter at the hardpoints. The tanks are baffled, have a flush mounted filler, a vent, sight gauge, and drain.

3. Fixed tank system:

Located at the Hemet-Ryan Air Attack Base, CDF also has incorporated their system with a Sheetcraft 340-gallon, two-door fixed tank. Instead of the hose going into bucket, the hose was routed to the center of the tank, then split to each tank compartment. This was done with two PVC pipe manifolds mounted in the tank compartments.

Survey Comments Regarding the CDF Systems

Based upon the survey responses, the CDF systems have been quite successful and relatively trouble free. The only equipment failures reported were one cockpit dispensing control head had some problems in the automatic mode, and one pump solenoid malfunction after 2 or 3 years of use.

SEI Industries "Sacksafoam"

SEI Industries, Inc., the manufacturer of the widely used Bambi Bucket, also manufactures and markets their "Sacksafoam" foam injection system for use with the Bambi Bucket. The system can be purchased fitted into a Bambi Bucket or as a separate option to be installed into a currently used Bambi Bucket.

The system consists of a collapsible fabric foam sack (or bladder) and pump mounted in the bucket, and a control unit located in the cockpit. The foam tank remains in place when storing the bucket. All connectors are prewired and the system uses the 24-v dc power supply from the helicopter. There is an agitator option available for large buckets.

The digital control unit is located in the cockpit by either Velcro mount or installation in the instrument panel. Daily total drops and number of drops with current foam concentration are indicated by two dump counters and system status is shown by indicator lights. A reference chart indicating number of drops available at various concentrations is located on top of the control unit.

Release of foam concentrate into water sources is prevented by a check valve in the tank outlet. Foam can be dispensed at any time during flight.

Survey Comments Regarding the SEI System

Of the seven respondents who had used the Sacksafoam system, all but one had specific positive comments regarding its use. However, only one user said there were no problems. The problems cited were: One burned out control box for unknown reasons, the pump gumming up if not cleaned

up thoroughly, minor problem of bucket floating on water source unless the foam reservoir is full, and the system is messy to refill and requires two people to refill. Also mentioned was the opinion that the wiring should be better protected and of better quality.

After using the Sacksafoam during the 1991 fire season, several personnel in the Forest Service Pacific Southwest Region (R-5) provided some additional information regarding this system. All who had used it liked the general concept of the system, and felt that it worked very well, but had some common suggestions for improvements. Two problems were discovered.

First, when using the Sacksafoam with larger ships (particularly the Bell 204, 205, or 212), the larger bucket is very difficult to load into these ships with the Sacksafoam system inside the bucket. It requires two persons to load the bucket to prevent back injuries. One Helitack foreman reported that a crewmember sustained a back injury from trying to load a bucket with the foam system all alone. Secondly, unless the bucket is successfully loaded vertically, the bladder (even when capped and plugged as provided) leaks.

CONCLUSIONS AND RECOMMENDATIONS

Helicopter foam injection systems seem to be very popular with those who have used them. Additional development of systems and operating guidelines is definitely needed. Guidelines, and perhaps standard operating procedures, for the use and maintenance of helicopter foam injection systems should be developed and distributed.

Although the majority of the systems are used with buckets, there is a place for both fixed tank and bucket foam injection systems. Therefore, any requirements or procedures established should accommodate the use of both types of systems.

All systems in use should be evaluated against the "Foam Dispensing Equipment Requirements for Contract Helicopters" in addition to good judgement. A copy of this document is enclosed as appendix B. The weight requirement in this document may be unnecessarily restrictive, and should be changed from 40 to 50 pounds.

With 64 percent of the respondents preferring the concentrate tank located outside of the helicopter, there is an obvious concern over foam concentrate spillage and its possible effects on the aircraft. As stated in appendix B, the preferred location for foam concentrate tanks and system is exterior to the helicopter. If the concentrate tank and system is inside the helicopter the containment requirement found in the standard is imperative.

Likewise, a great deal of concern was expressed over spillage during concentrate loading. The requirement found in the current standard which states that "...a system must be employed such that any spillage of the concentrate will not come into contact with the helicopter" is imperative.

From the comments made regarding the Chemonics models, it appears that the Canadian 'Jector Jr and Sr models are not as well liked by users as the U.S. models. The CDF systems are very well liked with minimal equipment problems. Likewise the Sacksafoam system has been generally well received, but less so, in general, when used in larger helicopters such as the Bell 204.

It is recommended that the following possible changes be considered by SEI to improve the Sacksafoam system:

1. Seal the system more effectively so that in the event the bucket tips over in the helicopter with a full concentrate bag, the concentrate will not leak into the helicopter cargo compartment.

2. Or, consider the use of quick disconnects to remove the foam concentrate bladder from the bucket before stowing into the helicopter. If the foam concentrate bladder needs to be carried in the helicopter, then perhaps carry it in a spill-proof container of some kind.

3. Or, perhaps a system is needed to pump the concentrate out of the bladder prior to stowing.

4. Evaluate changing the dimensions of the larger capacity (such as the 324-gallon bucket) to be proportioned wider and shorter to enable easier loading of a bucket with Sacksafoam inside into the Bell 204, 205, and 212 series helicopters.

Note: At the time of this publication, SEI is working toward solutions to these system problems.

REFERENCES

1. "Fire-Trol Products by Chemonics, Foam Injection Units," a brochure by Chemonics Industries.

2. "Helicopter Bucket Foam Injection System, a System Developed by the California Department of Forestry and Fire Protection," prepared by Monsanto Company, Wildfire Division. May 19, 1988.

3. "New Technology Provides New Solutions," a brochure from SEI Industries. 1990.

4. "Foam Dispensing Equipment Requirements for Contract Helicopters" published in Volume 3, No.1 1990 of Foam Applications for Wildland & Urban Fire Management.

APPENDIX A

HELICOPTER FOAM INJECTION SYSTEM SURVEY
16 JULY 1990

1. Does your organization use helicopter foam injection systems? _____

If yes, what models and how many? _____

Please describe each system used including foam concentrate capacity

If possible, please enclose a photo of systems used.

Which ships are you using the foam systems with (state type and tail number)?_____

What types of foam concentrate used?_____

2. Do you use buckets?_____

3. Have you used the SEI "Sacksafoam" system? If yes, please comment on success/problems with system._____

4. Have you used any other bucket injection system? If so please comment.

5. If you have not used a bucket injection system, would you be interested in one?_____

6. Have you used fixed water tank systems? If yes, what models of tank and systems? _____

Please enclose photos if possible.

7. What are your thoughts regarding fixed tank versus bucket (pros/cons, experiences with each)? _____

_____

_____

_____

8. Where is your preferred foam concentrate tank location (i.e., onboard, outside)? _____

_____

_____

9. For any systems used, were there any problems with mechanical components? If yes, please describe. _____

_____

_____

_____

10. Was the drop alone sufficient for foam/water mixing, or was pre-mixing necessary? _____

_____

11. How many gallons of concentrate do you carry and how many would you want to carry? _____

_____

12. How many drops do you make and how many do you want to make per concentrate load? _____

_____

13. What is your preferred method of refilling the concentrate tank versus how you presently refill? _____

_____

_____

14. Additional comments on foam injection systems. _____

_____

_____

_____

_____

15. Name and title of person responding _____

_____

Address: _____

_____

_____

_____

Phone and DG: _____

APPENDIX B

FOAM DISPENSING EQUIPMENT REQUIREMENTS FOR CONTRACT HELICOPTERS

by John Seevers, Ph.D.
Under contract to USDA Forest Service
San Dimas Technology & Development Center

Call-when-needed (CWN) contracts permit helicopter contractors to furnish equipment for dispensing foam and retardant concentrates into buckets. Since the equipment is relatively new to the USDA Forest Service, detailed design or performance specifications are not yet available. What follows indicates interim measures, until it is decided what equipment we will standardize on. Thus, until specifications are developed, the evaluation criteria presented here can be used—along with good judgement.

GENERAL REQUIREMENTS

Compatibility of Materials: The materials used in construction of any foam dispensing unit must be compatible with all foams, and resistant to corrosion, erosion, etching, or softening. To evaluate the materials, submerge a sample in foam concentrate for 96 hr, then in a 1-1/2 percent solution for 96 hr. Any change indicates that the material must not be used.

Restraint: The foam pumping unit containment vessel and concentrate must be affixed to the helicopter in a way to prevent injury to personnel or damage to the helicopter. The design must meet the ultimate inertia forces specified in FAR 23.56 1(b)(2). All parts of the foam pumping unit must be designed so that at all points of contact with the helicopter, no abrasion or damage occurs to the helicopter.

Location of Unit: The preferred mounting location of the foam pumping unit and containment vessel is external to the helicopter, perhaps attached to or within the water supply.

Routing of Hose: The hose used to carry the concentrate must be routed out the side of the helicopter away from the pilot. Hoses must be routed in a manner that will not interfere with flight controls.

Breakaway Fittings: Any hose must have a disconnect that will pull away from the hose when the bucket is released. The disconnect must be close to the helicopter to keep the hose from beating against the helicopter. The helicopter side of the disconnect must be able to hold the fluid pressure in the line, and be able to be pulled apart at one-third the bucket empty weight. The lower part of the hose must be securely attached to the bucket such that, if the bucket is released, a sufficient load is applied to the disconnect to release it.

Containment: Any unit mounted inside the helicopter (other than those that have STC's or 337's), must have a containment vessel around the pumping unit and concentrate storage supply. The containment vessel must be able to hold 125 percent of the concentrate supply. Even in moderate turbulence, the containment vessel must be able to contain the foam concentrate. The discharge hose and fittings must be able to withstand 150 psi, or two times the rated maximum pressure output of the pump, whichever is greater. The discharge hose that is inside the cabin must have a containment sleeve of clear hose so that leaks will be visible.

Size: The unit must be small enough to easily fit into or onto the helicopter.

Weight: The foam dispensing system empty weight shall not exceed 40 lb.

Maintenance: The foam dispensing system is expected to require no major maintenance during each fire season.

Foam Quantity: The unit shall carry a minimum of 5 gal of concentrate for each 100 gal of bucket capacity.

Installation: Installation of the unit must not require any major or permanent modifications to the helicopter.

Power to Operate: Power source for the dispenser must be obtained from the helicopter by installing a MS 3116F-12-3P, three-pin connector on the cord to the unit. Pin A shall be +28 vdc and pin B for ground. (This is the same plug used for the infrared imagining system.)

Vibration: The unit must be designed and constructed so as not to be damaged or fail due to vibration or shock loading when installed in the helicopter. The unit must not cause undue vibration in the helicopter during operation or in flight. The unit must be designed and installed so as not to cause any concentrated stress on the helicopter.

OPERATIONAL REQUIREMENTS

Operation: The pilot of the aircraft must be able to operate the unit with a minimal level of attention so as not to interfere with normal flying of the aircraft. An automatic system would be preferred. Under no circumstances can any phase or aspect of the foam dispensing system impair the flight safety of the aircraft. Once the control is set for flow rate, there should be no adjustment necessary to the unit.

Flow Rate: The system must be capable of dispensing a variable amount of concentrate, in flight, to achieve a mixture ratio ranging from 0.1 to 1.0 percent by volume, in 0.05 percent increments. (Example: For a water bucket load of 250 gal, a mixture ratio of 0.50 percent would require 1.25 gal of injected concentrate; the next selected increment of 0.55 percent would require 1.375 gal of injected concentrate.)

Concentrate Loading: Loading of 5-gal containers is preferred. If bulk loadings is to be used, a system must be employed such that any spillage of the concentrate will not come into contact with the helicopter. Servicing must be accomplished during normal refueling time for the helicopter and take no longer than the refueling operation.