PESTICIDE EXPOSURE TO APPLICATORS DURING DORMANT SPRAYING OF TREES WHILE IN AN ENCLOSED CAB EQUIPPED WITH A CHARCOAL AIR FILTRATION SYSTEM IN CALIFORNIA, JANUARY 1986

By

Rhoda Wang, Staff Toxicologist
Frank Schneider, Associate Environmental Hazards Scientist
Dorothy Alcoser, Environmental Hazards Scientist
Steve Saiz, Environmental Hazards Scientist
Cathy Cooper, Agricultural Chemist II
Margaret Bisbiglia, Associate Environmental Hazards Scientist

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California Department of Food and Agriculture
Division of Pest Management, Environmental
Protection and Worker Safety
Worker Health and Safety Branch
1220 N Street, Sacramento, California 95814

SUMMARY

Eleven applications were monitored during dormant spraying of trees with parathion and methidathion while in an enclosed cab using a charcoal air filtration system. Applicator's potential exposure was monitored for a period of three to seven hours with samples being collected for air concentrations and dermal exposure. For dermal protection when outside the cab, the applicators also wore Tyvek[R] coveralls as part of their regular work clothing. They did not wear respirators while in the cab but used them when outside the cab and during loading. Levels of dermal and inhalation exposure from parathion during ten of the applications including three operators who mixed and loaded averaged less than 70 micrograms per hour (0.07 mg/hr). Air concentrations found in the breathing zone of workers and ambient air inside the cab were significantly lower than those found outside the cab. The efficiency of the filter system averaged 95 percent.

INTRODUCTION

Agricultural pesticide applicators are exposed to the potential health risks of pesticides through inhalation and dermal absorption. Some pesticide applicators using air blast sprayers in orchards have had dermal exposures measured that ranged from 0.7 to 69.7 milligrams (mg) per hour at application rates of 0.5 to 3 pounds active ingredient per acre (Hackathorn and Eberhart, 1985). In studies conducted using enclosed cabs, Spittler and Bourke (1985) found a three to five-fold decrease in dermal exposure associated with the use of cabs. This study was undertaken to determine the effectiveness of a commercially available enclosed cab with a charcoal air filter system during dormant spray operations in orchards. Dermal and airborne levels were used to estimate total worker exposure. Airborne levels were used to determine the efficiency of the cab's air filtration system.

METHODS AND MATERIALS

The enclosed cab used in all applications was a Nelson Orchard Spray Cab. The cab uses an air filtration system that develops positive pressure inside the cab by means of a blower. The filter system consists of three separate filters; a pre-filter, high-efficiency filter (HEPA), and charcoal filter. Seals are used at all joints while mats are used at openings for rods and levers. While the cab is not airtight it is effectively sealed to maintain the positive air flow. Pressure inside the cabs was above 0.03 inches of water.

All applications were made using air blast sprayers capable of throwing spray above and through the tree. Spray tank capacity ranged from 400 to 500 gallons. They had the capability to spray one load in 3/4 to 1-1/4 hours. The trees being sprayed were either peaches or almonds.

Ten applications were monitored using parathion and one application used methidathion. The materials were applied at rates of 1/2 to 2 pounds active ingredient in 75 - 100 gallons of water per acre. In three applications the applicators also loaded the material and in two other applications only minor assistance in the loading was provided by the applicator. Exposure time for the workers monitored ranged from three to seven hours.

Air samples were taken using portable personal sampling pumps set at a flow rate of one liter per minute. Glass fiber filters (37 mm diameter, 0.3 um pore size) were used as the sampling media followed by XAD-4 resin (40/80 mg 2-stage sorbent tubes). The applicator wore one pump for a personal breathing zone sample, another was placed inside the cab, and one was placed outside the cab at the air intake. Air pumps were calibrated before and after the exposure period with a Kurz Model 540S mass flow meter.

Dermal exposure was monitored using 12-ply surgical gauze pads mounted in waterproof envelopes (foil backed paper). This method is like that of Durham and Wolfe (1962). The envelopes had an exposed pad area of 23.75 square centimeters. The pads were mounted on the outside and under standard Tyvek^{R} coveralls worn by the workers. The pads were placed under the coveralls so only one layer of the coverall material covered the pad. Pads were located on the arms, legs, chest, and back. Additionally, one pad was placed outside the cab approximately two feet behind the applicator.

Handwash samples were taken using 400 milliters of a solution containing 0.5 percent of a surfactant (Sur-Ten) in distilled water. The solution was poured into one-gallon plastic bags, then the applicator washed his hands inside the bag. This rinse solution was then poured off into a glass jar.

One applicator/loader volunteered to submit urine samples for 24 hours following exposure. Two pre-exposure urine samples were collected prior to exposure followed by collection of the entire amount of urine in separate containers at each voiding. All samples were shipped on wet ice and then stored frozen at the laboratory until analysis. All analyses were carried out by the Worker Health and Safety Laboratory, Chemistry Laboratory Service, California Department of Food and Agriculture, using methods outlined by Maddy, et al. (1982).

RESULTS

Dermal exposure calculations are presented in Table 1, the data are extrapolated using body surface areas (Popendorf and Leffingwell, 1982; Popendorf, 1976). The data are the sum of all body surface areas times the appropriate pad sample location in ug/cm^2. Calculations for outside of the coveralls are based on 17,118 square centimeters excluding hands and feet. Calculations for under the coveralls assume no protection for the head from protective equipment. Average gauze pad results for the head, neck, and shoulder of each applicator are used to estimate head exposure. The hand exposure level is the total amount found in the handwash sample. Results of gauze pad samples placed outside the cab behind the applicator averaged 1.2 mg per pad for eight of the applications.

Table 2 reports the air concentrations during the time sampled. Shown below are the inhalation sample results from the personal, inside cab, and outside cab (ug/m^3) for applications 1-6.

Sample Location	n	Mean	Standard Deviation	Minimum	Maximum
Personal	6	1.050	0.602	0.4	2.1
Inside	6	0.567	0.308	0.3	1.0
Outside	6	11.200	3.569	5.6	15.0

Paired t-tests applied to these data showed that, on the average, there was significantly less potential inhalation exposure within the cab (P=0.003). Further, there was insufficient evidence to suggest a difference between the personal and inside cab sample results (P=0.1528). For workers who mixed and loaded pesticides, the air monitoring demonstrated unanimously lower parathion concentrations inside the cab; however, due to the small sample size and possibly sample variation of air concentrations, such difference did not achieve statistical significance.

Table 3 presents para-nitrophenol levels found in the urine of applicator #11. This applicator also mixed and loaded the material. The total excretion of para-nitrophenol from this applicator was very low. Previously reported levels of applicators who were protected and careful averaged 0.8 ppm (Davis, et al., 1966).

Table 4 presents information on the use patterns.

DISCUSSION

Analysis of potential dermal and inhalation exposure during application shows considerable exposure reduction during the application. Data previously collected by this Department reported dermal exposure levels ranging from 14 - 99 mg per day using air blast sprayers without a cab (Maddy, et al., 1982). Durham (1965) and Jegier (1964a) reported levels averaging 17.9 mg and 49.5 mg per day, respectively. Excluding applicator #10, the highest exposure for an eight hour day is 2.5 mg for a loader/applicator and 0.36 mg for an applicator. (Applicator #10 was excluded because of splash and contamination of gauze pad while hand pouring methidathion, making his exposure 32,369.3 micrograms.) The lowest value found in the literature was that of Jegier (1964b) reporting a mean level of 2.4 mg hour. The mean for applications 1-9 and 11 is 0.07 mg/hr.

Applicators # 1 - 6 sometimes got out of the cab for breaks, and/or to talk with the supervisor while adjustments to equipment were being made and during loading operations. An observer could see how a worker could get small amounts of material on his clothing during these periods.

In other studies involving enclosed cabs (Casterton, 1982 and Taschenberg, Minnick and Bourke, 1975) air levels found outside the cab were in excess of what was considered safe. The air concentrations in our study did not exceed the established permissible exposure limit (PEL) for parathion of 100 micrograms per cubic meter. There is no established PEL for methidathion. Air concentrations inside the cab were significantly reduced. Efficiency for the closed cab and filter system averaged 95 percent by comparing concentrations inside the cab to that entering the intake. A 95 percent confidence interval of 100-87 percent protection was constructed using Feiller's Theorem for the ratio of two random variables (Hubert, 1980). There are factors that could cause an increase in air levels inside the cab. These factors are leaving cab doors open while loading, entering the cab with heavily contaminated clothing and equipment and not changing air filters at recommended intervals. During monitoring of the applications on occassion workers would leave the door of their cabs open while loading. While it is unlikely any significant exposure would occur, it could contribute to the very low levels found inside the cab. The data supports use of an enclosed cab with a filter as a replacement for a respirator during application. It also indicates that waterproof protective clothing is not needed while working in an enclosed cab.

CONCLUSION

Enclosed cabs can achieve a considerable reduction in worker exposure during application. To achieve this reduction, good work practices must also be followed during mixing and loading.

Using sophisticated air filtration systems with a well maintained enclosed cab and following the manufacturer's suggested service requirements, the need for a respirator during applications is eliminated.

TABLE 1

DERMAL EXPOSURE ESTIMATED FROM
GAUZE PADS AND HANDWASH SAMPLES
IN MICROGRAMS/PERSON

Application No.	Outside Coveralls	Under Coveralls	Handwash	Hours Exposed	Notes
1	1404.6	48.0 [a/]	5.8	6.9	Apply only
2	120.3	NDR	4.0	6.4	Apply only
3	754.9	295.0	11.5	6.9	Apply only
4	509.2	40.0	6.2	6.6	Apply only
5	455.0	276.0	27.4	6.8	Apply only
6	488.0	25.0	10.6	5.3	Apply only
7	2773.6	529.0	165.8	4.7	Assisted loading w.p
8	463.0	52.0	lost	3.0	Assisted loading w.p.
9	8710.0	86.0	160.7	4.5	Closed system loading
10	91897.0	32369.3 [b/]	461.0	4.4	Hand pour
11	18491.0	1276.0	not taken	3.8	Loaded wettable powder

a/ Minimum detectable level for gauze pads 0.05 ug/sample

b/ Includes splash on shin pads after filling the tank. Without this skin exposure the calculation would be 1026 ug.

NDR - no detectable residues

TABLE 2

AIR CONCENTRATION REPORTED IN MICROGRAMS/CUBIC METER

Application No.	Sample Location Personal	Inside Cab	Outside Cab	Hours Sampled	Notes
1	1.3	0.9	5.6	6.9	Apply only
2	0.4	0.3	8.6	6.4	Apply only
3	ND	1.0	15.0	6.9	Apply only
4	1.0	0.3	14.0	6.6	Apply only
5	0.9	0.5	11.0	6.8	Apply only
6	2.1	0.4	13.0	5.3	Apply only
7	0.7	0.3	5.4	4.7	Assisted loading
8	4.7	1.1	4.6	3.0	Assisted loading
9	0.7	0.2	5.8	4.6	Closed system loading
10	2.5	3.0	15.5	4.4	Hand pour
11	11.0	13.7	87.3	3.8	Loaded wettable powder

Minimum detectable limit - glass fiber filter 0.06 ug/sample
XAD-4 0.5 ug/sample

Results presented as a total of the two samples. Only two detectable results were reported from XAD-4 sorbent tubes - applicators # 7 and # 11.

ND - none detected

TABLE 3

PARA-NITROPHENOL CONCENTRATIONS
IN THE URINE SAMPLES OF APPLICATOR # 11

Time		Concentration (ppm)	Volume (ml)	Micrograms/ Volume
Pre-night before application		ND	45	-
12/18/85 before application		ND	60	-
Post 12/18	1645	0.068	80	5.44
	2030	0.032	65	2.08
12/19	0530	0.022	90	1.98
	0730	0.012	30	0.36
	0830	0.016	45	0.72
	0915	ND	50	-
	1100	ND	35	-
	1225	ND	30	-

TABLE 4

USE PATTERN INFORMATION

Application No.	Pesticide Used	Formulation	Lbs. a.i./acre	Carrier	Application Equipment	Spray Volume Gallons Per Acre	Temperature Range F°
1	Parathion	E.C.	0.5	Water	Air Blast Sprayer	75	60-65
2	Parathion	E.C.	0.5	Water	Air Blast Sprayer	75	60-65
3	Parathion	E.C.	0.5	Water	Air Blast Sprayer	75	60-65
4	Parathion	E.C.	0.5	Water	Air Blast Sprayer	75	58-68
5	Parathion	E.C.	0.5	Water	Air Blast Sprayer	75	58-68
6	Parathion	E.C.	0.5	Water	Air Blast Sprayer	75	58-68
7	Parathion	W.P.	2.0	Water	Air Blast Sprayer	100	56-58
8	Parathion	W.P.	2.0	Water	Air Blast Sprayer	100	55-51
9	Parathion	E.C.	1.0	Water	Air Blast Sprayer	100	40-43
10	Methidathion	E.C.	1.5	Water	Air Blast Sprayer	100	55-60
11	Parathion	W.P.	1.5	Water	Air Blast Sprayer	100	42-44

E.C. - Emulsifiable concentrate
W.P. - Wettable powder

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