UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

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OFFICE OF
PESTICIDES AND TOXIC SUBSTANCES

MEMORANDUM

SUBJECT: Revised Worker Exposure Values for Cyfluthrin

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Based on revised usage parameters supplied by the Benefits and Use Division, EAB has recalculated exposure values for PCO's applying cyfluthrin as a crack and crevice spray. A copy of the assessment is attached.

cc: Chris Dively, PM Team #15

1.0 INTRODUCTION

Mobay Corporation has applied for registration of Tempo 2 insecticide, a liquid concentrate formulation containing cyfluthrin at 2 lb ai/gal. Cyfluthrin is a nonsystemic synthetic pyrethroid, intended for use in and around buildings and structures and their immediate surroundings and on modes of transport. Application is by hand pressurized or power operated sprayer as a 0.05% spray. Application is to be restricted to licensed pest control operators (PCO) only. Label instructions require the use of goggles or a face shield when handling cyfluthrin. Treatments include general or spot surface application, crack and crevice treatment, and pantry and premise pest control. Because EAB has no data measuring exposure to cyfluthrin, this exposure assessment was conducted using surrogate data from studies in EAB's data base. The following assumptions were required:

1. An average worker weighs 70 kg.

2. Exposures are not adjusted for dermal absorption.

3. The same worker performs both the mixing/loading and application tasks.

4. A PCO treats 25 apartments per day using 0.9 pints (0.1125 gallons) of finished spray per apartment at 0.0044 lb ai/gal. (1) Assuming exclusive use of cyfluthrin, the daily use of cyfluthrin would be:

$$\frac{0.1125 \text{ gal spray}}{\text{apt.}} \times \frac{0.0044 \text{ lb ai}}{\text{gal spray}} \times \frac{25 \text{ apt}}{\text{day}} = 0.012 \text{ lb ai/day}$$

5. Standard work clothing for PCO's includes long-sleeved shirts and long pants. Estimates have been provided for PCO's with and without protective gloves. Gloves are assumed to reduce exposure to the hands by 90%.

6. Fifty percent of the cyfluthrin that reaches worker clothing penetrates the clothing.

7. Residents are exposed for 15 hours per day.

8. The average breathing volume for a 70 kg male is 7.4 liters per minute at rest and 29 liters per minute during light activity. Assuming that an individual spends 2/3 of his time at rest and 1/3 at light activity, the weighted average breathing volume is 14.6 liters per minute or 13 m^3 per day.

9. The size of an average apartment is 1000 ft^2. (1) Assuming an 8-foot ceiling height, the volume of an average apartment is 227 m^3.

2.0 SUMMARY OF SURROGATE STUDIES

2.1 Exposure of Applicators to Chlorpyrifos

Heath and Spittler (2) monitored applicator exposure to chlorpyrifos during treatment of a dormitory building. Two liters of a 0.5% emulsion were applied to areas normally treated for insect pests. Pesticide application was by hand sprayer using pin or fan type nozzles at high, medium, or low pressure and at various distances from the target.

Dermal exposure was measured with gauze patches and cotton gloves. The four dermal patches were located on the exterior of the clothing on the chest, back, and outside of each leg just below the knee. A 26 cm^2 circular subsample of each patch was used for analysis. Respiratory exposure was determined by drawing air through a glass tube containing silica gel at a rate of 100 cm^3/minute.

Dermal patches, cotton gloves, and air sampling tubes were extracted with acetone, concentrated, and quantified by gas chromatography using a flame photometric detector in the phosphorus mode. Recoveries of spiked samples were 106%, 106%, and 88% for air samples, gloves, and gauze patches, respectively. Unfortunately there were no dermal pads located on the thighs or arms. The reviewer made the assumption that the rate of exposure for the arms was the same as that for the chest and that the exposure was uniform for all parts of the leg. The exposure for a body part is:

$$\text{Exposure (ug/body part)} = \text{amount on pad or glove (ug/cm}^2\text{)} \times \text{surface area (cm}^2\text{)}$$

Since 2 liters of a 0.5% emulsion were applied, the total amount of chlorpyrifos applied was:

$$\text{Amount applied (lb)} = \frac{2 \text{ liters}}{\text{application}} \times \frac{5.0 \text{ g}}{\text{liter}} \times \frac{1 \text{ lb}}{454 \text{ g}}$$

$$= 2.2 \times 10^{-2} \text{ lb/application}$$

The exposure per pound of chlorpyrifos applied is:

$$\text{Exposure (ug/kg/lb applied)} = \frac{\text{exposure (ug/kg)}}{2.2 \times 10^{-2} \text{ lb applied}}$$

The exposure data, adjusted for time, and adjusted for the amount of active ingredient applied, are shown in Table 1. Total dermal exposures are shown for applicators with or without protective gloves using fan or pin nozzles. Protective gloves are assumed to reduce hand exposure by 90%.

Table 1. Exposure of applicators to chlorpyrifos from crack and crevice treatment for cockroaches.

Body part	Amount/patch[a] (ug/cm^2)	Surface area (cm^2)	ug/body part	ug/body part/hour[b]	50% for clothed areas[c]	ug/kg/hr[d]	ug/kg/lb ai[e]
				Fan nozzle			
Chest	0.014	7670	107	357	179	2.6	35
Back	0.014	3550	50	167	84	1.2	16
Hands[f]	0.907	820	744	2480	2480	35	4.8×10^2
Legs	0.036	7510	270	900	450	6.4	87
Total dermal without gloves:							6.2×10^2
Total dermal with gloves:							1.9×10^2
				Pin nozzle			
Chest	0.011	7670	84	150	75	1.1	28
Back	0.008	3550	28	50	25	0.36	9.2
Hands[f]	0.392	820	321	575	575	8.2	2.1×10^2
Legs	0.018	7510	135	242	121	1.7	43
Total dermal without gloves:							2.9×10^2
Total dermal with gloves:							1.0×10^2
Total respiratory exposure (both application methods)[g]							4.1

[a] Mean values resulting from application using pin or fan type nozzles at high, medium, or low pressure and at various distances from the target.

[b] Mean application times for fan and pin nozzles were 18 and 33.5 minutes, respectively.

[c] Assuming 50% penetration for clothed areas.

[d] Assuming a 70 kg worker.

[e] Adjusted exposure per lb ai handled (ug/kg/lb ai) = ug/kg/hr x $\frac{\text{0.3 hr/appl. (fan) or 0.56 hr/appl. (pin)}}{\text{0.022 lb ai/application}}$

[f] Hand exposure measured using cotton gloves.

[g] Assuming a respiratory volume of 1200 l/hr.

2.2 Exposure of Applicators and Inhabitants to Dichlorvos

Gold et al. (3) measured the exposure of applicators and occupants to dichlorvos (DDVP) following treatment of single family homes for cockroach control. DDVP was applied with a hand sprayer to baseboards, around doors, and other areas normally treated for cockroaches. The pesticide was applied at an average rate of 0.189 g (37.8 ml) per m2. The average area treated per house was 103 m2 and took 25.5 minutes. An average house received a total of 19 g (0.042 lb) of active ingredient.

Applicators wore long sleeved polyester jumpsuits with an open collar, hard hats, respirators, and rubber gloves. Dermal exposure was measured using dermal pads located on the head, forearms, on the leg just above the ankle, chest, and back. Gauze pads were attached to the outer clothing or taped to the skin beneath the coveralls. Exposure of the hands was measured by hand rinse with 50 percent ethanol-water. Respiratory exposure of applicators was measured by drawing air through midget impingers containing ethylene glycol.

Potential exposure of inhabitants was measured using pads located on environmental surfaces and air samplers with a double impinger system. Pads were positioned prior to treatment and removed 2 hours post treatment. Pads were located on the refrigerator, kitchen table, and kitchen floor. Pads were combined prior to extraction and analysis. Air samples were taken for 24 hours prior to treatment and again at 2 and 24 hours post application. All samples were analyzed by gas chromatography using a nitrogen-phosphorous thermionic detector.

Dermal exposure was calculated by multiplying the surface area of a body part by the amount of DDVP on the appropriate pad. For unprotected areas the average value for exterior pads (head, forearms, leg just above the ankle, chest and back), 0.499 ug/cm^2/hr was used. For areas normally covered by clothing, 50% of the average value for exterior pads was used. The hands were protected by the rubber gloves and received 0.024 ug/cm^2/hr as determined by hand rinse. Respiratory exposure levels were 0.021 ug/l.

In order to compare the exposure values from this study with others in EAB's database the reviewer adjusted the exposures to a 70 kg worker with standard surface areas and by the total amount of material handled (Table 2). The exposure of environmental surfaces, as measured by environmental patches, was 0.319 ug/cm^2/hr. Air levels of DDVP declined after application and are summarized in Table 3.

Table 2. Exposure of applicators to dichlorvos from treatment of homes for cockroaches.

Body part	Surface area (cm^2)	Mean exposure[a] ($ug/cm^2/hr$)	ug/body part/hr	(ug/kg/hr)[b]	(ug/kg/lb ai)[c]
Face, front "v" of neck	800	0.499	399	5.7	57
Head (minus face)	650	0.25	163	2.3	23
Back of neck	110	0.499	55	0.79	7.9
Back trunk	3550	0.25	888	13	1.3×10^2
Front trunk	3550	0.25	888	13	1.3×10^2
Upper arms	2910	0.25	728	10	1.0×10^2
Forearms	1210	0.25	303	4.3	43
Thighs	3820	0.25	955	14	1.4×10^2
Legs and feet	3690	0.25	923	13	1.3×10^2
Hands	820	0.024	20	0.29	2.9
Total dermal with gloves:					7.6×10^2
Total dermal without gloves:					7.6×10^2
Respiratory[d]					3.6

[a] For areas normally covered by clothing, 50% of the mean value for exterior pads was used.

[b] Assuming a 70 kg worker.

[c] Adjusted exposure per lb ai handled (ug/kg/lb ai) = ug/kg/hr x $\frac{0.43 \text{ hr/application}}{0.043 \text{ lb/application}}$

[d] Assuming a respiratory volume of 1200 l/hr.

Table 3. Environmental exposure to DDVP following application to homes.

Room pads	0.319 ug/cm^2/hr
Air samples	
0-2 hour	548 ug/m^3
2-24 hour	183 ug/m^3

2.3 Pesticide Levels in Ambient Air

Wright et al. (4) measured the concentration of pesticides in room air following crack and crevice treatment with insecticides. The pesticides were applied to rooms in a university dormitory using hand sprayers or dusters. The compounds and formulations are listed in Table 4.

Table 4. Formulations Applied to Dormitory Rooms for Insect Control

Compound	Type of Formulation	Spray Conc. (%)
Bendiocarb	Wettable powder	0.5
Chlorpyrifos	Emulsifiable conc.	0.5
Acephate	Emulsifiable conc.	1.0
Diazinon	Emulsifiable conc.	1.0
Fenitrothion	Emulsifiable conc.	1.0
Propoxur	Emulsifiable conc.	1.1
Carbaryl	Dust	5.0

Air was monitored using a personal type sampler located near the center of the room. Midget impingers containing hexylene glycol were used to trap bendiocarb, carbaryl, chlorpyrifos, diazinon, fenitrothion, and propoxur. Polyurethane foam was used to trap acephate. Air was sampled for 4 hours before

application, immediately after application, and at 1, 2, and 3 day intervals. Samples were extracted with an appropriate solvent and quantified by GLC or HPLC.

The airborne concentrations of insecticides are summarized in Table 5. Air levels of all insecticides, except acephate, reached a maximum immediately after application followed by a decrease to less than 1 ug/m^3 after 3 days. Bendiocarb was not detected on the second or third day. The air levels were correlated with the amount of material applied per 100 m^3 of room volume. This correlation increased with elapsed time.

Table 5. Airborne Concentrations of Insecticides Following Application to Rooms. Values are in ug/m^3.

Insecticide	Appl. rate (g/100 m^3)	Pretreat.	Day 0	1	TWA[a]	2	3
Acephate	18.5	ND[b]	1.3	2.9	2.6	0.5	0.3
Bendiocarb	9.5	ND	7.7	1.3	2.4	ND	ND
Carbaryl	6.3	ND	1.3	0.2	0.4	0.1	0.01
Chlorpyrifos	8.2	0.1	1.1	1.1	1.1	0.8	0.3
Diazinon	18.0	0.2	1.6	0.6	0.8	0.5	0.4
Fenitrothion	21.9	ND	3.3	1.1	1.5	0.8	0.5
Propoxur	20.4	ND	15.4	2.7	4.8	1.8	0.7
MEAN			4.5	1.4	1.9	0.64	0.31
Correlation Coefficient (r)			0.31	0.53	--	0.59	0.82

[a] Time weighted average for day 1.

[b] ND; not detected - value of 0 used for calculations.

3.0 CALCULATION OF EXPOSURES

3.1 Applicator Exposure

A PCO treats 25 apartments per day using 0.1125 gallons of finished spray per apartment at 0.0044 lb ai/gal. (1) Assuming exclusive use of cyfluthrin, the daily use of cyfluthrin would be:

$$\frac{0.1125 \text{ gal spray}}{\text{apt.}} \times \frac{0.0044 \text{ lb ai}}{\text{gal spray}} \times \frac{25 \text{ apt}}{\text{day}}$$

$$= 0.012 \text{ lb ai/day}$$

In order to estimate applicator exposure to cyfluthrin, the exposures from the surrogate studies were adjusted by the relative amounts of material handled. Daily applicator exposure, based on the data from Gold et al. is:

Total dermal exposure with protective gloves

0.012 lb ai/day x 7.6×10^2 ug/kg/lb ai = 9.1 ug/kg/day

Total dermal exposure without protective gloves

0.012 lb ai/day x 7.6×10^2 ug/kg/lb ai = 9.1 ug/kg/day

Respiratory exposure

0.012 lb ai/day x 3.6 ug/kg/lb ai = 4.3×10^{-2} ug/kg/day

Daily applicator exposure, based on the data from Heath and Spittler is:

Total dermal exposure with protective gloves (fan nozzle)

0.012 lb ai/day x 1.9×10^2 ug/kg/lb ai = 2.3 ug/kg/day

Total dermal exposure without protective gloves (fan nozzle)

0.012 lb ai/day x 6.2×10^2 ug/kg/lb ai = 7.4 ug/kg/day

Total dermal exposure with protective gloves (pin nozzle)

0.012 lb ai/day x 1.0×10^2 ug/kg/lb ai = 1.2 ug/kg/day

Total dermal exposure without protective gloves (pin nozzle)

0.012 lb ai/day x 2.9×10^2 ug/kg/lb ai = 3.5 ug/kg/day

Respiratory exposure (fan and pin nozzles)

0.012 lb ai/day x 4.1 ug/kg/lb ai = 4.9×10^{-2} ug/kg/day

3.2 Exposure of Residents

Residues of DDVP were found on environmental surfaces; however, a method is not available to estimate dermal exposure of residents of treated houses from wipe tests. This assessment will be confined to respiratory exposure only, based on surrogate data from Wright et al. (4)

The amount of cyfluthrin applied to each apartment is:

$$\text{g cyfluthrin per apartment} = \frac{0.00048 \text{ lb}}{\text{apt}} \times \frac{454 \text{ g}}{\text{lb}} = 0.22 \text{ g/apt}$$

If the average volume for an apartment is 227 m3, then the application rate per 100 m3 is:

$$\text{Appl. rate } (\text{g}/100 \text{ m}^3) = \frac{0.22 \text{ g/apt}}{227 \text{ m}^3/\text{apt}} \times 100 \text{ m}^3 = 0.1 \text{ g}/100 \text{ m}^3$$

The concentrations presented by Wright et al. can be adjusted by the application rate:

$$\text{Adjusted cyfluthrin conc.}(\text{ug}/\text{m}^3) = \text{Measured surrogate conc.}(\text{ug}/\text{m}^3) \times \frac{\text{applied g (cyfluthrin)}/100 \text{ m}^3}{\text{applied g (surrogate)}/100 \text{ m}^3}$$

A 70 kg resident breathing an average volume of 14.6 liters per minute would breath 13 m^3 per day. The daily exposure would be:

$$\text{Daily exposure } (\text{ug/kg/day}) = \text{Air conc. } (\text{ug}/\text{m}^3) \times \frac{13 \text{ m}^3}{\text{day}} \times \frac{1}{70 \text{ kg}}$$

The adjusted concentrations and daily exposures are presented in Table 6.

4.0 SUMMARY AND CONCLUSIONS

Based on data from surrogate studies and on usage data from BUD, the dermal exposure of PCOs wearing protective gloves is estimated to range from 1.2 to 9.1 ug/kg/day (100 to 760 ug/kg/lb ai). For applicators not wearing protective gloves, dermal exposure estimates range from 3.5 to 9.1 ug/kg/day (290 to 790 ug/kg/lb ai). Respiratory exposure is approximately 5×10^{-2} ug/kg/day for PCOs.

Respiratory exposure to residents is estimated to be 2.5×10^{-3}, 7.6×10^{-4}, and 3.6×10^{-4} ug/kg/day for days 1, 2, and 3, respectively.

Table 6. Estimated Cyfluthrin Concentrations and Daily Exposures of Residents After Treatment of Home. Concentrations are in ug/m^3 and exposures are in ug/kg/day.

Surrogate Compound	Day 1		2		3	
	Concentration[a]	Exposure[b]	Concentration	Exposure	Concentration	Exposure
Acephate	1.4×10^{-2}	2.6×10^{-3}	2.7×10^{-3}	5.0×10^{-4}	1.6×10^{-3}	3.0×10^{-4}
Bendiocarb	2.5×10^{-2}	4.6×10^{-3}	0	0	0	0
Carbaryl	6.3×10^{-3}	1.2×10^{-3}	1.6×10^{-3}	3.0×10^{-4}	1.6×10^{-4}	3.0×10^{-5}
Chlorpyriphos	1.3×10^{-2}	2.4×10^{-3}	9.8×10^{-3}	1.8×10^{-3}	3.7×10^{-3}	6.9×10^{-4}
Diazinon	4.4×10^{-3}	8.2×10^{-4}	2.8×10^{-3}	5.2×10^{-4}	2.2×10^{-3}	4.1×10^{-4}
Fenitrothion	6.8×10^{-3}	1.3×10^{-3}	3.7×10^{-3}	6.9×10^{-4}	2.3×10^{-3}	4.3×10^{-4}
Propoxur	2.3×10^{-2}	4.3×10^{-3}	8.8×10^{-3}	1.6×10^{-3}	3.4×10^{-3}	6.3×10^{-4}
MEAN	1.3×10^{-2}	2.5×10^{-3}	4.1×10^{-3}	7.6×10^{-4}	1.8×10^{-3}	3.6×10^{-4}

[a] Sample calculation: $2.6\ ug/m^3 \times \frac{0.10\ g/100\ m^3}{18.5\ g/100\ m^3} = 1.4 \times 10^{-2}\ ug/m^3$

[b] Sample calculation: $\frac{1.4 \times 10^{-2}\ ug}{m^3} \times \frac{13\ m^3}{day} \times \frac{1}{70\ kg} = 2.6 \times 10^{-3}\ ug/kg/day$

In order to estimate the exposure of PCOs and residents to cyfluthrin, the exposures from surrogate studies were adjusted by the relative amounts of material handled. These exposure estimates assume that PCOs are wearing long-sleeved shirts and long pants; values have been provided for workers wearing or not wearing protective gloves. The estimates are not adjusted for the dermal absorption of cyfluthrin.

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REFERENCES

1. Memorandum from Yuen-shaung NG (BUD) to George T. LaRocca (RD) entitled, "Projected parameters and data for application exposure for applying cyfluthrin (Tempo 2, Baythroid) to, in and around buildings," dated February 6, 1987.

2. Heath, J. L. and T. D. Spittler (1985). "Determination of the Technique of Using a Compressed Air Sprayer that Optimizes Applicator Safety and Cockroach Efficacy." Pest Management, Vol. 4(2), pp. 12-18.

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