AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D. C. 20523

BIBLIOGRAPHIC INPUT SHEET

FOR AID USE ONLY
Batch 39

1. SUBJECT CLASSIFICATION
A. PRIMARY: TEMPORARY
B. SECONDARY:

2. TITLE AND SUBTITLE
Malaria insecticide research; annual report,1962/1963

3. AUTHOR(S)
(101) HEW/PHS/CDC

4. DOCUMENT DATE
1963

5. NUMBER OF PAGES
44p.

6. ARC NUMBER
ARC 614.4323.C734

7. REFERENCE ORGANIZATION NAME AND ADDRESS
HEW/PHS/CDC

8. SUPPLEMENTARY NOTES (Sponsoring Organization, Publishers, Availability)
(Research summary)

9. ABSTRACT

(HEALTH R & D)

10. CONTROL NUMBER
PN-AAC-477

11. PRICE OF DOCUMENT

12. DESCRIPTORS

13. PROJECT NUMBER

14. CONTRACT NUMBER
PASA 5903-7 Res.

15. TYPE OF DOCUMENT

AID 590-1 (4-74)

PADA 5403-7 (Rev.)
PN-AAC-477

614.4323
C734
1963

Biology/Chemistry Section, Technology Branch

Communicable Disease Center

Public Health Service

U. S. Department of Health, Education, and Welfare

Report of Activities for the Year Ending

June 30, 1963

Reimbursable Contract with the

U. S. Agency for International Development

June 30, 1963

Savannah, Georgia

TCR/
Original File Copy

TABLE OF CONTENTS

	Page
CHEMICAL STUDIES	1
Surveillance of Quality of 75% DDT Water-dispersible Powders	1
Collaborative Tests with Other Laboratories	5
A. Approval of Laboratories for Compliance Analyses	5
B. Studies on the AID and WHO Suspensibility Tests	6
Specifications for Malathion Water-dispersible Powders	7
Development of Improved Spontaneous DDVP Vaporizers	8
INSECT RESISTANCE STUDIES	9
Residual Fumigant Studies at Savannah, Georgia	9
A. *Anopheles quadrimaculatus*	9
B. *Culex pipiens quinquefasciatus*	15
Field Experiment in Haiti with DDVP Residual Fumigant	18
Evaluation of Compounds as Residual Agents for the Control of Adult Mosquitoes	19
Chemosterilant Studies	29
A. *Anopheles albimanus*	29
B. *Culex pipiens quinquefasciatus*	32
EQUIPMENT DEVELOPMENT STUDIES	39
Pressure Regulators	39
Specifications	40
Testing	40
Erosion with Dieldrin	41

CHEMICAL STUDIES

Surveillance of Quality of 75% DDT Water-dispersible Powders

A number of years ago it was found essential to set up a program to enable the continuous survey of the storage stability of 75% DDT powders manufactured for AID malaria programs. This was accomplished by including in the AID specification a requirement that a 1/2 pound sample out of every 5000 pounds manufactured be supplied to this laboratory. A representative number of these samples from each manufacturer is checked for suspensibility as soon as possible after receipt and then periodically every three months for at least a year. This type of surveillance has proven invaluable in improving and maintaining the quality of DDT powders supplied for AID malaria eradication programs. The main objectives of the program are as follows:

(1) To provide immediately available reference samples of each batch sent overseas so that if difficulties with any material are reported from the field, a sample of the batch or batches reported defective can be examined immediately and the field can be advised how the defective material can be returned to a usable condition if possible. In order to make effective use of the system the manufacturer, contract and batch numbers which are on the drums containing the defective material must be supplied to this laboratory. Before this surveillance program was established it often took 3 to 6 months before samples of defective product reported from the field could be obtained for examination by this laboratory.

(2) Because of the complex nature of wettable powder formulations it is extremely difficult if not impossible to provide a specification

which will assure at all times the supply of powders which have adequate storage life. The present AID specification (No. 2373-1) for 75% DDT is designed to provide powders which are not likely to increase in particle size under tropical storage conditions. This is the most serious change that can take place because once this happens to a sufficient extent the powder will be unusable in hand-spraying equipment. While the specification eliminates powders which will show substantial change in particle size in storage, it does not necessarily eliminate powders which have other defects which can result in poor suspensibility after shipment and storage in tropical climates. These defects are more subtle and usually involve the surface active materials necessary in the formulations. Examination of batch samples from each manufacturer over a period of time is the only way that defects of this kind can be detected. Thus, the batch samples received from each 5000 pounds enable a continuous check on each manufacturer's product for these latent defects and as soon as any show up the manufacturer is advised and steps are taken to correct the defects. This procedure has proven quite effective in maintaining the high quality of products being manufactured for AID programs.

(3) Surveillance of batch samples for storage stability provides a complete check on the effect of changes made in the specification which are designed to improve storage quality. The samples also provide adequate experimental materials for studying methods of

improving the specification. Thus, the "Accelerated Storage Treatment" was developed and tested out with batch samples before incorporation into the present specification (No. 2373-1). FY-1963 is the first full year of purchases since incorporation of this new Accelerated Storage Treatment. A summary of the experience is given below.

Some five hundred batch samples taken at random from those received from seven different formulators supplying 75% DDT powders for AID programs were examined for initial suspensibility and at intervals of three months after receipt. All samples represent batches manufactured to meet AID specification No. 2373-1 and are from FY-1963 purchases. Table 1 is a summary of the results of the examination of these samples. A sample was deemed defective if its suspensibility fell below 1.20 after storage for three months or longer. The number of defective batches from suppliers C and D are much too high. These defective batches occurred mostly in the first part of the year and the trouble was corrected so that currently these formulators have very few if any defective batches showing up in their production. The average percent defective for the year is a 11.9. Because of corrective action taken as a result of the findings presented in Table 1, current production from all suppliers is estimated to be less than 5% defective. The defective batches are almost entirely due to something other than increase in particle size and it seems doubtful whether any serious difficulty

Table 1

Manufacturer	Total Batch Samples Tested	No. Batch Samples Defective	% Defective
A	132	0	0
B	86	11	12.8
C	84	33	39.3
D	25	9	27.7
E	8	0	0
F	60	0	0
G	128	9	7.0
Total	523	Total 62	Av. 11.9

will develop in field use since the criteria for defective material is set rather high and the type of defect involved rarely gives trouble in field use. A study of all the data obtained on the batch samples from FY-1963 production indicates that the "Accelerated Storage Treatment" does effectively prevent the purchase of products which tend to increase in particle size on storage especially at the elevated temperatures frequently encountered in tropical areas. For the present at least it will be necessary to depend on the surveillance program to detect latent defects and see that corrective action is taken to maintain the high quality of 75% DDT powders being supplied to AID malaria eradication programs.

Collaborative Tests with Other Laboratories

A. Approval of Laboratories for Compliance Analyses

All laboratories used by GSA for analysis of samples of wettable powders purchased for AID must be approved by TDL. Approval is based on an evaluation of the competence of the laboratory in question. Such competence is determined by submitting a series of samples which have been carefully examined by TDL analysts. If the laboratory under examination obtains analytical results on the samples submitted that compare favorably with the results obtained by TDL, then the laboratory is approved. If the initial efforts of the laboratory are unsatisfactory, additional analyses are requested until the laboratory can demonstrate that they are competent to do the analyses required in the specification concerned.

GSA requested evaluation of the competence of three of their own laboratories to conduct compliance analyses for 75% DDT water-dispersible powders made to AID Specification No. 2373-1. All three laboratories received approval. From time to time these and other laboratories already approved by TDL are re-checked for competence as deemed desirable. Some analysts tend to introduce modifications consciously or unconsciously in the test procedure for suspensibility which may cause low or high results. The suspensibility test procedure is highly empirical and unless followed precisely, variable results will be obtained.

B. Studies on the AID and WHO Suspensibility Tests

The suspensibility test used in the AID specification is based on an older test originally recommended by a WHO Expert Committee on Insecticides. Subsequently, a later committee made some rather major changes in the WHO method and as a result the AID and WHO methods give quite different results. Since most 75% DDT powders used in malaria programs throughout the world are supplied by USA formulators whether purchased by WHO agencies or AID it would be highly desirable to bring the AID and WHO specifications into closer agreement. As part of an effort to bring this about, a series of duplicate samples were supplied to several laboratories in Europe and their suspensibility tests by both AID and WHO methods were compared with those obtained by TDL. The net result of this study shows that most laboratories prefer the AID method both from the standpoint of reproducibility and ease of manipulation. A recommendation that the WHO adopt the AID procedure is being put before the next WHO Expert Committee dealing with this subject which will meet in 1965.

Specifications for Malathion Water-dispersible Powders.

A performance specification for 50 percent water-dispersible malathion powder (AID No. 2361-1) was issued August 7, 1962. Since it had been found that a satisfactory 50 percent product can be manufactured at a substantial cost advantage over a 25 percent powder, a specification for only the 50 percent material was issued at this time. In December, 1962 AID purchased about 100,000 pounds of 50 percent malathion and another 50,000 pounds in January, 1963. Because of the relatively small quantities purchased during this period, it was not practical for any of the commercial laboratories to set up facilities for the procedures in the new specification. This laboratory, therefore, ran all tests on the three acceptance samples and 54 batch samples involved. It was found that only 3 out of the 16 batches that composed the material in Acceptance Sample No. 2 for the December shipment were low in suspensibility. These three batches caused the suspensibility of the composite sample to fall below the acceptable tolerance. Results of suspensibility tests on batch samples after 6 months storage in Savannah indicate that the storage stability is satisfactory. Although the 50% product specified in Specification No. 2361-1 is not as stable as the 25% formulation developed by American Cyanamid it is believed that it is adequate as an alternate to 75% DDT when resistance or other factors demand a change. Studies are being continued with malathion wettable powder formulations. In the meantime it is recommended that 50% malathion wettable powder be purchased only in amounts which will fill immediate needs avoiding particularly the building up of large stocks which are likely to be held in storage for long periods of time.

Development of Improved Spontaneous DDVP Vaporizers

Studies in Savannah, Upper Volta and Haiti have indicated that the "residual fumigant technique" for malaria eradication using DDVP as the toxic agent still shows considerable promise. However, these studies have also shown that unless a spontaneous DDVP vaporizer can be developed which will produce vapor at a rate at least three times greater than the wax or resin formulations now available the residual fumigant technique will not be economically feasible. A new approach to this problem was taken during the year and as a result a new type of vaporizer was developed which shows great promise. This vaporizing unit produces 4 - 5 times more vapor per square inch of surface than either the "wax sausage" or the "resin slab". Some technical difficulties have developed but it is believed that with further study these can be overcome and a practical unit will result.

INSECT RESISTANCE STUDIES

Residual Fumigant Studies at Savannah, Georgia.

A. *Anopheles quadrimaculatus*

Further tests of residual fumigant dispensers were run with plywood, mud, and bamboo houses of 1,000 cu. ft. each. The roofs on the mud and bamboo houses were of thatch. The amount of ventilation varied according to the experiment. During the cooler part of the season, the studies were made in insulated huts equipped with heaters to maintain the temperatures above 70° F.

The following types of dispensers were tested:

(1) 25 percent DDVP (Montan wax-dibutyl phthalate) as pellets or cylinder

(2) 25 percent DDVP (Montan wax-ethyl acetate), cylinder

(3) 50 percent DDVP (Montan wax-dibutyl phthalate), cylinder

(4) 30 percent DDVP (resin), tube (all resin formulations of polyvinyl chloride provided by courtesy of Shell Chemical Company, 110 W. 51st Street, New York 20, New York)

(5) 10 or 20 percent DDVP (resin), strip

(6) 20 percent DDVP (resin), strand

(7) 50 percent DDVP liquid (provided by courtesy of CIBA Limited, Basle, Switzerland)

Dispensers were suspended from the roof peak rafter, approximately 9 feet above the ground.

Efficacy of the treatment was measured by exposing caged, dieldrin-resistant Anopheles quadrimaculatus at 2', 6', and 9' levels at the mid line of one wall and at the 2' level in each of the four corners. Fifty to 100 mosquitoes were contained in each of the seven cages. During the warm part of the season, the exposure period was from 8:00 P.M. to 8:00 A.M. When the heaters were in operation during the cool months, the exposure time was 4 hours and the tests were made during the day. After exposure, the caged mosquitoes were placed with food in a noncontaminated room (temperature 80° F., 70 percent relative humidity) and held for 24-hour female mortality determinations.

The initial comparison test included four DDVP-Montan wax formulations and one DDVP-resin dispenser in huts with eave ventilation only. The DDVP-Montan wax units for the first 6 weeks (Table 2) gave essentially 100 percent kills. When 4-hour exposures were used, the 25 percent DDVP-wax-dibutyl phthalate formulations gave superior results through week 9. On week 10 the mortalities with all wax formulations were below 70 percent. When the exposure period was increased to 12 hours on week 11, the wax formulations produced complete mortalities. Only the standard 25 percent DDVP-wax cylinder continued to give 95 to 100 percent kills through week 16 and this formulation was definitely superior to the three others. Subsequent tests with 1-inch pellets again indicated that this formulation was not superior to the wax cylinder.

The DDVP-resin cylinders installed on 3/26/63 gave erratic results during the first 3 weeks and were replaced with new units on April 12, 1963.

Table 2

Mortalities of caged A. quadrimaculatus at various periods after installation of one dispenser/plywood hut on 3/26/63, eave ventilation.

Dispenser Age (Weeks)	Temp. °F.	Exposure (hours)	Percent Kill with Formulation			
			25%-C a/	DE-25 b/	25%-P c/	50% d/
7	86	4	100	98	100	96
8	81	4	90	64	96	61
9	90	4	99	89	99	69
10 e/	82	4	62	43	68	30
11	70-72	12	100	100	100	100
12	72-75	12	100	98	100	55
13	74-78	12	100	100	100	90
14	74-78	12	100	99	16	8
15	76-82	12	95	24	59	5
16	74-84	12	98	49	-	-
17	74-82		-	-	-	-
18	74-80		-	-	-	-
19	76-81		-	-	-	-

a/ 25 percent DDVP (Montan wax-dibutyl phthalate) as cylinder.

b/ 25 percent DDVP (Montan wax-ethyl acetate), cylinder.

c/ 25 percent DDVP (Montan wax-dibutyl phthalate) as 1/2-inch pellets.

d/ 50 percent DDVP (Montan wax-dibutyl phthalate), cylinder.

e/ Huts artificially heated weeks 1-10.

The latter gave 16 weeks of effective kills and were equivalent in activity to the standard wax unit.

A further test with the 30 percent DDVP-resin tube, 5-1/2 in. long, 1/4 in. thick, 1-1/4 in. outside diameter, during the May-August period indicated that it was less effective than an equivalent dosage of 20 percent DDVP-resin strand, 1/8 in. in diameter (Table 3). The tube gave 11 weeks of effective kills in the door-eave ventilated plywood hut as compared to 16 weeks in a similarly ventilated hut treated with strand.

Comparative tests of DDVP-Montan wax cylinder, DDVP-resin tube, and the DDVP-liquid dispenser were conducted in the bamboo and mud huts using three units per hut. Each hut had door-eave-window ventilation. Results indicated 3 to 5 weeks general effectiveness for the three types but the weekly kills were too erratic to permit any valid conclusion as to individual superiority.

On September 25, one unit each of three types of DDVP-resin strips (XP-606, 622, 623), 10" x 2.5" x 0.22", one 50-ft. length (cut into 12-inch pieces) of each of two types of DDVP-resin strands (XP-596, 620), 1/8" in diameter, and a standard DDVP-Montan wax dispenser were installed in plywood huts with eave ventilation only. Temperature levels permitted 5 weeks of overnight exposures. During that period, formulations XP-622, XP-606, XP-620, and XP-596 gave superior results (Table 4). On week 5 when temperatures were between 50 - 69, all formulations except XP-620 gave poor results. Tests during weeks 6

Table 3

Mortalities of caged A. quadrimaculatus at various periods after installation of DDVP-resin dispensers on 5/29/63, maximum ventilation.

Dispenser Age (Weeks)	Temp. °F.	One Unit in Each	
		30% DDVP Shell Resin Tube	20% DDVP XP-59% Shell Resin Strand
1-9	-	99-100	100
10	76-86	86	100
11	74-84	71	75
12	74-80	12	100
13	76-82	18	100[a]

a/ 98 to 100 percent through week 16, 63 and 11 percent on weeks 17 and 18.

Table 4

Mortalities of caged A. quadrimaculatus at various periods after installation of one dispenser per plywood hut on 9/25/63, eave only.

Disp. Age (Wks.)	Temp. °F.	Exposure (Hours)	Percent Kill with Formulations					
			XP-596 a/	XP-620 a/	XP-606 b/	XP-622 b/	XP-623 b/	25%-C c/
1	70-77	12	100	100	100	100	100	100
2	69-72	12	100	100	100	100	99	100
3	62-72	12	98	100	100	100	63	43
4	66-72	12	70	100	99	100	62	75
5	50-69	12	19	71	32	49	4	11
6	80	4 d/	100	100	33	100	100	100
7	70-80	4	83	100	57	100	62	86
8	75-79	4	4	91	34	73	15	27
9	75-80	4	49	100	91	100	71	100
11	75-80	4	65	99	49	96	30	48
13	75-79	4		98		94		

a/ 20 percent DDVP-resin strand.

b/ 20 percent DDVP-resin strip.

c/ 25 percent DDVP-Montan wax standard.

d/ Artificial heat used to maintain temperature.

through 13 were limited to 4-hour daytime exposures in heated huts. Formulation XP-620 and XP-622 gave effective kills through week 13 and were definitely superior to the other four formulations. The superiority of XP-622 slab over the other two slab formulations is correlated with its greater vapor production rate. XP-622, aged 2, 4, 8, and 12 weeks yielded 10, 6.6, 5.4, and 2.6 milligrams of DDVP vapor per hour as compared to 5.8, 4.2, 2.8, and 2.3 and 3.0, 2.3, 1.7, and 1.5 milligrams per hour for XP-606 and XP-623, respectively (data provided through courtesy of Shell Chemical Company, 110 W. 51st Street, New York 20, N. Y.). Strand XP-620 also had a higher vapor production rate than XP-596. The superiority of the resin over the wax formulation is further reflected in the smaller amounts of DDVP in the resin dispenser (i.e., 20, 30, and 50 g. per strip, strand, wax dispenser, respectively).

The previous data indicate that residual fumigant action can be obtained with DDVP in various formulations. Obviously, the type of formulation as well as the amount of vaporizing surface is important to the vapor production rate and, therefore, its biological effectiveness. In these tests, the strip and strand formulation of DDVP-resin showed the highest level of biological activity.

B. Culex pipiens quinquefasciatus

Residual fumigants containing DDVP were evaluated against Culex pipiens quinquefasciatus breeding in catch basins in Savannah, Georgia. Comparative evaluation was made of three types of DDVP dispensers and one type was used in a large-scale study.

The area selected for treatment approximated one-fifth of the catch basins in Savannah, Georgia. This zone consisted of approximately 555 city blocks with a contiguous area of 27 city blocks left as an untreated control.

Certain physical features of the basin were suspected of affecting the fumigant qualities and action of the dispenser: type of basin drain, depth and volume of water in the basin, volume of water normally remaining within the basins; height of the air column; air volume of the basin; size, shape, and orientation of the basin inlet at curb, size, configuration, and construction material of the basin interior.

The dispenser units were suspended by means of a perforated metal hanger at the top and bottom of the air volume to determine the most effective vapor release site. A limited number were wholly immersed in the residual water.

Evaluation of the treatment was based on 3-hour exposures of caged adults and weekly inspection for larval production in 44 selected test basins. Further evaluation of the over-all treatment was made weekly by inspections for breeding and adult exposure tests in 10 additional randomly selected basins. As a field control for the adult exposure, five basins in the untreated area were surveyed and tested weekly. Checks were maintained in the laboratory and transport vehicle on each test day as indicators of adverse influence from other factors on the test insects.

All adult test specimens used throughout this study were reared from a colony established from the endemic C. p. quinquefasciatus Say population. For testing, approximately 100 three-day-old adults of both sexes were confined in a 3-1/2" x 4" cylindrical wire test cage. Cages were transported to the field in a shallow case designed to prevent mortality from desiccation.

Inspections for breeding in a basin were carried out the day prior to the adult exposure. The average number of immatures per dip present determined the breeding index for the basin.

Maximum biweekly temperatures for the first 20 weeks of testing ranged from 92° F. to 100.3° F. while the minimum temperatures for the same period were recorded as 69° F. to 74.7° F. Water temperatures through the first 12 weeks of inspection averaged from 77° F. to 84° F., a range well within that acceptable for the breeding of C. p. quinquefasciatus.

The data showed that the physical features of the basin exerted little or no influence on the over-all effectiveness of the dispensers tested.

Variations occurred in the length of residual action of the formulations tested and considerable differences in effectiveness were observed in the individual basins. Complete mortality of caged adult females exposed ranged from 8 to 27 weeks when the dispenser was mounted above the water level. Control for all formulations with this mount averaged 16-1/2 weeks. Satisfactory control mortalities continued beyond 19 weeks in over 35 percent of these units. Basins with dispensers submerged in the

water remained free of larvae for 18 to 32 weeks and averaged 25-1/4 weeks for all such mountings.

Average weeks of effective control achieved, by formulation and dosage based on caged adult tests, were:

Dosage, No. of Dispenser Units	Formulation		
	Anhydrous Wax	Resin	Liquid Drip
1	15	11	11
2	18	12	-

The three formulations of DDVP tested offer definite promise as effective control materials against C. p. quinquefasciatus breeding in catch basins.

Field Experiment in Haiti with DDVP Residual Fumigant.

In Haiti approximately 4,500 homes in the Arcahaie area were treated with DDVP-wax dispensers during July-August, 1962. A second application was made in December-January, 1963, a third in April 1963. Approximately 23,000 dispensers were installed in each treatment, 5 to 6 units per house. Biological data indicated effective kills of caged Anopheles albimanus females for 12 to 16 weeks after the units were installed. Biological tests are continuing as are the malariometric surveys conducted under the direction of PAHO and SNEM.

Residual applications of Sevin at 2 g./m.^{2} to occupied homes in Sources Matelas, Haiti, were shown to give kills of 70 percent or better for 15 weeks of A. albimanus confined beneath plastic cones. At that point, accidental spraying of the test area terminated the evaluation. Bayer 39007 at 2 g./m.^{2} was much less effective than Sevin. At 1 g./m.^{2} Sevin gave satisfactory kills for 5 to 10 weeks, Bayer 39007 for 3 weeks. Wall surfaces involved were whitewashed mud, thatch, and wood. Further tests of Sevin versus Bayer 37344 are in progress.

Evaluation of Compounds as Residual Agents for the Control of Adult Mosquitoes.

To evaluate the effect of surface and other factors on the potential of new organophosphorus and carbamate insecticides as residual treatments, tests were conducted out-of-doors under a shed that protected the treated panels from rain but exposed them to the variations of temperature, relative humidity, and wind movement. The test surfaces included clay, whitewashed clay, thatch, galvanized metal, plywood, whitewashed plywood, bamboo, cement plaster, and brick. Panels from 1961 that were retreated in 1962 contained the same surfaces tested in the previous year. In the tests with synergized formulations, only cement plaster, brick, and plywood surfaces were used.

All panels (1' x 4') were treated in vertical position under the shed using a 1-gallon compression sprayer equipped with an 8004 nozzle. Plywood inserted on both sides of the panel under treatment protected the adjacent panels from contamination during the spraying operation. The following toxicants and dosages were tested as suspensions:

	Compound	Percent Active Ingredient	g./sq.m.
1.	Sevin	50 or 85	1, 2
2.	Sevin:DDT	50:75	2:0.5
3.	DDT	75	0.5
4.	Bayer 39007	50	1, 2
5.	Bayer 39007:Sevin	50:50	1:1
6.	Bayer 39007:DDT	50:75*	2:0.5
7.	Bayer 39007:Piperonyl butoxide	12.5:12.5	1:1
8.	Bayer 39007:Piperonyl butoxide	8.3:16.7	1:2
9.	Hercules 9699	50	0.25, 0.5, 1
10.	Bayer 39731	50	0.5, 1, 2
11.	Bayer 41831	40	0.5, 1, 2
12.	Bayer 47940	25	0.5, 1, 2
13.	Bayer 46676	25	0.5, 1, 2
14.	Bayer 37344	50	0.5, 1, 2
15.	Malathion	25	1

* Mixed to give desired proportions.

Panels treated in 1961 with Sevin or Bayer 39007 at 1 or 2 g./sq. m. were retreated at the same rate in 1962. In addition, panels made with bamboo from Indonesia, Thailand, Viet-Nam, and the Philippines were retreated in 1962 with Sevin at 1 g./sq. m.

Evaluation of the treatments was by exposure of dieldrin-resistant Anopheles quadrimaculatus females to the deposits for 1 hour beneath a plastic cone. Three replicates were made on each surface with 10 females in each cone. Tests were at 2-week intervals. Different sites were employed each time. After exposure, the specimens were held at 80° F. and 70 percent relative humidity for 24 hours, at which time the percent mortality was determined.

To compare relative effectiveness of nine surfaces with combined data from tests with nine toxicants an index was used. For each surface, the index was obtained by totaling the maximum number of weeks that each of the nine toxicants gave 90 percent or more mortality on that surface. The maximum index was the sum of the maximum numbers of weeks regardless of surface. The data (Table 5) for treatments of nine toxicants (Sevin, Bayer 39007, 39731, 41831, 46676, 47940, 37344, malathion, and Hercules 9699) at 1 g./sq. m. clearly indicate that deposits on thatch and plywood showed the greatest longevity. Each gave indexes of 124 compared to the maximum index of 132. Residues on clay, whitewashed clay, and cement plaster were the least effective while deposits on bamboo, metal, whitewashed plywood, and brick were intermediate in their longevity.

When a dosage of 2 g./sq. m. was used, seven residues on thatch were slightly superior to those on plywood, deposits on it producing an index of 110, the maximum number possible. Plywood had a total of 104. Although the general groupings remained the same, deposits on metal gave the longest

Table 5.

Relative order of effectiveness of deposits of nine toxicants on nine surfaces at 1 g./sq. m. based on number of weeks the surface showed 90 percent kill of *Anopheles quadrimaculatus*. Maximum index:132.

Surface	Index
Thatch	124
Plywood	124
Metal	102
W. Plywood	88
Bamboo	88
Brick	76
Cement Plaster	59
W. Clay	34
Clay	16

period of effectiveness in the intermediate group and the sequence of cement plaster and whitewashed clay was reversed in the least effective group. The data show that the increase in dosage of B-39731, B-41831, and B-47940 from 1 to 2 g./sq. m. improved their effectiveness on whitewashed clay, cement plaster, and whitewashed clay, respectively (Table 6). On whitewashed clay, 1 g./sq. m. of B-39731 gave only 58 percent kill at week 2 but at 2 g./sq. m. the same toxicant gave 12 weeks of 90 percent or better kills. On cement plaster, the same dosage increase with B-41831 produced 8 additional weeks of effectiveness. Sevin at 2 g./sq. m. (from 85 percent WW) gave kills above 90 percent at week 22 on whitewashed clay and bamboo even though deposits on either surface at 1 g./sq. m. did not produce a similar kill at the initial inspection on week 4. It also was apparent that some compounds (e.g. H-9699 and B-39731) were ineffective on certain surfaces (i.e. cement plaster) regardless of dosage.

Sevin at 1 g./sq. m. was used in 1961 and in 1962 to treat bamboo from Thailand, Indochina, Philippine Islands (two types), and Indonesia. The bamboo from the Philippine Islands and from Thailand was evaluated on both the outside and inside surfaces. All surfaces gave similar satisfactory results through the 16-week period of study.

Formulations of piperonyl butoxide and Bayer 39007 at 1:1 and 2:1 ratios and of B-39007 alone were tested on cement plaster, brick, and plywood. At 1 g. of B-39007/sq. m. kills of 90 percent were obtained on cement plaster for 2 weeks only with the piperonyl butoxide:B-39007 formulations and for 8 weeks with B-39007 alone. On the brick and plywood surfaces

Table 6

Number of weeks that various surfaces treated with various insecticides gave mortalities of 90 percent or more of dieldrin-resistant *A. quadrimaculatus* females exposed for 1 hour. Plus sign indicates weather terminated tests.

Toxicant	g/m²	Clay	W. Clay	Thatch	Metal	Plywood	W. Plywood	Bamboo	Cement Plaster	Brick
B-39731	0.5	0	0	2	0	2	2	2	0	0
	1.0	0	0	6	2	6	6	6	0	6
	2.0	2	12	12	6	12	12	6	0	12
B-41831	0.5	0	0	10	4	10	6	2	0	4
	1.0	0	4	12	6	12	14+	6	4	6
	2.0	0	6	14+	12	14+	14+	12	12	12
B-46676	0.5	0	0	0	2	2	2	2	0	0
	1.0	0	0	6	4	4	8+	4	0	0
	2.0	0	4	10	8	8	8	8	6	8
B-47940	0.5	0	0	4	2	8+	8+	4	2	4
	1.0	0	0	10+	4	8	8	4	2	4
	2.0	0	8	12+	8	12+	8	8	4	8
B-37344	0.5	0	0	16+	16+	16+	12	12	0	12
	1.0	0	10	16	20+	20+	16	16	14	20+
	2.0	4	16	20+	20+	16	20+	20+	16	20+
B-39007	1.0	10	6	20+	16	20+	10	20+	8	16
	2.0	6	14	20+	16	20+	16	20+	12	20+
(B-39007: (Sevin	1.0: 1.0	0	12	20+	16	20+	20+	20+	20+	20+
(B-39007: (DDT	2.0: 0.5	8	20+	20+	12	20+	20+	20+	16	20+
DDT	0.5	4	8	10	12	8	8	0	8	12
(Sevin: (DDT	2.0: 0.5	12	12 1/	20+	20+	20+	20+	20+	20+	20+
Sevin 2/	1.0	0	0	18+	16	16	16	0	16	16
	2.0	0	22+	22+	22+	22+	22+	22+	22+	22+
Sevin 3/	1.0	4	10	22+	22+	22+	18	14	18	10
	2.0	8	22+	22+	22+	22+	22+	22+	22+	22+
H-9699	0.25	8	0	10	4	0	0	0	0	0
	0.5	0	0	14+	10	12	0	2	0	2
	1.0	2	0	16+	12	16+	4	10	0	10
Malathion	1.0	0	4	16	16	16	4	8	8	4

1/ 81 percent mortality at week 20.
2/ Suspension from 85 percent wettable powder.
3/ Suspension from 50 percent wettable powder.

tested, the three formulations gave similar results for the 14 weeks tested except the 1:1 formulation that was ineffective on brick.

The combination of B-39007:Sevin at 1:1 g./sq. m. proved less effective than either compound at 2 g./sq. m. on clay and whitewashed clay (Table 6). The combination treatment was superior to B-39007 (2 g./sq. m.) and appeared equivalent to Sevin (2 g./sq. m.) on cement plaster and whitewashed plywood. On the brick, plywood, thatch, and bamboo, similar effectiveness was obtained with the three formulations.

Results from the Sevin:DDT at 2:0.5 g./sq. m. showed that the combination formulation was equivalent in effectiveness to Sevin at 2 g./sq. m. on all surfaces except clay and whitewashed clay (Table 6). On clay, the Sevin:DDT deposit gave 12 weeks of kills above 90 percent as compared to 8 weeks with the 50 percent w.w. Sevin alone. On this same criterion, Sevin alone gave 22 weeks effectiveness on whitewashed clay versus 12 weeks for the Sevin:DDT treatment. However, when the criterion was related to kills above 80 percent both treatments on whitewashed clay gave similar results. Treatment with DDT at 0.5 g./sq. m. did not give effective kills for more than 12 weeks on any surface.

A formulation of B-39007:DDT at 2:0.5 g./sq. m. gave 8, 20, 20, and 16 weeks of kills above 90 percent on clay, whitewashed clay, whitewashed plywood, and cement plaster, respectively, as compared to 6, 14, 16, and 12 weeks, respectively, for B-39007 alone on the same surfaces (Table 6).

On metal, the combination formulation was slightly less effective than B-39007 alone and on thatch, plywood, brick, and bamboo, the two formulations gave similar results.

Comparative evaluation of the durability of residues from the nine compounds tested at 1 g./sq. m. (Table 6) revealed that B-39731, B-41831, B-46676, and B-47940 were inferior in effectiveness to malathion. At the same dosage, malathion was inferior to H-9699 on brick, clay, and bamboo but superior on metal, whitewashed clay, and cement plaster.

Deposits of B-37344, Sevin, and B-39007 at 1 g./sq. m. were superior to those of malathion. On brick, B-37344 residues lasted 20 weeks as compared to 10 and 16 weeks for deposits of Sevin and B-39007. Sevin was the most effective toxicant on cement plaster and whitewashed plywood, while B-39007 gave superior results on bamboo and clay. On whitewashed clay, Sevin and B-37344 each produced 10 weeks of effective kills versus 6 for B-39007.

When B-37344, Sevin, and B-39007 are compared at 2 g./sq. m., Sevin was the most effective toxicant. On all surfaces, it showed a period of activity equal to or greater than either of the other two compounds.

Formulations of Sevin derived from 50 percent and 85 percent wettable powders indicate that on all surfaces except clay, the treatments at 2 g./sq. m. were equal in effectiveness during the 22-week test period (Table 6). On clay, finished spray from the 50 percent formulation gave

8 weeks of 90 percent kills as compared to 0 weeks for the treatment derived from the 85 percent powder. At 1 g./sq. m. the treatment with the 85 percent powder was less effective than that derived from the 50 percent powder on all surfaces except brick.

The sections treated in 1961 and 1962 with Sevin at 1 and 2 g./sq. m. showed essentially similar results to panels treated only in 1962. On clay, the panel treated in 1962 gave better results than those that received two applications. The opposite was true for the 1 g./sq. m. treatment on brick. With B-39007 the panels treated only in 1962 showed greater effectiveness of the deposits at 1 g./sq. m. on brick, metal, bamboo, and clay. However, on whitewashed plywood the panel receiving treatment both years gave 90 percent kills for 20 weeks versue 10 weeks for the single 1961 application. At 2 g./sq. m., the same was true. However, on six of the remaining seven surfaces no differences existed in the periods of effectiveness of the two types of treatment with B-39007.

The foregoing data again reveal that the type of surface treated has a profound effect upon the biological life of the chemical deposits thereon. Clay, whitewashed clay, and cement plaster are most detrimental to the residues while thatch and plywood appear to be most conducive to prolonged activity. Metal, bamboo, brick, and whitewashed plywood are intermediate in their effect on the life of the deposits. With the possible exception of clay, the detrimental influence of a surface can be overcome by using different toxicants or by increasing the dosage applied. Thus B-39731 and H-9699 at 2 g./sq. m. are ineffective on cement plaster in contrast

to Sevin and B-37344. On the same surface, B-41831 at 0.5 g./sq. m. produces no kills above 90 percent but at 1 and 2 g./sq. m. yielded 4 and 12 weeks effectiveness.

Although the application of whitewash to a surface has been considered a detriment to the efficacy of insecticide treatment, the data for all compounds except H-9699 show that deposits on whitewashed clay were more effective than those on clay alone. This effect was most obvious with B-39731, B-41831, B-47940, B-37344, and Sevin at 2 g./sq. m.

Carbamate insecticides are usually degraded by alkaline media but whitewash applied to surfaces rapidly changes from calcium hydroxide to calcium carbonate. Apparently the latter does not have a marked effect upon the longevity of the deposits as indicated by the extended action of Sevin, B-37344, and B-39007 at 2 g./sq. m. Chemical analysis of the whitewash mix prior to use and of the applied whitewash 20 weeks after application indicated the calcium carbonate content to be 51.8 and 52.8 percent, respectively.

The tests reveal that three compounds, B-39007, B-37344, and Sevin, have potential as residual treatments against anopheline mosquitoes, with Sevin showing the greatest promise. The superiority of the results from a 50 percent wettable powder over those from an 85 percent powder again indicates that toxicant alone is not the only factor in a formulation that influences the longevity of the residues.

Chemosterilant Studies

A. Anopheles albimanus

Biology and behavior of normal strains were investigated in the laboratory at about 80° F. and 50 to 70 percent relative humidity. The "Tecometal" strain, which laid more eggs and lived longer than the "Shell" strain, was selected for further work.

Various combinations of small numbers of mosquitoes were studied to determine the minimum number necessary for an acceptable degree of mating. Viable eggs were obtained in only about 1 percent of the numerous tests with single pairs of mosquitoes confined in a variety of cages. From 2 to 10 pairs of mosquitoes as well as imbalanced numbers of males and females were placed in WHO Adult Resistance Test Kit tubes (clear plastic, 5" long by 2" diameter). Four males with two females produced the highest number of eggs per female and the highest viability, but there was excessive variability in repeated tests.

Daily collections of eggs, held in distilled water for 3 days, showed wide variation in the percentage of hatch. Eggs from 25 to 400 pairs of mosquitoes confined in colony cages averaged about 50 percent hatch. When eggs were held in tap water for 6 days; hatching rates, of eggs from 25, 50, 100, and 125 pairs of adults confined in gallon cartons, were 67, 84, 76, and 52 percent, respectively.

In tests with different cages, the longevity of females was the shortest in small screen cages (3-1/2" x 4"), next in colony cages (17-1/2" x 18" x 23"), WHO plastic tubes (2" x 5"), waxed vials (1" x 2"), and longest

in gallon cartons (6-3/4" x 7"). With 50 pairs of adults in cartons, average longevity (50 percent) was 30 days for females and 14 days for males. Maximum observed longevity was 68 days for females and 44 days for males.

Mating usually begins when adults are more than 24 hours old but may occur on the first night after emergence. Females will mate either before or after a blood meal and when fully engorged but will not lay eggs without a blood meal. Virgin females will lay a few eggs (usually less than 20 percent of the normal number), none of which hatch. Males will mate with more than one female. Viable eggs were obtained from females 41 days after mating.

The number of eggs a single female deposited in 24 hours varied considerably; the maximum was 172. One female oviposited eight times during her lifetime and 55 percent of the eggs hatched. Eggs were collected from females that were 61 days old. About 60 percent of the eggs hatch on the second day after oviposition, 35 percent on the third, 3.5 percent on the fourth, and 1.5 percent on the sixth. In two cases, hatching was observed on the 10th day.

No differences in the hatching rates of eggs from adults of early or late developing pupae were observed. The percentage of males decreased from 66.5 on the first day of pupation, to 58.2 on the second, and 37.0 on the third day.

The similar size of male and female pupae prevented effective use of a mechanical separator that has been used for other species of mosquitoes.

Tepa, one of the alkylating agents, has been applied to Anopheles albimanus in the larval and adult stages. Larval treatments were applied to water containing late third and early fourth instar larvae. Dosages ranged from 5 to 20 ppm for a 24-hour period during which the larvae were not fed. At the highest dosage, only 9.2 percent of the larvae completed development to the adult stage. There was no difference between adult yields at the lower dosages. However, the starvation period reduced the yield in one reference to 43 percent. The number of eggs produced were progressively reduced with an increase in concentration of tepa: reference - 6.3/female/day; 5 ppm - 4.7; 10 ppm - 2.2; 15 ppm - 1.0; and 20 ppm - 0.1. The viability followed the same pattern, giving 77.7 percent, 58.4 percent, 27.3 percent, 14.1 percent, and 2.2 percent, respectively. There was no recovery of egg viability with the passing of time; therefore, the effects on the larvae were permanent. The longevity of the adults was apparently not adversely affected except in the case of the 20 ppm treatment (50 percent mortality in the 30-33 days as opposed to 12 days in the 20 ppm).

Tepa was included in the honey-water furnished to adult mosquitoes in such a manner as to prevent the mosquitoes from contacting the solution with any part of their bodies except the proboscis. Concentrations of 0.50, 0.75, and 1.0 percent tepa caused increasing mortality when fed for three consecutive nights. A concentration of 0.25 percent had no

apparent effect on longevity in one test, but in another 0.1 percent may have caused a slight decrease. A single night's feeding on tepa did not give complete sterility of either sex unless the mosquitoes were starved for 24 hours preceding treatment. The starvation period, however, caused male mortalities up to 72 percent and female mortalities to 28 percent.

It was necessary to furnish 0.1 or 0.0075 percent tepa-honey water solution for three consecutive nights in order to obtain complete sterility of males. The number of eggs obtained increased with decreased concentrations. At 0.025 percent, about the same number of eggs were obtained as would be expected from virgin females. At 0.1 percent, only 0.1 egg/female/day was deposited.

B. Culex pipiens quinquefasciatus

Detailed knowledge of normal behavior and techniques for obtaining the required experimental data were prerequisites to investigations of chemosterilants. A selected strain that feeds on rabbits was satisfactory for colony maintenance and egg production, but consistent feeding was not obtained in tests with less than 500 adults in a container. To overcome this problem, a procedure for feeding with a sucrose-blood solution was developed.

Fresh beef blood, obtained at a local slaughter house, was thoroughly mixed with sodium citrate (3.25 grams/liter) to prevent clotting and sucrose added to produce a 10 percent solution. The bottled solution

was frozen at 0° F. to hemolyze the blood. For feeding the mosquitoes, a 15-drum clear plastic snap-top vial is used. Approximately 100 holes, made with a hot needle, extend around the vial in a band from 3/4" to 2-1/4" from the bottom. The inside of the vial is lined with a single layer of paper toweling to act as a wick. A similar strip of celluloid is placed inside the paper towel wick to force the towel firmly against the sides of the vial, to aid in the capillary movement of the sucrose-blood solution up the wick and to retard drying of the sucrose-blood solution. Five to 10 milliliters of sucrose-blood solution is placed in the vial and the vial is inserted through a small, close-fitting hole in the top of the container. The adults (male and female) come to the feeder, insert their proboscis through the perforations, and take up the sucrose-blood solution from the wick. Tests established that females were attracted to sucrose rather than blood. The ingestion of blood was incidental to feeding on sucrose.

Using the above-described technique, oviposition was apparently normal and egg viability was approximately 90 percent. Larvae from these eggs developed normally and adults appeared healthy. All of the Culex used in these studies were routinely maintained in this manner. Stock colonies of approximately 10,000 adults ingested 20 ml./day from a total of two feeders. For experimental tests, dependable oviposition was obtained from 25 females in 1-gallon cartons with a single 15-dram-size feeder and from single females in 1-pint cartons with a 3-dram-size feeder.

In early tests, all efforts to obtain consistent mating in 1-gallon containers holding 25 males and 25 females failed as well as efforts to mate single pairs. Two thousand pupae from the stock colony cage were placed in cages 12" x 12" x 12" and the emerging adults were kept in a laboratory having a normal day-night light period. Mating occurred and the progeny from these small crowded colonies were used as the parental stock for the main colonies. After three generations of such rearing, tests using 500 adults and 50 adults per 1-gallon carton indicated that consistent mating was occurring with an average egg viability of 96 percent.

In order to determine the percentage of females successfully mated or fertilized in 1-gallon cartons, 100 mixed pupae were placed in a gallon carton and the emerged adults held for 7 days. At that time 15 females were aspirated at random and individually caged in pint cartons and fed sucrose-blood. Of the 15, ten produced eggs within a 3-week period. Of the 10 females producing egg rafts, only one female produced a non-viable raft. The average viability of the others was better than 95 percent. As a result of these and other tests, all mating tests are now routinely conducted in 1-gallon cartons.

In tests of chemosterilization by larval exposure, trays (9" x 15-1/2" x 2-1/2") containing approximately 1,500 third instar larvae in 1 liter of water were treated with sufficient technical metepa (methaphoxide) to produce concentrations of 10 and 20 parts/million. After pupation in the

metepa solution, four cartons of 25 treated males from each concentration and equal numbers of normal females were maintained on sucrose-blood solution in 1-gallon cartons. Eggs obtained from those females mated with males exposed to 10 ppm metepa had 83 percent hatch while those from females mated with males exposed to 20 ppm had 70 percent hatch.

To determine the effects of length of exposure and concentration of metepa upon larval development and subsequent sterility, rearing trays containing 200 third instar larvae each were treated with metepa at 10, 20, and 30 ppm. At each concentration, larvae were exposed for 24, 48, and 72 hours. After exposure, the larvae were removed from the metepa, rinsed thoroughly, and placed in untreated larval rearing media to complete development. Some pupation occurred prior to completion of the 72-hour larval exposure. Pupation in all concentrations and for all exposure periods ranged from 80 percent to 98 percent, with the lowest percent pupation from the 72-hour exposure to 30 ppm metepa. Larval treatment did not change the sex-ratio of adults.

When 25 males from each of these larval exposures were caged with 25 normal females, the eggs gave a normal hatching rate of 90 percent. Of the 96 rafts obtained in this test, only 8 gave less than 76 percent hatch and none of the rafts were sterile.

To measure the results of metepa residues on adult specimens, a collapsible plywood box having inside dimensions of 12" x 12" x 12" was used. A clear plexiglass top was placed on the box to facilitate observations and subsequent removal of the exposed adults. The adults did not rest upon the

plexiglass top, but rested upon the sides and bottom of the box. All plywood surfaces were treated with 500 mg./sq. ft. of metepa in 95 percent ethanol and permitted to dry and age for 12 and 36 hours. Exposures of 1,000 and 2,000 adult males 4 days old resulted in death of all specimens within a 4-hour period. Several experiments were conducted to determine whether the mortality was from the toxicity of the compound through tarsal uptake or from the vapors. Tests conducted with a constant air flow through the exposure box to remove the vapors resulted in no disturbance of the resting adults and no mortality was observed with 4-hour exposures. Using this technique, 4-day-old adult males were exposed for 4 hours to panels 1 week old having a residue of 500 mg./sq. ft. The males were then removed and caged with normal females at the ratio of 100 treated males with 100 virgin females in gallon cartons. Sucrose-blood was supplied and a total of 55 rafts (4,568 eggs) were collected over a 4-day period. None of the eggs were viable.

For applying consistent amounts of metepa to the body surfaces of adult mosquitoes, a modified Hoskins-Caldwell spray chamber was employed. Two ml. of metepa in an 85:15 mixture of 95 percent ethanol:glycerol solution was sprayed as a fine mist into an upper chamber. A small exhaust fan was used to gently move the mist from the upper chamber through the screened ends of a 1-pint carton containing 25 adults. As the mist passes through the carton, particles impinge upon the body of the adults. The treated specimens are removed from the exposure cartons and placed in 1-gallon cartons for mating.

Tests have been conducted with concentrations of 0.5, 1.0, 1.5, and 2.0 percent metepa in ethanol:glycerol. In these tests 4-day-old males were treated with each of the concentrations. Sucrose-blood was fed to 25 treated males and 25 virgin untreated females confined in a mating carton. Egg rafts were collected daily and larvae counted to determine viability. The percent of eggs that hatched decreased as the concentration of metepa was increased (Table 7). The hatching rate of eggs from untreated controls was over 90 percent. Treatment of males did not change the average egg production of 72-90 eggs per raft.

Table 7

Percent hatch of eggs from females mated with males treated with 0.5, 1.0, 1.5, and 2.0 percent metepa in an ethanol:glycerol mist.

Percent Conc. Metepa	Total Number Eggs	Total Number Larvae	Percent Hatch
0.5	1,711	1,086	63
1.0	2,742	890	32
1.5*	6,122	1,554	25
2.0*	7,344	1,286	17

* These data are combinations of two tests. All tests consist of four cartons of 25 treated males and 25 normal females.

EQUIPMENT DEVELOPMENT STUDIES

Pressure Regulators

Flow regulators have demonstrated major economics in field use but a minor objection to them, as developed to date and used in the field, has been their fall-off in delivery with use. This has necessitated a daily or weekly exchange of regulators. To overcome this difficulty, regulators made with Viton A were developed and obtained in trial quantity. Preliminary laboratory investigations were completed during FY-1962. During the current year, these regulators have been exhaustively tested in the laboratory. It is found that the regulator under these test conditions maintains its delivery rate within the specified limits during the passage of 1,500 gallons of spray suspension. As a result of this flow, through the nozzle tip-regulator combination, the increase in delivery rate was 5.5%. This may be compared with 4.8% increase for a flow of 250 gallons through an 8004 tip without regulation. This low erosion rate, combined with narrowing limits of tolerance for the initial discharge, should make it possible for the nozzle tip regulator combination to be used without change for at least one spraying season on most programs.

The economy achieved by the Viton A regulators should be even greater than that found with the system employing the early regulators inasmuch as initial delivery rate has been specified as 757 ml. The original regulators were giving initial deliveries in the neighborhood of 840-870 ml.

Trials have been conducted with the regulators in conjunction with cone, hollow cone, and jet spray pattern nozzles. These operate satisfactorily with regulated flow as long as the nozzle tip is designed to deliver approximately 757 ml. per minute. The regulators will also work with oil and emulstions, contrary to some previous reports, but the delivery rate will be different for a given nozzle tip and regulator as compared with water.

The most recent and accurate evaluation of unregulated, mechanically regulated, and disc regulated flow techniques has been studied and the results plotted as found in Figure 1. The advantages of the disc regulation are obvious. The contribution of AID to the regulation of insecticide flow was publicized in a paper, Hall, L. B. and Taylor, J. E., "Regulated Flow of Insecticides", Bulletin of the World Health Organization, 27, 297-281, 1962.

Specifications

The AID specification for sprayers was further revised to bring it up to date to meet modern practice and resulted in AID Specification No. 7705-2, January 23, 1963.

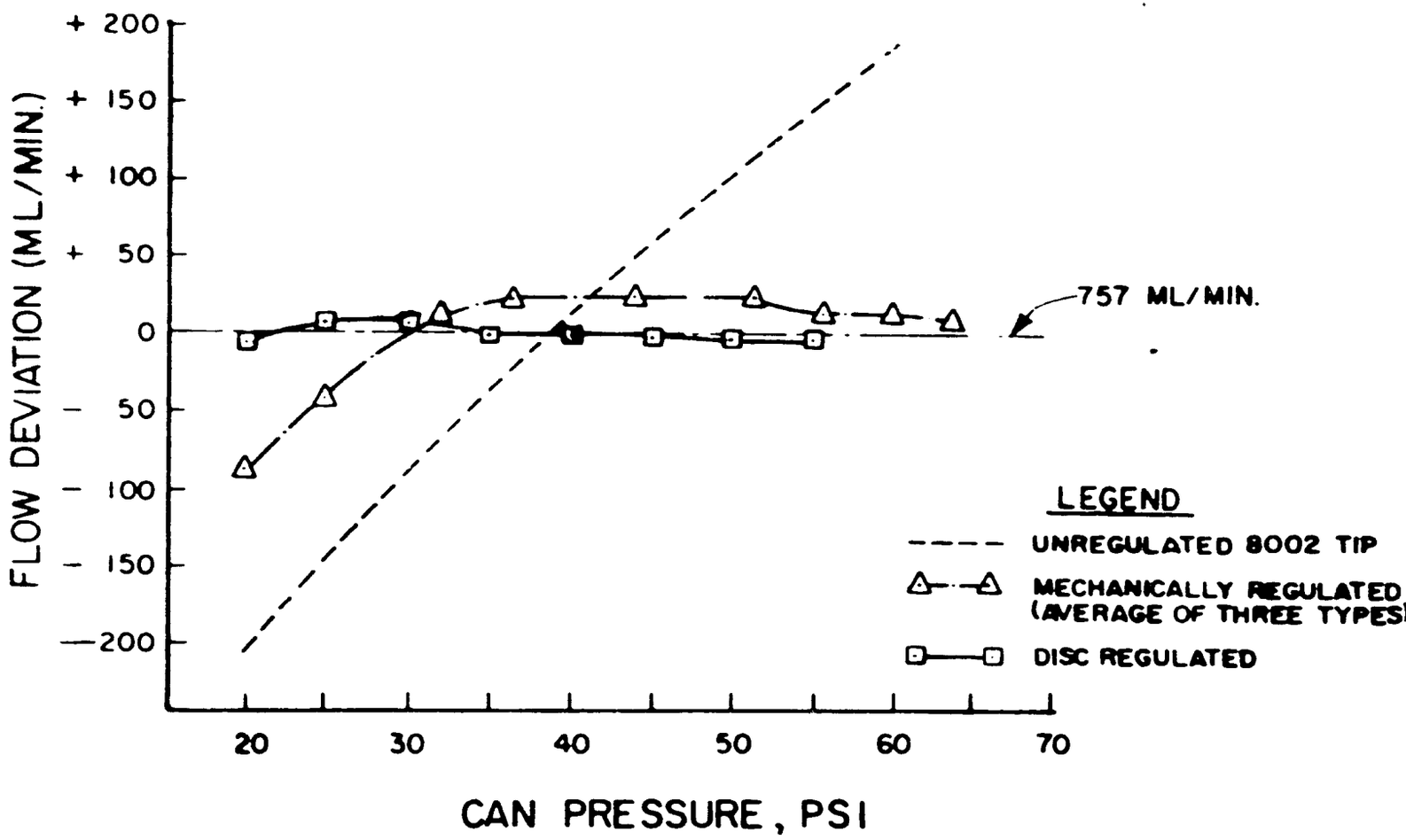
Testing

Three groups of sprayers were given complete performance tests during the fiscal year for compliance with the AID specification and inclusion in the preferred bidders list.

Erosion with Dieldrin

Field problems have given rise to the question as to whether or not water suspensions of dieldrin erode nozzle tips as rapidly or more rapidly than water suspensions of DDT. Laboratory tests which involve the passage of both insecticides through 8002 SS nozzle tips, unregulated, at 40 p.s.i. indicate that the erosion with dieldrin is very closely comparable to the erosion with DDT.

SPRAYER DISCHARGE RATES WITH UNREGULATED, MECHANICALLY REGULATED, & DISC REGULATED FLOW.



S-394-2 2/28/68