Shaughnessy #: 128831

EAB Log-Out Date: SEP 30 1987

To: George LaRocca
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From: Michael Firestone, Acting Chief
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Attached please find the EAB review of...

Reg./File No.: 3125-~~GLR~~ 352

Chemical: Cyfluthrin

Type Product: Insecticide

Product Name: Tempo 2

Company Name: Mobay

Submission Purpose: Greenhouse and ornamental use exposure assessment

ZBB Code: _____ ACTION CODE: 116

Date In: 8/28/87 EAB # 70921

Date Completed: 9/28/87 TAIS (level II) Days

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Deferrals To:

_____ Ecological Effects Branch

_____ Residue Chemistry Branch

_____ Toxicology Branch

_____ Benefits and Use Division

Monitoring study requested by EAB: / /

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 on ornamentals (including nurseries, yards, ornamental gardens, and greenhouses). A previous exposure assessment by EAB (March 16, 1987 plus memorandum dated September 17, 1987) calculated exposure to applicators and residents resulting from the PCO application of cyfluthrin to indoor use sites. Label instructions require the use of goggles or a face shield when handling cyfluthrin.

Because EAB has no data measuring exposure to cyfluthrin, this exposure assessment was conducted using surrogate data from studies in EAB's database. This assessment provides respiratory and dermal exposure estimates for mixer/loaders and applicators involved in the application of cyfluthrin to commercial greenhouses and dermal exposure estimates for mixer/loader/applicators (combined tasks) applying cyfluthrin to outdoor ornamental plants and shrubs. The following assumptions were required:

1. An average worker weighs 70 kg.

2. Exposures are not adjusted for dermal absorption.

3. Workers are assumed to handle 0.014 lb ai/day for greenhouse application (1) and 0.03 lb ai/day for outdoor ornamentals (2).

4. Standard work clothing includes long-sleeved shirts and long pants. Protective gloves are assumed to afford a 90% reduction in dermal exposure to the hands.

5. Respiratory exposure for workers applying cyfluthrin to outdoor ornamental plants and shrubs is negligible compared to dermal exposure.

2.0 REVIEW OF SURROGATE STUDIES

2.1 Greenhouse Application

Exposure of workers was measured during application of Aliette (Fosetyl-Al, 80% wettable powder) to greenhouse ornamentals at Columbus, New Jersey (3). Mixer/loader and applicator exposures were measured separately for four different workers. The tasks were changed so that no worker performed the same one twice, yielding a total of four replicates each for the mixing/loading and application functions. All workers wore the label required long-sleeved shirts, long trousers and impermeable gloves. Workers also wore baseball hats and respirators which are not required by the label. Each replicate consisted of either mixing/loading

or application of 12 tanks of spray mixture. The tanks contained 57 grams of formulated material (45.6 grams of active ingredient) in 2.5 gallons of water. This concentration matches the maximum application rate of 5 pounds of formulation per 100 gallons. The mixer/loader weighed the material from a bag of bulk material on a top loading balance and transferred the required amount into the tank. The tank was then filled with 2.5 gallons of water, capped, pressurized with carbon dioxide, and shaken to mix the contents. Each mixer/loader handled a total of 684 grams of formulation (547 grams or 1.2 pounds of active ingredient) during each replicate. The applicator then sprayed the diluted material onto the foliage until runoff. Power for the spray was provided by a carbon dioxide cylinder strapped to the worker's back. Application took 53-65 minutes, with an average time of 58 minutes.

Respiratory exposure was measured by drawing air at a known rate through a cassette containing a fiberglass filter. The cassette was attached to the worker's collar in the breathing zone. Pump flow rates were determined before and after the sampling interval.

Dermal exposure was measured using gauze pads attached to the hat, shoulders, chest, upper arms, forearms, thighs, and lower legs. In order to estimate the effectiveness of protective clothing, duplicate sets of pads (except hat pad) were used, one located on the outside of the clothing and the other inside of the garments. The pads consisted of a 3-inch$_2$ square gauze pad in an aluminum lined paper envelope. A 25 cm^2 circular area was exposed to the environment. Exposure of the hands was measured by hand washes with 10 percent isopropyl alcohol. The hands were washed 3 times before and after exposure. The washes for each hand were pooled prior to analysis.

Samples were stored frozen prior to analysis. A 10 percent aliquot of the hand wash was mixed with an equal volume of methanol and 5 ml of methoxyethanol. The water was evaporated under vacuum using a rotary evaporator. The residue was then methylated with diazomethane, reduced in volume, and brought to a final volume of 5 ml with methoxyethanol:acetonitrile (50:50). Gauze pads and fiberglass filters were extracted twice with methanol:deionized water (50:50), followed by evaporation and methylation. The methylated derivatives were quantified by gas chromatography using a phosphorous specific flame photometric detector. The limit of detection for the dosimeters was 0.2 ug and 2.0 ug for hand washes. The recoveries of spiked samples are presented in Appendix A.

The average exposures of mixer/loaders and applicators are summarized in Tables 1 and 2, respectively. The equations used to obtain these values are presented in Appendix B. Respiratory exposures were much lower than dermal for both mixer/loaders and applicators. Respiratory exposure was approximately 10 percent of the hourly exposure of applicators and 1 percent of that for mixer/loaders.

Respiratory exposures to both types of workers dropped to about 1 percent of dermal when considered on the basis of amount of active ingredient handled. Dermal exposure of workers wearing the label required protective clothing averaged 4.0×10^2 ug/hr (3.3×10^2 ug/lb ai) and 5.5×10^2 ug/hr (6.8×10^2 ug/lb ai) for applicators and mixer/loaders, respectively. The use of protective clothing reduced the dermal exposure of applicators by 99 percent and that of mixer/loaders by 85 percent. The difference in the degree of protection reflects the greater exposure of the face and neck of the mixer/loaders. When the uncovered portions of the body are omitted from the calculations, the degrees of protection are 98 for applicators and 92 percent for mixer/loaders. Hand exposures, usually relatively high, contributed only about 7 percent to the total dermal exposure, indicating the effectiveness of the use impermeable gloves in reducing exposure. Mixer/loaders removed their gloves between mixings which may account for the higher hand exposures of these workers. Applicators did not remove their gloves during the application procedure.

2.2 Outdoor Application to Ornamentals

2.2.1 Home Gardener Exposure to Carbaryl

Kurtz and Bode (4) measured the exposure of home gardeners to carbaryl. The investigation was extensive, comparing different formulations of carbaryl and different crop heights. For this assessment, values for the wettable powder formulation and mean values for both crops treated have been used.

Carbaryl was applied to corn and beans by volunteers recruited from the neighboring community. Agway 5% carbaryl dust was applied by dust pump and Union Carbide XLR which is a liquid formulation containing 43% carbaryl was applied by hand held pressurized sprayer. Each formulation was applied to each crop by 12 individuals.

Dermal exposure was measured by placing 100 cm^2 gauze patches on Tyvek coveralls or directly to exposed skin. Pads were placed on a face mask, shoulders, back, chest, forearms, thighs, shins, ankles, and shoes. Hand exposure was measured by hand rinses with ethanol containing 0.3% sodium hydroxide. An additional gauze pad covered by denim or blue jean material was also attached to the calf to measure protection provided by these materials.

Loading and emptying the dust pumps or mixing the liquid were measured with the application. Each applicator was given 15 minutes to treat the crop. After each work function a 25 cm^2 section was cut from the center of the pads and placed in glass sample tubes for analysis.

The average quantity of active ingredient handled by the dust applicators was 9.5 g on corn and 11 g on beans. The ranges were

quite large for the dust formulations, 2.1 to 15 g on corn and 1.2 to 34 g on beans. The large ranges resulted from some individuals barely dusting the leaves to others intent on producing totally white leaves. An average of 3.2 and 3.0 g ai were handled for use of the liquid formulation on corn and beans, respectively. Narrow ranges around the means were observed for the liquid formulation.

The quantity of carbaryl detected on the patches or in the hand rinses and the estimated exposure to the different body areas are presented in Table 3.

2.2.2 Home Gardener Exposure to Diazinon

Applicator exposure to diazinon during application to lawns and shrubs was measured by Davis et al. (5). Three workers applied a 25% liquid concentrate with a final concentration of 469-625 ug/ml. Application was made using approximately 5 gallons (18.9 L) of finished spray by compressed air, or 30 gallons (114 L) by hose-end sprayer. The average application time was 30 minutes.

Applicators wore short-sleeved shirts, long pants, and shoes; clothing was assumed to afford 100% protection. Cellulose pads were attached to the shoulders, upper center of the back and chest, the outside of the forearms, and the front of the thighs and ankles. A 25 cm^2 subsample from the center of each pad was used for analysis. Hand exposure was measured by hand rinses in ethanol. Gauze-faced filters, worn in modified dust respirators, were used to measure respiratory exposure.

Respirator filters and cellulose pad samples were Soxhlet extracted with hexane:acetone (41:59). Extracts from filters and pads, and alcohol hand rinses were quantified by GC equipped with electron capture or flame photometric detectors. Residue values were corrected for method recovery and for storage stability losses. Estimated exposure to hands and total dermal exposure is shown in Table 4.

3.0 CALCULATION OF EXPOSURES

3.1 Mixer/Loader Exposure - Greenhouse Application

In order to estimate mixer/loader exposure to cyfluthrin resulting from greenhouse application, the exposure values from the surrogate study were adjusted by the relative amounts of material handled, and by 70 kg workers. For a commercial greenhouse, dermal exposure to mixer/loaders is estimated to be:

Unprotected (patches outside worker clothing)

$$\frac{4.8 \times 10^3 \text{ ug}}{\text{lb ai}} \times \frac{1}{70 \text{ kg}} \times \frac{0.014 \text{ lb ai}}{\text{day}} = 0.96 \text{ ug/kg/day}$$

Protected (assuming long-sleeved shirt, long pants, and gloves)

$$\frac{6.8 \times 10^2 \text{ ug}}{\text{lb ai}} \times \frac{1}{70 \text{ kg}} \times \frac{0.014 \text{ lb ai}}{\text{day}} = 0.14 \text{ ug/kg/day}$$

Protected (assuming long-sleeved shirt, long pants, and no gloves)

$$\frac{1.1 \times 10^3 \text{ ug}}{\text{lb ai}} \times \frac{1}{70 \text{ kg}} \times \frac{0.014 \text{ lb ai}}{\text{day}} = 0.22 \text{ ug/kg/day}$$

Respiratory exposure calculations were based on the assumption that the respiratory volume of an average worker is 1.2 m^3 per hour:

$$\frac{6.6 \text{ ug}}{\text{lb ai}} \times \frac{1}{70 \text{ kg}} \times \frac{0.014 \text{ lb ai}}{\text{day}} = 1.3 \times 10^{-3} \text{ ug/kg/day}$$

3.2 Applicator Exposure - Greenhouse Application

Dermal exposure to applicators treating a commercial greenhouse, adjusted by the amount of cyfluthrin handled and by 70 kg workers, is estimated to be:

Unprotected (patches outside worker clothing)

$$\frac{1.3 \times 10^4 \text{ ug}}{\text{lb ai}} \times \frac{1}{70 \text{ kg}} \times \frac{0.014 \text{ lb ai}}{\text{day}} = 2.6 \text{ ug/kg/day}$$

Protected (assuming long-sleeved shirt, long pants, and gloves)

$$\frac{3.3 \times 10^2 \text{ ug}}{\text{lb ai}} \times \frac{1}{70 \text{ kg}} \times \frac{0.014 \text{ lb ai}}{\text{day}} = 6.6 \times 10^{-2} \text{ ug/kg/day}$$

Protected (assuming long-sleeved shirt, long pants, and no gloves)

$$\frac{5.1 \times 10^2 \text{ ug}}{\text{lb ai}} \times \frac{1}{70 \text{ kg}} \times \frac{0.014 \text{ lb ai}}{\text{day}} = 0.10 \text{ ug/kg/day}$$

Respiratory exposure calculations were based on the assumption that the respiratory volume of an average worker is 1.2 m^3 per hour:

$$\frac{2.7 \text{ ug}}{\text{lb ai}} \times \frac{1}{70 \text{ kg}} \times \frac{0.014 \text{ lb ai}}{\text{day}} = 5.4 \times 10^{-4} \text{ ug/kg/day}$$

3.3 Mixer/Loader/Applicator Exposure - Outdoor Ornamental Application

In order to estimate worker exposure to cyfluthrin, the exposures from the surrogate studies were adjusted by the relative amounts of material handled. Worker exposure from the surrogate studies, calculated using weighted averages (total number of replicates was 38), is 4.2×10^3 ug/kg/lb ai for workers not wearing protective gloves and 4.1×10^3 ug/kg/lb ai for workers wearing gloves.

Without gloves:

$$4.2 \times 10^3 \text{ ug/kg/lb ai} \times \frac{0.03 \text{ lb ai}}{\text{day}} = 1.3 \times 10^2 \text{ ug/kg/day}$$

With gloves:

$$4.1 \times 10^3 \text{ ug/kg/lb ai} \times \frac{0.03 \text{ lb ai}}{\text{day}} = 1.2 \times 10^2 \text{ ug/kg/day}$$

4.0 CONCLUSIONS

Based on data from surrogate studies and on usage parameters provided by BUD, the dermal exposure to mixer/loaders and applicators treating greenhouse ornamentals with cyfluthrin and wearing protective gloves is estimated to be 0.14 ug/kg/day and 6.6×10^{-2} ug/kg/day, respectively. Dermal exposure to workers not wearing gloves is estimated to be 0.22 ug/kg/day (mixer/loaders) and 0.10 ug/kg/day (applicators). Respiratory exposure to these workers is estimated to be 1.3×10^{-3} ug/kg/day (mixer/loaders) and 5.4×10^{-4} ug/kg/day (applicators).

Dermal exposure to mixer/loader/applicators (combined tasks) treating outdoor ornamentals with cyfluthrin and wearing protective gloves is estimated to be 1.2×10^2 ug/kg/day; dermal exposure without gloves is 1.3×10^2 ug/kg/day. Respiratory exposure to these workers is assumed to be negligible compared to dermal exposure.

These exposure estimates assume that workers are wearing long-sleeved shirts and long pants. Hand exposure is assumed to be reduced by 90% when protective gloves are worn. The exposure estimates are not adjusted for dermal absorption.

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REFERENCES

1) Memorandum from Yuen-shaung NG (BUD) to Joseph C. Reinert (EAB) entitled "Projected Parameters and Data for Application Exposure for Applying Cyfluthrin (Tempo 2, Baythroid) to Greenhouse Non-food," dated Nov. 11, 1986.

2) Memorandum from Yuen-shaung NG (BUD) to Laurie C. Lewis (EAB) entitled "Projected Parameters and Data for Application Exposure for Applying Cyfluthrin (Tempo 2, Baythroid) on Ornamentals (Outdoor)," dated Aug. 25, 1987.

3) Fenske, Richard A. 1985. Worker Exposure to Aliette During Greenhouse Applications. Rhone-Poulenc, Inc., Monmouth Junction, NJ.

4) Kurtz, D.A. and W.M. Bode. 1985. Application Exposure to the Home Gardener. In Dermal Exposure Related to Pesticide Use, ACS Symposium Series 273, pg. 139-161.

5) Davis, J.E., E.R. Stevens, D.C. Staiff, and L.C. Butler. 1983. Potential Exposure to Diazinon During Yard Applications. Environmental Monitoring and Assessment. 3:23-28.

Table 1. Average Exposure of Mixer/Loaders to Fosetyl-Al during Application of Aliette to Greenhouse Ornamentals.

Body Part	Surface Area (cm^2)	Unprotected (ug)	Protected[a] (ug)
Face	650	2.7×10^2	2.7×10^2
Front of Neck	150	62	62
Back of Neck	110	3.6	3.6
Chest	3550	6.3×10^2	91
Back	3550	1.2×10^2	18
Left Upper Arm	660	2.6×10^2	22
Right Upper Arm	660	4.3×10^2	25
Left Forearm	610	3.3×10^2	1.1×10^2
Right Forearm	610	3.2×10^2	1.2×10^2
Left Thigh	1125	2.2×10^3	5.8
Right Thigh	1125	8.5×10^2	16
Left Lower Leg	1190	82	8.3
Right Lower Leg	1190	51	4.8
Left Hand	--	21	21
Right Hand	--	35	35
Total Dermal (ug)		5.7×10^3	8.1×10^2
Time (minutes)		89	89
Total Dermal (ug/hr)		3.8×10^3	5.5×10^2
Pounds of ai handled		1.2	1.2
Total Dermal (ug/lb ai)		4.8×10^3	6.8×10^{2b}
Respiratory (ug)		7.9	7.9
Respiratory (ug/hr)		50	50
Respiratory (ug/lb ai)		6.6	6.6

[a] Assumes worker is wearing long sleeve shirt, long trousers, and gloves.

[b] Calculated value, assuming 90% hand protection is afforded by protective gloves, is 1.1×10^3 ug/lb ai.

Table 2. Average Exposure of Applicators to Fosetyl-Al during Application of Aliette to Greenhouse Ornamentals.

Body Part	Surface Area (cm^2)	Unprotected (ug)	Protected[a] (ug)
Face	650	76	76
Front of Neck	150	18	18
Back of Neck	110	17	17
Chest	3550	1.5×10^2	7
Back	3550	1.0×10^3	50
Left Upper Arm	660	1.5×10^2	2.7
Right Upper Arm	660	53	14
Left Forearm	610	1.5×10^2	28
Right Forearm	610	6.0×10^3	1.0×10^2
Left Thigh	1125	1.6×10^3	21
Right Thigh	1125	8.5×10^2	13
Left Lower Leg	1190	1.3×10^3	8.4
Right Lower Leg	1190	3.9×10^3	5.9
Left Hand	--	12	12
Right Hand	--	12	12
Total Dermal (ug)		1.5×10^4	3.9×10^2
Time (minutes)		58	58
Total Dermal (ug/hr)		1.6×10^4	4.0×10^2
Pounds of ai handled		1.2	1.2
Total Dermal (ug/lb ai)		1.3×10^4	3.3×10^2[b]
Respiratory (ug)		3.2	3.2
Respiratory (ug/hr)		28	28
Respiratory (ug/lb ai)		2.7	2.7

a Assumes worker is wearing long sleeve shirt, long trousers, and gloves.

b Calculated value, assuming 90% hand protection is afforded by protective gloves, is 5.1×10^2 ug/lb ai.

Table 3. Applicator exposure to carbaryl from treatment of corn and beans.[a]

Body part	Amt/Patch (ug/cm^2)	SA_2 (cm^2)	ug/body part	ug/body part/hr	50% for clothed areas	ug/kg/hr	ug/kg/lb ai[b]
Shoulders	0.058	2910	169				
Chest	0.075	3550	266				
Forearms	0.08	1210	98				
CHEST (TOTAL)			533	2132	1066	15	5.4×10^2
BACK (TOTAL)	0.072	3550	256	1024	512	7.3	2.6×10^2
Thigh	0.842	3820	3218				
Cuff	1.94	2380	4617				
Shoe	2.88	1310	3773				
LEGS (TOTAL)			11608	46432	23216	3.3×10^2	1.2×10^4
HANDS (TOTAL)[c]	0.184	820	151	604	604	8.6	3.1×10^2
Total Dermal (assuming no gloves)						3.6×10^2	1.3×10^4
Total Dermal (assuming gloves)							1.3×10^4

[a] Mean values for both crops were used; exposure values are from application of a wettable powder formulation.

[b] $$\text{Adjusted exposure per lb ai handled (ug/kg/lb ai)} = \text{ug/kg/hr} \times \frac{0.25 \text{ hr/application}}{0.007 \text{ lb ai/application}}$$

[c] Hand exposure measured using hand rinses. Hand exposure, assuming 90% hand protection is afforded by protective gloves, is 31 ug/kg/lb ai.

Table 4. Applicator exposure to diazinon from treatment of lawns and shrubs.

Body part	(ug/hr)[a]	(ug/kg/hr)	(ug/kg/lb ai)[b]
Hands[c]	5650	80.7	1.8×10^2
Total dermal[d]	6250	89.3	1.9×10^2

[a] Data provided only allows an estimate of potential dermal exposure to unclothed areas when normal work clothing is worn; clothed areas were assumed to afford 100% protection.

[b] Adjusted exposure per lb ai handled (ug/kg/lb ai) $= 80.7 \text{ ug/kg/hr} \times \frac{0.5 \text{ hr/appl.}}{0.023 \text{ lb/appl.}}$

[c] Hand exposure was measured using hand rinses. Hand exposure, assuming 90% hand protection is afforded by protective gloves, is 18 ug/kg/lb ai.

[d] Total dermal exposure, assuming protective gloves are worn is 28 ug/kg/lb ai.

APPENDIX A. Recovery of Fosetyl Al from Sampling Media

Sampling Medium	Type	Spike Level (ug)	Percent Recovery
Gauze Pad	Method Dev.	0.50	117
		5.00	106
		50.00	130
	Field[1]	24.0	96
		240.0	98
	Laboratory[2]		98
	Storage (6 wk)	0.5	80
		5.0	120
		50.0	91
	Storage (9 wk)	0.5	120
		5.0	166
		50.0	110
Fiberglass filter	Method Dev.	0.50	117
		2.00	106
		10.00	119
	Field[1]	1.0	108
		10.0	102
	Laboratory[3]		119
	Storage (6 wk)	1.0	120
		10.0	70
	Storage (9 wk)	1.0	70
		10.0	106
Hand Wash	Method Dev.	10	85
		100	88
		1000	81
		10000	104
	Field[1]	100	83
		1000	95
	Laboratory[4]		85
	Storage (4 wk)	10	130
		100	86
		1000	84
		10000	126

[1] Average of daily spikes.

[2] Spikes ranged from 0.5 to 50 ug.

[3] Spikes ranged from 1.0 to 10.0 ug.

[4] Spikes ranged from 10 to 1000 ug.

APPENDIX B. Calculation of Worker Greenhouse Application Exposures.

1) Dermal

The exposure of a particular portion of the body was calculated by multiplying the amount found on the dermal monitors, in ug/cm^2, by the surface area of the appropriate body part. For example, the exposure of the chest of mixer/loader number 1 was:

$$\text{Exposure of chest (ug)} = \frac{0.30 \text{ ug}}{\text{cm}^2} \times 3550 \text{ cm}^2 = 1.1 \times 10^3 \text{ ug}$$

The visor of the baseball hats appeared to reduce the exposure of the hat pad. Therefore, the mean of the exposures of the shoulders and chest were used to estimate the exposure of the face. The hand wash procedure sampled the entire surface area of the hands and no adjustment for surface area was necessary. The total exposure is the sum of the individual exposures of the body parts.

The total dermal exposures were adjusted by the time spent performing the tasks and by the amount of active ingredient handled. The hourly dermal exposure is:

$$\text{Exposure (ug/hr)} = \frac{\text{Exposure (ug)}}{\text{elapsed time (min)}} \times \frac{60 \text{ min}}{\text{hr}}$$

In order to adjust the dermal exposure for the amount of active ingredient handled, the total dermal exposure was divided by 1.2, the number of pounds of active ingredient used in each replicate.

2) Respiratory

The calculation of respiratory exposure was based on the assumption that the respiratory volume of an average worker is 1.2 m^3 per hour. The following equation was used to calculate respiratory exposure:

$$\text{Respiratory Exposure (ug/hr)} = \frac{\text{amount on filter (ug)}}{\text{volume collected } (\text{m}^3)} \times \frac{1.2 \text{ m}^3}{\text{hr}}$$

Respiratory exposures were also normalized by the amount of active ingredient by dividing the amount found on the filter by the amount of actve ingredient handled (1.2 lbs).

APPENDIX C. Calculation of Worker Outdoor Ornamental Application Exposures.

Carbaryl -- Workers applied 3 g (0.007 lb) of carbaryl in 15 minutes. The adjusted dermal exposure of the hands would be:

$$\text{Adjusted exposure per lb ai handled} = 8.6 \text{ ug/kg/hr} \times \frac{0.25 \text{ hr/application}}{0.007 \text{ lb/application}}$$

$$= 3.1 \times 10^2 \text{ ug/kg/lb ai}$$

Diazinon -- Workers using compressed air sprayers applied an average of 547 ug/ml of diazinon; 18.9 liters of finished spray was applied in 30 minutes. The average amount of diazinon applied per operation was:

$$\frac{547 \text{ ug}}{\text{ml}} \times \frac{18.9 \text{ l}}{\text{operation}} \times \frac{1000 \text{ ml}}{\text{liter}} \times \frac{1 \text{ g}}{10^6 \text{ ug}} \times \frac{1 \text{ lb}}{454 \text{ g}}$$

$$= 0.023 \text{ lb/operation}$$

Adjusting the dermal exposure of the hands by the amount of material applied gives:

$$\text{Adjusted exposure per lb ai handled} = 80.7 \text{ ug/kg/hr} \times \frac{0.5 \text{ hr/application}}{0.023 \text{ lb/application}}$$

$$= 1.8 \times 10^2 \text{ ug/kg/lb ai}$$