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

OFFICE OF  
PREVENTION, PESTICIDES AND  
TOXIC SUBSTANCES

MEMORANDUM

April 19, 1999

SUBJECT: HED's Review of "*Determination of Exposure and Dose of General Pest Control Operators to Chlorpyrifos During the Routine Applications of Dursban Pro Insecticide to Cracks/Crevices and Spots.*" MRID 44444801. DP Barcode: D241777 and D241838. Case No. 818975. PC Code: 059101.

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TO: Mark Hartman  
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Attached is a review of a study (44444801) that was conducted by Versar, Inc., under the supervision of HED. It has undergone secondary review and has been revised to reflect Agency policies. HED has recalculated the chlorpyrifos dermal exposure estimates using a dermal absorption factor of 3% based on the recommendation of the Hazard Identification Assessment Review Committee (HIARC) in the March 4, 1999 report. In addition, all exposure estimates were normalized to a 70 kg body weight in accordance with HED policy for passive dosimetry measurements.

**Conclusions**

This study characterizes exposures to professional pest control operators (PCO) during application of 0.29% Dursban Pro® (EPA Reg No. 62719-166) on cracks, crevices, and spot treatment of residential and commercial buildings. A total of ten professional male PCOs from

three state-wide and local pest control companies were evaluated. Five of the ten volunteers performed a second replicate for a total of fifteen replicates.

Dermal exposure was quantified using passive dosimetry (long cotton underwear, cotton coveralls with long sleeves and long pant legs, and cotton socks; hand washes; and head patches. Inhalation exposure was measured using a personal air pump attached to the test subject's belt. The pump was connected with a cassette containing a polyvinyl chloride filter and a cellulose support pad (37-mm diameter, 0.8- $\mu$ m pore size) followed by a Chromosorb 102 vapor collection tube to evaluate inhalation exposures in the breathing zone of workers.

The amount of active ingredient (ai) handled per replicate ranged from 0.09 g to 31.04 g (mean = 9.20 g; S.D. = 9.77 g). The volume applied per replicate ranged from 0.02 gallons to 2.8 gallons (mean = 0.84 gal.; S.D. = 0.84 gal.). The sampling time per replicate ranged from 248 to 591 minutes (mean = 378 minutes). Of the sampling time, 2.3 percent (12 minutes) to 43 percent (154 minutes) was used for actual spraying activities (mean = 21 percent, or 76 minutes). The equipment used for spraying the product was a 2-gallon, hand-pressurized B & G sprayer

As shown on Table 4, the data were used to estimate dermal and inhalation unit exposures ( $\mu$ g/lb ai) based on the worker-specific amount handled (lb ai) per day, and the worker-specific total dermal or inhalation exposure based on the dosimetry measurements. The mean dermal and inhalation unit exposures were then used to calculate the total dermal and inhalation doses for three scenarios (average, minimum and maximum) based on the range of chlorpyrifos (lb ai) handled by the PCOs during the 15 replicates. As shown on Tables 3 and 5, the amount (lb ai) handled per worker varied significantly and ranged from 0.0002 to 0.0684 lb ai, with a mean of 0.02 lb ai.

A summary of the exposure estimates that should be used in the risk assessment are presented in Table 5. Because the dermal and inhalation unit exposure data sets are lognormally distributed, the current HED policy is to use the geometric mean for assessing exposures. Therefore, as shown on Table 5, the total dermal exposure ranges from 0.005 to 1.75  $\mu$ g/kg/day, with a mean of 0.51  $\mu$ g/kg/day (based on the geometric mean dermal unit exposure). The exposure estimates resulting from inhalation range from 0.0015 to 0.52  $\mu$ g/kg/day, with a mean of 0.15  $\mu$ g/kg/day (based on the geometric mean inhalation unit exposure). Exposure estimates based on the arithmetic mean are approximately three times higher. This study demonstrates that on average 71% of the total exposure to PCOs during crack and crevice treatment results from dermal exposure, while inhalation exposure contributes on average approximately 29% of the total dose.

The exposure data partially meet the criteria specified in Subdivision U (currently referred to as Series 875 Group A). There is a large variation in the results, due primarily the large range of chlorpyrifos ai handled (0.09 to 31.04 g), volume applied per replicate (0.02 to 2.8 gallons), sampling time (248 to 591 minutes or 4 to 9.85 hours), spray time (12 to 154 min) and percent chlorpyrifos handled (0.05 to 0.53%). In fact, only two of the fifteen replicates reflect the maximum recommended label concentration of 0.5% chlorpyrifos; an average of 0.29% chlorpyrifos was handled by the fifteen PCOs. In addition, it is possible that different

tasks/activities associated with pesticide application in residential and commercial locations contributed to the range of exposures. However, the impact of applicator activities can not be determined due to an absence of study details. Despite the limitations, the data collected in this study are of sufficient scientific quality to be used in the Reregistration Eligibility Decision (RED) document.

An Exposure and Dose Study - Determination of Exposure and Dose of General Pest Control Operators to Chlorpyrifos during Routine Applications of Dursban Pro<sup>®</sup> Insecticide to Cracks/Crevices and Spots (MRID # 444448-01) was submitted in support of the registration requirements for the insecticide Dursban Pro<sup>®</sup> Insecticide. The requirements for this study were specified by the U.S. Environmental Protection Agency under OPPTS 875 Guidelines of Occupational and Residential Exposure Test Guidelines (U.S. EPA, 1995).

The following information could be used to identify the Study:

Title:	Determination of Exposure and Dose of General Pest Control Operators to Chlorpyrifos during Routine Applications of Dursban Pro <sup>®</sup> Insecticide to Cracks/Crevices and Spots
Sponsor:	K.D. Racke DowElanco 9002 Purdue Road Indianapolis, Indiana 46268-1189
Performing Laboratory:	Midland Industrial Hygiene Service Center The Dow Chemical Company Midland, Michigan 48674
Authors:	J.R. Vaccaro P.G. Murphy T.A. Marino K.K. Beard E.L. Stolz D.E. Stolz S.W. Maxey D.W. Huff
Report Dates:	November 25, 1997
Identifying Codes:	MRID # 444448-01

## EXECUTIVE SUMMARY

Dursban Pro<sup>®</sup> is a chlorpyrifos-based pesticide used to control indoor insects. The purpose of this study was to estimate the exposure and dose of chlorpyrifos to professional pest control operators during application of Dursban Pro<sup>®</sup> on cracks, crevices, and spot treatment of residential and commercial buildings.

Chlorpyrifos (o,o-diethyl-o-(3,5,6-trichloro-2-pyridinyl) is the active ingredient in all Dursban insecticide formulations. A pre-assayed (22.4 percent) lot of DURSBAN PRO<sup>®</sup> Specialty Insecticide (Lot # JL19169331) was utilized in this study. Eighty mL of a liquid concentrate (22 percent active) in a bottle was mixed with 1 gallon of water to yield a mixture of approximately 0.5 percent chlorpyrifos in strength. This 0.5 percent diluted mixture was applied in cracks, crevices, in cupboards, and in kitchens and bathrooms of both residential and commercial buildings.

Fifteen replicates were included in this study. The replicates consisted of ten professional male pest control operators (PCO) who were drawn from a pool of volunteers from three state-wide and local pest control companies. Five of the ten volunteers performed a second replicate bringing the total replicates to fifteen.

Dermal exposure was quantified using: (1) long cotton underwear, cotton coveralls with long sleeves and long pant legs, and cotton socks; (2) hand washes in 250 mL of a dilute anionic surfactant (dioctyl sodium sulfosuccinate); and (3) head patches (denim; 4" X 4"). Inhalation exposure was measured using a personal air pump attached to the test subject's belt. The pump was connected with a cassette containing a polyvinyl chloride filter and a cellulose support pad (37-mm diameter, 0.8- $\mu$ m pore size) followed by a Chromosorb 102 vapor collection tube to evaluate inhalation exposures in the breathing zone of workers.

The amount of active ingredient (ai) handled per replicate ranged from 0.09 g to 31.04 g (mean = 9.20 g; S.D. = 9.77 g). The volume applied per replicate ranged from 0.02 gallons to 2.8 gallons (mean = 0.84 gal.; S.D. = 0.84 gal.). The sampling time per replicate ranged from 248 to 591 minutes (mean = 378 minutes). Of the sampling time, 2.3 percent (12 minutes) to 43 percent (154 minutes) was used for actual spraying activities (mean = 21 percent, or 76 minutes). The equipment used for spraying the product was a 2-gallon, hand-pressurized B & G sprayer.

Method validation, field recovery, laboratory recovery, and storage stability studies were conducted and reported as averages above 80 percent.

The amount of chlorpyrifos found in hand washes ranged from 3.2  $\mu$ g to 1722  $\mu$ g (mean = 405.4  $\mu$ g; S.D. = 492.7  $\mu$ g). The amount of chlorpyrifos found in the socks and head patches averaged 8.2  $\mu$ g (S.D.= 12 percent) and 14.9  $\mu$ g (S.D. = 10.7  $\mu$ g), respectively. The amount of chlorpyrifos found in the arm, leg and trunk segments of the underwear averaged 45.5  $\mu$ g (S.D.= 50.0  $\mu$ g), 61.5  $\mu$ g (S.D. = 105.9  $\mu$ g), and 54.7  $\mu$ g (S.D. = 40.8  $\mu$ g), respectively. The amount of chlorpyrifos found in the arm, leg and trunk segments of the coveralls averaged 602  $\mu$ g (S.D.= 590  $\mu$ g), 4019  $\mu$ g (S.D. = 8228  $\mu$ g), and 1191  $\mu$ g (S.D. = 778  $\mu$ g), respectively. Penetration

through the coveralls onto the underwear was calculated and varied from an average of 2.51 percent on the leg portion, to 10.6 percent on the arm portion. The average TWA for inhalation exposure ranged from  $0.12 \mu\text{g}/\text{m}^3$  to  $6.92 \mu\text{g}/\text{m}^3$  (mean =  $1.9 \mu\text{g}/\text{m}^3$ , S.D. =  $1.85 \mu\text{g}/\text{m}^3$ ).

Total amount of absorbed chlorpyrifos found in all the dosimeters averaged  $29 \pm 20 \mu\text{g}$  with the exclusion of overall portion. Total absorbed dose ranged from  $0.06 \mu\text{g}/\text{kg}$  to  $1.09 \mu\text{g}/\text{kg}$  (mean =  $0.41 \pm 0.29 \mu\text{g}/\text{kg}$ ). As shown on Table 4, the data were used to estimate dermal and inhalation unit exposures ( $\mu\text{g}/\text{lb ai}$ ) based on the worker-specific amount handled (lb ai) per day, and the worker-specific total dermal or inhalation exposure based on the dosimetry measurements. The mean dermal and inhalation unit exposures were then used to calculate the total dermal and inhalation doses for three scenarios (average, minimum and maximum) based on the range of chlorpyrifos (lb ai) handled by the PCOs during the 15 replicates. As shown on Tables 3 and 5, the amount (lb ai) handled per worker varied significantly and ranged from 0.0002 to 0.0684 lb ai, with a mean of 0.02 lb ai.

A summary of the exposure estimates that should be used in the risk assessment are presented in Table 5. As shown on Table 5, the total dermal exposure ranges from 0.014 to  $4.67 \mu\text{g}/\text{kg}/\text{day}$ , with a mean of  $1.37 \mu\text{g}/\text{kg}/\text{day}$ . The exposure estimates resulting from inhalation range from 0.004 to  $1.4 \mu\text{g}/\text{kg}/\text{day}$ , with a mean of  $0.41 \mu\text{g}/\text{kg}/\text{day}$ . This study demonstrates that on average 71% of the total exposure to PCOs during crack and crevice treatment results from dermal exposure, while inhalation exposure contributes on average approximately 29% of the total dose.

In summary, this study only partially met the requirements contained in OPPTS 875 guidelines of the Occupational and Residential Exposure Test Guidelines (U.S. EPA, 1995). Variability of the results need to be further examined, and caution should be taken when interpreting the study results or generalizing the results. A better definition and analysis of the tasks performed is needed.

## Study Background

Dursban Pro<sup>®</sup> is a chlorpyrifos-based pesticide used to control indoor insects. The purpose of this study was to estimate the exposure and dose of chlorpyrifos to professional pest control operators during application of Dursban Pro<sup>®</sup> on cracks, crevices, and spot treatment of residential and commercial buildings.

A few studies have been reported that monitored air concentrations of chlorpyrifos during typical applications. Hayes et al. (1980) monitored applicators during routine crack and crevice / broadcast treatments in a full 8-hour shift and reported a mean time-weighted average (TWA) concentration of airborne chlorpyrifos as  $7.45 \mu\text{g}/\text{m}^3$  with all the concentrations less than  $27.6 \mu\text{g}/\text{m}^3$ . In a Dow Chemical internal report (1975), Vaccaro monitored two pest control operators during their applications of various types of residential and commercial buildings, and reported a 4-hour TWA of  $5 \mu\text{g}/\text{m}^3$  and a 5-hour TWA of  $7 \mu\text{g}/\text{m}^3$ , respectively. The current Threshold Limit Value (TLV) for chlorpyrifos is  $200 \mu\text{g}/\text{m}^3$ .

## Test Site

Both residential and commercial buildings were included in this study.

## **Materials, and Application**

Chlorpyrifos (o,o-diethyl-o-(3,5,6-trichloro-2-pyridinyl) is the active ingredient in all Dursban insecticide formulations. It is a high molecular weight (350.5) organophosphate, and is a white solid at room temperature with a melting point of approximately 41°C. The vapor pressure of chlorpyrifos is  $1.87 \times 10^{-5}$  mm of Hg at 20°C. Chlorpyrifos is a cholinesterase inhibitor with a pharmacokinetic half-life in humans of approximately 24 hours. It has an acute oral LD50 (rats) of 96-270 mg/kg and an acute dermal LD50 (rabbits) of 1580-1801 mg/kg (McCollister; 1990). Chlorpyrifos has been found to be non-teratogenic in laboratory animals and non-carcinogenic in two separate lifetime studies in rats. A pre-assayed (22.4 percent) lot of DURSBAN PRO<sup>®</sup> Specialty Insecticide (Lot # JL19169331) was utilized in this study.

Fifteen replicates were included in this study. The replicates consisted of ten professional male pest control operators (PCO) who were drawn from a pool of volunteers from three state-wide and local pest control companies. Five of the ten volunteers performed a second replicate bringing the total replicates to fifteen.

## **Sampling**

Dermal exposure was quantified using: (1) long cotton underwear, cotton coveralls with long sleeves and long pant legs, and cotton socks; (2) hand washes in 250 mL of a dilute anionic surfactant (dioctyl sodium sulfosuccinate); and (3) head patches (denim; 4" X 4") . The coverall was directly worn over the underwear; i.e., no shirts or pants. The underwear simulated human skin. The amount of chlorpyrifos found on the underwear was treated as if deposited on the skin and was subject to a 3 percent absorption rate into the body. At the lunch break, end of the day, and periodically throughout the day, each replicate's hands were doused with 250 mL of dilute dioctyl sodium sulfosuccinate, followed by 250 mL of deionized water. The aqueous extracts were combined in the same bowl. The bowl was further rinsed with 200 mL of ethyl acetate and combined with the aqueous extracts, along with 15 grams of sodium chloride to enhance phase separation. Socks were worn under a pair of work shoes, and the denim head patch was worn on the front of a baseball type cap.

Inhalation exposure was measured using a personal air pump attached to the test subject's belt. The pump was connected with a cassette containing a polyvinyl chloride filter and a cellulose support pad (37-mm diameter, 0.8- $\mu$ m pore size; Gelman Sciences, Ann Arbor, MI.) followed by a Chromosorb 102 vapor collection tube (66-mg front section, 33-mg back section; SKC Inc., Eight Four, PA.). The filter and the tube were used to trap aerosol and vapor, respectively. The closed-cassette was attached to the test subject's collar or other positions in the breathing zone. The air flow rate was approximately 1 liter per minute, and was measured prior and after sampling and in some cases mid-way through the sampling period.

## **Treatment Information**

Eighty mL of a liquid concentrate (22 percent active) in a bottle was mixed with 1 gallon of water to yield a mixture of approximately 0.5 percent chlorpyrifos in strength. This 0.5 percent diluted mixture was applied in cracks, crevices, in cupboards, and in kitchens and bathrooms of both residential and commercial buildings. Treatments with additional insecticide aerosol products containing pyrethrum, safrotin, and chlorpyrifos were also conducted (see "Comments" below). Treatment information and handling data is summarized in Table 15 of this report's Appendix. The amount of ai handled per replicate ranged from 0.09 g to 31.04 g (mean = 9.20 g; S.D. = 9.77 g). The volume applied per replicate ranged from 0.02 gallons to 2.8 gallons (mean = 0.84 gal.; S.D. = 0.84 gal.). The sampling time per replicate ranged from 248 to 591 minutes (mean = 378 minutes). Of the sampling time, 2.3 percent (12 minutes) to 43 percent (154 minutes) was used for actual spraying activities (mean = 21 percent, or 76 minutes). The equipment used for spraying the product was a 2-gallon, hand-pressurized B & G sprayer.

In addition, tank mix samples were taken for each tank mix for verification, and gave an assay range of 0.05 percent to 0.53 percent (mean = 0.29 percent).

### **Sample Storage and Handling**

After sampling, the cotton coveralls and underwear were segmented into three, designated as sleeves, trunk, and legs, respectively. Along with socks and head patches, these samples were placed into jars or vials (head patches) and stored below ambient temperature prior to analysis. The hand wash extracts were stored frozen until analysis. The sampling tubes and cassettes for air monitoring were stored and shipped below ambient temperature, and kept frozen in the laboratory prior to analysis.

### **Laboratory Analysis**

The dermal samples (coveralls, underwear, and socks) were each extracted with acetonitrile while being hand-shaken for about 10 seconds every half hour for 3 hours, based on a procedure modified from the validated methodology (see "QA/QC, Method Validation"). The validated methodology (used for patches) was modified for use of denim coverall portions, long underwear portions, and pairs of socks (i.e., full scale). The extraction volumes used for coverall arm, leg, and torso sections were 700, 1,300, and 3,000 mL, respectively. The extraction volumes used for underwear arm, leg, and torso sections were 500, 900, and 1,400 mL, respectively.

The front and back sections of the Chromosorb 102<sup>®</sup> tubes were desorbed separately in 4-dram vials with 5 mL of acetonitrile, and the GLA-5000 filter and support pad were desorbed with 5 mL of acetonitrile while being mechanically-shaken for about an hour.

All the dermal samples, hand washes, and inhalation samples were analyzed by gas chromatography (GC) using an electron capture detector (ECD).

### **QA/QC**

#### Method Validation



The method validation for the use of denim coveralls, long underwear, and sock for dermal exposure assessment with the use of DURSBAN PRO<sup>®</sup> was conducted. The validation included spiking of patches from each of the clothing matrices with DURSBAN PRO<sup>®</sup> over a chlorpyrifos concentration range of 0.068 to 14  $\mu\text{g}/\text{cm}^2$ . The patches were each extracted with 30 mL of acetonitrile in 12-dram vials while being shaken for an hour. Recoveries were determined by using GC/ECD (see Appendix for specification). The use of hand washes for hand exposure assessment of DURSBAN PRO<sup>®</sup> was also validated over a chlorpyrifos concentration range of 0.026 to 85  $\mu\text{g}/\text{mL}$ . After adding 15 gram of sodium chloride, the hand wash samples (500 mL) were extracted with 200 mL of ethyl acetate in the field. The aliquots were then analyzed by GC/ECD. A method validation for the extraction and analysis of airborne chlorpyrifos samples as described in the "Laboratory Analysis" section of this document was previously reported by Myers et al. (1995) and is referenced. The recovery results were used for correction of data.

### Field Recovery

Field spikes were prepared in the field close to the application sites. Samples of socks, head patches, coveralls, underwear, air sampling tubes, cassette filters, and hand washes were fortified at "high" and "low" levels. In addition, blanks were prepared for each set of spikes. All the field recovery samples were exposed to the same environmental conditions as the actual samples. The recovery results were used for correction of data.

### Laboratory Recovery

Laboratory recovery samples were included with each of field sample sets. However, the results were not used for correction of data.

### Storage Stability

Storage stability data were collected and reported only for dermal dosimeter samples, however were not used for correction of data. Stability for hand washes was reported in other studies with good recoveries (Protocol Study, 1997; Hugo et al., 1993; Murphy et al., 1992).

### **Clothing/Protective Clothing**

Each volunteer was dressed in long cotton underwear, a cotton overall with long sleeves and long pant legs, cotton socks, chemically-resistant shoes and protective gloves during the mixing process. Eye protection was used by the PCOs when chlorpyrifos was sprayed overhead.

### **Data Summary**

#### Method Validation

Recoveries for hand washes, over a chlorpyrifos concentration range of 0.026 to 85  $\mu\text{g}/\text{mL}$ , ranged from 72.2 percent to 112 percent (mean = 99 percent; S.D. = 11 percent) as presented in Table 1 of the original report. The total relative precision of the method at the 95 percent

confidence level was 26 percent. Recoveries for the use of denim, long underwear, and sock patches, over a chlorpyrifos concentration range of 0.068 to 14  $\mu\text{g}/\text{cm}^2$ , averaged  $96.8 \pm 7.1$  percent,  $107 \pm 6.7$  percent, and  $111 \pm 14$  percent, respectively, as presented in Table 2 to Table 4 of the original report. The total relative precision of the method at the 95 percent confidence level for denim, long underwear, and sock patches was 17, 15, and 28 percent, respectively. As reported, the extraction and analysis method for patches was shown to be applicable to denim coverall portions, long underwear portions, and pairs of socks (i.e., full scale) when the surface area of material to extraction solvent volume ratio is held constant. The average recoveries for denim coverall portions, long underwear portions, and pairs of socks were  $89 \pm 16$  percent,  $94 \pm 15$  percent, and  $87 \pm 6.8$  percent, respectively. The method for the extraction and analysis of airborne chlorpyrifos samples, as reported by Myer et al. (1995), was validated over a chlorpyrifos concentration range of about  $\sim 0.1$  to 25  $\mu\text{g}$  ( $0.1 - 26 \mu\text{g}/\text{m}^3$ , assuming a 960-L air) with recoveries for tubes averaging  $95.7 \pm 7.5$  percent and filter recoveries averaging  $99.0 \pm 9.1$  percent. The total relative precision at 95 percent confidence was 16.8 percent. In conclusion, all the methods are applicable to the extraction and analysis of chlorpyrifos.

### Field Recovery

Field recovery data for filters and tubes averaged 128 percent with a S.D. of 28 percent with exclusion of an outlier (cs-tb-25), as presented in Table 6 of the original report. Any recovery below 100 percent was used to correct the data. Recoveries for hand washes ranged from 79 to 137 percent (mean = 111 percent; S.D. = 17 percent), as presented in Table 7 of the original report. Recoveries for the socks and head patches averaged 105 percent (S.D.= 20 percent) and 107 percent (S.D. = 15 percent), respectively, with exclusion of two outliers, for socks as presented in Table 8 of the original report. Recoveries for the arm, leg and torso segments of the coveralls averaged 92.4 percent (S.D.= 10 percent), 93.7 percent (S.D. = 17 percent), and 102.6 percent (S.D. = 9 percent), respectively, as presented in Table 9 to Table 11 of the original report. Recoveries for the underwear arm, leg, and trunk segments averaged 106 percent (S.D.= 13 percent), 94.2 percent (S.D. = 14 percent), and 95.3 percent (S.D. = 6 percent; with exclusion of two outliers), respectively, as presented in Table 12 to Table 14 of the original report. In conclusion, field recoveries were satisfactory, however, several unusual high values were noted (see "Comments" below).

### Laboratory Recovery

Laboratory recoveries for filters, tubes, denim coveralls, long underwear, socks, and hand washes averaged  $95 \pm 8.5$  percent,  $89 \pm 8.1$  percent,  $83 \pm 16$  percent,  $91 \pm 9.4$  percent,  $89 \pm 8.1$  percent, and  $110 \pm 13$  percent, respectively.

### Storage Stability

Storage stability results for dermal dosimeter samples (denim, long underwear, and socks) indicated that the samples could be stored for at least two months at freezer temperature, as presented in Table 5 of the original report.

## Exposure

Table 1 (and Table 18 in the original report) summarizes chlorpyrifos deposition on various dosimeters. The amount of chlorpyrifos found in hand washes ranged from 3.2  $\mu\text{g}$  to 1722  $\mu\text{g}$  (mean = 405.4  $\mu\text{g}$ ; S.D. = 492.7  $\mu\text{g}$ ). The amount of chlorpyrifos found in the head patches and socks averaged 8.2  $\mu\text{g}$  (S.D. = 12 percent) and 14.9  $\mu\text{g}$  (S.D. = 10.7  $\mu\text{g}$ ), respectively. The amount of chlorpyrifos found in the arm, leg and trunk segments of the underwear averaged 45.5  $\mu\text{g}$  (S.D. = 50.0  $\mu\text{g}$ ), 61.5  $\mu\text{g}$  (S.D. = 105.9  $\mu\text{g}$ ), and 54.7  $\mu\text{g}$  (S.D. = 40.8  $\mu\text{g}$ ), respectively. The amount of chlorpyrifos found in the arm, leg and trunk segments of the coveralls averaged 602  $\mu\text{g}$  (S.D. = 590  $\mu\text{g}$ ), 4019  $\mu\text{g}$  (S.D. = 8228  $\mu\text{g}$ ), and 1191  $\mu\text{g}$  (S.D. = 778  $\mu\text{g}$ ), respectively. Penetration through the coveralls onto the underwear was calculated and varied from an average of 2.51 percent on the leg portion, to 10.6 percent on the arm portion (see "Comments" below).

The average TWA for inhalation exposure ranged from 0.12  $\mu\text{g}/\text{m}^3$  to 6.92  $\mu\text{g}/\text{m}^3$  (mean = 1.9  $\mu\text{g}/\text{m}^3$ , S.D. = 1.85  $\mu\text{g}/\text{m}^3$ ).

## Dose

As per the EPA guideline OPPT 875.1000, the estimated surface area of the head region is 1,300  $\text{cm}^2$ , and is used for estimating the total deposition of chlorpyrifos on the head region from the head patch results. A 3 percent absorption rate was used for calculating absorbed amount of chlorpyrifos through the intact skin based on the recommendation of the HIARC (March 4, 1999, Doc. No. 013249, Zendzian et al., 1995). As for inhalation dose estimates, DowElanco used a breathing rate of 20 liters per minute (L/min), and 7.5 L/min were used for spraying activities (light activity) and non-spraying activities (resting), respectively (Snyder et al., 1974). These inhalation rates are consistent with those recommended in the USEPA Exposure Factors Handbook (1997) (i.e., rest = 6.66 L/min, sedentary activity = 8.33 L/min and light activity = 16.6 L/min). Total amount of absorbed chlorpyrifos found in all the dosimeters averaged  $29 \pm 0.20$   $\mu\text{g}$  with the exclusion of coverall portion, as presented in Table 4. Total absorbed dose was further estimated by dividing the absorbed amount of chlorpyrifos by the default 70 kg body weight, in accordance with HED policy of using dosimetry data. Total absorbed dose ranged from 0.06  $\mu\text{g}/\text{kg}$  to 1.09  $\mu\text{g}/\text{kg}$  (mean =  $0.41 \pm 0.29$   $\mu\text{g}/\text{kg}$ ). Dermal exposure contributes an average of 71 percent, and inhalation exposure contributes an average of 29 percent.

As shown on Table 4, the data were used to estimate dermal and inhalation unit exposures ( $\mu\text{g}/\text{lb ai}$ ) based on the worker-specific amount handled (lb ai) per day, and the worker-specific total dermal or inhalation exposure based on the dosimetry measurements. The mean dermal and inhalation unit exposures were then used to calculate the total dermal and inhalation doses for three scenarios (average, minimum and maximum) based on the range of chlorpyrifos (lb ai) handled by the PCOs during the 15 replicates. As shown on Tables 3 and 5, the amount (lb ai) handled per worker varied significantly and ranged from 0.0002 to 0.0684 lb ai, with a mean of 0.02 lb ai.

A summary of the exposure estimates that should be used in the risk assessment are presented in Table 5. As shown on Table 5, the total dermal exposure ranges from 0.014 to 4.67  $\mu\text{g}/\text{kg}/\text{day}$ ,

with a mean of 1.37  $\mu\text{g}/\text{kg}/\text{day}$ . The exposure estimates resulting from inhalation range from 0.004 to 1.4  $\mu\text{g}/\text{kg}/\text{day}$ , with a mean of 0.41  $\mu\text{g}/\text{kg}/\text{day}$ .

### Data Analysis

Coefficient of variability (CV) for the amount of chlorpyrifos found on various dosimeters was calculated by Versar to examine the variability of the data. CV ranged from 65 to 205, and indicated a considerable variability among test results, as presented in Table 1. Such variability could be partially explained by a wide range of spraying times among test subjects (and also wide range of ai applied as shown in Table 3). However, other potential components could contribute to variability including individual test subjects' work practices, points treated (e.g., baseboard vs. utility sinks), extraction, and laboratory analysis, etc. As evidenced when examining the results in Table 3, the total dermal absorption unit exposure and total inhalation unit exposure ( $\mu\text{g}$  per pound of active ingredient handled ) covered a very wide range (ranging from 57 to 22000  $\mu\text{g}/\text{lb ai}$ ; mean = 4782  $\mu\text{g}/\text{lb ai}$  for dermal and 53 to 7833  $\mu\text{g}/\text{lb ai}$ ; mean = 1432  $\mu\text{g}/\text{lb ai}$  for inhalation. It is not possible to estimate each of the contributing factors individually based on the existing study design and results. In addition, it is not appropriate to generalize the results; and caution should be taken when interpreting the results. It will provide better estimates if study was designed based on a same "task" or "activity" with a same application time. Uniformity in tasks performed and application time would help to examine variability contributed by other components.

### **Review Summary**

Compliance with OPPTS 875 guidelines of the Occupational and Residential Exposure Guidelines (U.S. EPA, 1995) is critical for determining whether a study is acceptable to the Agency. The itemized list below is based on the "Checklist for Applicator Monitoring Data" and summarizes the major points of OPPTS 875 guidelines:

- *Typical end use product of the active ingredient tested.* This criterion was met as a commercial product was used in the study.
- *End use product handled and applied using recommended equipment, application rates, and typical work practices.* The PCOs wore the clothing recommended by the label, and used a B and G sprayer, which is the typical equipment used for crack and crevice applications. The amount of product applied was consistent with the label which recommends an application of 0.25-0.5% Dursban Pro. However, only two of the fifteen replicates reflect the maximum recommended label concentration of 0.5%; an average of 0.29% chlorpyrifos was handled by the fifteen PCOs. In addition, the label does not specify a maximum quantity to be applied per application; in this study the quantity applied ranged from 0.09 to 31 g ai/application. Based on the general description provided, it appears that typical work practices and work duration (4 to 9.5 hours) were employed during this study, although specific details on the worker tasks/activities were not provided.
- *For outdoor exposure monitoring at least five replicates at each of at least three*

*sites for each job function with the exception of pilots should be monitored. Pilots should have at least three replications at each of at least three sites. This criterion is not applicable to this study.*

- *For indoor exposure monitoring at least five replicates at each of at least three sites for each job function must be monitored. This criterion was partially met. There were fifteen replicates included in this study, and it appears that each application was at a different location, although the actual number of test sites was not specified. Based on the field recovery data reported, there are at least three sites (Roseville, Lansing, and Kalamazoo).*
- *Monitoring period is sufficient to collect measurable residues, but not excessive so that residue loss occurs. The criterion was met. The sampling time averaged 378 minutes, and the spray time averaged 76 minutes (S.D. = 46 minutes).*
- *Dermal and/or inhalation exposure must be monitored by validated methodologies. Biological monitoring is consistent with and supported by pharmacokinetic data accepted by the Agency. This criterion was met as the method validation study was conducted with an acceptable precision and accuracy (refer to "Data Summary" above). There was no biological monitoring conducted in this study.*
- *Quantity of active ingredient handled and duration of monitoring period reported for each replicate. This criterion was met (refer to "Treatment Information" above).*
- *Clothing worn by each study participant and location of dosimeters reported. This criterion was met (refer to "Clothing/Protective Clothing" and "Sampling" above). Workers wore the clothing specified on the labels which includes coveralls, long sleeved shirts, gloves, chemically-resistant footwear, and eye protection when spraying overhead.*
- *Quantitative level of detection is at least 1  $\mu\text{g}/\text{cm}^2$ . As reported, the estimated limit of quantification (LOQ) was 0.02  $\mu\text{g}/\text{sample}$  for filters and tubes; 0.2  $\mu\text{g}/\text{sample}$  for hand washes; 2  $\mu\text{g}/\text{sample}$  for socks; 0.09  $\mu\text{g}/\text{sample}$  for hat patches; 3  $\mu\text{g}/\text{sample}$  for arm portion samples; 5  $\mu\text{g}/\text{sample}$  for leg portion samples; and 8  $\mu\text{g}/\text{sample}$  for trunk portion samples (10  $\mu\text{g}/\text{sample}$  for coverall trunks).*
- *Storage of samples consistent with storage stability data. It appears that this criterion was met, although sufficient details were not provided in the study report. The storage stability results indicated a maximum of two months for storage, however the length of time between sampling and laboratory analysis was not reported. It appears that the results were analyzed within two months based on the dates of the chromatographs ( December 1996 and January 1997), and the*

time the study was initiated (late November and early December).

- *Efficiency of extraction in laboratory provided as mean plus minus one standard deviation. Lower 95% confidence limit is not less than 70% based on a minimum of seven replications per fortification level or prior Agency approval of extraction methodology provided.* The criterion was met (refer to "QA/QC" above).
- *At least one field fortification sample per worker per monitoring period per fortification level for each matrix. At least one field blank per worker per monitoring period for each matrix.* The criterion was partially met. The study did not provide details with respect to the time and location of each replicate. There is insufficient information on Tables 6 to 14 of the original report to determine if these criteria are fully met.

## Comments

Additional notes and data gaps critical to the scientific validity of the study, not addressed above, are presented below. The following issues were identified:

- As noted in the original report, field recovery samples were exposed for the same length of time as the actual samples. However, with a wide range of sampling time for the actual samples (ranging from 248 to 591 minutes), it was not clear which length of time the field recovery samples were based on.
- Dates of sampling, and extraction and analysis of the samples were not reported. Although based on the chromatographical charts provided, the laboratory analysis may have been conducted in December 1996, and January 1997.
- Sampling time was greater than spray time. It was not clear that mixing activities were monitored and included in the results.
- Assay results of the tank mixes indicated a lack of uniformity (ranging from 0.05 to 0.53 percent). As stated by the authors on page 13 of the original report that "it is a common procedure ..... to shake the spray vessel". However, it was not clear whether this procedure is performed.
- Geographic information was not provided. It should be noted that size, ventilation, configuration etc. will have impact on the sampling results, in particular for air sampling.
- Pyrethrum, safrotin, and chlorpyrifos (PT-270) was also applied. Their impact on the results, such as interference, needs to be examined.
- Laboratory analysis procedure was not described for head patches. The same procedure for other dermal samples is therefore, assumed.

- As noted in the original report, the same pair of chemically-resistant work shoes were worn during the conduct of the second replicates. Therefore, it was likely that contamination was carried over from the first set of replicates to the second set.
- It was not clear whether blank samples were collected for method validation, laboratory recovery, and storage stability studies.
- It was not clear whether eye protection was worn during the mixing process. It should be noted that handling of the 23.5 percent concentrate is possible during mixing process.
- Discrepancy for penetration from coveralls onto underwear (simulating intact skin) was noted (see Table 2 of this report).
- Based on EPA guideline OPPTS 875.1400, inhalation rate for male with light activities is 29 liters/min. The use of 20 liters/min in this study will underestimate estimates for inhalation exposures. However, the inhalation rates used in this study are more conservative than those recommended in the more recent USEPA Exposure Factors Handbook (1997) (p 5-24, where an average of rest and sedentary activity is 7.5 L/min, and light activity is 16.6 L/min), and could slightly overestimate inhalation exposure.
- As noted in the original report, some unexplained high recoveries were obtained for filter/tube field spikes (42,800 percent), and sock patch field spikes (538, and 524 percent).
- Results in Table 19 indicate that six individuals performed a second replicate, which differs from the study text that states only five individuals performed a replicate.

In summary, this study only partially met the requirements contained in OPPTS 875 guidelines of the Occupational and Residential Exposure Test Guidelines (U.S. EPA, 1995). Variability of the results need to be further examined, and cautions should be taken when interpreting the study results or generalizing the results. A better definition and analysis of the tasks performed is needed.

## References

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**Table 1. Summary of Chlorpyrifos Residues on Various Dosimeters**

Dosimeter	Mean ( $\mu\text{g}$ )	Standard Deviation ( $\mu\text{g}$ )	C.V. (%)
Hat Patch <sup>a</sup>	8.2	12.0	146
Socks	14.9	10.7	72
Hand Wash	405.4	492.7	122
Coverall Arms	602	590	98
Coverall Trunk	1191	778	65
Coverall Legs	4019	8228	205
Underwear Arms	45.5	50.0	110
Underwear Trunk	54.7	40.8	75
Underwear Leg	61.5	105.9	172
Filter cs	0.8	1.0	125

<sup>a</sup> The amount on the hat patch extrapolated to the entire area of the head including the face.

**Table 2. Results of Penetration Percentage (%) from Coveralls to the Underwear Dosimeters**

	Mean	Mean (Versar)	S.D. (Versar)	C.V. (Versar)
Arm	10.6	14.07	18.76	133
Leg	2.51	2.78	2.80	100
Trunk	N/A	4.53	3.84	83.6

**Table 3  
Summary of Worker Exposure Data**

Code	Tank Mix (%)	Estimated Applied Volume (gal)	Amount ai Handled (g) (c)	Amount ai Handled (lb)	Spray Time (Min)	Sampling Time (Min)	Spray Time TWA (ug/m3) (a)	Sampling Time TWA (ug/m3)	Inhalation Dose from Spraying (ug/kg/day) (b)
A	0.41	2	31.04	0.0684	154	248	5.6	3.4	0.25
B	0.17	1	6.43	0.0142	101	424	1.8	0.4	0.05
C	0.15	1	5.68	0.0125	133	372	1.5	0.6	0.06
D	0.2	0.13	0.98	0.0022	58	535	18.4	2	0.30
E	0.2	0.06	0.45	0.0010	25	373	7.2	0.5	0.05
F	0.05	0.05	0.09	0.0002	29	441	1.7	0.1	0.01
G	0.08	0.38	1.15	0.0025	69	385	3.0	0.5	0.06
H	0.34	0.02	0.26	0.0006	12	475	46.4	1.2	0.16
I	0.29	1	10.98	0.0242	114	591	35.7	6.9	1.16
J	0.53	0.79	15.85	0.0349	24	285	32.5	2.7	0.22
K	0.22&0.18	2.8	21.2	0.0467	63	281	6.0	1.4	0.11
L	0.31	2	23.47	0.0517	98	248	4.4	1.7	0.12
M	0.29	0.47	5.16	0.0114	94	282	0.5	0.2	0.01
N	0.45	0.75	12.77	0.0282	135	430	10.3	3.2	0.40
O	0.49&0.53	0.13	2.51	0.0055	36	294	30.0	3.7	0.31
A. Mean	0.29	0.84	9.2	0.020	76	378	14	2	0.22
Std Dev.	0.15	0.81	8.0	0.02	42.0	103.2	15.5	1.9	0.3
Geomean		0.40	3.57	0.008	60.67	364.23	6.69	1.12	0.12

(a) TWA (ug/m3) = Amount found (ug) / (Spray time (min) \* Average flow (L/min)\* m3/1000L). Individual data obtained from Table 16 of the Dow Study. Calculation assumes that the average flow rate is applicable to the spray time and the total sampling time.

(b) Inhalation dose (ug/kg/day) = (spray time (min/day)\*TWA spray time (ug/m3)\* 20 L/min\* m3/1000L) / 70 kg. A ventilation rate of 20 L/min was used, which is slightly higher than the USEPA recommended value of 16.6 L/min for light activity.

(c) Value obtained from Table 20 of the Study report.

**Table 4**  
**Summary of Chlorpyrifos Dermal and Inhalation Exposure**

Code	Inhalation Exposure ug (f)	Chlorpyrifos Dermally Absorbed (ug) (a)						Total Dermally Absorbed (ug) (b)	Absorbed Dermal Dose (Unit Exposure) ug/lb ai (d,g)	Total Exposure (ug) (c)	Inhalation Exposure (Unit Exposure) ug/lb ai (d,g)	Total Dose (ug/kg) (e)	Dermal Dose %	Inhalation Dose %
		Hands	Head	Feet	Arms	Legs	Trunk							
A	15.8	0.09	0.72	0.18	1.44	0.87	0.6	3.9	57	19.7	231	0.28	19.8	80.2
B	2	51.6	0.3	0.15	0.72	0.03	1.08	53.88	3794	55.9	141	0.80	96.4	3.6
C	2.5	6.96	1.92	1.41	0.45	0.69	1.2	12.63	1010	15.1	200	0.22	83.5	16.5
D	9.5	18.6	3.6	0.9	4.26	1.44	1.95	30.75	13977	40.3	4318	0.58	76.4	23.6
E	1.5	0.57	0.27	0.24	0.39	1.05	0.75	3.27	3270	4.8	1500	0.07	68.6	31.4
F	0.4	1.65	0.06	0.33	0.45	0.39	0.66	3.54	17700	3.9	2000	0.06	89.8	10.2
G	2	2.1	0.78	0.42	0.54	0.39	0.66	4.89	1956	6.9	800	0.10	71.0	29.0
H	4.7	1.56	0.81	0.36	3.6	1.83	5.04	13.2	22000	17.9	7833	0.26	73.7	26.3
I	40.5	23.37	0.36	0.45	4.62	3.51	3.54	35.85	1481	76.4	1674	1.09	47.0	53.0
J	6.7	4.26	10.44	0.45	0.48	0.99	1.02	17.64	505	24.3	192	0.35	72.5	27.5
K	3.9	28.77	11.97	0.27	0.18	0.33	0.99	42.51	910	46.4	84	0.66	91.6	8.4
L	5.4	10.11	12.48	0.27	0.33	0.45	1.35	24.99	483	30.4	104	0.43	82.2	17.8
M	0.6	25.89	0.15	0.42	0.9	0.9	1.86	30.12	2642	30.7	53	0.44	98.0	2.0
N	15.9	6.3	1.56	0.6	1.35	12.93	2.31	25.05	888	41.0	564	0.59	61.2	38.8
O	9.8	0.54	0.93	0.3	0.78	1.62	1.65	5.82	1058	15.6	1782	0.22	37.3	62.7
A. Mean	8.08	12.16	3.09	0.45	1.37	1.83	1.64	21	4782	29	1432	0.41	71.26	28.74
std dev	10.28	14.77	4.53	0.32	1.50	3.19	1.22	16	7030	20	2115	0.29		
G.M.	4.20	4.42	1.04	0.38	0.85	0.84	1.35	14	1790	21	532	0.30		

(a) Assumes 3% dermal absorption.

(b) Sum of dermal absorbed doses from hands, head, feet, arms, legs and trunk.

(c) Sum of dermal absorbed dose and inhalation dose.

(d) Total dermal unit exposure (ug/lb ai) = total dermal exposure (ug) / worker-specific amount ai handled (lb) presented on Table 3. Total inhalation unit exposure (ug/lb ai) = inhalation exposure (ug) / worker-specific amount ai handled (lb) presented on Table 3.

(e) Total Dose (ug/kg) (based on worker-specific rates used in the study) = Total Exposure from inhalation and dermal routes (ug) / 70 kg body weight.

(f) Inhalation exposure obtained from Table 17 of the Study report.

(g) This data set is lognormally distributed based on the Shapiro Wilk test.

**Table 5  
Dermal and Inhalation Doses for the Risk Assessment**

	Mean Dermal Absorption (Unit Exposure) ug/lb ai (a)	Mean Inhalation Exposure (Unit Exposure) ug/lb ai (a)	Total Absorbed Dermal Dose (ug/kg/day) (b)			Total Inhalation Dose (ug/kg/day) (c)		
			Application Rate			Application Rate		
			Minimum	Mean	Maximum	Minimum	Mean	Maximum
Arithmetic Mean	4782	1432	0.014	1.37	4.67	0.004	0.41	1.40
Geometric Mean	1790	532	0.005	0.51	1.75	0.0015	0.15	0.52

(a) Arithmetic and Geometric Mean unit exposure calculated on Table 4.

(b) Total Absorbed Dermal Dose (ug/kg/day) = Mean Dermal Unit Exposure (UE) (ug/lb ai) \* lb ai handled/day/ 70 kg body weight.  
Where lb ai handled per day is as follows from Table 3 (minimum 0.0002 lb ai, mean 0.02 lb ai and maximum of 0.0684 lb ai).

(c) Total Inhalation Dermal Dose (ug/kg/day) = Mean Inhalation Unit Exposure (UE) (ug/lb ai) \* lb ai handled/day/ 70 kg body weight.  
Where lb ai handled per day is as follows from Table 3 (minimum 0.0002 lb ai, mean 0.02 lb ai and maximum of 0.0684 lb ai).

## **Appendix**

## GC Specifications

Gas Chromatography:	Hewlett Packard 5890
Autosampler:	Hewlett Packard 7673
Column:	J&W Scientific DB-17, 30 m X 0.25 mm, 0.5 micron film
Head Pressure:	15 psi
Carrier/Makeup Gas:	Nitrogen
Injection Parameters:	duplicate, 1-uL split injection at 280°C, ~60 mL/min split
Detector Temperature:	300 °C
Oven Temperature:	260 °C, run time of 7 minutes

# *Non-Dietary Exposure Review*

**Subject:** HED's Review of "Determination of Exposure and Dose of General Pest Control Operators to Chlorpyrifos During the Routine Applications of Dursban Pro Insecticide to Cracks/Crevices and Spots." MRID 44444801. DP Barcode: D241777 and D241838. Case No. 818975. PC Code: 059101

**Guidelines:**

**Other:** Exposure Review Study

**DP Barcode:** D241838, D241777

**MRIDs:** 44444801

**Chemical Codes:** 059101 Chlorpyrifos (ANSI)

**Formulation Type:**

**Exposed Individual:**

**Application Method:**

**Outdoor Use Sites:**

**Indoor Use Sites:**

**Greenhouse Use Sites:**

**Other Use Sites:**

**Airborne Techniques:**

**Dermal Techniques:**

**Hand Techniques:**

**Foliar Techniques:**

**Indoor Surf.**

**Techniques:**

**Reviewers:** Deborah Smegal

**Review Approvers:** Steve Knizner Approved on: April 19, 1999



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