EVALUATION OF A MULTI-ENGINE AIRCRAFT IN THE ULV APPLICATION OF DIBROM

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While much has been published regarding the application of insecticides at ultra low volume rates, most authors fail to give a complete description of the equipment utilized. This paper will, therefore, consider in detail a spray system designed specifically for ULV application from a multi-engine aircraft.

A compressed air system was designed which basically resembles the system recommended by the Chevron Chemical Company (Carter, 1967). The system was installed in a Douglass C-47 procured from the Air Force in late 1966.

Fig. 1 is a schematic drawing of the air and liquid systems utilized. A 24-volt, 37 amp compressor is used to produce necessary air pressure. The compressor is controlled by a pressure-sensitive switch within the limits of 90 to 125 psi. A safety valve is maintained at 127 psi; further protection is provided by a circuit breaker and manual switch mounted in the electrical junction box of the aircraft.

Compressed air is stored within the compressor's small integral reservoir and in three reserve storage tanks. Air is routed from the reservoirs through a regulator to the air on-off valve, past a vent valve to the insecticide tank groups. The air on-off valve allows for the adjustment of the air system without pressurizing the insecticide tanks.

Insecticide tanks are stainless steel carbonated beverage containers. Each tank has two fittings, the inlet or air fitting, and the outlet or liquid fitting. The latter has a draw-down tube which extends

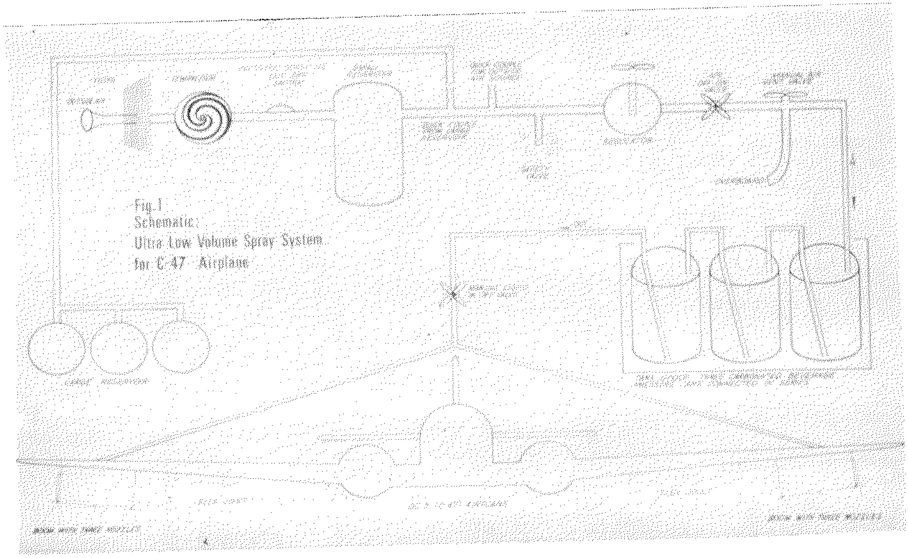

Figure 1

to within ½ inch of the tank bottom. Both inlet and outlet fittings on each tank are modified by the removal of check valves which restricted the flow of insecticides, causing a need for a greater operating pressure. Also the neoprene "O" rings supplied with the tanks tended to dissolve in such insecticides as Dibrom, and had to be replaced.

The system has a series of 12 such tanks, arranged in groups of 3, called tank groups. Each group is contained within a fiberglass-lined and covered plywood box, with overlapping lid to insure against spillage within the aircraft. Fig. 2 illustrates the manner in which individual tank groups are secured to the aircraft.

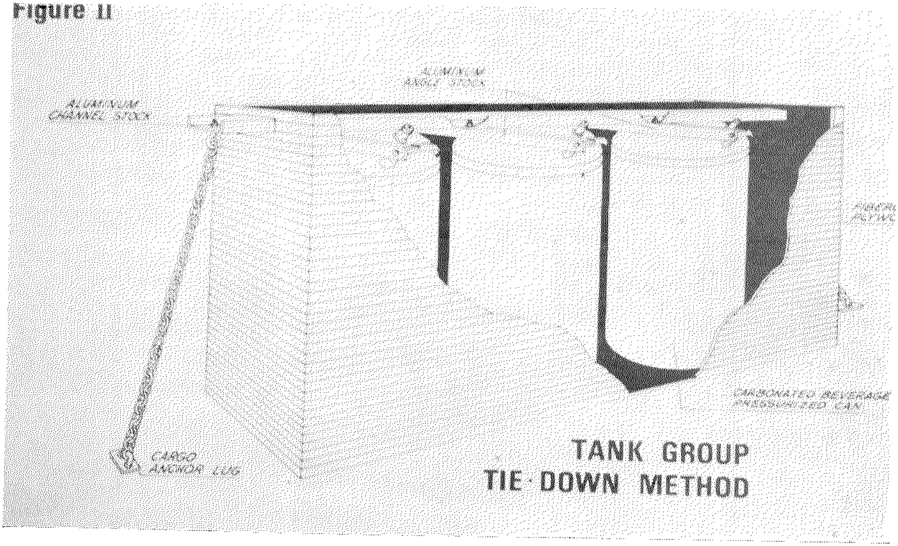

Figure 2

All the tanks within the system are connected in series by means of carbonated beverage dispenser tubing, as illustrated in Fig. 1. The tubing enters and exits individual tank group boxes via the same opening through which the aluminum channel stock protrudes (Fig. 2).

Insecticide line consists of a ½ inch semi-rigid translucent nylon tubing (1500 lb. rating). This is connected to the outlet fitting of one tank group and proceeds to a manual liquid on-off valve. The tubing then enters a section of hydraulic conduit, which ducts it through the aircraft skin. A "T" routes the line to the wings where it enters a 1¼ inch Simplex Streamline Boom. This boom is constructed in two sections, the main boom and the nozzle boom. The former is attached 6 inches below the wing by means of angled sections of aluminum and is gapped approximately mid-wing to form a flex joint allowing for wing movement (Fig. 1). Six attachments are made by 5 aluminum angle brackets on each main boom, and the inboard bracket which is secured by bolts extending through the wing root. The aluminum angle brackets are mounted by extending the screws from wing inspection plates.

The nozzle boom is attached 30 inches below the wing to insure that no spray will contact the aircraft. Attachment is made by two angle sections of aluminum covered with an airfoil shaped shroud. Two stainless steel rods extending forward from the nozzle boom to the wing serve to dampen vibrations. Three nozzles are attached to each boom.

Although the system will handle any liquid insecticide, it was primarily designed to distribute Dibrom. Because of the corrosive nature of this chemical, tanks are loaded just prior to use. All tank groups are first filled with air, and pressure-tested at 175 psi. Insecticide is then poured through a 100-mesh sieve into an outside tank, similar to those of the tank groups. This tank differs in that it has a vent valve in its lid for depressurizing after loading is completed. Tubing is attached from the outlet fitting of this tank to the outlet fitting of a tank in the spray system. Air pressure of 20–70 psi is applied to the outside tank, forcing the liquid into the spray tanks. One tank in the spray system is always left unfilled to act as a surge chamber. The outside tank is vented when all the liquid has reached the tank groups to prevent vibration in the tubing which could cause a line rupture. The procedure is repeated until the desired number of tanks are filled.

Once the craft is airborne, the air on-off valve is opened to pressurize the tank groups. The tanks are vented via the manual air vent valve prior to landing. This procedure is followed as a safety precaution to prevent pressurized spillage in the event of a mishap in landing or take-off. As a further safety measure, all personnel aboard the aircraft are issued gas masks. In the event of a line rupture, this would prevent the temporary blinding effect of Dibrom laden atmosphere.

Air pressure is also used in unloading the unused insecticide. The large air reservoir tanks used in spraying are disconnected and an outside air source is substituted. The system is pressurized and the liquid pushed outward into two tanks, one of which serves as a surge chamber. When one of these tanks is filled, the system is vented and the liquid set aside for storage. This procedure is repeated until all the tank groups are emptied.

After each use, it is imperative that the remaining Dibrom in the system be removed, the *entire* system flushed with isopropyl alcohol, the quick couplings on each tank individually cleaned and the "O" rings inspected. This practice *must* be accomplished *immediately* after each use to prevent and remove Dibrom oxidation products which tend to clog the system.

Static and dynamic testing of the spray system was conducted in August and September of 1967. The compressor's integral reservoir was used as an air supply in static calibration tests. The large reservoir air tanks are attached to the system by means of a quick disconnect fitting (Fig. 1), therefore filling of these tanks for such tests is not necessary. A series of four dynamic tests was designed to determine what combination of nozzle size, type, configuration and spray altitude would yield desirable spray patterns.

A review of the literature furnished little regarding optimum particle size and density for adult mosquito control with Dibrom. Control had been achieved with malathion at .3 lb. per acre, when particle size ranged from 50 to 60 μ at a density of 10 droplets per square inch. (Anon., 1967). Rogers (1967, personal communication) stated that particles of 50 to 60 μ are best suited to penetrate vegetation. It was decided, therefore, to attempt to produce particles within this range and determine effective swath width as that portion of the swath showing the greatest density.

In all tests, Dibrom was applied at the rate of .1 lb. per acre. Air speed was maintained at approximately 150 mph., at an altitude of 150 feet, unless stated otherwise. Boom pressure was set at 60 psi for Test I and at 35 psi in subsequent tests. All tests were conducted as soon as practical after sunrise, when temperatures ranged from 55° to 70° F., with wind velocities averaging less than 5 knots. Final determination of acceptable operating conditions was made with small toy balloons filled with helium. These balloons react quickly to existing thermal conditions, such as inversion and lapse layers. Treatment was made only after balloons were observed to travel upward at a rather constant rate. No application was made when balloons drifted erratically, because it was felt that spray deposits would likewise be inconsistent.

Determination of particle size, density, and swath width was made with Dibrom sensitive dye cards as described by Koundakjain (1965). Dye cards were placed at 40-foot intervals perpendicular to the line of flight in rows measuring 2,500 feet in length to insure impingement regardless of the amount of drift. Applications were made along a line paralleling wind direction to help minimize lateral drift. All tests were conducted in open areas.

In Test I, six TeeJet 8002 nozzles with 50-mesh strainers were angled 45° from horizontal into the leading edge of the wing.

Test II was flown using six 8004 TeeJet nozzles in a trailing position horizontal to the wing. This trailing configuration was used in all subsequent tests. Dye cards were placed in 3 rows to be recovered 10, 15, and 20 minutes after treatment, to furnish information on time required for impingement to occur.

Test III was designed to study the feasibility of using the aircraft speed to achieve particle break-up and produce acceptable particle size and distribution. The two inboard nozzles on each boom were plugged and the one remaining nozzle removed so that the material exited through the ⅛″ pipe opening to which the nozzle normally attaches.

Test IV studied the resultant particle size and distribution of the spray when application was made at varying altitudes, and in the form of a pencil stream rather than a fan or cone. Disc type tip orifices without cores were used to produce the pencil stream. Six D-4 disc type tips were used in applications made at 100 feet and also at 150 feet altitude. Likewise, two applications were made using four D-5 tips and plugging the inboard nozzles on each boom to maintain application rate of .1 lb. per acre. Both the D-4 and D-5 tips were used with 50-mesh strainers.

RESULTS. The 8002 nozzles angled into the leading edge of the wing (Test I) produced an erratic spray pattern. Impingement occurred in three separate segments, each averaging 350 feet in length along the 2,500 foot row of dye cards. Because of the inconsistent swath, determination of particle size and density was considered superfluous and therefore omitted.

Dye cards used in Test II indicate 15 minutes is sufficient time to allow for impingement. Recovery of the first row of cards began 10 minutes after treatment, and the first card showing impingement was reached after an additional 5 minutes had passed, i.e., at least 15 minutes had elapsed before this impinged card was recovered. The remaining rows showed similar particle density and size.

The 8004 nozzles used in the trailing position indicated an effective swath width of approximately 800 feet on all three rows of dye cards; particle size averaged 74.5 μ, with an average density of 1.4 particles per square inch.

Test III, in which the material exited through two ⅛″ pipe openings, produced a very erratic swath of 1,000 feet. Particle size ranged from 58 to 160 μ, with an average of 100 μ; particle density was approximately .6 per square inch.

Test IV compared results using D-4 and D-5 disc orifices at an altitude of 100 and 150 feet. Application at 100 feet with the six D-4 orifices produced an effective swath of 480 feet; particle density throughout this swath remained at a rather constant 8.5 per square inch. The range of particle sizes produced and the percentage of each is shown in Fig. 3.

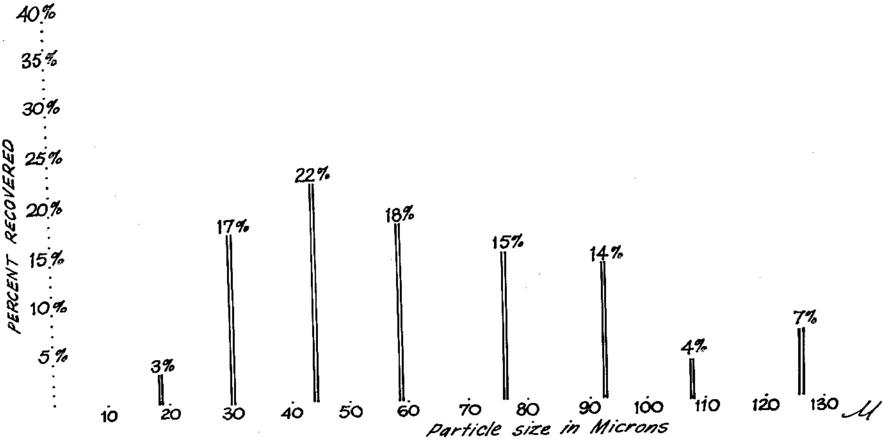

FIG. 3—Particle size range and distribution produced using six D-4 disc orifices at an altitude of 100 feet.

As indicated, sizes ranged from 18 to 128 μ, with an average of 62.2 μ. The majority of particles produced (22 percent) measured 44 μ.

Application made at 150 feet with the same nozzle configuration increased the effective swath to 520 feet; however, particle density was reduced to 2.2 per square inch. Particle size ranged from 8 to 109 μ, with an average of 75.6 μ, as shown in Fig. 4. Thirty-seven percent of the recovered particles measured 76 μ.

The four D-5 orifices making application at an altitude of 100 feet produced an effective swath of 440 feet. Particle size was rather evenly distributed and ranged from 18 to 160 μ, for an average of 86 μ; density remained at 3.5 per square inch.

D-5 orifices used at an altitude of 150 feet decreased the swath to 320 feet. The size of the particles recovered averaged 128.8 μ in a range of 24 to 193 μ. The density of these particles was approximately 2.1 per square inch.

DISCUSSION. Test I indicated that positioning the 8002 nozzles into the leading edge of the wing produced excessively small particles and resulted in an erratic swath.

Test II showed that a more desirable swath was produced when the nozzles were used in a trailing position. Apparently the 150 mph. speed of the C-47 is sufficient at this treatment rate to give good particle break-up when nozzles are trailing. This test also indicated that dye cards should remain in place until at least 15 minutes have elapsed from treatment time to insure impingement.

Results of Test III indicated that the craft speed is not sufficient for particle break-up without the aid of nozzles.

Test IV using six D-4 disc type orifices at 100 feet gave an average particle size (62 μ) which most nearly approximated that considered optimum by Rogers (50–60 μ). Since good control has been achieved with malathion at .3 lb. per acre at a density of 10 droplets per square inch, it is felt that the 8.5 particles per square inch achieved with Dibrom applied at .1 lb. per square inch should likewise yield good control. The spray patterns produced with the D-4 orifices operating from 150 feet and those produced with

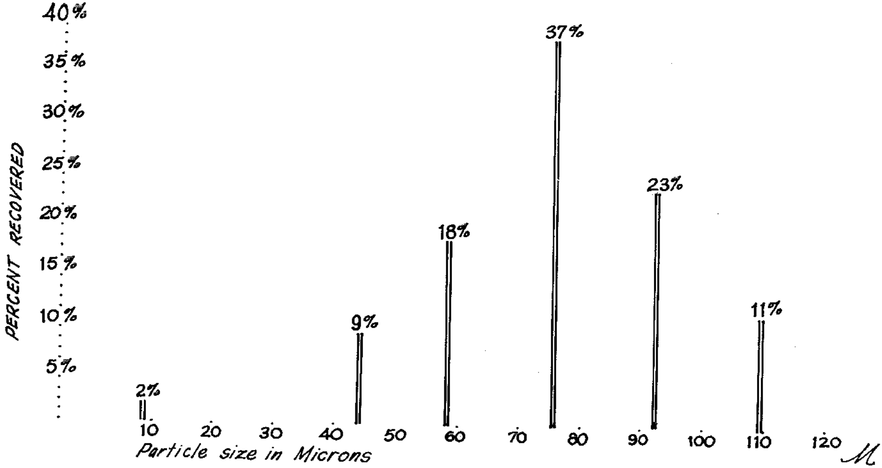

FIG. 4—Particle size range and distribution produced using six D-4 disc orifices at an altitude of 150 feet.

the D-5 orifies at 100 and 150 feet were similar with regard to particle size and density. However, the D-4 orifices gave a much larger swath, and therefore should be superior to the D-5 orifices.

The mosquito breeding season had come to an end before conclusive mortality tests could be conducted. Based on assumptions derived from these tests, attempts to control adult mosquitoes will be made using the six D-4 disc type orifices from an altitude of 100 feet. However, obstructions in some areas may force application to be made from an altitude of 150 feet.

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