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

JAN 10 1990

OFFICE OF
PESTICIDES AND TOXIC SUBSTANCE

MEMORANDUM

SUBJECT: RE-EVALUATION OF CHLORPYRIFOS LAWN CARE EXPOSURE STUDY
(HED Project # 9-0609)

TO: Dennis Edwards
Product Manager 12
Registration Division (H7505C)

FROM: David Jaquith
Environmental Chemistry Review Section
Non-Dietary Exposure Branch
Health Effects Division (H7509C)

THRU: Michael Firestone, PhD., Section Head
Environmental Chemistry Review Section
Non-Dietary Exposure Branch
Health Effects Division (H7509C)

THRU: Charles L. Trichilo, PhD., Chief
Non-Dietary Exposure Branch
Health Effects Division (H7509C)

Please find below the NDEB review of ....

RD or SRRD Record #: 237316

Caswell #: 219AA

Date Received: 02/03/89 Review Time: 5 days

Deferral to: _____ Biological Analysis Branch/BEAD

_____ Science Analysis & Coordination Branch

_____ TB - Insecticide/Rodenticide Support Section

_____ TB - Herbicide/Fungicide/Antimicrobial Support Section

1.0 INTRODUCTION

In September 1987 NDEB/EAB evaluated a study submitted by Dow Chemical Company (MRID No. 400260-01) measuring the potential exposure of workers applying the insecticide chlorpyrifos to residential turf. The study was submitted in support of continued registration of the registrant's line of turf products. The review is attached as Appendix A. The reviewer pointed out several technical deficiencies in the study design, such as a lack of dosimeters on the back and arms of the workers. The reviewer estimated exposures to these areas by extrapolating from dosimeters located on other body surfaces. Specifically, the exposure of the forearms was estimated using exposure values obtained from the hands and the upper arm exposure was estimated by taking the mean of the value of the hand exposure and that of the sternum. The ratio of the back of the thighs to the front was used to adjust the chest exposure in order to estimate that of the back. Head and neck exposures were extrapolated from the chest and back values as outlined in the Agency's Pesticide Assessment Guidelines - Subdivision U - Applicator Exposure. It was noted that the need to estimate exposures to surfaces with no dosimeters using patches located elsewhere could result in error in exposure assessment, possibly overestimating the actual exposure by an appreciable degree. The registrant has submitted a rebuttal to the Agency's assessment and has requested a reevaluation of the study (Record No.237316). This review contains a second evaluation of that exposure study.

2.0 CONCLUSIONS

At the request of the registrant, Dow Chemical Company, NDEB has re-evaluated a study measuring the potential exposure of workers applying the insecticide chlorpyrifos to turf using a powered hand spray. The study design did not include dermal patches on the arms or back. The registrant attempted to justify the omission of these dosimeters by citing another study measuring exposure to golf course workers using similar equipment (1). Hand exposure in that study, monitored using patches attached to the wrists, was the greatest contributor to total dermal exposure. Examination of photographs taken during that study showed that the dosimeters extended slightly up the forearms, indicating that the forearms may receive appreciable exposure. The previous Agency reviewer noted these deficiencies and estimated the exposures of these areas by extrapolating from other dosimeters. Specifically, forearm exposure was estimated using levels found on the hands, forearms by using the mean of the sternum and hand values, and back exposure by adjusting the chest exposure by the ratio of residues found on the front and back of the legs. NDEB continues to believe that this approach is reasonable and agrees with the approach of the previous review. However, NDEB also realizes that these extrapolations increase the uncertainty associated with these data. Despite the

technical weaknesses in the study, and the resulting increase in uncertainty, NDEB finds the study to be usable for estimation of the exposures of these workers. The study provides a reasonable estimate of these exposures. The registrant is urged to submit protocols to the Agency for review prior to the conduct of any future studies. The recalculated exposure values are presented in Table 1.

3.0 DESCRIPTION OF STUDY

CITATION: Vaccaro, J.R. (1986) Evaluation of Airborne and Whole Body Exposure of Lawn Care Specialists to Chlorpyrifos During Routine Treatment of Turf. Accession No. 400260-01.

Exposures of the potential dermal and respiratory exposures of lawn care pest control operators to chlorpyrifos were measured during the application of the insecticide to residential turf. The material was applied, at the normal industry application concentrations (0.07-0.1 percent), using power hose end sprayers attached to reservoirs located on trucks. Spray tank mix concentrations were not reported.

Exposures were monitored during twelve applications, 2 each with 6 different workers. Each application cycle consisted of a work period of approximately 30 minutes of actual spray time. Spray time was defined as the time the hose was uncoiled to the time the hose was rewound onto the truck. Exposures during the mixing/loading procedure were not measured. Dermal exposure of the body was monitored using 2 inch by 2 inch gauze patches, located outside of the clothing, on the sternum, groin, thighs (front and back), and calves (also front and back). Dermal exposure of the hands was measured using cotton gloves. No protective gloves were reported to be worn during this study. Respiratory exposure concentrations were measured by drawing air through glass tubes, at a rate of 200 cc per minute, using calibrated personal sampling pumps. Chromosorb 102 was used as the trapping agent. The dosimeters were used for a 30 minute work period, after which they were replaced by a second series for the next trial. The dosimeters were desorbed with hexane and residues quantified by gas chromatography using an electron capture detector.

4.0 CALCULATION OF EXPOSURES

The study design included dermal dosimeters at 10 different locations on the body. Patches on the back and arms were not included as recommended by the Pesticide Assessment Guidelines-Subdivision U. These omissions required additional extrapola-

tions in order to estimate exposures to these body areas. The assumptions used by NDEB to estimate exposures of these workers are presented below:

1) Workers are assumed to weigh 70 kg and have standard surface areas as presented in the Pesticide Assessment Guidelines-Subdivision U.

2) Gloves are assumed to offer 90 percent protection to the hands. Fifty percent protection is assumed for other areas covered by clothing when assessing acute toxicity endpoints. Four different clothing scenarios were examined in this assessment; assuming the wearing of either long or short sleeve shirt, and with or without gloves.

3) Workers are assumed to have a respiratory volume of 1.7 m^3 per hour while applying the pesticide.

4) Dermal exposures are not corrected for dermal absorption.

5) Chlorpyrifos is applied for 5 hours per day.

In order to adjust for missing dosimeters on the arms and back, the previous reviewer used values from existing dosimeters for estimation of exposures to these areas. NDEB believes that these adjustments were reasonable and included the same types of adjustments in this review.

Hand Exposure

The values measured on the hands were used to estimate each forearm exposure. The equation used is:

$$\text{Forearm Exposure (ug)} = \frac{\text{Hand Exposure (ug)}}{410\ cm^2} \times 605\ cm^2$$

Upper Arm Exposure

The mean of the sternum pad and hand values was used to calculate upper arm exposures. The equation used for estimation of the exposure each upper arm is:

$$\text{Upper Arm Exposure (ug)} = \frac{\text{Mean of Sternum and Hand (ug)}}{\text{Patch surface area } (cm^2)} \times 1455\ cm^2$$

Back Exposure

Exposure of the back was estimated by adjusting the values obtained from the chest measurement (mean of sternum pad and

groin pad) by the ratio of the residues measured on the front and back of the legs. The correction factor is:

$$CF = \frac{\text{(Sum of exposures on back of legs, both calves and thighs)}}{\text{(Sum of exposures on front of legs, both calves and thighs)}}$$

The mean value of the chest and groin patches was then calculated. This value was then adjusted by the correction factor, CF. The equation used for estimation of back exposure was:

$$\text{Back exposure (ug)} = \frac{\text{Mean of Sternum and Groin pads (ug)}}{\text{Patch Surface Area (cm}^2\text{)}} \times CF \times 3550\ \text{cm}^2$$

The mean dermal exposures of the applicators for the four clothing scenarios are presented in Tables 2-5.

Respiratory Exposure

The estimated respiratory exposures of these workers are presented in Table 6. It was assumed that the workers have a respiratory volume of 1.7 m^3 per hour. Exposure was calculated for the spray time only, the contribution due to air levels in the truck were not included.

REFERENCES

1) Freeborg, R.P., W.H. Daniel, and V.J. Knonopinski (1985) Applicator Exposure to Pesticides Applied to Turfgrass IN R.C. Honeycutt, G. Zweig, and N.N. Ragsdale (Eds.), Dermal Exposure Related to Pesticide Use, Discussion of Risk Assessment, ACS Symposium Series #273, (pp287-295). American Chemical Society, Washington D.C.

Attachments:
Tables 1-6
Appendix A.

cc: Chlorpyrifos file (with attachments)
Circulation (with attachments)
TB-IRS (with attachments)
SACB (with attachments)
Correspondence file (with attachments)

Table 1. Summary of Exposures of Workers to Chlorpyrifos (Dursban) Applied to Turf Using Hand-Held Power Spray Equipment.

	Long sleeves, no gloves	Long sleeves, gloves	Short Sleeves no gloves	Short sleeves gloves	Respiratory
mg/hr	44.84	27.81	58.00	41.00	3.3×10^{-3}
mg/day	224.19	139.07	290.00	205.00	1.7×10^{-2}
mg/kg/hr	0.64	0.40	0.83	0.59	4.7×10^{-5}
mg/kg/day	3.20	1.99	4.1	2.93	2.4×10^{-4}

Table 2. Dermal Exposures of Workers Applying Chlorpyrifos (Dursban) to Turf Using Powered Hand-Spray. Workers are assumed to wear long sleeve shirts, long pants, and no gloves.

Body Area	Surface Area (cm^2)	Clothing Factor	ug per patch	Spray Time (min)	Dermal Exposure			
					Unadjusted		Adjusted for Clothing	
					(ug)	(ug/hr)	(ug)	(ug/hr)
Front of Neck	110	1.0	0.75	28.4	3.2	6.8	3.2	6.8
Chest	1775	0.5	0.75	28.4	52	109	26	55
Groin	1775	0.5	4.0	28.4	278	607	139	303
Back	3550	0.5	1.8[1]	28.4	243	512	122	256
Left Thigh Front	562.5	0.5	39	28.4	850	1725	425	863
Right Thigh Front	562.5	0.5	29	28.4	625	1357	312	678
Right Thigh Back	562.5	0.5	28	28.4	601	1267	300	634
Left Calf Front	595	0.5	135	28.4	3105	6567	1553	3283
Left Calf Back	595	0.5	27	28.4	623	1300	312	650
Right Calf Front	595	0.5	186	28.4	4290	8954	2145	4477
Right Calf Back	595	0.5	19	28.4	446	932	223	466
Left Upper Arm	1455	0.5	2.1	28.4	119	245	60	123
Right Upper Arm	1455	0.5	9.6	28.4	543	1145	272	573
Left Forearm	605	0.5	NA	28.4	2100	3426	1050	1713
Right Forearm	605	0.5	NA	28.4	11207	23683	5604	11841
Left Hand	410	1.0	NA	28.4	1423	2914	1423	2914
Right Hand	410	1.0	NA	28.4	7595	16001	7595	16001
TOTAL DERMAL EXPOSURE					34103	70751	21564	44837

1 Extrapolated from chest values and ratio of residues on front and back of legs.

2 Not Applicable. No dosimeter used, exposure based on hand value.

Table 3. Dermal Exposures of Workers Applying Chlorpyrifos (Dursban) to Turf Using Powered Hand-Spray. Workers are assumed to wear long sleeve shirts, long pants, and gloves.

Body Area	Surface Area (cm^2)	Clothing Factor	ug per patch	Spray Time (min)	Dermal Exposure			
					Unadjusted		Adjusted for Clothing	
					(ug)	(ug/hr)	(ug)	(ug/hr)
Front of Neck	110	1.0	0.75	28.4	3.2	6.8	3.2	6.8
Chest	1775	0.5	0.75	28.4	52	109	26	55
Groin	1775	0.5	4.0	28.4	278	607	139	303
Back	3550	0.5	1.8[1]	28.4	243	512	122	256
Left Thigh Front	562.5	0.5	39	28.4	850	1725	425	863
Right Thigh Front	562.5	0.5	29	28.4	625	1357	312	678
Right Thigh Back	562.5	0.5	28	28.4	601	1267	300	634
Left Calf Front	595	0.5	135	28.4	3105	6567	1553	3283
Left Calf Back	595	0.5	27	28.4	623	1300	312	650
Right Calf Front	595	0.5	186	28.4	4290	8954	2145	4477
Right Calf Back	595	0.5	19	28.4	446	932	223	466
Left Upper Arm	1455	0.5	2.1	28.4	119	245	60	123
Right Upper Arm	1455	0.5	9.6	28.4	543	1145	272	573
Left Forearm	605	0.5	NA[2]	28.4	2100	3426	1050	1713
Right Forearm	605	0.5	NA	28.4	11207	23683	5604	11841
Left Hand	410	0.1	NA	28.4	1423	2914	142	291
Right Hand	410	0.1	NA	28.4	7595	16001	760	1600
TOTAL DERMAL EXPOSURE					34103	70751	13448	27813

1 Extrapolated from chest values and ratio of residues on front and back of legs.

2 Not Applicable. No dosimeter used, exposure based on hand value.

Table 4. Dermal Exposures of Workers Applying Chlorpyrifos (Dursban) to Turf Using Powered Hand-Spray. Workers are assumed to wear short sleeve shirts, long pants, and no gloves.

Body Area	Surface Area (cm^2)	Clothing Factor	ug per patch	Spray Time (min)	Dermal Exposure			
					Unadjusted		Adjusted for Clothing	
					(ug)	(ug/hr)	(ug)	(ug/hr)
Front of Neck	110	1.0	0.75	28.4	3.2	6.8	3.2	6.8
Chest	1775	0.5	0.75	28.4	52	109	26	55
Groin	1775	0.5	4.0	28.4	278	607	139	303
Back	3550	0.5	1.8[1]	28.4	243	512	122	256
Left Thigh Front	562.5	0.5	39	28.4	850	1725	425	863
Right Thigh Front	562.5	0.5	29	28.4	625	1357	312	678
Right Thigh Back	562.5	0.5	28	28.4	601	1267	300	634
Left Calf Front	595	0.5	135	28.4	3105	6567	1553	3283
Left Calf Back	595	0.5	27	28.4	623	1300	312	650
Right Calf Front	595	0.5	186	28.4	4290	8954	2145	4477
Right Calf Back	595	0.5	19	28.4	446	932	223	466
Left Upper Arm	1455	0.5	2.1	28.4	119	245	60	123
Right Upper Arm	1455	0.5	9.6	28.4	543	1145	272	573
Left Forearm	605	1.0	NA[2]	28.4	2100	3426	2100	3426
Right Forearm	605	1.0	NA	28.4	11207	23683	11207	23683
Left Hand	410	1.0	NA	28.4	1423	2914	1423	2914
Right Hand	410	1.0	NA	28.4	7595	16001	7595	16001
TOTAL DERMAL EXPOSURE					34103	70751	28217	58392

1 Extrapolated from chest values and ratio of residues on front and back of legs.

2 Not Applicable. No dosimeter used, exposure based on hand value.

Table 5. Dermal Exposures of Workers Applying Chlorpyrifos (Dursban) to Turf Using Powered Hand-Spray. Workers are assumed to wear short sleeve shirts, long pants, and gloves.

Body Area	Surface Area (cm^2)	Clothing Factor	ug per patch	Spray Time (min)	Dermal Exposure			
					Unadjusted		Adjusted for Clothing	
					(ug)	(ug/hr)	(ug)	(ug/hr)
Front of Neck	110	1.0	0.75	28.4	3.2	6.8	3.2	6.8
Chest	1775	0.5	0.75	28.4	52	109	26	55
Groin	1775	0.5	4.0	28.4	278	607	139	303
Back	3550	0.5	1.8	28.4	243	512	122	256
Left Thigh Front	562.5	0.5	39	28.4	850	1725	425	863
Right Thigh Front	562.5	0.5	29	28.4	625	1357	312	678
Right Thigh Back	562.5	0.5	28	28.4	601	1267	300	634
Left Calf Front	595	0.5	135	28.4	3105	6567	1553	3283
Left Calf Back	595	0.5	27	28.4	623	1300	312	650
Right Calf Front	595	0.5	186	28.4	4290	8954	2145	4477
Right Calf Back	595	0.5	19	28.4	446	932	223	466
Left Upper Arm	1455	0.5	2.1	28.4	119	245	60	123
Right Upper Arm	1455	0.5	9.6	28.4	543	1145	272	573
Left Forearm	605	1.0	NA	28.4	2100	3426	2100	3426
Right Forearm	605	1.0	NA	28.4	11207	23683	11207	23683
Left Hand	410	1.0	NA	28.4	1423	2914	142	291
Right Hand	410	1.0	NA	28.4	7595	16001	760	1600
TOTAL DERMAL EXPOSURE					34103	70751	20101	41368

1 Extrapolated from chest values and ratio of residues on front and back of legs.

2 Not Applicable. No dosimeter used, exposure based on hand value.

Table 6. Respiratory Exposure of Workers Applying Chlorpyrifos (Dursban) to Turf Using Power Hand Spray Equipment. Respiratory volume is assumed to be 1.7 m^3 per hour.

Rep.	Spray Time	Flow Rate (ml/min)	Volume Sampled (L)	ug Found	Conc. (ug/cu m)	Exposure (ug)	Exposure (ug/hr)	Exposure (ug/day)	Exposure (ug/kg/day)
1	30.0	197	7.9	0.020	2.53	2.15	4.30	21.52	0.31
2	30.0	197	14.2	0.040	2.82	2.39	4.79	23.94	0.34
3	27.7	205	14.1	0.016	1.13	0.89	1.93	9.65	0.14
4	28.7	205	16.0	0.037	2.31	1.88	3.93	19.66	0.28
5	29.9	206	20.6	0.024	1.17	0.99	1.98	9.90	0.14
6	26.9	NS[1]	NS	NS	NS	NS	NS	NS	NS
7	26.3	205	7.8	0.015	1.92	1.43	3.27	16.35	0.23
8	27.0	205	9.2	0.027	2.93	2.25	4.99	24.95	0.36
9	29.5	202	11.1	0.013	1.17	0.98	1.99	9.95	0.14
10	27.7	202	10.3	0.009	0.87	0.69	1.49	7.43	0.11
11	25.8	206	9.7	0.020	2.06	1.51	3.51	17.53	0.25
12	31.3	206	11.3	0.027	2.39	2.12	4.06	20.31	0.29
MEAN	28.4	203	12.0	0.02	1.94	1.57	3.29	16.47	0.24

[1] No Sample.

HED Project No 9-0609 Appendix A Enclosure

Shaughnessy #: 059101

EAB Log-Out Date: SEP 2 1987

To: Dennis Edwards
Product Manager #12
Registration Division (TS-767C)

From: Michael Firestone, Acting Chief
Special Review Section
Exposure Assessment Branch
Hazard Evaluation Division (TS-769C)

Attached, please find the EAB review of...

Reg./File No.: 464-404

Chemical: Chlorpyrifos

Type Product: Insecticide

Product Name: Dursban 4E

Company Name: Dow Chemical USA

Submission Purpose: Support of the existing registration of the Dow turf insecticide line of products

ACTION CODE: 605

Date In: 12 FEB 87 EAB #: 70260

Date Completed: 28 AUG 87 TAIS Code:

Deferrals To:

_____ Ecological Effects Branch

_____ Residue Chemistry Branch

XX Toxicology Branch

_____ Benefits and Use Division

Monitoring study requested by EAB: /___/

Monitoring study voluntarily conducted by registrant: /XXX/

1.0 INTRODUCTION

Dow Chemical USA has submitted an exposure assessment for applicators of chlorpyrifos (Dursban 4E) to turf. This submission is in support of the existing registration of the Dow turf insecticide line of products.

2.0 DISCUSSION OF DATA

Dow conducted an exposure assessment measuring both respiratory and dermal exposure to chlorpyrifos. The company used Dursban 4E, a 4 lb/gal emulsifiable concentrate for the study. The application rate was approximately 1.1 lb ai/A. There were a total of six replicates measured in this study and no protective clothing was employed by the applicators. The mean area sprayed by each applicator was 49,000 ft^2/hr. Dow estimates that an applicator will apply 1000 gallons of finished spray solution to 250,000 ft^2 per day. Therefore, an average applicator will be applying chlorpyrifos for 5 hours per day [(250,000 ft^2/day)/(49,000 ft^2/hr) = 5 hr/day]. No data were provided for exposure via mixing/loading. Therefore, surrogate data will be employed to estimate exposure to mixer/loaders. A number of assumptions will be necessary for this assessment. They are:

1. An average worker has a mass of 70 kg.

2. Exposure is not corrected for dermal absorption.

3. Total spray time is five (5) hours per day.

Specific study information is provided below.

2.1 METHODS: RESPIRATORY EXPOSURE

Dow estimated respiratory exposure by calculating short-term time weighted average exposures for six replicates during routine application of chlorpyrifos. Dow employed battery operated DuPont P-200 vacuum pumps which were used to draw air through 150 mg of chromosorb 102 solid sorbent contained in glass tubes. The approximate air flow rates were 200 cc/min. Each sample trial was conducted over 30 minutes of actual spray time. Dow defined spray time to be from the time the hose was uncoiled until the hose was completely recoiled back on the truck. When the initial 30-minute trial was concluded, the tube was removed, capped and stored for future analysis. A new tube was then attached and used for the second trial. The chromosorb 102 was extracted with hexane and analyzed by GC using Electron Capture detection.

2.2 METHODS: DERMAL EXPOSURE

Dow estimated dermal exposure by placing 2" x 2" gauze pads at various locations of the body. Hand exposure was measured by using cotton glove liners. As with the respiratory measurements, two 30-minute trials were conducted. The patches were attached with safety pins to the outside of the uniform. Each pad had a small piece of 2 mil polyethylene behind it to prevent contamination of the patches by the contaminated clothing. The patches were located at the following areas: sternum, fly, back and front of each thigh, and back and front of each calf. No measurements were made of arm, neck, head, or back exposure. After the first 30-minute spray trial, both the gauze pads and the glove liners were removed and replaced. The gauze pads were put into narrow analysis vials with screw tops while the glove liners were placed in dark bottles with polyseal caps. Both were later desorbed with hexane and analyzed by GC. The liners were sufficiently heavy that appreciable absortion into the weave could be obtained. A total of six replicates were employed.

2.3 QUALITY ASSURANCE

The chromosorb 102 tubes, glove liners and gauze patches were all spiked in the field with known amounts of chlorpyrifos using a microliter syringe and stock solutions of 0.094 ug/uL and 0.94 ug/uL of chlorpyrifos. The recovery of chlorpyrifos from fortified samples ranged from 80 to 106% of the spiked value.

2.4 RESULTS: RESPIRATORY EXPOSURE

The short-term time weighted averages (TWAs) are presented in Table 1 of the Dow report. Two sets of values are presented, one for each 30-minute trial. Therefore, for each replicate, the mean of the two values will be used for the TWA. Replicate #3 only had one measured TWA so that given value will be used. Using the standard breathing rates found in Subdivision U of the Pesticide Assessment Guidelines, assuming light work (29 L/min), the following exposures can be calculated:

Replicate	TWA (ug/m^3)	Exposure (ug/hr)
1	2.7	4.7
2	1.7	3.0
3	1.2	2.1
4	2.4	4.2
5	1.1	1.9
6	2.3	4.0

Sample calculation:
2.7 ug/m^3 x 1 m^3/1000 L x 29 L/min x 60 min/hr = 4.7 ug/hr

The range of exposures was 1.9-4.7 ug/hr with a mean of 3.3 ug/hr. Assuming a 5 hr workday, applicator exposure would be expected to average 16.5 ug/day. For a 70 kg individual, exposure would be 0.24 ug/kg/day.

2.5 RESULTS: DERMAL EXPOSURE

The values for the residues of chlorpyrifos recovered from the gauze pads and glove liners are presented in Tables 2-4 of the Dow report. Hand exposure was measured directly by the use of cotton glove liners. Therefore, the values presented (in mg) are considered to represent the whole hand. The sum of the values of the two 30-minute trials gives hand exposure in mg/hr. The results are presented below:

Replicate Number	Right Hand (mg/hr)	Left Hand (mg/hr)	Both Hands (mg/hr)
1	10.94	7.57	18.51
2	23.00	2.33	25.33
3	16.30	1.27	17.57
4	14.85	0.67	15.52
5	10.64	2.64	13.28
6	15.41	2.60	18.01
Mean	15	2.8	18

These data indicate that exposure was much greater for the right hand as compared to the left hand (as much as 22 times higher). This disparity can be accounted for by assuming that the applicators were all right-handed and, as such, exposed their right hands to contamination from the spray nozzle due to the close proximity of the hand to the nozzle.

The body exposure was presented as ug/patch/hr. The data are presented below:

Patch Area	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Median
Sternum	3.0	0.8	0.5	2.4	0.4	1.9	1.4
Groin	2.4	1.7	5.3	12.5	11.8	16.3	8.3
L thigh	27.5	24.0	10.1	52.6	111.1	242.6	40
L thigh (b)	2.4	97.3	10.6	4.2	37.0	94.1	24
R thigh	24.5	38.5	24.7	114.6	24.7	116.8	39
R thigh (b)	36.5	210.4	12.9	31.3	3.1	34.5	33
L calf	450.2	313.1	247.2	302.2	127.2	175.8	270
L calf (b)	64.5	21.4	45.2	66.5	92.3	24.5	55
R calf	446.5	443.5	296.5	379.8	193.1	472.8	410
R calf (b)	87.3	25.4	34.9	45.3	27.9	11.1	31

One major flaw of this study is the lack of upper body data. No data were presented with which to estimate neck, arm (upper and lower), back or head exposure. Therefore, several assumptions must be made in order to estimate such exposure. These assumptions are as follows: 1) hand exposure values (in ug/cm2) will be used to estimate forearm exposure; 2) the mean of hand exposure (in ug/cm2) and the sternum pad will be used to estimate upper arm exposure; 3) back exposure will be calculated as 40% of chest exposure (this is based on the ratio of back to front exposure as seen on the thigh and calf pads); and head and neck exposures will be calculated from the sternum pad and back exposure (in ug/cm2). These assumptions may grossly overestimate upper body exposure but, in the absence of sufficient data, they will be deemed acceptable.

Where two patches were used to measure exposure, the mean of the two pads will be used to calculate exposure. Each patch was 2" x 2" which is approximately 25.81 cm^2. Using the body surface areas found in Subdivision U of the Pesticide Assessment Guidelines, the following exposures can be calculated:

Body Part	Surface Area (cm^2)	ug/pad/hr	ug/cm^2/hr	ug/body part/hr	ug/body part/day*
Chest	3550	4.9	0.19	670	3.4×10^2
Back	3550	2.0	0.077	270	1.4×10^2
Neck, front	150	1.4	0.054	8.1	4.1×10^1
Neck, back	110	0.56	0.022	2.4	1.2×10^1
Head	1300	0.98	0.038	49	2.5×10^2
Upper arm, R	1455	---	18	26000	1.3×10^5
Upper arm, L	1455	---	3.4	4900	2.5×10^4
Forearm, R	605	---	36	22000	1.1×10^5
Forearm, L	605	---	6.8	4100	2.1×10^4
Hand, R	410	---	36	15000	7.5×10^4
Hand, L	410	---	6.8	2800	1.4×10^4
Thigh, R	1910	36	1.4	2700	1.4×10^4
Thigh, L	1910	32	1.2	2300	1.2×10^4
Calf, R	1190	220	8.5	10000	5.0×10^4
Calf, L	1190	160	6.2	7400	3.7×10^4
TOTAL				98000	4.9×10^5

Calculated (EPA)

*Based on a 5 hour workday.

$$\text{Dermal Exposure} = \frac{4.9 \times 10^5 \text{ ug/day}}{70 \text{ kg individual}} = 7.0 \times 10^3 \text{ ug/kg/day}$$

Converting to mg/hr, the total body exposure is 98 mg/hr or 4900 mg/day. This estimate is based on 100% absorption of

chlorpyrifos by the skin and does not take into account the protective value of clothing. Clothing can be estimated to reduce exposure by roughly 50% to covered areas. EAB will assume that applicators wore short-sleeved shirts and long pants. With this assumption, the exposure to chlorpyrifos is reduced to 71 mg/hr or 360 mg/day; for a 70 kg individual, exposure is estimated to be 5.1 mg/kg/day. Hand exposure accounts for 31% of this exposure. The use of protective gloves could reduce hand exposure by up to 90%. Assuming that such gloves are worn, exposure is reduced to 55 mg/hr or 270 mg/day; for a 70 kg individual, exposure is 3.9 mg/kg/day.

2.5 SURROGATE MIXER/LOADER DATA

The Dow study reflected the use of chlorpyrifos as a 4 lb/gal emulsifiable concentrate (Dursban 4E) mixed as 1 gal + 40 fl oz (1.31 gal) of Dursban into 800 total gallons. A total of 4 gallons of finished spray is needed to cover each 1000 ft^2. Considering the above, the following application rate can be derived:

$$\frac{1.31 \text{ gal Dursban 4E}}{800 \text{ gal solution}} \times \frac{4 \text{ lb ai chlorpyrifos}}{1 \text{ gal Dursban 4E}} = 6.55 \times 10^{-3} \text{ lb ai/gal}$$

$$6.55 \times 10^{-3} \text{ lb ai/gal} \times 4 \text{ gal}/1000 \text{ ft}^2 = 2.62 \times 10^{-5} \text{ lb ai/ft}^2$$

$$2.62 \times 10^{-5} \text{ lb ai/ft}^2 \times 1 \text{ ft}^2/2.295684 \times 10^{-5} \text{ A} = 1.14 \text{ lb ai/A}$$

EAB utilized three articles found in the published literature to estimate mixer/loader exposure. These exposures were calculated assuming that the mixer/loader wore normal work attire consisting of a long-sleeved shirt and long pants as well as protective gloves. If actual hand exposure under the protective gloves was not measured, EAB assumed that exposure to the unprotected hand would be reduced 90% by protective gloves. If actual measurements of exposure under clothing were not measured, EAB assumed that clothing provided 50% protection to covered areas.

The exposure during open pour mixing/loading is 0.93 mg/lb ai based on 18 replicates in a study by Abbott, et al. (1987). The exposure during closed system mixing/loading is 0.015 mg/lb ai based on 9 Dubelman, et al. (1982), and 9 Peoples, et al. (1979), replicates.

Treating 250,000 ft^2 per day at a rate of 2.62×10^{-5} lb ai/ft^2 will require 6.55 lb ai. Therefore, assuming a 70 kg individual, the following exposures can be calculated.

Open Pour Mixing/Loading

$$\frac{0.93 \text{ mg/lb ai} \times 6.55 \text{ lb ai/day}}{70 \text{ kg individual}} = 8.7 \times 10^{-2} \text{ mg/kg/day}$$

Closed System Mixing/Loading

$$\frac{0.015 \text{ mg/lb ai} \times 6.55 \text{ lb ai/day}}{70 \text{ kg individual}} = 1.4 \times 10^{-3} \text{ mg/kg/day}$$

3.0 DISCUSSION

The registrant has recommended that applicators wear permeation resistant gloves (especially when recoiling the hose), impervious pants and permeation resistant footwear such as neoprene boots in an effort to reduce exposure. EAB agrees with this recommendation. However, EAB is concerned that no upper body data were presented in this report. While it may be true that lower body and hand exposure are the major components of dermal exposure in this type of application, without any data to quantify upper body exposure, EAB must assume that such upper body exposure exists and may be significant. The extrapolations to upper body exposure presented in this report may overestimate such exposure but they are needed to provide some sort of exposure estimates for these regions. EAB would rather overestimate than underestimate exposure to these areas. Therefore, the registrant may wish to submit another study that quantifies upper body as well as lower body exposure to show if upper body exposure is negligible compared to lower body exposure. Mixer/loader data should also be presented in such a study. Study guidance can be found in Subdivision U of the Pesticide Assessment Guidelines. A protocol outlining the study should be submitted to the Agency for review and approval by EAB prior to study initiation.

4.0 CONCLUSIONS

EAB has estimated exposure to applicators to be 0.24 mg/kg/day for respiratory and 5.1 mg/kg/day for dermal. The use of protective gloves would reduce dermal exposure to 3.9 mg/kg/day. Mixer/loader exposure is estimated to be 8.7×10^{-2} mg/kg/day for open pour and 1.4×10^{-3} mg/kg/day for closed system.

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