INTRODUCTION

The acceptance of the Canadair CL-215 Air Tanker as a viable aircraft for fire suppression in North America has yet to overcome some resistance, however, the success the province of Quebec has had with these aircraft is impressive. The use of 2 of these aircraft for the budworm spray program has indicated that the aircraft is versatile and capable of performing well in other than the fire suppression role. The new probe system that was designed by Knox Hawkshaw and installed by Field Aviation has undergone extensive field testing and all indications are that this has enhanced the aircraft's water pickup capabilities. It improves aircraft stability and handling ease when picking up water and also provides shorter pickup range and pickup time. The "Fire-Trac" system, another Field Aviation inovation, has yet to be used and tested however their short-term retardant installation has been experimentally tested on a limited basis.

The short-term retardants that are commercially available for forest fire suppression are relatively few and when one considers only those products that can be effectively used in a probe-pickup operation the choice becomes either Gelgard or Tenogum. Since Tenogum disperses readily and does not clog the injection system like Gelgard, the power of selection is non-existant. Tenogum, a free flowing formulation of vegetable colloids disperses readily in cold water, has rapid solubility and hydration and is practically unaffected by changes in pH or mineral content of fresh waters. Tenogum and water form an inspissator (syrup or gel) which when applied to fuels lies as a continuous gel-like layer until it dehydrates. The additive, a fine powder, has no fire retarding properties hence its role in the inspissator is solely to change the form of water. The advantage of using this additive is primarily in changing the consistency, that is, the viscosity of the water to improve the drop pattern configuration and drop concentration. Load breakup is reduced and droplet disintegration is minimized therefore losses due to drift are minimal even under high wind conditions. The ability to drop from greater heights is an important advantage in itself.

THE INSTALLATION

Introduction of Tenogum into the water stream during pickup depends primarily on the free-flow characteristics of this powder. Since Tenogum does not react with the water vapour normally in the air and has excellent flow and dispersal characteristics, pressurization by a water-free gas such as Nitrogen is not necessary. The installation consists simply of a storage bin (300 lb. capacity), a metering hopper (15 lb capacity) and the associated plumbing of pipes, valves, switches etc. as sketched in Appendix A. There are two such installations in the aircraft, one for each tank.

The powder is loaded through a port in the roof of the aircraft directly into the bin thereby eliminating the possibility of aircraft contamination in the event of an accidental spill. Normally Valve #1 is open and Valve #2 is closed consequently the powder is permitted to flow into the metering chamber which in essence resembles 2 cones (having slopes corresponding to the critical angle of flow of Tenogum powder) welded together. The metering hopper capacity has been fixed at 15 lb. of Tenogum, therefore, there are no provisions for altering inspissator viscosity without reducing the amount of water. On arming the retardant system, the pressure sensing switch is put on "Alert" to simultaneously rotate the valves when the water pressure builds up in the loading duct.

During water pickup Valve #1 closes and Valve #2 opens to permit the powder to flow into the water stream but as soon as loading is terminated, the valve positions are once more returned to "Normal" and the metering hopper is recharged, by gravity, for the next pickup. Baffles in the water duct eliminate water backup into the Tenogum system. There is a separate liquid dye injection system for colouring the inspissator red.

THE TESTS

The initial testing carried out at the airport at St. Honore, Quebec, on June 20, 1974 to determine the efficiency of the Tenogum installation indicated that:

(a) Tenogum flowed freely into the metering bin during recharging.

(b) Tenogum flowed freely into the water stream during pickup within the loading time duration.

(c) Tenogum dispersed readily and uniformly throughout the entire tank load

(d) water backup into the metering hopper did not occur

Ocular examination of the drop pattern on the grassy field revealed that the gel film thickness was rather thin due to low inspissator viscosity. Because of the need to increase the concentration by 0.05%, 15 lb. of Tenogum per tank load was not adequate. Lesser amounts of water (480 gal/tank) were also picked up but the accuracy of the tank gallonage indicator was not known so there was doubt as to the actual concentration. Testing was to resume at a later date to determine inspissator viscosity at ground level for different drop heights and concentrations.

Testing was resumed on July 17, 1974 at Quebec City, however, due to high wind velocities and extreme qustiness the conditions were not conducive to data gathering. Samples were caught from 3 drops and the viscosity was measured shortly after collection and again some 20 hours later. The results are presented in Appendix B.

Assuming that the aircraft gallonage indicator estimates of amount of water picked up were equally accurate each time the concentration of 0.30% was not as viscose as desired (Drop #1). The tabular viscosity values for the some sample are very variable, however, it must be born in mind that the inspissator is thixotropic in nature and changes viscosity readily with change in shear. Comparisons can only be validly considered if the spindle number and rpm are the same in each case. When the inspissator is left to stand undisturbed it loses some of its viscosity and becomes more fluid, however, on rapid agitation for at least 15 seconds its viscosity returns. The viscositv of the drop test samples was remeasured some 20 hours later by first measuring the viscosity of the undisturbed fluid then again after having agitated it violently for one minute. The increase in viscosity due to agitation ranged from 60 to 80%, however, percentage increase did not follow any set pattern.

Although Drop #2 concentration was supposedly 0.35% the viscosity readings for this batch were lower than for Drop #1 (0.30% concentration). The reason for this anomaly were not immediatly evident.

Drop #3, concentration of 0.35%, was more viscose as expected. This batch of inspissator had good coating qualities (the depth of gel-like layer was generous and the film adhered well to provide a uniform thick coating on the rocks etc. on which it had fallen). Viscosity comparisons of drop test samples with those mixed in the laboratory indicated the laboratory samples were much more viscose, for the same Tenogum concentration, Appendix C. However one must bear in mind that shear sensitivity of Tenogum may be the main reason for these viscosity variations, more so than concentration differences. The shearing differences between a laboratory stirrer and the combined shearing occurring during aircraft loading and the load dropping through the air may be sufficiently different to account for their drastic variations.

The test indications were that even though Tenogum dispersion and load uniformity were excellent a concentration of 0.35% was required to yield the desired inspissator.

To get this concentration it was necessary to reduce the quality of water per tank to 425 gal., however, this means under-utilization of the aircraft. Therefore, installations or product changes must be considered.

RESOLUTION OF PROBLEMS

The only problem with this installation is that the amount of powder input can not be altered to change concentration therefore, the product strength must be increased (condensed) so that 15 lb/600 gal water will give a 0.35% concentration or the metering hopper must be increased in size to accommodate 21 lb. of Tenogum powder. Since the rate of powder flow into the water duct has not yet been determined, increasing the hopper capacity may not be the real answer for the new probe pickup time is considerably less than that of the conventional probe. If the loading time is too short to permit the entire hopper load of Tenogum to pass into the water stream, the valve and duct diameter below the metering hopper would have to be increased accordingly.

There are two considerations that are important in deciding whether product or installation changes should be made: (1) the cost of 42 lbs. of Tenogum per load as presently manufactured and the cost of the installation in its modified form; (2) the cost of 30 lbs. of fortified Tenogum aircraft load and the cost of the installation in its present form. If changing the installation is the route that is taken it would be advisable to install a variable volume metering hopper such as proposed in Appendix D.

Answers are required for the following:

1. how many seconds does 15 lb. of Tenogum powder require to enter water duct?

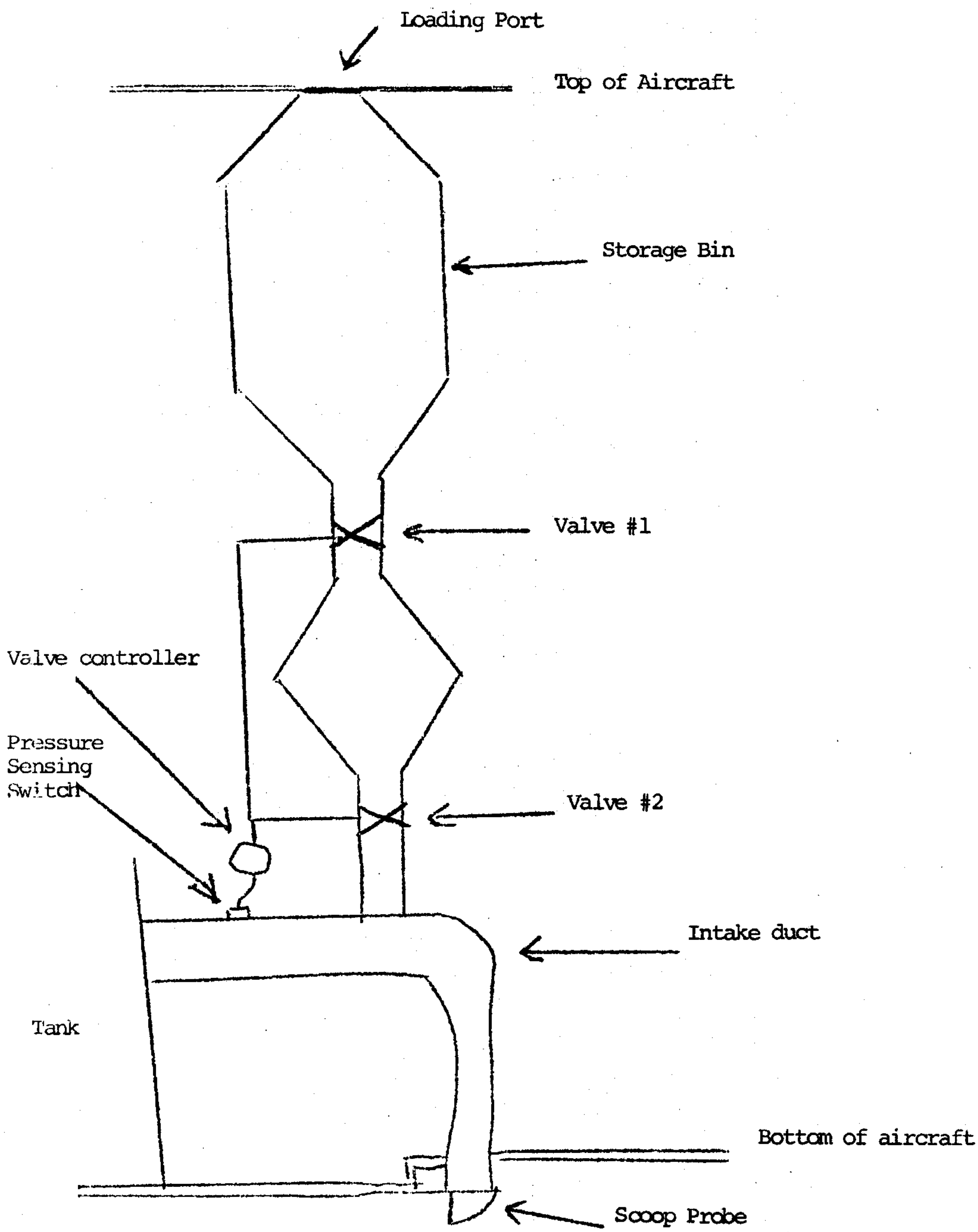
2. how does aircraft drop height affect Tenogum viscosity?

3. how does viscosity within the aircraft tank compare with that on the ground?

4. how accurately can the pilot determine gallons on board using the indicator during actual pickup?

E. Stechishen
July, 1974

Sketch of Short-term Retardant Installation.



Brookfield LVF Viscosity Readings for Test Drops.

A. Drop #1 - 500 gal/tank, 15 lb. Tenogum, height 125 ft.

1. Viscosity in cps after drop

rpm	60	30	12	6
Spindle #2	149	229	435	645
Spindle #3	188	218	550	880

2. Viscosity 20 hours later, agitated before measurement

rpm	60	30	12	6
Spindle #2	250	411	800	1345
Spindle #3	288	488	1040	1720

B. Drop #2 - 425 gal/tank, 15 lb. Tenogum, height 125 ft.

1. Viscosity in cps after drop

rpm	60	30	12	6
Spindle #2	141	226	425	730
Spindle #3	168	252	470	800

2. Viscosity 20 hours later, agitated before measurement

rpm	60	30	12	6
Spindle #2	184	296	585	1000
Spindle #3	212	340	570	1080

C. Drop #3 - 425 gal/tank, 15 lb. Tenogum, height 100 ft.

1. Viscosity in cps after drop

rpm	60	30	12	6
Spindle #2	222	357	690	1130
Spindle #3	252	416	820	1400

2. Viscosity 20 hours later, agitated before measurement

rpm	60	30	12	6
Spindle #2	310	501	998	1695
Spindle #3	346	560	1200	2060

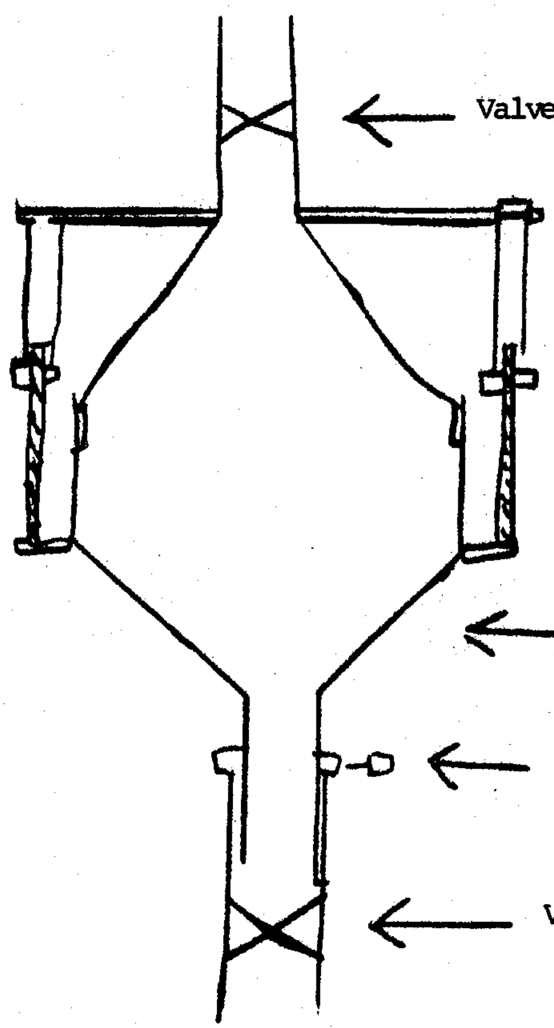
Brookfield LVF Viscosity Readings for Laboratory Samples.

All measurements @ 60 rpm.

Concentration	Spindle #2	Spindle #3
0.20%	267	294
0.25	310	368
0.30	387	416
0.35	404	562
0.40	410	452 *
0.45	(500 +)	600

* May be a recording error.

Sketch of Variable Volume Metering Hopper.



By thumb nut adjusters (3) the volume of the metering hopper could be changed thereby facilitating the selection of whichever concentration one desires.