

Aedes aegypti Handbook Series No. 5

HANDBOOK OF INSECTICIDE APPLICATION

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HANDBOOK OF INSECTICIDE APPLICATION

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INTRODUCTION

The application of insecticides to achieve an immediate reduction of the yellow fever mosquito *Aedes aegypti* is one of the most important activities of the *Aedes aegypti* Eradication Program. It is essential that the insecticidal treatment is made in a thorough, effective, economical and safe manner. To attain this goal and achieve eradication, the spraymen must know the materials and equipment, and use the proper techniques of spraying.

The purpose of spraying is to kill *Aedes aegypti* mosquitoes by applying an effective insecticide in those water-holding containers and on those surfaces where *Aedes aegypti* adults, pupae, larvae, or eggs may be present or may later be deposited.

Three methods of insecticide application are now used in the *Aedes aegypti* Eradication Program:

- a. Power Spraying - A truck-mounted tank with gasoline engine-powered pump equipped with hoses and nozzles is used to apply insecticide to large accumulations of containers, particularly in substandard residential and commercial areas.
- b. Hand Spraying - A 1- to 4-gallon hand-pumped, hand-carried compressed-air sprayer is used to apply insecticide to areas with a few containers. Small hand applicators are sometimes used to apply liquid insecticides for spot treatment.
- c. Hand-Dusting - A hand-carried insecticidal dust applicator is used to apply dry forms of insecticide, such as dusts or granules, to individual containers, particularly those with cuttings.

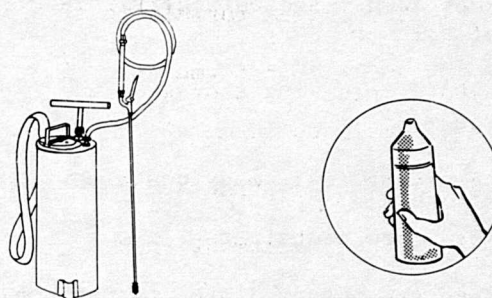
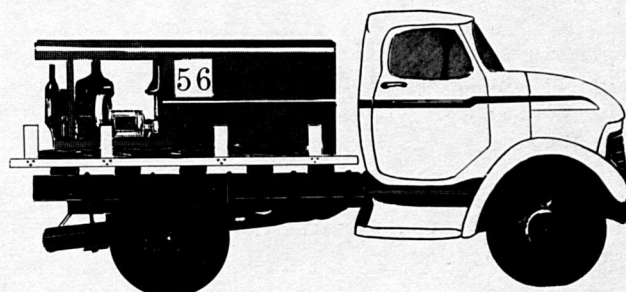


Figure 1. Insecticidal application equipment

This handbook describes some of the techniques of insecticidal application and is to be considered as a guide rather than as procedural policy. The policies and procedures for insecticidal treatment are covered in "Operational Letters" and "Guidelines" issued by Headquarters.

SELECTION OF EQUIPMENT

The primary purpose of insecticidal application is basically the same, regardless of the method chosen, namely the distribution of an effective insecticide into water-holding containers where *Aedes aegypti* larvae are, or later may be present. The use of the spray as an adulticide or as a residual surface spray is secondary to the larvicidal effect.

The type of equipment to be used in a particular area is determined by the area supervisor. No hard-and-fast rules can be established with regard to the selection of equipment for a particular area. In general, however, the following guidelines are suggested:

Large premises with well kept lawns, small number of breeding containers	Compressed-air hand sprayer or duster
Small premises with well kept lawns or gardens, small number of breeding containers, trailer courts, motels, etc.	Compressed-air hand sprayer or duster
Middle-class houses, with moderate number of containers, intermediate <i>Aedes aegypti</i> infestations	Optional: Power sprayer or compressed-air hand sprayer
Low socioeconomic area. Dilapidated houses, accumulations of containers, poorly kept lawns, and shrubbery, high number of <i>Aedes aegypti</i>	Power sprayer
Auto junkyard, plumbing storage, tire yards	Power sprayer
Overgrown vacant lots, many containers	Power sprayer
Vacant lots, few containers	Hand sprayer

There are intermediate, transitional, or over-lapping situations that will require a judgment by the foreman as to the appropriate method of insecticide application. Such decisions must be consistent with the objectives of the Program, as well as with good practice of safe, selective application of the insecticide to containers and sites where *Aedes aegypti* are present.

A wall map in the area office may be used to indicate the special problem sites, the general power-spraying sites, and the sites that are to be treated with hand sprayers.

PROCEDURES FOR INSECTICIDE APPLICATION

STRATEGY OF OPERATION

The primary object of application of residual insecticide is to kill larvae of *Aedes aegypti*, either those in the container at the time of application, or those that hatch from eggs in the container following flooding. These eggs may be in the container at the time of spraying, or they may be laid on the container walls some time after the spray application and hatch following rains or other flooding.

In order to ensure a complete kill of yellow fever mosquito larvae, the spray operation must be thorough, aiming at total coverage both in quantity and quality; the dosage must be adequate.

The frequency of application is determined by the biological activity of the insecticide applied (at intervals of 3 months in areas where DDT is used and 2 months in areas where malathion is used).

The strategy of operation should be planned so that schedules for insecticide application are well timed according to the period of larval and adult activity of *Aedes aegypti* - that season of the year when average temperatures are above 50°F. for weeks or months. Thus in much of Georgia, South Carolina, and northern Alabama, the application of residual spray to water-holding containers beginning in April and May would allow complete coverage in most zones before the over-wintering eggs hatch. In parts of Florida, Puerto Rico, and Texas, breeding may occur throughout the year, and the number of positive containers is governed more by the amount of rainfall than by daily temperature.

ASSIGNMENT OF WORK

At the beginning of each day the foreman fills out the first three lines of Form 2.3, "Block Treatment Record," (Figure 2) for each spray crew and gives these forms to the crews as their assignments for the day. These assignments are made before or during the period when sprayers are loaded and checked. The trucks are assigned to a zone where they will be reasonably close together, to simplify supervision of the operation. One way in which this can be handled is to start with the southeastern block in a zone where the first truck crew or hand spray crew is assigned (Figure 3). The other crews are assigned to contiguous blocks to the west, and work northward as blocks are completed. The foreman should remain in the area with the trucks to provide good supervision and support.

BLOCK TREATMENT RECORD

County Tiller Cycle 3
 Sector A Zone 14 Block 167
 Date 3-V-66 Crew Brown & Hyde
 Type of Insecticide Used _____ % Concentration of Finished Spray _____
 No. of Gallons of Finished Spray Used in Block _____
 Other Insecticide Used _____ Amount _____

No.	Premises Address	Closed	Refused	Exterior Treated		Interior treated or comments
				Power Sprayer	Hand Sprayer	
1						
2						

Figure 2. Block treatment record

PROCEDURES IN TREATING BLOCKS

In each block the spray crew starts at the southwest corner and writes with chalk where it can be seen easily from the street - for example, on a curbstone, the sidewalk, a utility pole, or a smooth-barked tree. The time of day, the day, month, and year of treatment, an arrow indicating the direction of spraying, and initials of the crew are legibly written. The days of the month are written in Arabic numerals (1, 2, 3, 4, etc.) and the months in Roman numerals (I for January, II for February, III for March, etc.). For instance, if a crew begins treatment at 8:00 AM on May 3, 1966, they write '8:00 AM, 3-V-66', arrow pointing to the left, and their initials (Figure 4).

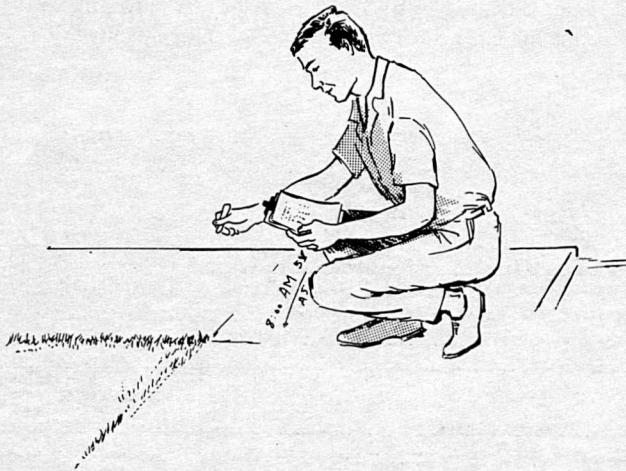


Figure 4. Marking location of work area

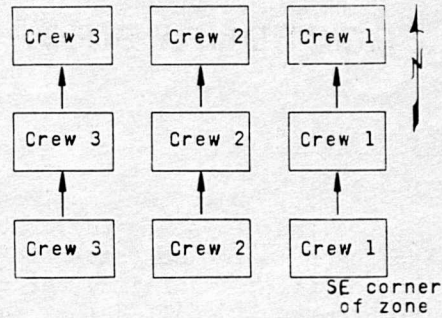


Figure 3. Assignment of blocks for treatment

Before spraying is begun, the crew leader notes on Form 2.3 the amount of insecticide in the tank, the type of insecticide used, and the percentage concentration of the finished spray. This makes it possible to subtract the amount of spray left after completing the block and to enter the difference in the space following "No. of Gallons of Finished Spray Used in Block." If a duster or hand sprayer is used in addition to the power sprayer, this is entered on the last line of the heading.

If hand sprayers are being used, the sprayman begins with the premises on the southeast corner and works around the block in a clockwise fashion. If power equipment is being used, it often saves time for the two men in a spray team to separate and walk around the block in opposite directions, contacting an adult in each household to obtain permission to spray water-holding containers in the yard. Each sprayman should identify himself to the owner or occupant of the premises. He should be polite but persuasive.

Regulations of State and local departments of health concerning entry into private property must be observed. Ordinarily, permission to enter a specific premises must be obtained from the occupant. It can not be over-emphasized that the success of the eradication program rests directly upon the cooperation of the public.

As the spray crew enters each premises the crew leader records the address on Form 2.3 and makes a check mark in the appropriate column - Closed, Refused, Power Sprayer, Hand Sprayer, Interior Treated or Comments. He follows this procedure until the entire block has been treated.

Insofar as possible, spraying should be carried out systematically. Because of the variety of ways that houses or other buildings may be placed on a lot, only general rules can be given with regard to insecticidal application. When possible, the spraymen should start to the right of the entrance and proceed around the edges of the lot in a counter-clockwise direction to the rear center of the premises. Special attention should be given to containers that may be hidden under vegetation, or rubble, or in out-buildings. In many situations the spraymen will work to the middle of the back of the lot and then go to the building in the center, working around the building completely to the rear again and then follow in a counter-clockwise fashion around the edges to the main entrance (Figure 5).

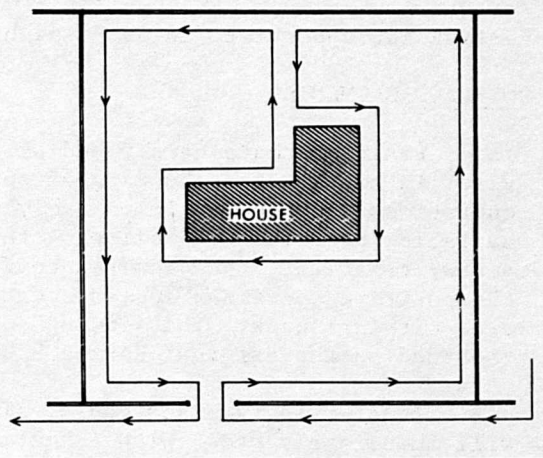


Figure 5. Direction of travel when spraying premises

A power spray crew is composed of a sprayman who applies the insecticide, and a hoseman who handles the hose. Ordinarily, the more experienced man acts as crew leader and is responsible for reporting. The men alternate in the two positions as sprayman and hoseman to make the work less arduous and provide a change of task.

The sprayman and hoseman are jointly responsible for finding every container on each premises and making certain that all containers receive adequate, but not excessive, treatment. The spray is directed at containers rather than at vegetation and other non-breeding sites. Care is taken at all times to avoid damaging plants, animals, animal feeds, automobiles, and other property. Both crew members function as a close-working team in doing a good job.

The sprayman regulates the amount of treatment to suit the size of container. The hoseman stays 8 to 10 feet behind the sprayman, keeping the hose slack between them to facilitate good handling of the spray gun. Both of them maintain vigilance in order not to miss hidden containers. The team does not leave a premises until all potential breeding places have been treated. A missed container may mean that an entire block will become reinfested.

In unkempt vacant lots where containers are hidden by heavy vegetation, and cannot be readily found and treated, it may be necessary to apply area coverage to assure treatment of the containers. It is preferable to have such lots cleared by the owners, or by action of local health authorities in implementing public-nuisance ordinances. In spraying a vacant area, it is preferable to take the hose

to the rear of the lot (Figure 6) and spray in 10-foot swaths toward the front of the lot. In this way the crew does not have to walk through treated vegetation, and an orderly procedure simplifies a complete coverage of the area.

When treatment of a block has been completed, the sprayman draws a diagonal line through the marks that he made when starting work in the block. This will assist the supervisor in locating him.

OTHER TREATMENTS

Positive containers found by a supervisor in his routine checking of spray operations are treated immediately with a suitable insecticide. Following this supervisory treatment, the premises containing the positive container and adjacent premises are re-treated by the responsible spray crew within a week. The finding and treatment of positives by supervisors are recorded on the original Form 2.3 by the supervisor.

Insofar as is practicable, all program people will carry dust dispensers and will immediately treat with insecticide all positive containers found during the course of inspection activities. Prior to treatment an adequate sample of larvae will be taken for subsequent identification under a microscope. Treatment by inspectors is not a substitute for scheduled insecticidal treatments. However, if all containers on a block are treated, this fact will be reported by the inspector on Form 2.3.

TREATMENT CYCLES

Three-month cycles of spraying are standard in areas using DDT, and two-month cycles are standard in areas using malathion. Special problem sites with exceptionally favorable breeding places are scheduled for monthly cycles. These sites include used-tire storage yards, junkyards, and businesses storing used appliances such as old sinks, toilets, and bathtubs outdoors. It is difficult to achieve eradication in these places, especially when used tires, junk, and appliances are continuously received from and shipped to distant locations (Figure 7).

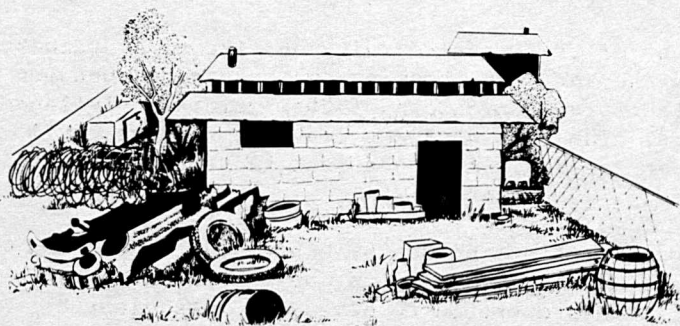


Figure 7. Special problem area

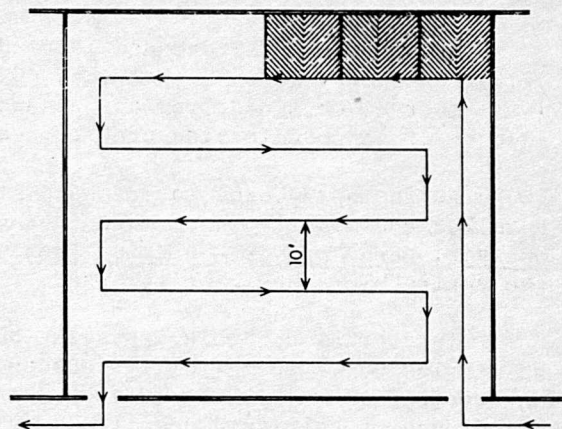


Figure 6. Procedure for area spraying

The area supervisor together with the Project Officer, should determine which types of site in each zone are to be placed on a monthly inspection and spraying cycle, and record on Form 2.28 (Sites Requiring Special Attention). Such monthly cycles are continued until the area supervisor believes that such frequent treatment is no longer necessary. The inspection is done concurrently with the insecticidal application.

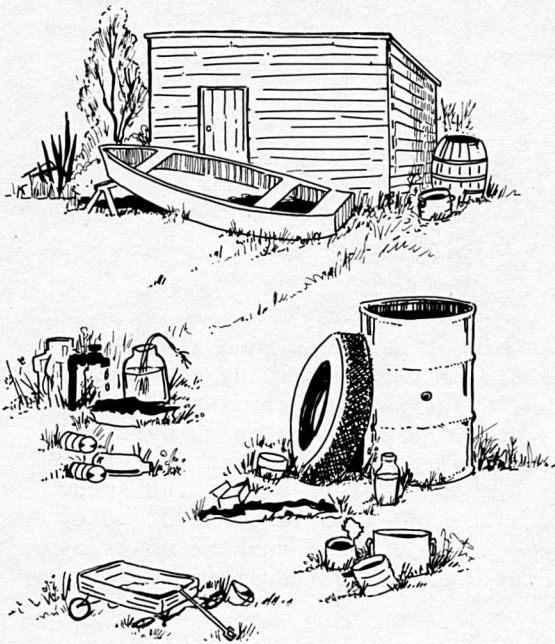


Figure 8. These should be sprayed

Judgment must be used in applying insecticides. Interior walls and ceilings of old sheds or other outbuildings are sprayed, together with any potential breeding containers in such sheds or outbuildings. This does not pertain to walls and ceilings or garages or carports, but all containers which are potential breeding sources for *Aedes aegypti* in such structures are treated.

The interiors of residences are not treated for adult mosquito control except where such spraying has been approved. All interior water-holding containers where mosquitoes are breeding are treated as well as others deemed necessary in the judgment of the area supervisor.

THESE SHOULD NOT BE TREATED

The interior of residences, unless approved by higher headquarters

Open areas, such as well-kept lawns, without containers

Feeding troughs in cattle barns or poultry yards

Aluminum boats, automobiles

Worm beds and fish bait boxes with crickets or cockroaches

Beehives and their immediate surroundings

Fruit trees and vegetable plots

Fish ponds

THESE SHOULD BE TREATED

All discarded buckets, tin cans, jars, or other containers holding water, or that could hold water allowing *Aedes aegypti* to breed (Figure 8).

The insides of old tires.

Junk automobiles and accessories.

Containers in overgrown vacant lots.

Trash or rubbish dumps, to the extent necessary to insure treatment of hidden containers.

Bromeliads and other air plants are treated only with the water suspension or with dust. They must never be treated with the emulsion as the xylene solvent may injure these or other sensitive plants (Figure 9).



Figure 9. Bromeliads

Sensitive plants such as:

Arborvitae	Bananas	Hibiscus	Papaya
Philodendron	Poinsettia	Ferns	Gardenias
Roses	Laurel	Orchids	

POWER SPRAYING

The power sprayer is particularly useful in problem areas such as junk automobile yards, storage areas for old tires, and vacant lots with many scattered containers. Power equipment is also used to advantage in many premises in commercial or lower socioeconomic residential areas where there are large numbers of water-holding containers and many actual or potential breeding places for the yellow fever mosquito. The high pressure makes it possible to direct the spray into masses of containers and obtain penetration to hidden collections of water not easily reached with hand sprayers. The 100- to 300-gallon tank on power sprayers provides the large volume of insecticidal spray required for treating such problem areas.

DESCRIPTION OF EQUIPMENT

The power spraying unit consists of a truck-mounted tank containing an agitator and a reciprocating or centrifugal pump. The agitator and pump are belt-driven by an air-cooled gasoline engine (Figure 10). A pressure regulator valve with a tank return by-pass is located between the pump and the discharge line. A pressure gauge measuring pounds per square inch (PSI) and a simple on-off valve are connected in the discharge line next to the hose connector.

The unit has two 250-foot lengths of 3/8" internal diameter high-pressure hose of good quality with no more than three splices in each 250-foot length and no section under 50 feet long (when new) and an adjustable orchard spray gun. For routine spraying with 250 feet of hose the pressure is 250 pounds per square inch at the pump. This pressure can be reduced when drift or splash would be objectionable, as at trailer parks, or during days with strong winds. For 500-foot lengths, to reach more distant points, the pressure at the pump is increased to 450 or 500 pounds; otherwise friction due to added hose

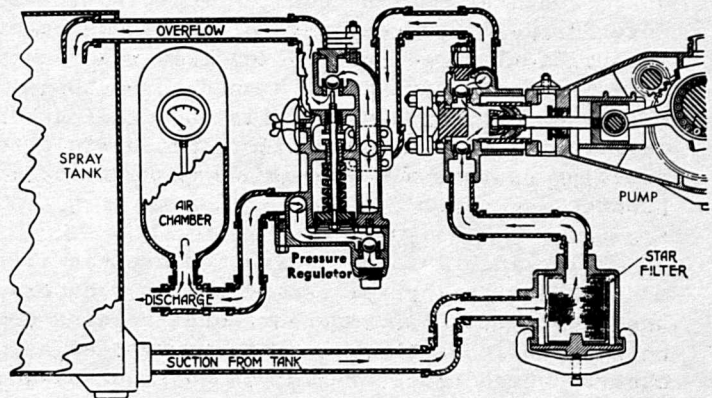


Figure 10. Flow diagram of hydraulic power sprayer

length would reduce the pressure at the nozzle. Some power spray units are equipped with a 500-foot hose reel. The 250 feet of hose used in the routine operations is mounted on the reel, with the extra 250 feet being carried as a spare. Care must be taken to avoid dragging the hose when the unit is moved from premises to premises, since dragging causes excessive wear.

Nozzle face discs are available with at least three orifice sizes: 15, 30, and 60, with the 60 orifice being the largest. For routine premises spraying the number 30 nozzle orifice is used on many project areas. The spray pattern is adjustable from a wide angle cone to a solid stream as desired with the control handle.

POWER SPRAYING PROCEDURES

The spray team must obtain permission from an adult householder before proceeding with spraying operations. As a rule when the two-man team drives into a new block, the men separate and go around the block in opposite directions, contacting an adult on each premises, if possible. After permission is obtained, the leader systematically plans his spraying operations for the block.

The man carrying the spray gun is called the sprayman. The second man is known as the hoseman. The work may be alternated, if each man is adequately trained to do both jobs. Both men look for containers to be sprayed as they proceed through the premises.

The amount of insecticide delivered depends upon a number of factors including: concentration of insecticide, pressure, orifice size, speed of movement of the spraymen, type of spray pattern, and length of time valve is open.

In general, the wide-angle cone spray is used for spraying and the spray is directed into potential or actual water-holding containers. The sprayman moves at a steady rate and whenever a container is discovered, opens the valve for a sufficient time to place the insecticide in the container or containers. HE MUST NOT OVERSPRAY. The solid stream spray pattern has limited use in the *Aedes aegypti* eradication program. It is used primarily for reaching containers otherwise inaccessible, such as tree holes and junk auto or tire yards.

The objective of spraying is to treat all containers that hold water or may later hold water and produce *Aedes aegypti* larvae. The reason for spraying harborage areas, such as dense hedgerows or piles of old lumber and trash, is to get spray into containers that may be hidden, and to place a residual deposit on adjacent surfaces where the adults may rest. Some sites with very dense foliage have to be cleared before spraying can be done effectively. In clean premises where it is obvious that potential or actual containers are not present, no spraying is done.

Hose Handling

Spray hoses are awkward and difficult to handle on a residential premises unless one plans the route of spraying in advance (see Figure 5). Trees, buildings, and other obstacles must be considered. In very deep lots the most satisfactory plan is to start spraying at the back of the lot and move toward the truck (see Figure 6). In this way, the hose is laid out along the route of spray coverage, taking care not to injure plants and shrubbery. In vacant lots the sprayman and the hoseman work from the back to the front and thus minimize contact with sprayed vegetation.

The hoseman works 8 to 10 feet behind the sprayman and moves the hose as needed (Figure 11). This frees the sprayman from pulling the hose and permits him to give full attention to the spraying of containers. The hoseman avoids damage to the hose by not kinking it, permitting it to rub against sharp edges, or dragging it over pavement. Care in handling the hose prolongs its useful life.



Figure 11. Hose handling

OPERATION AND MAINTENANCE OF EQUIPMENT

The manufacturer's instructions on operation, maintenance, and lubrication of the power spray unit must be followed carefully each day that the sprayer is used. Pumps and pipes must be drained and flushed with clear water at the conclusion of the operational season to prevent damage due to corrosion or freezing during the winter. Recommendations of the manufacturer must be followed to prepare equipment for use and storage. Defective parts are replaced as needed. The truck and power spray unit are thoroughly cleaned weekly.

Check List for Motor Vehicles

The following items are checked at regular intervals as specified by area supervisors:

- | | | |
|-------------------|--------|----------|
| Oil level | Water | Fan belt |
| Windshield wipers | Horn | Lights |
| Tires | Brakes | |

This equipment must be in good operating condition at all times and any deficiency must be corrected immediately as a safety measure. In most areas the maintenance of the vehicle is the responsibility of the General Services Administration, but the operator has the responsibility for reporting any deficiencies in his equipment.

Maintenance Procedures

Hour meters are needed for all motors on the power sprayers for organizing preventive maintenance schedules. Preventive maintenance charts should be kept for all vehicles and spray motors. Dates, speedometer readings, hour meter readings, and various necessary maintenance actions such as greasing and oil changing are needed at least weekly. Sprayer maintenance-and-repair wall charts and records are described in Operational Letters from Branch Headquarters. All equipment should be kept free of spilled insecticide and washed weekly by the crew to which it is assigned. This is in addition to daily cleaning of hose, spray guns, filter screens, and transfer of insecticide, where desirable, into one or more sprayer tanks.

HAND SPRAYING

There are many instances where hand spraying of insecticides for *Aedes aegypti* eradication is the method of choice. This is particularly true for sites with few containers and light infestations, in better-class residential areas, and in sites not accessible to the power spraying unit. The hand sprayer is useful in treating specific containers where the amount of insecticide applied is small and the application must be controlled accurately to avoid wind drift and unnecessary contamination of nearby fish ponds or plants sensitive to the spray.

DESCRIPTION OF HAND SPRAYER

Hand sprayers are small, self-contained units with a capacity from less than 1 pint to as much as 5 gallons. The larger sprayers are often called knapsack sprayers, as they are carried on the back, or suspended from one shoulder by a strap. These sprayers are operated hydraulically, or by means of compressed air or carbon dioxide. The hydraulic sprayers, like the power sprayers, have a liquid pump which forces the spray liquid out of the hose and nozzle. The compressed-air and carbon dioxide sprayers deliver spray as a result of the gas pressure (air or CO₂) upon the liquid in the tank.

The 3-gallon compressed-air sprayer used in *Aedes aegypti* eradication is the most popular type of hand sprayer, except perhaps the flit gun and the aerosol sprayer. Millions of similar sprayers have been used for home and garden spraying. The Armed Forces used these sprayers for insect control and for decontamination purposes. Hand sprayers of this type are used in the world wide malaria eradication program. Thus this sprayer has been highly developed and proven to be an excellent insecticide applicator, one that meets a large need in this program.

The sprayer used by *Aedes aegypti* personnel has a 3-gallon stainless steel tank, which holds the liquid insecticide and the compressed air to produce a spray pressure of 30-50 pounds per square inch (Figure 12). It is provided with a self-seating cover and pressure release valve, an air pump, and a dip tube. A $\frac{3}{4}$ " inner diameter spray hose is attached to the dip tube in the head of the tank and to the spray gun assembly. The spray gun assembly consists of a hose nipple with built-in strainer, a cut-off valve, the wand, and the nozzle.

The pump assembly has a piston with a leather or plastic cup that fits snugly into the pump cylinder. An inlet valve is located in the base of the piston to admit air to the piston on the up-stroke. This valve closes and prevents the escape of air on the down-stroke. An outlet check valve is located at the bottom of the pump cylinder,

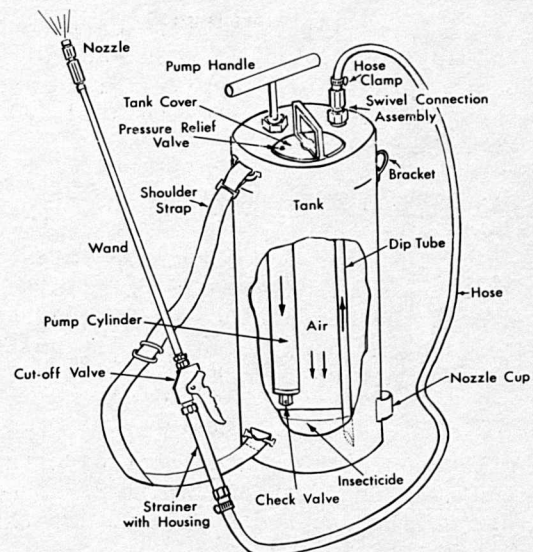


Figure 12. Detailed diagram of hand sprayer

and is opened by the pressure of the air in the cylinder on the compression down-stroke. The check valve prevents insecticide formulation from entering the pump cylinder. This permits the air to enter and build up pressure in the tank chamber containing the insecticide formulation.

A dip or outlet tube, extending almost to the bottom of the tank, is attached to the delivery hose. A filter screen is located in the upper part of the dip tube to screen out dirt particles that might clog the nozzle. Another filter screen is mounted in the nipple of the cut-off valve assembly where the other end of the hose is mounted. The cut-off valve serves as the spray gun handle as well as a means for controlling the flow of spray. An 18-inch length of brass tubing, known as the wand, serves as an extension of the spray hose and has a nozzle attached to the end. One or two additional wands may be attached to treat places that are out of reach. Various types of nozzles are available depending upon the type of spray application desired. In the *Aedes aegypti* eradication program, a type which produces a turbulent cone spray is used.

The tank of the compressed air sprayer is filled to the fill mark (about the 3/4 level) with the diluted spray liquid. Air is compressed into the remaining space by applying 40-50 strokes of the pump. After unlocking the pump handle, it should be raised to its full length and pushed all the way down steadily. This action should be repeated until the pumping becomes noticeably difficult. Do not use rapid, sharp, short strokes as this is inefficient and tiring.

Pumping must be repeated at frequent intervals to maintain a spraying pressure averaging 40 pounds per square inch. The number of strokes necessary to develop adequate pressure will increase as the spray liquid level drops and the air space in the tank becomes greater.

After pumping, the spray pattern is tested by briefly opening the cut-off valve. The spray should be delivered with some force in an even, symmetrical cone shape. Suspensions require occasional agitation to prevent the solid particles from settling to the bottom of the sprayer.

Extra insecticide is carried by the foreman in his pickup truck to replenish the sprayman's supply when needed. The hand sprayer is sometimes filled from the power spray truck supply. Since hand spray application is selective and limited amounts of insecticide are used, adequate daily supplies for 6 spraymen are easy to carry.

HAND SPRAYING PROCEDURES

The sprayman obtains permission from an adult householder immediately before spraying a premises. If permission to treat is refused, the sprayman courteously states the benefits to be derived and urges reconsideration. If permission is still refused, he does not argue but politely and promptly leaves the premises. All refusals must be reported in writing to the foreman on Form 2.3.

With permission obtained, the sprayman systematically proceeds counter-clockwise around the house, searching for actual or potential water-holding containers and treating each one as it is found. Observations and movements of the sprayman are deliberate and systematic so that no containers, wet or dry, are missed or overlooked.

When a container is located, the sprayman holds the nozzle tip about one foot from it and opens the cut-off valve. The amount of spray delivered depends upon the size of the container and the treatment judged to be adequate by the sprayman. The function of spraying is to apply sufficient insecticide to all containers that are actual or potential breeding sites for *Aedes aegypti*.

MAINTENANCE OF HAND SPRAYER

The sprayman disassembles and cleans the nozzle tip if spray delivery is irregular. He must not use a metal wire, knife, or nail to clear the nozzle opening. A soft probe such as a toothpick or broom straw is used. The nozzle usually becomes clean when the disassembled parts are washed in a strong stream of water.

All major repairs are made at area headquarters. Minor repairs can be made in the field by the foreman, who should be equipped with the necessary tools and spare parts. If the compressed-air sprayer operates improperly, and cannot be fixed in a few minutes by the sprayman, he should turn it in to his foreman, who will replace it with another sprayer in operating condition.

At the end of each operating day the hand sprayer is emptied and rinsed with fresh water which is poured out. Approximately $\frac{1}{2}$ gallon of clean water is then added and discharged through the hose and nozzle to rinse these parts. The nozzle, hose screen, and dip tube screen are disassembled and cleaned daily.

The spray can is then dried and stored in special racks with filler cap off. The nozzle is attached to a wall fitting to insure adequate drainage of wand and hose (Figure 13).

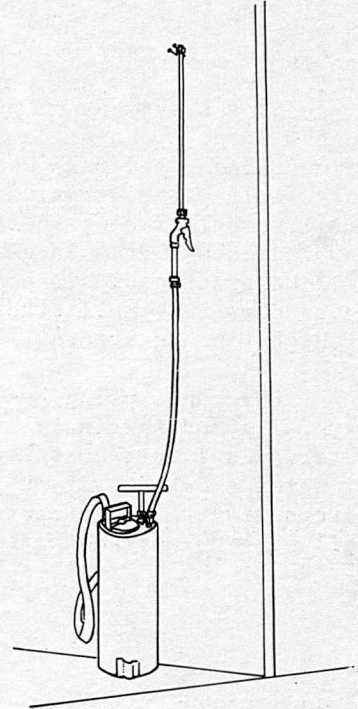


Figure 13. Storage of hand sprayer

HAND DUSTING

DESCRIPTION OF HAND DUSTERS

Hand dusters are used to contain and apply insecticides in dry form. The toxic ingredient of the insecticide is coated upon a suitable powder, such as pyrophyllite or talc, or is mixed with a binder or base and formed into small pellets or granules. These dusters have many forms varying from the small 2-ounce squeeze can to the 12-ounce polyethylene bottle, the rubber bulb duster, and the rotary duster which may hold five or more pounds of dust or granules. Dust applicators are all alike in that the material need not be mixed fresh each time it is to be used, the dust or granule being a stable form of insecticide.

HAND DUSTING PROCEDURES

The small 12-ounce polyethylene squeeze bottle and the bulb duster are best suited for spot treatments made during inspections of premises, and for treatment of sites that cannot more conveniently and safely be treated by other equipment during spray operations. Typical sites best suited for dusting are flower vases, or other containers with plants in water, tree holes, and any small container that is found positive for *Aedes aegypti* during an inspection. Insecticidal dusts must never be applied to aquariums or fish bowls.

Spot treatment of potential water containers with dust or granules during dry season inspections may serve to provide insecticidal protection in advance of the rainy season, and make use of the fact that the inspector is already on the premises. This would prove practicable only in the better residential areas where there are a small number of containers. Further investigations on the use of dust or granules may indicate that a larger applicator such as the plunger duster or rotary duster will be practicable in poorly sanitized sites. These are the larger dusters used in gardens and small truck crop farms. The use of this method is at the discretion of higher headquarters.

Personnel using the concentrated 75 percent DDT powder must use this material carefully and sparingly. Only 0.3 gram (1/15 teaspoonful) is required per pint of water. Care must be taken in estimating the amount of insecticide, and the amount of water treated. It must be remembered, too, that dusting is recommended only as an alternative to the preferred growing of plant cuttings in sand, vermiculite, or soil with no surface water exposed.

INSECTICIDES

As the insecticide is the most important weapon in the Program, it is important that all supervisors and spraymen understand the different formulations, their characteristics, and their correct use. Even the safest of insecticides is a poison and must be treated as such to prevent injury to man, his pets, wildlife, and plants.

TYPES OF INSECTICIDE FORMULATIONS USED ON THIS PROGRAM

The DDT and malathion used since the beginning of this eradication program are purchased as emulsifiable concentrates. As the name implies, these products are a highly concentrated form of insecticide that must be diluted before use. It consists of a basic chemical, such as DDT, dissolved in xylene and containing an emulsifying agent (Figure 14). It is a clear solution and not a finished spray ready for application. The concentrate is diluted in water to form immediately a true emulsion, a milky mixture, and no longer a solution. After emulsions are sprayed on water, the xylene evaporates leaving the insecticide. When emulsions are sprayed on dry surfaces, both the xylene and water evaporate leaving a deposit of DDT as very fine crystals.

DDT water-dispersible powder is now the insecticide of choice for areas where DDT is effective against *Aedes aegypti*. It consists of a basic insecticide, a carrier such as pyrophyllite, and a wetting agent. This material, too, is a concentrate and is ordinarily not used as an insecticide before it is diluted to a finished spray.

Technical Grade Insecticide	+ Inert Carrier	+ Wetting Agent	+ Water
= Insecticidal Dust or Granular Insecticide			
= Wettable (Dispersible) Powder			
= Suspension			
Technical Grade Insecticide	+ Solvent	+ Emulsifier	+ Water
= Solution			
= Emulsifiable Concentrate			
= Emulsion			

Figure 14. Components of insecticidal formulations

The water-dispersible powder is used primarily to prepare a suspension of insecticide in water. The emulsions and suspensions have similar action against *Aedes aegypti* larvae.

Emulsions:

1. Leave only a slightly visible deposit on surfaces
2. Are more expensive
3. May cause burning of vegetation due to the solvent
4. Penetrate into porous materials
5. Require no special storage facilities

Suspensions:

1. Leave a more visible deposit
2. Are much less expensive
3. Do not burn vegetation except certain vegetables
4. Leave a surface deposit on porous materials
5. Require dry storage

An insecticidal dust such as 10 percent DDT consists of a basic insecticide mixed with an inert material, such as talc or pyrophyllite, which serves to dilute the insecticide to proper strength and to carry the insecticide to the point of application. The 75 percent water-dispersible DDT has been employed as an insecticidal dust on this Program to avoid stocking a larger variety of insecticides, and because it is readily dispersed in water in containers to form a suspension. No true insecticidal dust is presently being used on this Program.

Neither DDT nor malathion are suitable for use as insecticides until prepared in a suitable formulation. DDT in commercial grade is a heavy, waxy material that cannot be either sprayed or dusted. The concentrates used in *Aedes aegypti* eradication are excellent materials developed over a long period of years.

FORMULATING FINISHED SPRAYS

It is the responsibility of all supervisors to make certain that mixing of finished spray be done accurately to assure a product with the recommended concentration of insecticide. In a good operation no concentrate is spilled and sprayers are filled quickly and methodically. In some areas certain personnel are assigned responsibility for spray mixing and making certain that both vehicles and sprayers are provided with fuel.

Mixing the Suspension

The water-dispersible DDT powder is purchased in sealed containers in suitable size for use, thus eliminating the necessity of weighing materials when mixing a full load. One 40-pound package of 75 percent water-dispersible DDT in 290 gallons of water will charge the 300-gallon power sprayer with 1.25 percent finished spray (Figure 15). One 0.7-pound package of 75 percent water-dispersible DDT concentrate in $2\frac{1}{2}$ gallons of water will charge the hand sprayer with a 2.5 percent finished spray suspension (Figure 16). One-half of a 0.7-pound package is used if it is desired to mix a 1.25 percent spray. The suspension, rather than the emulsion, is discussed first as it is the formulation of choice when using DDT.

40 lbs. of 75% water-dispersible DDT	+	290 gals. of water	=	290+ gals. of 1.25% suspension
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Figure 15. Suspension formulation for power sprayer

When charging power sprayers nearly the full amount of water is added. Then the insecticide is added as the tank is filled to the operating level. The pump and agitator are not run until later as excessive foaming may occur in areas with reasonably soft water.

0.7 lbs. of 75% water-dispersible DDT	+	$2\frac{1}{2}$ gals. of water	=	$2\frac{1}{2}$ + gals. of 2.5% suspension
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Figure 16. Suspension formulation for hand sprayer

Hand sprayers may be charged anywhere in the field where clean water is available. Occasional shaking of the sprayer may be required to maintain a good suspension.

Mixing the Emulsion

The 25 percent DDT emulsifiable concentrate is purchased in 55-gallon steel drums. Good practice dictates that the concentrate be added to the spray tank while adding the water from a standpipe, thus requiring only one stop for the mixing operation. This can be accomplished by providing a metering pump to aspirate the concentrate from the drum and pump a measured amount into each sprayer. As the practice of using an emulsion is declining it may be impractical to purchase metering pumps, and the current practice of aspirating concentrate from the drum with the sprayer pump, suction hose, and metering pipe or the use of three 5-gallon cans of concentrate may prove satisfactory.

DDT emulsifiable concentrate is diluted 1 part to 19 parts of water to produce a 1.25 percent finished emulsion spray, or 15 gallons for a 300-gallon power sprayer (Figure 17). The concentrate is diluted 1 part to 9 parts of water to produce a 2.5 percent emulsion for the hand sprayer (Figure 18).

15 gals of 25% DDT emuls. conc.	+	285 gals. of water	=	290+ gals. of 1.25% emulsion
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Figure 17. Emulsion formulation for power sprayer

1 quart of 25% DDT emuls. conc.	+	2½ gals. of water	=	2½ gals. of 2.5% emulsion
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Figure 18. Emulsion formulation for hand sprayer

Malathion is used as a 2.5 percent emulsion requiring dilution of the 82 percent concentrate at the rate of 8.8 gallons per 290 gallon tank of spray and 10 fluid ounces to charge the 2½ gallon sprayer.

SAFETY PRECAUTIONS

When properly formulated and applied, the insecticides used in the *Aedes aegypti* program may be used without harm to human beings, household pets, birds, or wildlife (except fish and other cold-blooded animals).

PRECAUTIONS IN HANDLING INSECTICIDES

Persons preparing finished spray from emulsifiable concentrates should avoid direct contact with the liquids. Neoprene or other protective gloves should be worn. In case of spillage, contaminated skin areas must be washed promptly with soap and water. If the eyes are affected, they should be flushed immediately with clean water before obtaining first aid treatment. Gloves are not required when mixing the suspension, but inhalation of the 75% powder should be avoided and, where necessary, respirators may be used. The emulsifiable concentrates contain the highly flammable solvent xylene; consequently smoking in the vicinity of storage and loading areas is not permitted.

PRECAUTIONS IN APPLYING INSECTICIDES

There are certain situations where spraying cannot be done unless care is taken. Methods are being developed to treat these special problem sites. The usual insecticides should not be applied to:

- a. Fish ponds
- b. Bee hives and their immediate surroundings
- c. Interiors of residences
- d. Fish bait farms that raise crickets, cockroaches, earthworms, etc.
- e. Pets or domestic animals

- f. Bird baths or feeders
- g. Cisterns or drinking water supplies
- h. Children's toys, except those obviously discarded
- i. Open areas such as well-kept lawns
- j. Fruit trees and vegetable plots
- k. Flowers and shrubs with tender growth

Special attention must be given to the possibility of wind drift. Spraying must be restricted on windy days because the drift may kill fish, bees, or vegetation. If local opposition develops to treating certain types of containers, State and Branch assistance should be requested.

OTHER PRECAUTIONS

The power sprayer and engine have a number of exposed moving parts. Safety precautions should be observed when the power sprayer is in operation.

Particular attention to safety measures should be taken where there may be broken bottles, jagged metal edges, nails in boards, such as in vacant lots, unkempt yards, or auto junk yards. Medical attention, including a tetanus shot, must be obtained promptly if a sprayman is injured by one of these.

Driving safely is always a good habit to acquire. Particular attention should be given when backing the vehicle. The hoseman should direct the backing of the truck and provide appropriate signals, as the vision of the driver is obscured by the spray tank when making this maneuver. A loaded sprayer is heavy and difficult to stop at excessive speeds. Therefore these vehicles must always be kept under effective control.

Dog bites are dangerous and must be reported immediately to the area supervisor and health officer. Local health departments or animal control agencies may require that the dog be identified and confined for 10 days or more for rabies determination. The Branch will furnish all Federal employees with dog repellent, snake-bite kits, and other protective equipment when requested by project officers. Snake guards should be worn whenever men work in situations where snake bites are a risk. The Branch recommends that inspectors, spraymen, and foremen be provided with such safety devices, and be required to utilize them when necessary. Action on this latter recommendation is a responsibility of the states. If vehicles are provided with seat belts, the driver and passengers are expected to use them. Project officers will take appropriate action to assure the maintenance of safety precautions.

RECORD KEEPING

Operations of a large eradication program cannot be planned and accomplished without accurate and complete records. These records provide a current appraisal of the problem, and a meaningful account of progress toward eradication. All information on insecticidal operations must be derived from Form 2.3 "Block Treatment Record" (Figure 19). This form will be valuable and meaningful if the foreman periodically discusses progress in the local area with his crews, showing them the wall maps that give a perspective on the entire operation.

Figure 19.

BLOCK TREATMENT RECORD

County Tiller Cycle 3
 Sector A Zone 14 Block 167
 Date 3-V-66 Crew Brown & Hyde DB JH
 Type of Insecticide Used DDT Susp. % Concentration of Finished Spray 1.25
 No. of Gallons of Finished Spray Used in Block 89
 Other Insecticide Used — Amount —

No.	Premises Address	West St.	North Ave		East St.	Closed	Refused	Exterior Treated		Interior treated or comments
			South Ave					Power Sprayer	Hand Sprayer	
1	1692 South Ave.							✓		
2	1680 " "							✓		
3	Vacant lot (clean)							none		
4	1664 South Ave.						✓			BCC
5	1658 " "							✓		
6	1652 " "							✓		
7	1640 " "							✓		
8	1628 " "							✓		
9	408 West St.					✓				
10	420 " "					✓				
11	Vacant lot (8 old cars)							✓		BCC
12	440 West St.						✓			BCC
13	1601 North Ave.							✓		
14	1619 " "							✓		
15	1633 " "							✓		
16	1649 " "					✓				
17	1667 " "							✓		
18	1679 " "							✓		
19	1683 " "							✓		
20	1699 " "							✓		
21	443 East St.							✓		
22	Vacant lot (junk)							✓		BCC
23	Vacant lot (tires and cars)							✓		
24	411 East St.							✓		
25										
26										
27										
28										
TOTAL	24					3	2	18	0	0

ENTERING ASSIGNMENTS ON FORM 2.3

The foreman, in making the daily work assignments, will issue a Block Treatment Record (Form 2.3) for each block to be sprayed and a zone map to facilitate location of the blocks. He will also fill in the first three lines of the heading, including the date. This is later changed by the spray crew leader if the block is not completed on the day assigned, as the date on which the block was completed is the one to be recorded. The sprayman is responsible for completing the record and returning it to the foreman when the spraying of a block has been completed. The foreman is responsible for checking these forms for accuracy and completeness, and for using them in making supervisory checks. The following information will be recorded:

County: The name of the county where work takes place.

Sector: A grouping of zones within a county utilized by some Areas for further identification and work assignments. The sector is not recommended for inclusion in nomenclature unless designation has been established prior to December 1965.

Zone: A distinct operational subdivision of a county that encompasses one or more contiguous census tracts or census tract equivalents to:
(1) maintain reasonable zonal homogeneity with respect to socioeconomic and land-use factors; (2) maintain reasonable homogeneity with either Conditions "A" or "B" (see Operational Letter 1.3); and (3) include approximately 6,000 premises, or an area that may be operated as a unit on a cyclic basis by one foreman and approximately six inspector/spraymen. (The inclusion of an optimum number of premises is secondary to satisfying Items 1 and 2.)

Cycle: The interval of time during which a sequence of a recurring succession of operational work items is completed. (For example, a DDT-treatment cycle for a zone will be completed within a 3-month period and the subsequent treatment cycle will take place during the following 3-month period. Other types of cycles might be for inspection, fogging, treatment of water barrels, special problem sites, etc., with possibly varying intervals of time for each.)

Block No.: The serial number of the block which is being treated.

Date: The date spraying is completed in the block.

Crew: The initials or names of the sprayman or spraymen.

DATA ENTERED ON FORM 2.3 BY SPRAY CREW

Types of Insecticide Used, Percent Concentration of Finished Spray, Number of Gallons of Finished Spray Used in Block:

Record the insecticide used and formulation, such as DDT suspension, the concentration, and the number of gallons of finished spray used to treat the entire block. A dip stick can be used to measure the

amount of emulsion in the power spray tank before and after spraying any block, but a sight gauge should be used if provided. If hand spraying is done, a record should be kept of the number of gallons of finished spray used. Measuring marks on the side of the sprayer can serve as a guide to make this estimate.

Other Insecticides Used - Amount:

If another type of insecticide is used for treatment of certain sites in the block, the amount used is recorded. The back of the form is used when further explanation is required.

Premises Address and Number:

Fill in each house number and street name, and other identifying information such as "vacant lot." When interior as well as exterior sprayings are required, it may be necessary to list each apartment number within a building. The number assigned to a premises should be consistent from cycle to cycle, and the number of premises per block should also conform. This requires an inclusion of definitions of premises in on-the-job training.

Closed and Refused:

A closed premises is one where it was impossible to gain entry because the premises was locked or hazardous. A refused premises is one where the occupant has refused permission for treatment. These columns should be checked according to the situation.

Exterior Treated, Power Sprayer, Hand Sprayer:

Indicate by a check mark in the appropriate column the equipment used to treat the premises.

Interior Treated:

Indicate by a check mark if interior treatment is performed.

Supervisory Checks:

No column is provided for entering the initials of the supervisor for premises he has actually checked. His initials may therefore be entered in the blank margin to the right of the premises record, as in Figure 19.

After the form has been checked by the foreman to see if it is accurately filled out, he may enter his initials at the right, bottom, of the form.

SUPERVISION

Supervision implies the control of an activity to reach immediate objectives and ultimate goals. The foreman has field responsibility for all eradication activities of the Program, the yellow fever mosquito being eradicated under his personal direction. Supervision of this type requires making many decisions, based upon an understanding of the policies of the Project and Branch, and the methods and procedures for accomplishing the task.

The foreman makes daily work assignments utilizing Form 2.3 "Block Treatment Record," and field maps with the areas to be treated clearly marked. He supervises the insecticidal operation, assisting his men in handling difficult situations. He makes supervisory checks of 10 percent of treated blocks in order to assure a good operation. He receives the block forms at the end of the day, checks them, and posts the information on Form 2.12 "Zone Inspection and Treatment Record", (Figure 20). In addition to these tasks, the foreman discusses work plans and problems with the assistant area supervisor and plans work for the next day. Only in this well ordered way can he maintain control of the operation, and make certain that all actual or potential *Aedes aegypti* breeding sites receive adequate treatment.

TRAINING

Effective spraying of insecticides is a skill that requires training of new spraymen before they are sent out on the job, and daily assistance to all spraymen in improving techniques and procedures. A good spraying operation involves care and use of equipment, hose handling, footwork, correct application of insecticides, knowing what to spray and what not to spray, knowing the quantity of insecticide to apply, observing all safety precautions, and keeping accurate records. The foreman should continue "on-the-job" training for all spraymen, to maintain the spraying skills and to correct improper methods early before they become habitual and detrimental to the Program.

TRAINING AIDS

Many of the best training aids are those produced locally to suit a specific need. Colored slides of local situations, charts (Figure 21), and maps are necessary in an efficient training operation. The Branch has produced more than a hundred color slides that will supplement those made locally.

The motion picture M-1070, "Front Line of the Battle," was produced to support training in insecticidal application. It is not enough just to show the motion picture on a rainy day, for a training aid is of little importance unless it leads to group discussion. No two people see a motion picture in the same way, and the entire picture or short scenes may be used to promote interest and discussion. The supervisor must understand what he wants to "do" with a training aid before he can use it to good purpose.

ZONE INSPECTION AND TREATMENT RECORD

Area Dixon Community — Zone 14

No. Blocks in Zone 300

Inspection Activity Dates: Start _____ Finish _____ Cycle No. _____

No. Premises in Zone 6000

Treatment Activity Dates: Start 3-X-66 Finish _____ Cycle No. 3

INSPECTION

TREATMENT

Block No.	No. Premises In Block	Date Insp.	INSPECTION				Date Treated	No. Exteriors Treated		No. Interiors Treated	No. Gal. Finished Spray Used DDT's 1.25 Type %	Amount Other Insecticide Used	
			No. Exteriors		No. Interiors			Power Sprayer	Hand Sprayer			Type	%
			Insp.	W/Under accepti	Insp.	W/Under accepti							
167	24						18	0	0	89	—	—	
TOTAL													

Figure 20.

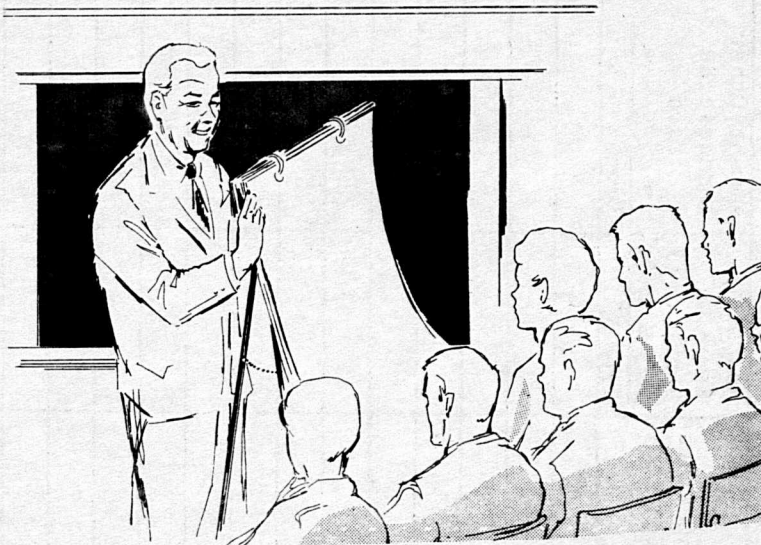


Figure 21. The use of a chart in training

The chalk board is another valuable training aid. Problems may be set up to be solved by the spraymen. Drawings and written material alike may be used with the chalk board.

Field demonstration of equipment, followed by individual and group participation, is probably the best use of a training aid, - the actual equipment used for operations. Thus the supervisor is able to employ many different approaches to training through the use of training aids.

PUBLIC RELATIONS

All public health activities are dependent upon the support of the people, as individuals and as groups. The participation of local health officials in broadcast or televised programs help to arouse interest through public understanding of the *Aedes aegypti* Eradication Program. News articles and talks at public meetings play an important part in good public relations.

The most essential factors in obtaining acceptance of the Program lie in the attitude, work habits, and public relations of the individual sprayman (Figure 22). Therefore all field personnel must be informed on the objectives and activities of the Program and must be given thorough training in meeting the individual householder and establishing acceptance of the insecticidal program.



Figure 22. Sprayman identifying himself to occupant