AD-A015 561

EVALUATION OF A METHOD FOR FIELD COLLECTION OF ULTRA-LOW VOLUME-SIZE AEROSOL DROPLETS

Edwards S. Evans, Jr., et al

Army Environmental Hygiene Agency

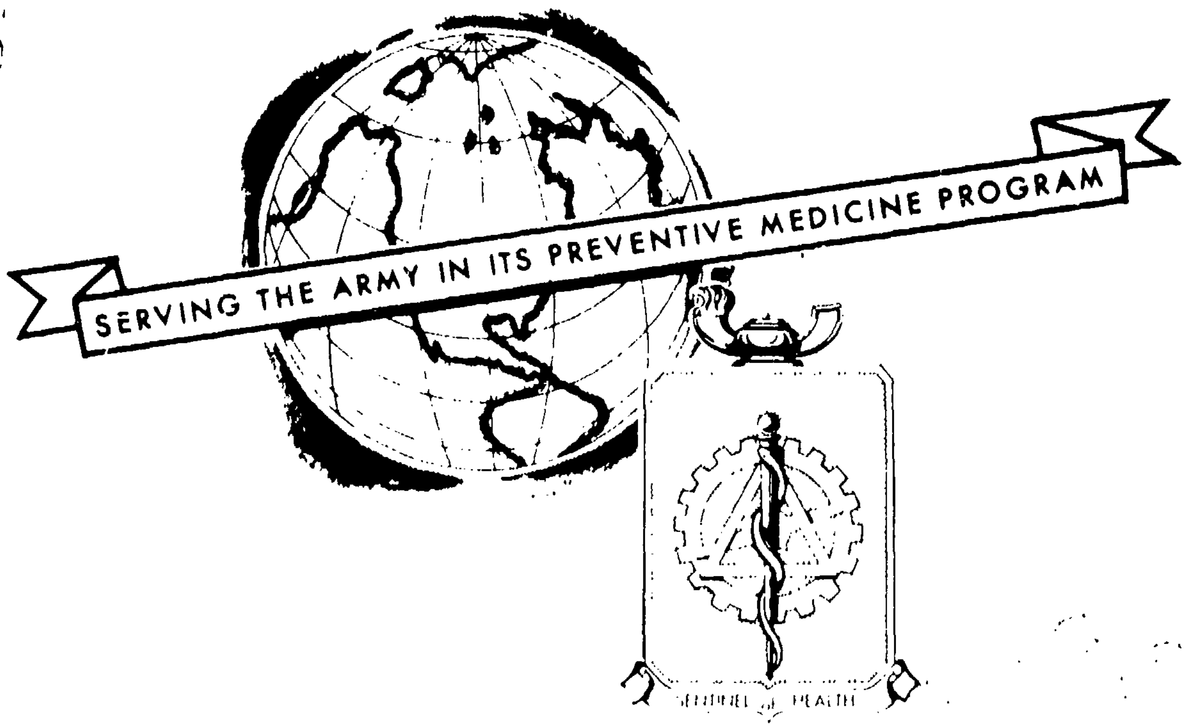
Prepared for:

Army Health Services Command

December 1974

290090

ENTOMOLOGICAL SPECIAL STUDY NO. 44-017-75/76
SUBTASK I - EVALUATION OF A METHOD FOR FIELD
COLLECTION OF ULTRA-LOW VOLUME-SIZE AEROSOL DROPLETS
SEPTEMBER - DECEMBER 1974



US ARMY
ENVIRONMENTAL HYGIENE AGENCY
ABERDEEN PROVING GROUND, MD 21010

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: 44-017-75/76
2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle): Evaluation of a Method for Field Collection of Ultra-Low Volume-Size Aerosol Droplets
5. TYPE OF REPORT & PERIOD COVERED: September - December 1974
6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s):

Edward S. Evans, Jr, Ph.D. Entomologist

Charles D. Davenport CPT, MSC Entomologist

8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: US Army Environmental Hygiene Agency, Aberdeen Proving Ground, MD 21010
10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS: Commander, USA Health Services Command, Fort Sam Houston, TX 78234
12. REPORT DATE
13. NUMBER OF PAGES: 12
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)
15. SECURITY CLASS. (of this report): Unclassified

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report): Approved for public release; distribution unlimited
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)
18. SUPPLEMENTARY NOTES
19. KEY WORDS (Continue on reverse side if necessary and identify by block number)
    - Aerosol Sampling
    - Droplet
    - Malathion
    - Pest Control Equip
    - Ultra-Low Volume
20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Studies were conducted to develop practical alternates to the hand-wave method for the field collection of ULV-size aerosol droplets. A comparative evaluation between the hand-wave method and settling chambers was made using aerosol droplets of malathion or Klearol, produced by a Micro-Gen MS2W-15, collected on Teflon-coated microscope slides. Settling chambers included large metal US Army shipping containers (MILVANS) and smaller plywood boxes of various dimensions.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

Item 20 (continued)

Results indicated an increased efficiency of the settling technique versus the hand-wave method in the collection of droplets less than 10μ in size. Size of the settling chamber did not reduce the overall collection efficiency of smaller aerosol droplets; however, placement of the Teflon-coated slides within the confines of the large MILVAN chambers showed significant variability (.01 level) in the largest droplet observed and the subsequently calculated volume median diameter. There was no significant variability observed between location of slides within the smaller plywood settling chambers.

Plywood settling chambers evaluated in this study appear to be a more practical and efficient method for the field evaluation of the aerosol producing efficiency of ULV insecticide sprayers.

DEPARTMENT OF THE ARMY
U. S. ARMY ENVIRONMENTAL HYGIENE AGENCY
ABERDEEN PROVING GROUND, MARYLAND 21010

23 SEP 1975

HSE-RE/WP

ENTOMOLOGICAL SPECIAL STUDY NO. 44-017-75/76 SUBTASK I - EVALUATION OF A METHOD FOR FIELD COLLECTION OF ULTRA-LOW VOLUME-SIZE AEROSOL DROPLETS SEPTEMBER - DECEMBER 1974

ABSTRACT

Studies were conducted to develop practical alternates to the hand-wave method for the field collection of ULV-size aerosol droplets. A comparative evaluation between the hand-wave method and settling chambers was made using aerosol droplets of malathion or Klearol, produced by a Micro-Gen MS2W-15, collected on Teflon-coated microscope slides. Settling chambers included large metal US Army shipping containers (MILVANS) and smaller plywood boxes of various dimensions.

Results indicated an increased efficiency of the settling technique versus the hand-wave method in the collection of droplets less than 10μ in size. Size of the settling chamber did not reduce the overall collection efficiency of smaller aerosol droplets; however, placement of the Teflon-coated slides within the confines of the large MILVAN chambers showed significant variability (.01 level) in the largest droplet observed and the subsequently calculated volume median diameter. There was no significant variability observed between location of slides within the smaller plywood settling chambers.

Plywood settling chambers evaluated in this study appear to be a more practical and efficient method for the field evaluation of the aerosol producing efficiency of ULV insecticide sprayers.

DEPARTMENT OF THE ARMY
U. S. ARMY ENVIRONMENTAL HYGIENE AGENCY
ABERDEEN PROVING GROUND, MARYLAND 21010

HSE-RE/WP

ENTOMOLOGICAL SPECIAL STUDY NO. 44-017-75/76
SUBTASK I - EVALUATION OF A METHOD FOR FIELD
COLLECTION OF ULTRA-LOW VOLUME-SIZE AEROSOL DROPLETS
SEPTEMBER - DECEMBER 1974

1. REFERENCES.

a. Letter, RDLW-ADB, US Army Land Warfare Laboratory, 20 February 1973, subject: Real-Time Measurement of Aerosols, LWL Task 04-B-73.

b. Letter, DASG-HCH-E, Office of The Surgeon General, 18 October 1974, subject: Real Time Measurements of Aerosols.

2. PURPOSE. To evaluate practical alternates to the hand-wave method for the field collection of ULV-size aerosol droplets.

3. GENERAL. The method utilized for the collection of ultra-low volume (ULV)-size aerosol droplets should be both practical under field conditions and efficient in the collection of droplets from 1-50 microns (μ) in diameter. In terms of convenience and simplicity, the hand-wave method could be considered suitable for use in routine field evaluations of droplets produced by ULV sprayers. However, both Rathburn[1] (1970) and Mount and Pierce[2] (1972) reported the hand-wave method to be inefficient in the collection of aerosol droplets less than 10μ in size. Mount and Pierce (1972) showed through comparative testing that settling and impaction methods were more efficient than the hand-wave method for the collection of droplets; however, both methods had major disadvantages. The size of the settling chambers (8 x 8 x 8 ft) used in the evaluation would not be readily available to pest management personnel. With the impaction technique, additional measurements and calculations must be made, thereby making this method relatively complicated and time consuming. In an effort to alleviate the disadvantages of the settling methods, tests were conducted to determine the minimum size of air-tight settling chambers necessary to obtain reliable results while maintaining practicality.

---

[1] Rathburn, C.B., Jr. 1970. Methods for assessing droplet size of insecticidal sprays and fogs. Mosq. News 30(4): 501-513.
[2] Mount, G.A. and N.W. Pierce. 1972. Droplet size of ultra-low volume ground aerosols as determined by three collection methods. Mosq. News 32(4): 586-589.

4. MATERIALS AND METHODS.

a. Aerosol droplets of malathion (NSN 6840-00-926-1481) or Klearol® were produced by a Micro-Gen® MS2W-15, mounted on the back of a 1/2 ton truck. Operating parameters of the machine included a flow rate of 2.1 fl oz/min and a pressure of 3.5 psi. When dispensing ULV insecticide at flow rates less than 3 fl oz/min with the Micro-Gen MS2W-15, the manufacturer recommends the use of only one nozzle; therefore, only one nozzle was operated in these studies (Parke,[3] personal communication).

b. All droplets were collected on Teflon®-coated glass microscope slides.* Following droplet collection, slides were stored in an air-tight slide box and transported to the laboratory for microscopic droplet measurement. Measurements of at least 200 droplets per slide were made at a magnification of 450x utilizing a calibrated ocular micrometer. Measured droplets were multiplied by a spread factor of 0.70 for malathion droplets and 0.52 for Klearol droplets to obtain a true diameter. Determination of volume median diameters (VMD or MMD) were made in the manner described by Yoemans[4] (1949). Frequency or numerical median diameters (FMD or NMD) and droplet size distribution, as discussed by Rathburn[1] (1970), were also calculated. Procedures for each droplet collection method were as follows:

(1) Hand-wave. Teflon-coated slides were secured to the end of a flat stick (18 inches long) with a spring-type paper clip. A single rapid, vertical pass was made down through the aerosol cloud, 6 ft from the nozzle. Volume median diameters were determined using the method for impinged slides (Yoemans,[4] 1949).

(2) Settling Chamber. Aersol droplets were introduced into air-tight chambers of varying dimensions and allowed to settle for 24 hours. The largest chambers were metal US Army shipping containers (MILVANS) with dimensions of 16L x 8W x 8H ft. Five Teflon-coated slides were placed, Teflon side up, on the floor of the container; one slide in the center and the other four 1 ft from each corner (Figure 1). Three plywood chambers

---

®Klearol is a registered trademark of WITCO Chemical Corp., New York, NY.
®Micro-Gen is a registered trademark of Micro-Gen Corp., San Antonio, TX.
®Teflon is a registered trademark of E.I. Dupont de Nemours and Co., Inc., Wilmington, DE.
[3] Parke, J. 1973. Personal Communication. Micro-Gen Corp., San Antonio, TX 78216.
[4] Yoemans, A.H. 1949. Directions for determining particle size of aerosols and fine sprays. U.S.D.A. ET-267, 7pp.
*Available from Gulva Associates, PO Box 249, Belle Chasse, LA 70037.

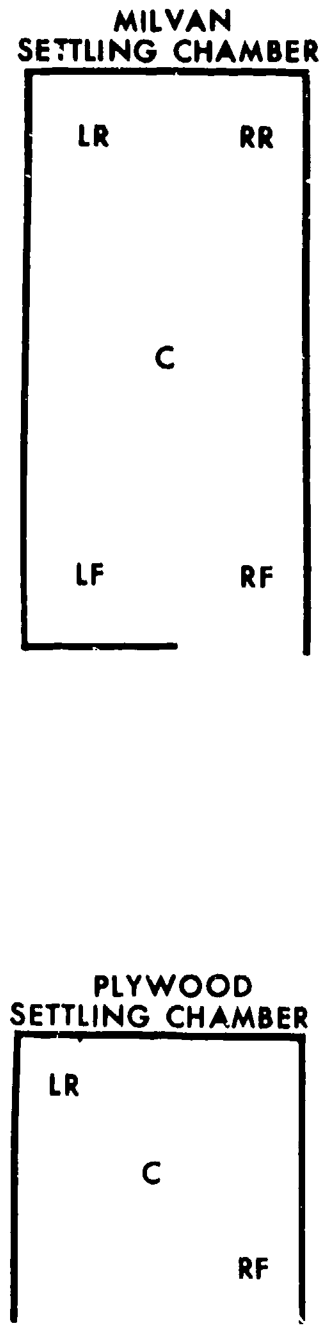


Fig. 1 Location of Teflon-Coated Slides in Settling Chambers

(21L x 17W x 20H in; 31 x 29 x 25 in; and 36 x 36 x 30 in, hereafter referred to as small, medium and large), placed 2 ft off the ground, were also utilized. Three Teflon-coated slides were placed on the bottom of each chamber; one slide at the center and the other two at the right front and left rear of the chamber (Figure 1).

c. Initial studies, using malathion, involved a comparison between the large MILVAN settling chambers and the hand-wave method. The truck-mounted Micro-Gen was driven past three MILVAN chambers at 5 mph. Distance from the machine nozzle to the chamber entrance was 1 ft. Aerosol droplets were collected with three hand-wave slides in a manner described previously. The test was replicated twice.

d. In the next series of tests, the diluent Klearol was used. The three plywood chambers were compared with the hand-wave method. The truck-mounted Micro-Gen was driven past each chamber at 5 mph. Distance from the machine nozzle to the chamber entrance was 10 ft. Aerosol droplets were collected using two hand-wave slides; one at the beginning of the test run and one at the end. The entire test was replicated seven times.

e. In the final series of tests, the three plywood chambers were again compared with the hand-wave method using the diluent Klearol. In this series, the truck-mounted Micro-Gen was stopped in front of each chamber and a 2-second blast of aerosol was introduced. Distance from the machine nozzle to the chamber entrance was 6 ft. Aerosol droplets were collected using three hand-wave slides. The entire test was replicated three times.

5. RESULTS AND DISCUSSION.

a. Malathion droplet characteristics for MILVAN settled and hand-wave slides are presented in Table 1. Average VMD for settled slides were 18.1, 15.6, and 22.1μ for each chamber as opposed to 17.9μ for hand-wave slides. A one-way analysis of variance indicated no significant variability between VMD of settled or hand-wave slides (.05 level). Average FMD, however, were less than 1.58μ for settled slides as opposed to 14.7μ for hand-wave slides. Settled slides indicated that greater than 50 percent of the total number of droplets measured were less than 2μ in diameter. The inefficiency of the hand-wave method in the collection of droplets less than 10μ in size contributed to the larger FMD. The largest drop collected using the hand-wave method was significantly different from settled slides (.05 level). The smallest droplet observed was the same for both droplet collection methods (1.58μ).

b. Of concern was the influence that location of the Teflon slides within the confines of the MILVAN settling chamber had on droplet characteristics. Table 1 presents VMD and largest droplets observed for slides located at the right front (RF), left front (LF), center (C), right

TABLE 1

MALATHION DROPLET CHARACTERISTICS -
MILVAN SETTLING CHAMBERS vs HAND-WAVE

MICRONS

Collection Method	Slide Location	VMD REP 1	VMD REP 2	FMD REP 1	FMD REP 2	Largest Drop REP 1	Largest Drop REP 2	Smallest Drop REP 1	Smallest Drop REP 2
Chamber 1	RF	27.7	-	<1.58	<1.58	47.5	-	1.58	1.58
	LF	14.1	9.5			19.0	20.6		
	C	18.0	28.4			33.2	47.5		
	RR	21.5	18.1			28.5	23.7		
	LR	19.2	6.8			25.3	12.7		
	$\bar{x}$	18.1		<1.58		28.7		1.58	
Chamber 2	RF	26.3	15.8			47.5	20.6		
	LF	12.0	13.3			19.0	25.3		
	C	16.9	18.0			30.1	55.4		
	RR	11.5	18.4			25.3	30.1		
	LR	8.8	15.1			17.4	20.6		
	$\bar{x}$	15.6		<1.58		29.1		1.58	
Chamber 3	RF	43.1	26.8			45.9	47.5		
	LF	20.9	19.5			31.6	31.6		
	C	22.8	17.9			34.8	33.2		
	RR	16.8	15.1			31.6	25.3		
	LR	25.5	13.4			22.1	23.7		
	$\bar{x}$	22.1		<1.58		32.7		1.58	

Collection Method	Slide Location	VMD 1	VMD 2	VMD 3	FMD 1	FMD 2	FMD 3	Largest Drop 1	Largest Drop 2	Largest Drop 3	Smallest Drop 1	Smallest Drop 2	Smallest Drop 3
Hand-Wave		17.6	18.0	18.2	14.4	15.2	14.5	39.5	47.5	55.4	1.58	1.58	1.58
	$\bar{x}$	17.9			14.7			47.4			1.58		

rear (RR), and left rear (LR) of the chamber. Analysis of variance indicated highly significant variability (.01 level). Slides located in the right front of the chamber had a significantly larger VMD than LF, RR, or LR slides. There was no significant difference in VMD between RF and C slides (.05 level). Examination of the largest droplet observed elucidates the variability in VMD. Right front slides had significantly larger droplets than LR, RR, or LR slides (.05 level). There was no significant difference between the largest droplet observed for RF and C slides.

c. Obviously, Teflon-coated slides located closest to the ULV machine nozzle (RF and C) collected the larger droplets (Figure 1). As might be expected, in a confined atmosphere, larger droplets did not drift from the front to the rear of the chamber or from right to left.

d. It was concluded that the MILVAN settling chambers were more efficient in the collection of aerosol droplets as compared to the hand-wave method. However, the variability inherent to the placement of Teflon slides within the confines of the chamber, as well as the limited practicality of these vans for routine field collection of aerosol droplets, led to the evaluation of another type of settling chamber. It was decided that reduction in the overall size of the chamber, and an increased opening in proportion to the size of the chamber for the introduction of the aerosol cloud, might alleviate the previously encountered variability.

e. In the next series of tests, using Klearol, the Micro-Gen was driven past the plywood settling chambers at 5 mph. Distance from the machine nozzle to the chamber entrance was 10 ft. A limited number of droplets was collected on both hand-wave and settled slides resulting in spurious data; therefore, the information gathered using this method will be excluded from this report.

f. Results from those tests in which the Micro-Gen was stopped for 2 seconds in front of each chamber at a distance of 5 ft from machine nozzle to chamber entrance were more conclusive and are presented in Table 2.

g. Results in regards to VMD and FMD for settled slides were similar to those settled slides from the MILVAN chambers. Volume median diameters were not significantly different from those calculated from hand-wave slides (.05 level). Settled slides from each of the three plywood chambers had an FMD less than 2μ. Again, the inefficiency of the hand-wave method in the collection of smaller droplets is discernible from the 12.5μ FMD. The smallest droplet encountered was the same (1.2μ) for both collection methods regardless of the size of the settling chamber. Again, the largest droplet observed using the hand-wave method was significantly larger than those collected using the plywood settling chambers (.05 level). However, an examination of droplet distribution (Table 3) indicates that although the hand-wave method was more efficient in the collection of larger droplets

TABLE 2

KLEAROL DROPLET CHARACTERISTICS - PLYWOOD SETTLING CHAMBERS vs HAND-WAVE

MICRONS

		VMD			FMD			Largest Drop			Smallest Drop		
Collection Method	Slide Location	REP			REP			REP			REP		
		1	2	3	1	2	3	1	2	3	1	2	3
Small Chamber	RF	10.7	9.0	12.6	1.7	<1.2	1.6	16.5	11.8	23.6	1.2	1.2	1.2
	C	14.3	10.3	12.0	1.7	1.6	1.4	22.4	15.3	17.7			
	LR	16.8	14.6	13.4	1.6	1.6	1.8	26.0	20.1	16.5			
	$\bar{x}$		12.6			<1.6			18.9			1.2	
Medium Chamber	RF	10.0	10.4	11.0	1.9	1.5	<1.2	20.1	23.6	16.5			
	C	12.3	14.9	17.7	1.2	1.9	1.7	21.2	27.2	15.3			
	LR	10.5	13.6	13.9	2.0	<1.2	<1.2	15.3	15.3	13.0			
	$\bar{x}$		12.7			<1.5			18.6			1.2	
Large Chamber	RF	12.4	18.0	9.1	2.2	<1.2	1.9	21.2	22.4	15.3			
	C	13.1	7.7	11.4	2.2	1.7	1.4	17.7	13.0	17.7			
	LR	12.2	13.3	11.7	2.0	1.4	1.4	16.5	16.5	14.2			
	$\bar{x}$		12.1			<1.7			17.2			1.2	
Hand-Wave	1	14.3	13.1	15.6	13.1	11.2	13.6	36.4	31.7	28.3	1.2	1.2	1.2
	2	13.7	13.7	14.4	12.0	12.5	12.3	33.0	29.5	26.0			
	3	13.4	13.6	15.1	12.1	11.8	13.6	27.2	28.3	26.0			
	$\bar{x}$		14.1			12.5			29.6			1.2	

TABLE 3

KLEAROL DROPLET DISTRIBUTION (%) - PLYWOOD SETTLING CHAMBERS VS HAND-WAVE

MICRONS

		<5			5-10			11-20			>20		
			REP			REP			REP			REP	
Collection Method	Slide Location	1	2	3	1	2	3	1	2	3	1	2	3
Small Chamber	RF	82.6	94.2	91.0	16.4	5.8	7.8	0	0	1.6	0	0	0
	C	83.9	91.1	83.6	11.1	8.0	13.8	5.1	0.8	2.6	0	0	0
	LR	81.0	86.0	89.8	14.4	10.0	7.9	2.7	3.9	2.4	0.5	0	0
	$\bar{x}$		87.0			10.6			2.1			0	
Medium Chamber	RF	81.5	87.6	89.5	15.3	8.5	9.0	3.2	3.8	1.4	0	0	0
	C	87.8	80.3	88.1	9.6	17.2	9.7	2.6	2.0	2.2	0	0	0
	LR	85.2	96.6	97.7	11.7	2.1	1.4	3.0	1.3	0.9	0	0	0
	$\bar{x}$		88.2			9.4			2.3			0	
Large Chamber	RF	73.6	88.5	82.8	21.6	10.1	15.8	4.6	1.4	1.3	0	0	0
	C	80.5	89.8	88.0	13.6	9.8	10.1	5.9	0.5	1.4	0	0	0
	LR	77.9	89.8	95.7	18.0	7.9	3.3	4.1	2.3	1.0	0	0	0
	$\bar{x}$		85.2			12.3			2.5			0	
Hand-Wave	1	12.2	7.1	1.9	35.1	42.7	34.3	51.4	47.4	61.0	1.4	2.8	2.3
	2	1.8	4.8	8.3	43.1	45.7	38.4	48.2	44.7	44.7	6.9	4.8	3.2
	3	4.0	9.4	10.3	35.7	48.0	24.8	58.5	41.7	62.2	1.8	0.8	2.8
	$\bar{x}$		6.6			38.6			51.7			3.0	

droplets greater than 20μ constituted only 3 percent of the total droplet distribution. Of more importance, is the efficiency of the settling chambers in the collection of droplets less than 10μ. There was no significant difference between the three chambers in regards to collection efficiency for the smaller sized droplets. Greater than 97 percent of the measured droplets collected on settled slides were 10μ or less in diameter.

h. Variability in regards to VMD and the largest droplet observed for slides at various locations within the plywood settling chambers is presented in Table 2. Whereas significant variability was encountered using the MILVAN chambers, no significant differences (.05 level) were observed for VMD and the largest droplet observed between settled slides located in the right front (RF), center (C), or left rear (LR) of the plywood chamber. The same results were obtained regardless of the size of the plywood chamber.

i. In summary, preliminary studies comparing settling versus the hand-wave method for the collection of ULV sized aerosol droplets indicated the increased efficiency of the settling technique in the collection of droplets less than 10μ in size. Size of the settling chamber did not reduce the overall collection efficiency of smaller aerosol droplets; however, placement of the Teflon-coated slides within the confines of the large MILVAN chambers showed significant variability in the largest droplet observed and the subsequently calculated VMD.

j. Statistical computations from data gathered following droplet measurements are important for evaluating the effectiveness of a particular aerosol cloud for adult mosquito control. As noted previously, calculated VMD for both hand-wave and settled slides were not significantly different. However, calculated FMD for hand-wave versus settled slides did differ significantly. In addition, a totally different distribution of droplets was obtained for the same aerosol cloud depending on the droplet collection method utilized. The VMD value, while important, does not give an indication of the number of droplets available for effective adult mosquito control. For this reason, FMD and droplet distribution information should be included, along with VMD, when presenting ULV size aerosol droplet characteristics.

k. The hand-wave method has been shown to be inefficient in the collection of droplets less than 10μ in size. Potential health hazards of the hand-wave method to pest management personnel, who must stand in the ULV insecticide aerosol to collect droplets, must also be considered. Settling chambers such as the ones evaluated in this study appear to be a more practical and efficient method for evaluating the aerosol producing efficiency of ULV insecticide sprayers.

6. CONCLUSIONS.

a. MILVAN and plywood settling chambers were more efficient than the hand-wave method for the collection of ULV-size aerosol droplets 10µ or less in diameter.

b. Location of the Teflon-coated microscope slides within the confines of the MILVAN settling chamber caused significant variability both in terms of the largest droplet observed and the subsequently calculated volume median diameter. There was no significant variability in terms of droplet collection efficiency between Teflon-coated slides placed at various locations within the plywood chambers.

c. The size of the plywood chambers evaluated did not affect the droplet collection efficiency. No significant differences between the three chambers in terms of VMD, FMD, or droplet distribution were in evidence.

7. RECOMMENDATIONS.

a. Continue to use the hand-wave method for the collection of ULV-size aerosol droplets since the hand-wave method has been utilized to establish requirements for the use of currently registered ULV insecticides and remains the accepted method for evaluating the performance of ULV insecticides.

b. Request the US Army Medical Research and Development Command to design and develop a portable settling chamber suitable for the field collection of aerosol droplets produced by ground ULV equipment.

c. Conduct further studies to evaluate prototype settling chambers and establish standing operating procedures for the use of such chambers by US Army pest management personnel. These studies should include:

(1) Elucidation of operational parameters of ULV-insecticide sprayers necessary for the most effective utilization of settling chambers.

(2) Determination of the optimum distance between a ULV-sprayer nozzle and settling chamber entrance for maximum efficient collection of aerosol droplets.

(3) Determination of the reliability of the settling chamber technique relative to specific registered ULV-insecticides and diluents.

(4) Determination of the minimum settling time required for aerosol droplets onto Teflon-coated slides within the confines of the air-tight settling chambers.

(5) Determination of the duration of aerosol droplets on Teflon-coated settled slides in regards to significant changes in droplet measurement and the subsequently calculated volume and frequency median diameters.

(6) Evaluation of the combatability of the settling chamber technique with automatic quantitative image analysis equipment currently available for aerosol droplet measurement.

EDWARD S. EVANS, Jr, Ph.D.
Entomologist
Entomological Sciences and
Pesticide Division

CHARLES D. DAVENPORT
CPT, MSC
Entomologist
Entomological Sciences and
Pesticide Division

APPROVED:

LINNAEUS B. SAVAGE
MAJ, MSC
Chief, Entomological Sciences and
Pesticide Division

WILLIAM G. PEARSON
COL, MSC
Director, Radiation and
Environmental Sciences