ACKNOWLEDGMENT

We wish to thank Mr. Fred Lesser, Superintendent of the Ocean County Mosquito Extermination Commission and his personnel for their aid in this study.

References Cited

Boyd, J. E. 1972. Malathion *In* Analytical methods for pesticides and plant growth regulators. Ed. G. Zweig and J. Sherma, Vol. 6, pp 419–431.

Clements, A. N. 1963. The physiology of mosquitoes. Pergamon Press, ix+399 pp.

Ruckelshaus, W. D. 1972. Consolidated DDT hearings. Opinion and order of the administrator. Federal Register 37(131):13369–13376.

Von Rumker, R., G. Kelso, F. Horay and K. A. Lawrence. 1975. A study of the efficiency of the use of pesticides in agriculture. U. S. Environmental Protection Agency. EPA-540/9–75–025 xi+240 pp.

A TRAILER-MOUNTED INSECTICIDE MIXING-LOADING UNIT [1]

J. A. ARMSTRONG

Forest Pest Management Institute, Environment Canada, Sault Ste Marie, Ont., Canada

ABSTRACT. Research and small operational applications to study efficacy of pesticides applied by air or ground application equipment are frequently jeopardized by the use of poorly designed, ineffective mixing equipment. The result is the application of a badly mixed and frequently contaminated formulation. A trailer-mounted mixing-loading unit capable of handling suspensions, emulsions and solutions is described. The mixing tank is fitted with a paddle agitation and recirculation mixing system, can be readily cleaned, and has accurate metering of formulation. It is a self-contained system for power supply. An extra tank to hold clean solvent permits quick cleaning of the plumbing to prevent cross-contamination of the test batches of material.

Experimental and operational application of pesticides, whether by ground apparatus or aircraft is frequently troubled by the lack of a suitable system for accurately formulating and dispensing single or repeat batches of material. In too many cases the insecticide is mixed using a temporary arrangement of tanks, hoses, meters, measuring containers and odd pieces of wood (to serve as mixing paddles). These are awkward to handle, lead to inaccuracies in measurement, result in badly mixed formulations, and present a potential for contamination from drips and leaks of material. Another problem arises when different formulations or different insecticides are being tested; in these cases it is important that the plumbing and tanks be cleaned of all residues to prevent cross-contamination. When working in the field, there is the problem of carrying the numerous items required when mixing and handling insecticides. These include safety gear (respirators, hard hats, protective clothing, cleaning material) radio, tools, measuring containers, funnels, small bottles (to take samples of formulated material for chemical standards), hoses, couplings, as well as the many other bits and pieces that are always necessary.

The unit described in this publication is

[1] Presented at the New Orleans meeting, March 1977.

the result of several years' experience with temporary mixing systems and has gone through 3 stages of evolution to reach its final form. The aim was to have a portable, self-contained, mixing-loading unit with storage facilities to carry all necessary associated equipment, which could be towed by a ¼ ton pick-up truck. The unit was to be able to handle solutions, emulsions, and wettable powder mixes. It would therefore need a good mixing system (paddle agitators) with a recirculation system so that all lines could be flushed and the tanks cleaned. The mixing tank had to have access for visual inspection to check on cleanliness as well as a means for adding powders and small amounts of material and for removing samples for analysis. The floor of the tank was to be sloped to ensure complete drainage. It was also decided that there should be 2 tanks on the unit; a larger main mixing tank and, located above it, a smaller tank which would normally serve as a reservoir of solvent or which could hold a formulated batch of insecticide. The plumbing of the unit was designed so that material (insecticide or any solvent) could be pumped from an external source, or from either of the 2 tanks to an external source, or to the appropriate mixing tank. For measurement of liquids, a meter capable of accurately measuring to 0.1 U.S. gallon was fitted and the plumbing was designed so that the meter could be by-passed. The pump was to be an insecticide resistant pump with a working capacity of 20 gpm and capable of handling more viscous materials (*Bacillus thuringiensis* Berliner has been used extensively in our trials). Fitted into the plumbing, on the intake side of the pump, was a filter.

Since the unit was to have an agitation system plus a pump, and with the work program such that the crew was frequently preparing mixes before sunrise or after sunset when light would be required, it was decided to have mounted on the unit a gasoline powered electric generator; the pump and agitator would be electric motor driven. The source of electric power was also an advantage in that repairs requiring the use of electric tools could be easily carried out.

The plumbing of the unit was designed to keep pipe lengths to a minimum. This permitted better accuracy of fluid measurement and easier decontamination of the plumbing. All piping is 1½ inch inside diameter with unions to permit removal of the pump and/or meter.

Figure 1 shows the arrangement of the tanks, piping, valves, filter, pump, and meter. Both tanks are of stainless steel; the top tank has a capacity of 100 gal (US) and the bottom tank has a capacity of approximately 300 gal (US). The upper tank is not only a source of solvent for quick cleaning of the piping but also serves as a header tank to provide prime to the pump (centrifugal) when material is being pumped from an external source. This tank has a sloped floor to permit complete drainage and is fitted with a sight gauge. The floor of the 300 gal. mixing tank slopes to a 2 in diameter outlet which is divided with the main drain line going to the inlet side of the pump. On the other branch is a valve with a quick-fit connection; this line is used in connection with suitable hose extensions and an auxiliary gasoline powered 60 gpm pump. When repeat loads are being delivered to a spray aircraft, the batch of insecticide is prepared and mixed and then transferred to the aircraft with the high-capacity pump, thus reducing the loading time

In the plumbing schematic the valves are numbered from 1–10. If, for example, it is desired to pump a measured amount of material from an external tank to tank E, valves 1, 3, and 4 are opened and the rest are closed. This directs the flow from the external tank through the filter, pump A, and meter into the 300 gallon tank. To pump a measured amount of mixed insecticide from tank E into an external tank (i.e., spray aircraft), valves 3, 9, and 10 are opened and the rest closed; if metering is not required, valve 2 is opened and valve 3 is closed. To transfer a complete tank mix of insecticide from tank E, the auxiliary pump B is used. The pump and hoses are connected, valves 7 and 8 opened (all

PLUMBING SCHEMATIC FOR MIXING UNIT

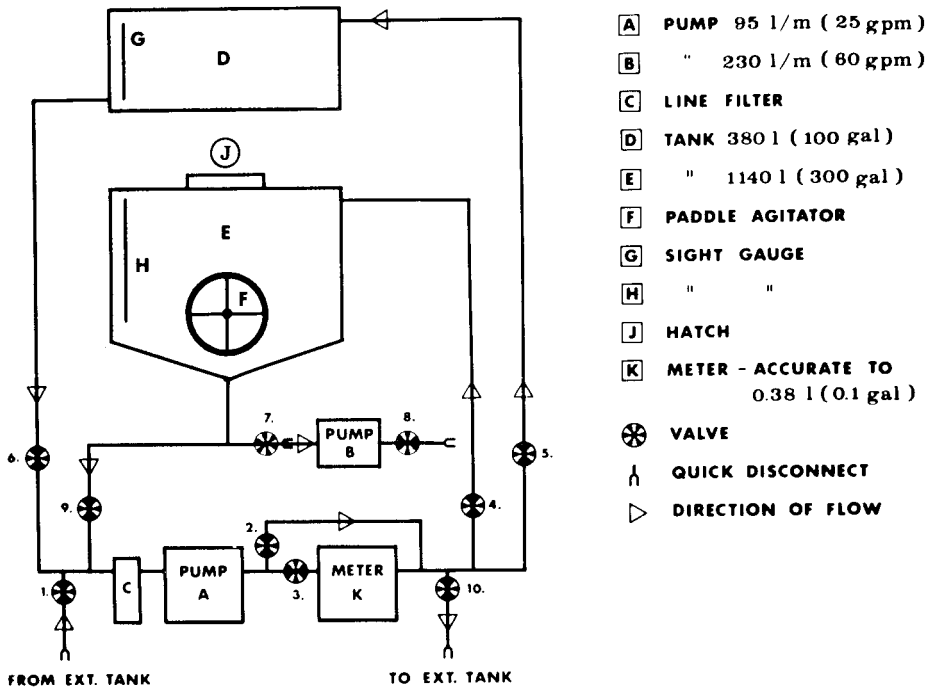

Fig. 1. Plumbing schematic for mobile mixing-loading unit.

other valves are closed) and the total contents of the tank are then pumped into the spray aircraft.

Valves 1, 7, 8, and 10 are ball valves, all others are gate valves. The use of ball valves, with the quick open or close capability at these positions, permits greater control when pumping material and gives better safety features in the prevention of leaks.

The paddle agitation system consists of 2 sets of paddles mounted on a horizontal shaft running the length of the tank. The paddle and shaft are of stainless steel connected by a 30:1 gear reduction box to a 1/3 HP motor giving a paddle rotation of about 55 rpm. The paddle blades are set with a slight twist to move the mixture lengthwise through the tank as well as giving a rotary mixing effect. The shaft enters the tank through a leakproof, frictionless, Viton-sealed, bearing mounted in a ½ in. thick stainless steel plate. The plate, again sealed with a Viton seal is bolted to the tank and covers a hole of sufficient diameter to permit extraction of the complete paddle unit. The end of the shaft is supported in the tank in a teflon-lined receptacle to provide a frictionless bearing.

The hatch opening is approximately 12 x 16 in.; fitted in the opening is a removable, stainless steel screen with a ½ in. mesh. The main mixing tank is also fitted with a sight gauge. Storage space for other equipment is in sets of lockable boxes on either side of the main mixing tank. The tank and side boxes are covered with steel decking which has a non-skid surface. The smaller 100 gal. tank is mounted above the 300 gal tank and it also is decked over, in

this case to provide protection to the tank. Also sitting on the deck above the main mixing tank is the generator; the model used is a 2 Kva Honda which provides sufficient power for either the pump or the agitator. The 100 gal tank is vented through a ½ in. diameter hole; the hatch on the 300 gal tank is sufficiently loose-fitting to allow passage of air when the tank is being filled or emptied.

Figure 2 is a photograph of the "control" end of the mixing unit showing the position of the 2 tanks, pump, filter, meter and plumbing as well as the agitator motor. Switches to control each motor are mounted on the frame of the trailer. All electric wiring is heavy-duty outdoor grounded wire, metal shielded for protection. The ends of the side boxes can be seen. To stabilize the trailer for working, the end is blocked and the support jack mounted on the trailer tongue is then screwed down to form a rigid support. The fire extinguisher is carried in a side box and is moved to the external mount when working. In the photograph on the side box can be seen the bracket for carrying the collapsible 30-ft radio antenna mast.

In Figure 3 the right-hand side box fitted with a drop door is opened to provide a work area. Within this side box (which is kept "clean") are kept full face respirators, first aid equipment, writing materials, etc. The tongue of the trailer is decked over to provide a standing platform when mixing insecticides. Mounted in front of the 300 gal tank is the spare wheel; above the 300 gal tank are mounted the generator and the 100 gal tank. The hatch opening is in front of the generator. On the antenna mast is fastened a cross-arm which supports a light. For convenience, the radio is kept in a vehicle and connected to the antenna lead for use. This keeps the radio operator away from the noise of the generator and with the 30-ft mast gives a good range. The left side boxes of the mixing unit are considered "dirty." In them are stored hoses, couplings, delivery nozzles, suction pipes, etc. The hose used is 1½ in. inside diameter rigid wall insecticide resistant hose. Three lengths of hose are carried; one 50 ft and the other two each 25 ft. All are fitted with male and female 1½" quick-fit connectors so they can be joined if necessary to give a longer delivery or suction hose.

Figure 4 shows the unit hitched to a vehicle with all accessories stowed. The radio antenna is mounted on a bracket on the top tank frame, the generator is covered with a fitted tarpaulin and the tower is collapsed and stowed for travel. Caps and plugs cover the ends of the hose connectors on the plumbing to keep dust out. The electrical motors of the pump and agitation system are both explosion-proof and shielded for outdoor use. These are not covered in transit. The complete unit empty weighs about 2000 lbs, and is fitted with stop and turn indicator lights and electric brakes to meet highway code specifications. The trailer is never towed with liquid in the tanks.

Exact dimensions of the unit are not given in this report. The first design made use of available 100 and 300 gal fuel oil tanks and all measurements were made to accommodate these. At a later date the stainless steel tanks were built and fitted into the existing unit. Operationally a mixing tank of 300 gal capacity has been most convenient. Virtually all our spray trials are carried out using a Cessna 185 fitted with a Sorensen tank. The load capacity of the Cessna 185 is 100 gal and hence the mixing unit can easily prepare 2–3 spray tank loads at one time. On occasion, when working with aircraft with a greater load capacity (Pawnee, Agwagon, etc., with 150 gal capacity), up to 2 batches can be handled. By preparing a primary 100 gal batch which is transferred to the upper 100 gal tank and then using the main tank, a batch of approximately 400 gal can also be prepared.

In the 3 years of use involving formulations of oil solutions with solvents such as No. 2, No. 4 fuel oils, Arotex 3470 (a product of Texaco Oil Company, Montreal, Canada), emulsions, wettable powders, and suspensions of biological materials, we have had no problems from leaks or corro-

Fig. 2. The mixing-loading unit "control" end showing a 100 gallon tank on top, filter, pump, drive unit for agitator, and meter.

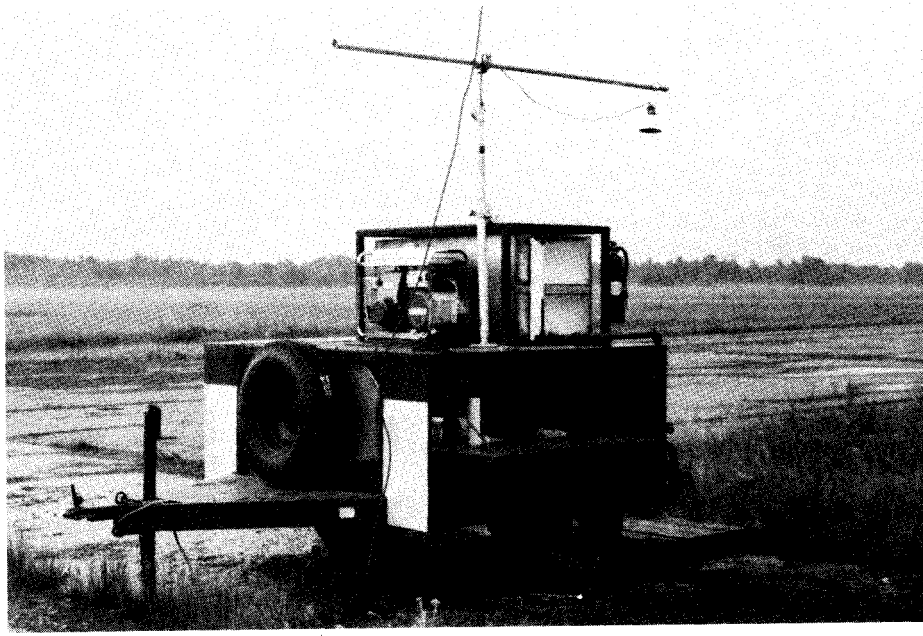

Fig. 3. Mixing-loading unit, side box open, generator on upper deck.

Fig. 4. Mixing-loading unit, with equipment stowed and hitched to pick-up.

sion. When using the powders and suspensions, the fine screen (20 mesh) is removed from the filter. The unit is highly mobile, is completely self-contained, can be brought in to use within 30 min. of arrival at the work site, and with its design assists to keep the work area neat and clean.

The design of this unit not only provides for a compact, efficient insecticide mixing system but it has many features to ensure worker and environmental safety. The electric motors are weather and explosion proof and the wiring is shielded and grounded. The use of a single power source (the gasoline-powered electrical generator) with a tank capacity for approximately 5 hr running time obviates the necessity of handling gasoline during a mixing-loading schedule which frequently occurs when separate gasoline-powered pumps and agitators are used. The platform provides a stable stage on which a crew member can stand to add material via the hatch, and the hatch is below waist-level of a crew member standing on the platform. Once all materials are in the mixing tank, the hatch is closed and all operations are then carried out from the "control" end of the unit. A person standing at the "control" end has, within easy reach all valves (with the exception of valve 8 for the auxiliary pump B) the switches to control the pump A and the agitator motor. The use of ball valves at 1, 7, and 10 allows for immediate cut-off of flow from or to an external system. The operator also has within his field of vision the meter and the 2 sight gauges so that volumes can always be checked. With the capability of carrying tools and a full complement of spare parts, there is neither the need, nor the temptation to carry out repairs and servicing with improper equipment. It has also been observed that with safety equipment readily available, workers are more willing to use it. On completion of a work program, all plumbing and tanks can be flushed by operating the appropriate valves, and the contaminated waste material is transferred to a separate tank for disposal at an approved site.