ESTIMATION OF EXPOSURE OF PERSONS IN CALIFORNIA TO PESTICIDE PRODUCTS THAT CONTAIN AZINPHOS-METHYL

By

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ABSTRACT

Azinphos-methyl (AZM) is an organophosphate insecticide. AZM is a highly toxic pesticide that can cause cholinesterase depression. It is used on many crops, primarily on fruit and nut trees. There were 156 illnesses/injuries associated with AZM exposure in California between 1987 and 1996. These cases were mostly systemic in nature. The human dermal absorption rate for AZM is between 16 and 21.5%. AZM is metabolized and eliminated relatively rapidly, mostly in urine of human and animals. Handlers' absorbed daily dosage (ADD) was estimated to be between 0.5 and 49 µg/kg/day, depending on their work activities. Field workers' exposure varied greatly also, depending on the amount of the dislodgeable foliar residues present at the time of field activity. Field workers' ADD was estimated to range from 2 to 80 µg/kg/day. The estimates of body burden after repeated exposure were between 1 and 99 µg/kg/day for handlers and between 3 and 96 µg/kg/day for field workers.

This human exposure assessment was prepared for incorporation into the risk characterization document for AZM because of possible cholinergic signs noted in laboratory rats.

Department of Pesticide Regulation
Worker Health and Safety Branch

Human Exposure Assessment

AZINPHOS-METHYL

November 30, 1992
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INTRODUCTION

This exposure assessment was revised, mainly to address the estimates of repeated exposure to workers. Urinary excretion half-life of 24 hours after dermal administration of AZM in humans (Thongsinthusak, 1999) suggests that human body burden may increase after repeated exposure. Based on the urinary excretion half-life of 24 hours, the body burden after several days of repeated exposure could reach up to 200% of a single day's exposure. At this level, the body burden reaches its steady state even if the exposure continues. Carrier and Brunet (1999) developed a model, also suggesting that the body burden after several days of repeated exposure could reach up to 200% of a single day's of exposure. Therefore, the 2001 revision of this exposure assessment document was warranted to include the estimate of workers' (handlers and field workers) body burden after several days of repeated exposure to AZM.

Since the worker personal protective equipment (PPE) and restricted entry interval (REI) requirements on the product label are currently substantially more restrictive than they were in 1993, the "Label Precaution" section was revised to reflect the current PPE and REI requirements. Other sections such as EPA Status, Usage, Illness, Dermal Absorption, and Dislodgeable Foliar Residue were also revised to include the updated information. In addition, worker exposure scenarios that were not included in the exposure assessment of 1993 were also included in this document. All estimates of exposure were revised using the updated dermal absorption rate, body weight, inhalation rate, and PPE.

GENERAL CHEMISTRY

Azinphos-methyl (O, O-Dimethyl S-[(4-oxo-1,2,3-benzotriazin-3 (4H)-yl) methyl] phosphorodithioate) is an organophosphate insecticide. Its trade name is Guthion®. Azinphos-methyl's empirical formula is $C_{10}H_{12}N_3O_3PS_2$ and its molecular weight is 317.3 daltons. Pure azinphos-methyl (AZM) has a melting point of ~74 °C and a vapor pressure of 1.6×10^{-6} mmHg at 20 °C. The octanol-water partition coefficient (K_{ow}) for AZM is 360. Its Henry's law constant

(K_h) is 2.55 x 10^{-8} atm-m^3/mol, at 25 °C. AZM is rapidly hydrolyzed in alkali, forming anthranilic acid, and is also hydrolyzed in acid at a slower rate. It is slightly soluble in water (30 mg/liter at 25 °C) and readily soluble in organic solvents except aliphatics. AZM is an acetylcholinesterase inhibitor (Hayes, 1982; Talbott, 1987; Talbott and Mosier, 1987).

EPA STATUS

Upon review and evaluation of available data and relevant information on AZM, the U.S.EPA issued guidance in 1986 for the reregistration of pesticide products containing AZM as the active ingredient. The U.S.EPA did not place AZM into the Special Review process at that time. The guidance document listed numerous data gaps, including reentry protection and other exposure data. It also called for revised labeling, including additional protective clothing and work safety statements.

Effective beginning the year 2000, U.S. EPA canceled azinphos-methyl uses on ornamentals and prohibited applications by fixed-wing aircraft or by chemigation (Cain, 1999). The Agency also reduced the maximum yearly application rate/acre to some fruit trees (apple, pear, peaches, and nectarines) by 25%. It also extended the restricted entry intervals for fields treated with azinphos-methyl to the levels that existed in California.

PRODUCTS

There were seven azinphos-methyl-containing products registered in California in July 2000. Azinphos-methyl is registered in California for agricultural uses. There are no home or garden uses. Wettable powder in water-soluble bags and emulsifiable concentrates are the two formulations available in California. According to the sales data for 1991, 1992, and 1993, wettable powder formulations constituted 96, 98, and 99% of the total sales, respectively (DPR, 1996). By 1996, wettable powder formulations constituted 99.5% of the total sale with the emulsifiable concentrate formulations covering the balance (DPR, 1997). All azinphos-methyl products are classified as restricted materials in California. These products are for sale to and use only by certified applicators or persons under their supervision. Azinphos-methyl can be applied by ground or aerial equipment. The highest rate of application is 2 lb. of active ingredient (a.i.)/acre. The frequency of application varies with crop. Updated azinphos-methyl labels contain several requirements for reducing spray drift. One of these label requirements prohibits aerial application within 150 feet and ground application within 100 feet of unprotected people or occupied dwellings.

USAGE

Azinphos-methyl is applied to a variety of fruits and vegetables in California. Almonds are the major use crop. From 1980 through 1996, the yearly total use in California was approximately 400,000 to 500,000 lb. The yearly use dropped significantly in 1997 and 1998 (Table 1), possibly because of some restrictions imposed by DPR for worker heath protection. A large quantity of azinphos-methyl is applied in agricultural areas of Kern County, constituting approximately 30% of the yearly total use in California. The application season starts in April and ends in August or September. Peak applications occur during May, June, and July in most counties.

The pesticide use reports for 1992 to 1998 indicate that approximately 85 to 95% of the total pounds azinphos-methyl used were applied to nut and fruit trees, with the balance applied to a long list of other crops including fruits, vegetables, and ornamentals (Table 1). Uses on cotton have been gradually declining for the past several years to non-existence in 1997.

Table 1

Reported Major Uses (lb Applied) of Azinphos-Methyl from 1992 to 1998[a]

Crop	1992	1993	1994	1995	1996	1997	1998
Almonds	235,612	214,232	192,739	172,129	174,520	154,306	97,953
Pears	66,174	69,281	56,069	70,142	48,828	50,162	6,047
Walnuts	74,392	51,292	58,049	60,906	87,882	50,614	35,655
Apples	46,497	43,960	36,737	37,714	39,057	36,225	13,418
Peaches	26,053	17,898	12,986	8,344	4,684	2,806	1,066
Pistachios	39,665	48,912	39,429	39,877	36,816	29,374	29,898
Subtotal	488,393	445,575	396,009	389,112	391,787	323,487	184,037
Cotton	1,120	638	6	181	129	0	0
All others	30,722	28,079	22,898	16,928	14,150	12,867	9,271
TOTAL	520,235	474,292	418,913	406,221	406,066	336,354	193,308

a - DPR, 1994; DPR, 1995; DPR, 1996a; DPR, 1996b; DPR, 1999a; DPR, 1999b; DPR, 2000.

HUMAN ILLNESSES

California Health and Safety Code requires that any illness suspected of being caused by a pesticide be reported by the examining physician to the county health officer within 24 hours (California Code of Regulation, Title 17, Section 105200). Review of these cases by the Pesticide Illness Surveillance Program of DPR indicated that, from 1987 through 1996, there were 156 illnesses/injuries associated with exposure to azinphos-methyl alone or in combination with other pesticides (Mehler, 1999).

Most of the illnesses (>80%) were systemic in nature. More than 75% of the reported illnesses, 120 cases, were associated with occupational exposure. A few cluster illnesses (one in 1987 involving 36 peach harvesters and one in 1993 involving 14 almond pruners) comprised the bulk of field worker illness cases. The rest of the occupational illnesses involved other workers during mixing/loading and application. Non-occupational illnesses accounted for 36 cases (25% of total) that resulted primarily from a few residue drift incidents to nearby residential areas. Two drift incidents accounted for the bulk of the non-occupational illnesses. Of the total 36 non-occupational illness cases, 26 cases occurred during 1987. These 26 non-occupational illness cases were associated with an incident of drift from an orchard to a near-by residential area. The remaining 10 non-occupational illness cases were reported during 1988 to 1996, 8 of which were associated with a single drift incident to a residential area during 1993. The affected individuals reported pesticide odor in the residential areas during the two drift incidents that were described above. They also reported symptoms such as headache, dizziness, vomiting, and nausea.

FORMULATIONS

Of seven AZM-containing products registered in California in 2001, four products are wettable powders that contain 50% a.i. and the other three products are 22% emulsifiable concentrates that contain 2 lb. of a.i./gallon. Bayer Corporation, Gowan Company, and Micro-Flo Company are the only three registrants in California for AZM.

LABEL PRECAUTION

All AZM-formulated products are toxicity category I (Danger, Poison) for their acute toxicity. AZM can be fatal if ingested. Hazards of ingestion, inhalation, and dermal and eye contact have been indicated on the product labels. The use of human flaggers is prohibited. Label personal protective equipment (PPE) statements require airblast applicators to be in a fully enclosed cab. If not in fully enclosed cab, they must wear the following PPE:

- Chemical resistant suit over long-sleeved shirt and long-legged pants
- Chemical resistant hood
- Full-faced respirator or half-faced respirator with a face shield
- Chemical-resistant footwaer plus socks

Applicators other than airblast must wear the following PPE:

- Coveralls over long-sleeved shirt and long-legged pants
- Waterproof gloves

- Chemical-resistant footwear plus socks
- Chemical-resistant headgear for overhead exposure
- Protective eyewear
- Dust/mist filtering respirator (MSHA/NIOSH approval number prefix TC-21C)

Mixer and loaders must wear:

- Coveralls over long-sleeved shirt and long-legged pants
- Waterproof gloves
- Chemical-resistant footwear plus socks
- Protective eyewear
- Chemical-resistant headgear
- Chemical-resistant apron when mixing or loading
- Dust/mist filtering respirator (MSHA/NIOSH approval number prefix TC-21C)

In California, workers must handle the concentrate using a closed system. When using a closed system mixing/loading, a long-sleeved shirt and long pants may be substituted for the protective suit and the respirator requirement listed above. If the application is made from an enclosed tractor cab or airplane, a long-sleeved shirt and long pants are considered adequate. Pilots must have chemical resistant gloves available in the cockpit and must wear them while exiting. Other applicators in enclosed cabs must have label-required PPE available in the cab and wear them to work outside the cab.

RESTRICTED ENTRY INTERVAL

Product label restricted entry intervals (REI) for hand harvesting and thinning AZM-treated crops are 30 days for citrus, 21 days for grapes, and 14 days for other tree crops such as apples, peaches, and nectarines. This is consistent with the current REI requirements for AZM in California. The label REI for other activities involving minimal contact with treated foliage such as mowing, irrigating, and scouting is 3 days in areas with less than 25 inches of rainfall. The REI for all other crops is 5 days in areas with less than 25 inches of rainfall.

DERMAL SENSITIZATION

Johnson and Sanborn (1998) reviewed two AZM dermal sensitization studies. These studies were conducted with guinea pigs. In one study, a formulated AZM product that contained 13.6% a.i. was used. The animals were tested with 0.05% AZM. In the other study, a technical product containing 92.8% a.i. was used. The technical product was tested at 12.5% AZM. While the formulated product, when tested at 0.05% was not a sensitizer, the technical AZM, when tested at 12.5% was a sensitizer in guinea pigs.

DERMAL TOXICITY AND ABSORPTION

Dermal penetration of AZM was studied by administering ^{14}C-AZM to the ventral forearms of six male human volunteers (Feldmann and Maibach, 1974). The dose was dissolved in a small amount of acetone to prepare a 0.25% solution. The site of application was not occluded. Participants were asked not to wash the application site for 24 hours. In order to determine the extent of AZM metabolites eliminated in urine, another group of six human volunteers was administered a dose (1 uCi) of ^{14}C-AZM intravenously (IV). Urine samples from all participants were collected for five days following ^{14}C-AZM administration. Radioactivity of the samples was measured using a scintillation counter. Mean five-day urinary ^{14}C recovery was 69.5% $\pm$6.9 of the administered IV dose. The results of urinary excretion following dermal administration were corrected for incomplete urinary excretion that was observed in the IV study. The mean of five-day ^{14}C recovery was 15.9% $\pm$7.9 of the administered dermal dose. The rate of elimination in urine varied with time, both in dermal and IV studies.

Table 2

Percent Urinary Elimination of ^{14}C-AZM Administered Dose (Dermal) in Human[a]

Hours after Administration	% Elimination/Hour[b]
0-4	0.044
4-8	0.202
8-12	0.294
12-24	0.276
24-48	0.207
48-72	0.125
72-96	0.059
96-120	0.040
Total	15.9 $\pm$ 7.9 (120 hours)

a - Feldmann and Maibach, 1974.
b - Corrected for incomplete urinary elimination (69.5%).

An additional AZM human dermal absorption study was conducted in 1999 in the Netherlands. The review of this study suggested a dermal absorption rate of 21.5% (Thongsinthosak, 1999). Eighteen healthy human volunteers (six/group) were administered ^{14}C-azinphos-methyl in isopropyl alcohol (IPA) or an aqueous suspension of Guthion 25 WP dermally at forearms. The first and second groups of volunteers were dosed at 2.6 and 9. 2 ug/cm^2 (^{14}C-AZM in IPA), respectively. The third group was dosed at 4.7 ug/cm^2 a.i. with aqueous suspension of Guthion 25 WP. The administered site was covered with an aluminum dome that had air holes. The exposure time was 8 hours. Urine and feces samples were collected for up to 312 hours and blood samples were collected up to 120 hours after the application. Samples were prepared and analyzed by Bechman liquid scintillation spectrophotometers. The majority of the absorbed dose was excreted in urine. The excretion in feces was approximately eight-fold less than in urine. The amount of applied dose recovered from the application site via tape stripping was minimal. The maximum excretion was reached in about 10 hours after the application. Dermal absorption was measured as the sum of percentage of the applied dose recovered in urine, feces, and tape stripping. Total recovery of the applied dose for all three groups ranged from 102 to 105%, suggesting AZM did not accumulate in the body during the study period. Mean dermal absorption values were 27.8 and 22.9% for groups one and two that were dosed with technical AZM. Mean dermal absorption for group three that was dosed with a 25 WP formulation of AZM was 21.5%.

A dermal absorption of 19% will be used to estimate human AZM absorbed dosages based on the average of the above two human dermal absorption studies.

METABOLISM

AZM was absorbed extensively and eliminated relatively rapidly in rats administered carbonyl-^{14}C-AZM orally or intravenously (Patzschke *et al*., 1976). Rats were dosed with 0.1 mg/kg and 2 mg/kg orally and intravenously, and 6 mg/kg orally. Recoveries were determined from the elimination of the activity in the exhaled air, urine, and feces. Less than 0.1% of the administered dose was recovered in the exhaled air in 24 hours following oral or intravenous dosing of 2 mg/kg AZM. Rats excreted 60% to 70% of the administered dose in urine and 25% to 35% of the administered dose in feces within 48 hours of dosing with 0.1 mg/kg or 2 mg/kg, regardless of the route of administration. These data indicate that oral bioavailability is virtually complete. Oral administration of a 6 mg/kg dose also showed similar recoveries in urine in 48 hours. The excretion of the radioactivity continued up to the last day of the observation (16 days) but at a very slow rate. Average recoveries were 97% to 100% of the administered dose for all doses. The amount of activity in the organs and tissues was 2% of the administered dose four days after oral or intravenous administration. This amount decreased to less than 1% 16 days after oral administration of 6 mg/kg.

In another study, when rats were administered carbonyl-^{14}C-AZM intravenously, approximately 65% of the radioactivity was recovered in the urine (Ecker, 1976). The activity was distributed among more than 10 spots in thin-layer chromatography. No parent compound was detected in urine. Only 10% of the activity in the urine was determined to be desmethyl-azinphosmethyl and 2% was identified as benzazimide (AZM metabolites). No other metabolites were identified in urine.

In a 1988 study, 72 hours after the administration of 0.125 mg/kg, 68 - 73% of the activity was recovered in urine and 21 - 26% of the activity was recovered in feces of rats dosed orally with (ring-UL-^{14}C)-AZM (Kao, 1988). The radioactivity was measured using a liquid scintillation counter. Metabolites were separated into peaks by a high performance liquid chromatograph (HPLC) radioactivity detector and characterized by different retention times in reference to the analytical standards. No mass spectral method was used to chemically identify these metabolites. In urine samples, a total of 12 radioactive peaks were separated by HPLC. Eight of these metabolites were characterized with reference standards and accounted for 59 to 68% of the total dose. The metabolites that were characterized are as follows:

Metabolite	% total dose	
	Lowest	Highest
Cysteinylmethylbenzazimide sulfone	13	30
Cysteinylmethylbenzazimide	0	2
Methylsulfinymethylbenzazimide	2	13
Benzazimide	0	4
Methylsulfonylmethylbenzazimide	14	20
Glutathionylmethylbenzazimide	0	14
Cysteinylmethylbenzazimide sulfoxide	0	12
Desmethyl isoazinphos-methyl	0	6

The proposed metabolic pathway of AZM in rats is shown in Figure 1.

The biokinetic behavior of benzazimide in rats was shown to be similar to that of the parent compound (AZM) (Weber *et al*., 1980). It was absorbed extensively (>95%) following oral administration and eliminated quickly. Only 1.3% of the administered dose was present in the animal, excluding the gastro-intestinal tract, 24 hours after the oral application. Recoveries ranged from 54% to 66% of the administered dose in urine and 33% to 45% of the administered dose in feces after 48 hours.

At least 10 metabolites were identified in tissues and/or milk of lactating goats dosed orally with [phenyl-UL-^{14}C]-AZM for 3 consecutive days (Gronberg *et al*., 1988). Two goats were sacrificed 17 to 18 hours after the last dose. No AZM oxygen analog was identified in tissues or milk samples. The identified metabolites were:

Azinphos-methyl
Benzamide
Benzamide-type conjugate
Benzazimide
Desmethyl azinphos-methyl oxygen analog
Desmethyl isoazinphos-methyl
Methylbenzazamide-type conjugates
Methylsulfinylmethylbenzazimide
Methylsulfonylmethylbenzazamide
Methylthiomethylbenzazimide

Two principal biochemical systems were suggested to be involved in metabolism of AZM in mice administered [P^{32}]-AZM, orally or intraperitoneally (March *et al*., undated). These are: 1) The oxidation of the thiono sulfur moiety to produce the thiol analog of AZM, an extremely potent cholinesterase inhibitor and 2) The hydrolysis of AZM and its thiol analog, producing compounds of lower toxicity. An in vitro metabolism study of AZM by mouse liver also demonstrated the formation of AZM oxygen analog as a result of oxidative desulfuration of AZM (Montoyama and Dauterman, 1972). The further degradation of AZM oxygen analog was slower than that of AZM.

DISLODGEABLE FOLIAR RESIDUES

A great number of AZM dislodgeable foliar residue (DFR) studies are available in-house from Worker Health and Safety Branch's data collection efforts and submissions by the registrants. A number of DFR studies are also available in the open literature. Generally, the leaf disc samples were rinsed and dislodgeable residues were analyzed by gas chromatography. In some of these studies, the leaf samples were frozen prior to dislodging the residues; the results are not included here since overestimation of DFR values could be derived from the absorbed residues released in the damaged leaves. The mean predicted DFR values of the referenced studies for each crop are shown in Table 3. Some studies provided only the range of DFR values. Schneider *et al*. (1994) found DFR ranging from 0.8 to 1.7 $\mu g/cm^2$ in peach orchards 51 days after AZM application, while McCurdy *et al*. (1994) observed DFR values ranging from 0.3 to 1.0 $\mu g/cm^2$ in peach orchards 30 days after AZM application. Schneider and Benson (1996) found DFR ranging from 0.01 to 4.0 $\mu g/cm^2$ in pears one to 20 days after AZM application. In a study conducted in the State of Washington, mean DFR ranged 0.3 to 3.67 $\mu g/cm^2$ with a median of 0.5 $\mu g/cm^2$ in apple orchards, two to 42 days post-application (Simcox *et al*., 1999). It appears that the foliar dissipation of AZM is relatively slow and crop dependent.

Table 3
Mean Predicted Dislodgeable Foliar Residues (µg/cm^2) of
Azinphos-Methyl in Different Crops

Sample Interval	Crops: Apples[a]	Pears[b]	Peaches[c]	Oranges[d]	Cotton[e]
Pre-application	ND-0.42	N/A	ND-0.67	N/A	N/A
Post (0 Day)	2.08 ±1.19	1.41 ±0.15	1.92 ±0.56	1.25	1.10 ±0.28
1	1.86 ±0.96	1.33 ±0.14	1.84 ±0.52	1.23	0.60 ±0.07
3	1.51 ±0.65	1.20 ±0.12	1.70 ±0.48	1.19	0.26 ±0.03
7	1.07 ±0.49	0.96 ±0.08	1.46 ±0.49	1.11	
14	**0.70 ±0.51**	**0.66 ±0.03**	**1.17 ±0.51**	1.00	
21	0.53 ±0.47	0.45 ±0.01	0.96 ±0.50	0.89	
30	0.40 ±0.39	0.28 ±0.01	0.76 ±0.47	**0.61**	
Formulation[f]	W.P.	W.P.	W.P./E.C.	W.P.	E.C.
Application Rate (lb. a.i./acre)	0.75-2.00	0.75-2.00	1.00-2.25	3.75	0.50
Average Daytime Temperature (^{o}F)	72-88	80	89-95	N/A	89-100

a - Maddy, Fong *et al*., 1985; Edmiston *et al*., 1984; Maddy, Edmiston *et al*., 1985.
b – Rech *et al*., 1987; Kiigemagi *et al*., 1978.
c - Maddy, 1975; Maddy *et al*., 1982; Maddy *et al*., 1984; Schneider *et al*., 1990; Spencer *et al*., 1993; Kraus, 1977.
d - Waggoner *et al*., 1970.
e - Ware *et al*., 1974; Cahill *et al*., 1975.
f - W.P. – Wettable powder; E.C. – Emulsifiable concentrate
ND - Not Detected N/A - Not Available
Bold - Reentry intervals and corresponding DFR

WORKER EXPOSURE

Mixer/Loader/Applicator Exposure:

Mixer/loader/applicator (M/L/A) exposure to AZM was monitored using two spray application systems (Schneider *et al*., 1987). One worker applied a wettable powder formulation AZM to almond trees at a rate of 1.5 lb. a.i./100 gal water/acre, using a conventional air blast sprayer. Two other workers applied the same formulation of AZM to almond trees at a rate of 1.4 lb. a.i./25 gal water/acre, using electrostatic sprayers. Gauze pads were mounted on the outside and under standard uncoated Tyvek® coveralls of each worker at arms, legs, chest, and back. A portable personal air sampling pump was fastened to the belt of each worker. Air was drawn through a glass fiber (0.3 µm pore size) and XAD-4 sorbent resin that was attached to the worker's collar (breathing zone). Hand washes were taken using Sur-Ten® solution to measure hand exposure.

Residues on pads at the back, chest, forearm, thigh, and shin of each worker were used to extrapolate exposure to the rest of the body regions. Body region surface areas recommended in the U.S.EPA Subdivision U were used for calculation (U.S. EPA, 1987). The coveralls were assumed as a layer of clothing (long-sleeved shirts and long pants) and the residues on the pads located under the coveralls were considered dermal exposure. The exposure to uncovered areas such as face, and neck were extrapolated from back and chest pads outside the coveralls. The exposure to hands was calculated based on residues found in the hand washes at the completion of the application.

The two M/L/As using electrostatic sprayers received lower dermal exposure/lb. a.i. sprayed when compared to the M/L/A using an air blast sprayer. The difference narrows when dermal exposure is presented per hour of work (Table 4).

In a separate worker exposure investigation, 16 applicators involved in mixing/loading and application were monitored for urinary dialkyl phosphate excretion, blood cholinesterase activity, and dermal exposure (Franklin *et al*., 1981). The applicators sprayed Guthion® 50 WP to orchards in British Columbia, at a rate of 0.625 lb. (0.28 kg) a.i./50-70 gal/acre using ultra-low volume air blast equipment. Each applicator was monitored for one day (2.5-9 hours). Ten area residents who were not involved in the spray operation were used as controls. Their blood and urine samples were taken at the same time baseline and pre-exposure samples were collected from the applicators.

Each applicator wore a short-sleeved cotton shirt, cotton pants, long-sleeved coveralls, a respirator with organic vapor/dust cartridges, gloves (cotton, leather, or rubber), and boots (leather or rubber). In addition to these clothing, four applicators wore rubber suits (coat and pants), and another four applicators wore rubber coats. A fluorescent tracer was used to observe dermal exposure under rubber clothing.

Blood samples were taken each day after the end of work. Urine samples were taken 0-16, 16-24, 24-40, and 40-48 hours following initial exposure. Air samples were taken during work in the breathing zone of four applicators. Dermal exposure pads were pinned to the underside of the clothing in such a position that the plastic backing of the pads rested against the skin. Pads were located at the chest, back, upper arm, lower arm, upper leg, and lower leg of each applicator. The tracer was observed under ultraviolet light (UV). Urine and pad samples were analyzed using a gas chromatograph with a flame photometric detector. Blood samples were examined for serum and red blood cell (RBC) cholinesterase activities.

Table 4

Exposure Estimate of Mixer/Loader/Applicators to Azinphos-Methyl
Using Electrostatic or Air Blast Application Equipment[a]

	Electrostatic Sprayers		Air Blast Sprayer
	Worker # 1	Worker # 2	Worker # 3
Spray duration (hrs)	2.6	7.0	7.0
Pounds a.i. sprayed	17.5	35.0	22.5
Body Region	µg	µg	µg
Head	1060	2455	6500
Neck	336	1464	2196
Hand	1226	463	246
Rest of Body	1440	1126	2472
Total Dermal Exposure	4,062	5,508	11,414
Dermal Exposure/lb. a.i.	232	157	507
Dermal Exposure/hr	1,562	787	1630
Daily Dermal Exposure	12,498	6,295	13,044
Potential Respiratory Exposure	N/D	N/D	459
Absorbed Daily Dosage[b] (µg/kg/day)	31.3	15.8	33.0

a - Data from study of Schneider et al., 1987.
b - Assuming: An 8-hour work day, dermal absorption of 19%, inhalation rate of 0.84 m^3/hr, respirator providing 90% protection, body weight of 75.9 kg (Thongsinthusak *et al*., 1993), 50% respiratory uptake (Raabe, 1988), and clothing consisting of a long-sleeved shirt, long pants, gloves, hat, and shoes.
ND - Non-detectable
a.i. - Active ingredient

No tracer was seen under the respirator. Tracer deposition was intensive on the neck, hands, and parts of the face that were not covered by the respirator. Tracer was also observed on the chest, shoulders, and lower arms under the rubber clothing, confirming the patch findings at these locations. AZM residues in the air samples taken from the breathing zone of the applicators ranged from 0.02 to 0.11 mg/m^3 with a mean of 0.05 mg/m^3. No serum or RBC cholinesterase depression greater than 15% from the baseline values was observed on the day of exposure. There were at least two individuals with 20% and 23% RBC cholinesterase depression from the baseline at post-exposure, but these were within the variation observed in the control group. No attempt was made to quantify dermal exposure to the face, neck, and hands where substantial exposure may have occurred based on observation of the tracer under UV light. AZM residue values on the pads under the clothing (Table 5) were used to measure dermal exposure to the rest of the body. One-half of the minimum detectable level (MDL) was assumed where non-detectable values were reported.

Table 5

Mean Azinphos-Methyl Residues on Pads at Various Parts of the Body[a]

# of Workers	Duration (hour)	Additional Clothing[b]	Chest	Back	Upper Arm	Lower Arm	Upper Leg	Lower leg
			(ng azinphos-methyl/cm^2/kg a.i. sprayed)					
4	4.1	Rubber Suit	2.5	1.3	1.3	5.6	1.3	1.3
4	4.7	Rubber Coat	2.1	2.4	1.8	3.6	1.6	1.9
8	5.8	None	1.3	1.5	1.8	3.4	1.6	1.3

a - Data from study of Franklin et al., 1981.
b - Clothing in addition to short-sleeved shirts, pants, coveralls, respirator and boots.
MDL = 2.5 ng/cm^2
a.i. – Active ingredient

Body region surface areas as recommended in the U.S.EPA Subdivision U (U.S. EPA, 1987) were used in Table 6 to calculate dermal exposure. The dermal exposure values were normalized for an 8-hour workday based on an average kg a.i. sprayed/hour.

Table 6

Mixer/Loader/Applicators' Estimated Daily Azinphos-Methyl Dermal Exposure Excluding Head, Neck, and Hands[a]

Spray Duration (hr)	Kg a.i. Sprayed	Additional Clothing[b]	Dermal Exposure (µg/person/kg a.i.)	Daily Dermal Exposure (µg/person/day)[c]
4.1	2.25	Rubber suit	33.2 ± 19.6	146
4.7	2.50	Rubber coat	38.8 ± 14.6	165
5.8	2.70	None	29.7 ± 5.9	113

a - Data from study of Franklin et al., 1981.
b - Clothing in addition to a short sleeved shirt, long pants, gloves (cotton, leather, or rubber), coveralls, boots, and half-face respirator.
c - Assuming an 8-hour work day.
a.i. - Active ingredient

AZM metabolites, expressed as AZM equivalents, in 48-hour urinary samples were reported as µg/kg a.i. sprayed. Since workers wore respirators, respiratory exposure was calculated from the mean residues found in the breathing zones. These values were normalized for an 8-hour workday to calculate ADDs.

Table 7

Mixer/Loader/Applicators' Estimated Azinphos-Methyl Absorbed Daily Dosage Based on Urinary Metabolites[a]

Additional Clothing[b]	48-hr Urinary Elimination (µg/person/kg a.i.)	Absorbed Daily Dosage (µg/person/day)[c]	Respiratory Exposure (µg/person/day)[d]	Absorbed Daily Dosage (µg/kg/day)[e]
Rubber suit	135 $\pm$ 18.1	909	17	12.2
Rubber coat	176 $\pm$ 87.1	1152	17	15.4
None	176 $\pm$ 105	1008	17	13.5

a – Data from study of Franklin et al., 1981.
b - Clothing in addition to a short sleeved shirt, long pants, gloves (cotton, leather, or rubber), coveralls, and boots.
c - Urinary elimination was corrected for incomplete urinary recovery (65%) in 48 hours.
d - Based on inhalation rate of 0.84 m^3/hour (Thongsinthusak et al., 1993), air residue of 0.05 mg/m^3, 50% respiratory uptake (Raabe, 1988), and respirator providing 90% protection (Thongsinthusak et al., 1993).
e - Body weight 75.9 kg and 8-hour workday (Thongsinthusak et al., 1993).
a.i. – Active ingredient

Assuming a 19% dermal absorption rate, the estimated daily dermal exposure excluding head, neck, and hands in Table 6 greatly underestimates the ADD when compared to those in Table 7. The estimated ADD values in this study (Table 7) are lower than those of the previous study (Table 4). The lower rate of application (0.625 lb./acre) in Franklin et al., 1981 study may have contributed to the lower ADD values. When M/L/As' ADD values were normalized for the maximum rate of application, the ADD values in these two studies appear essentially the same (Table 8).

Table 8

Azinphos-Methyl Mixer/Loader/Applicators' Estimated Absorbed Daily Dosage

Reference	Type of Sprayer	Crop	Protective Clothing	ADD[a] (µg/kg/day)
Schneider *et al*., 1987	Electrostatic	Almonds	**b**	22.6 – 44.7
Schneider *et al*., 1987	Air blast	Almonds	**b**	44.0
Franklin *et al*., 1981	Air blast	Orchards	**c** and rubber suit	39.0
Franklin *et al*., 1981	Air blast	Orchards	**c** and rubber coat	49.3
Franklin *et al*., 1981	Air blast	Orchards	**c**	43.2

a - Normalized for maximum application rate (2 lb. active ingredient/acre).
b - Long sleeved shirt, long pants, gloves, hat, and shoes.
c - Short sleeved shirt, long pants, gloves, coveralls, and boots.

The rubber suit or rubber coat did not provide additional protection to the applicators in this study. It is also interesting to note that clothing made of closely woven fabrics may not necessarily provide greater dermal protection against AZM sprays compared to some non-woven fabrics. When a spray application of an AZM formulation in the field was simulated in the laboratory, it was observed that closely woven fabrics such as cotton chambray permitted the greatest amount of penetration compared to non-woven fabrics such as Tyvek®, Gore Tex®, and Crown Tex® (Orlando *et al*., 1981). The penetration to the gauze layers placed under the fabrics was 0.014 to 0.023 µg AZM/cm^2 for non-woven fabrics and 0.46 to 0.56 µg AZM/cm^2 for closely woven fabrics. Regardless of AZM penetration and retention, one home laundry cycle with a heavy duty liquid detergent generally removes greater than 94% of AZM from different fabrics usually worn by farm workers (Easter and DeJonge, 1985).

In the absence of chemical specific exposure data for some additional work tasks, Pesticide Handlers Exposure Database (PHED) version 1.1 was used as surrogate. The exposures to aerial application crews (pilots and mixer/loaders), ground applicators using airblast or ground boom, and mixer/loaders of ground applications were estimated using the PHED (Table 9). Subset specifications and summary statistics for each scenario are included in Appendix A. The estimates were corrected for the protection provided by the current PPE requirements and maximum amount (lb a.i.) handled per day. The estimate of exposure to airblast mixer/loader/applicators has already been shown (Schneider et al., 1987). The estimate of exposure based on additional AZM airblast mixer/loader/applicator exposure data (Franklin, *et al*., 1986) was within the same range.

Table 9

Estimates of Azinphos-Methyl Exposure for Various Handler Work Tasks[a]

Work Task	Estimated Exposure			ADD[e] µg/kg/day
	µg/lb a.i.[b]	µg/lb a.i.[c]	lb a.i/day[d]	
Pilot	3.9	3.9	1000	9.8
M/L (aerial applications)	18.6	1.9	2000	9.5
Applicator ground boom	66.0	6.6	200	3.3
M/L (ground boom)	18.6	1.9	200	1.0
Applicator airblast	1572.3	157.2	100	39.4
M/L (airblast)	18.6	1.9	100	0.5

a - Pesticide Handler Exposure Database, Version 1.1.

b - Based on pilot wearing work clothing (in closed cockpit, wearing gloves when exiting) and ground boom applicator wearing work clothing (long-sleeved shirt, long pants, and footwear) and ground M/L (using water soluble bags in open pour loading system) and airblast applicator wearing work clothing and gloves.

c - Corrected, where appropriate, for label PPE requirement of coveralls, headgear, gloves, and half-faced respirator for ground boom applicators, fully enclosed cab or chemical resistant suit, hood, and a full-faced respirator for airblast applicators, and closed system loading with apron and gloves for mixer/loaders. Assuming closed system loading, or coveralls, headgear, and gloves, or closed cab, or chemical resistant suit and hood provide 90% dermal exposure protection (Thongsinthusak *et al*., 1993).

d - Based on pilot and aerial mixer/loader handling a maximum of approximately 500 and 1000 acres per workday, respectively and ground mixer/loader, boom applicator, and airblast applicator handling a maximum of approximately 100, 100, and 50 acres per workday, respectively (Haskell, 1998) at the label maximum application rate of 2 lb a.i./acre.

e - Based on dermal absorption of 19%, negligible inhalation exposure, and body weight of 75.9 kg (Thongsinthusak *et al*., 1993)

a.i. - Active ingredient

Field Worker Exposure:
In a citrus harvester exposure study, a group of 15 workers' baseline plasma and RBC cholinesterase values were determined at 7, 5, and 3 days prior to exposure (Waggoner *et al*., 1970). Orange trees were treated with a wettable powder formulation of AZM at the rate of 3.75 lb. a.i./acre. Workers entered the treated grove on the seventh day after the application. Workers spent approximately 7 hours picking oranges every day for 10 days. Plasma and RBC cholinesterase activity was determined after 2 and 5 days of work. Two workers wore new cotton gloves, skin patches, and air sampling devices each day for only one hour. Two skin patches were used, one on the forearm and one on the head. Leaf discs were also collected post-application at various intervals for DFR determination.

The average plasma cholinesterase activity levels at day 2 and day 5 of harvest were 28% and 40% below the average baseline, respectively. The average RBC cholinesterase activity levels at day 2 and day 5 were 14% and 12% below the average baseline, respectively. Residues in the gloves following one hour of harvesting ranged from 12.6 to 88.0 μg/cm^2. DFR on the 7th, 9th, and 11th day after application were 0.74, 2.2, and 0.82 μg/cm^2, respectively.

A similar study by the same authors with spray concentrate formulation at a rate of 2.25 lb. a.i./acre indicated significant RBC cholinesterase depression (Waggoner *et al*., 1970). Workers entered the treated area 7 days following the application. RBC cholinesterase activities were 28 and 40% below the average baseline 7 and 10 days after entry, respectively.

Table 10

Citrus Harvesters' Potential Hand, Arm, Head, and Respiratory Exposure to Azinphos-Methyl[a]

Days after Application	DFR Values	Gloves[b]	Arms[b]	Head[b]	Potential Inhalation	Potential Dermal	Transfer Factor[c]
at 3.75 lb a.i./acre							
	(μg/cm^2)	(μg/cm^2/hr)			(μg/L)	(μg/hr)	(cm^2/hr)
7	0.74	51.0	1.75	0.80	0.13	45,203	61,085
9	2.20	71.5	1.90	0.45	0.15	61,723	28,056
11	0.82	33.4	0.62	0.25	0.12	28,672	34,966
at 2.25 lb. a.i./acre							
7	0.26	14.3	0.24	0.17	0.05	12,237	47,065

a - Data from study of Waggoner et al., 1970.
b - Body part surface area as recommended in USEPA Subdivision U (Arms include forearms only) (U.S. EPA, 1987).
c - Based on hand, arms, and head potential exposure only.
a.i. – Active ingredient

Gloves may have over estimated hand exposure (Knarr, 1986; Davis *et al*., 1983). However, the extent of exposure to the trunk, which has been shown to contribute a substantial percentage of harvesters' dermal exposure (Schneider *et al*., 1990; Spencer *et al*., 1993; Spencer *et al*., 1991), was ignored. Therefore, the transfer factors derived for citrus harvesters in Table 10 may not be reliable.

A group of 28 harvesters entered a treated nectarine orchard 52 days following application of AZM at 0.7 lb. a.i./acre (Schneider *et al*., 1990). The harvesters wore long-sleeved shirts, long pants, socks, and shoes. Urine samples were taken each day for urinary metabolite analysis. Blood samples were taken on day five of the study and two weeks after the completion of the study for cholinesterase analysis. Dermal exposure was monitored using long-sleeved T-shirts, face/neck wipes, and hand washes. Potential daily dermal exposure was estimated at 17.2 $\pm$ 5.7 mg AZM plus AZM oxon/person/day. Arm and trunk residues accounted for over 90% of the potential dermal exposure. DMTP was the only metabolite detected in 48-hour urine samples, and it was equivalent to 0.28 - 1.52 mg AZM/person/day with a mean of 0.75 $\pm$ 0.44 mg/person/day. Cholinesterase activity remained within the baseline range (-7% to + 14%). Mean DFR for the four days of monitoring was 0.31$\pm$ 0.03 ug/cm^2. A transfer factor of 6935 cm^2/hour was calculated for <u>potential dermal exposure</u>. It is important to note that because of the hot weather the workers did not wear any clothing over the T-shirts that were used as the dosimeters. This may have contributed to an under-estimation of potential dermal exposure because some residues may have penetrated the T-shirts, and resulted in an under-estimation of the transfer factor. From the same study, daily dermal exposure of 8.0 mg/person/day can be estimated from the reverse calculation of the highest (1.52 mg AZM equivalent/person/day) residues found in the urine and 19% dermal absorption (1.52 X 100/19). This provides a transfer factor of 3226 cm^2/hour for harvesters <u>dermal exposure</u>.

A similar study of apple harvesters, peach harvesters, peach thinners, and peach proppers was conducted in California in 1989 (Spencer *et al*., 1993). The T-shirt (dosimeter) was worn under a long-sleeved shirt. Hand exposure was monitored by collecting hand washes and wipes. Face and neck wipes were also taken. Apple harvesters wore nylon knit gloves and their hand exposure was monitored using hand wipes. Daily dermal exposure, urinary metabolites, and cholinesterase activities were monitored. Mean daily dermal exposure was estimated at 1.7 mg for apple harvesters, 15.6 mg for peach harvesters, 13 mg for peach thinners, and 0.7 mg for peach proppers. Workers entered treated areas 43 days following application of AZM to apples and 32 and 52 days following AZM application to peach orchards. Urinary equivalent of AZM was measured at 1.0 mg for apple harvesters, 2.4 mg for peach harvesters, 1.9 mg for peach thinners, and 0.6 mg for peach proppers. Peach harvesters' mean RBC cholinesterase value declined significantly (19% in second draw and 15% in third draw) below the baseline. Transfer factors of 360 cm^2/hour and 3,038 - 3525 cm^2/hour were estimated based on dermal <u>exposure</u> of apple and peach harvesters, respectively. The low transfer factor for apple harvesters may be because of hedgerow pruning and the nylon gloves worn by them. The transfer factors for peach thinners and proppers were 3315 cm^2/hour and 174 cm^2/hour, respectively.

An additional peach harvester exposure monitoring in California during 1989 estimated a transfer factor of 2850 to 7430 cm^2/hour based on harvesters' <u>dermal exposure</u> to AZM residues (Spencer *et al*., 1991).

Ten cucumber harvesters' hand exposure was monitored using lightweight cotton gloves or washing with ethanol (Knarr, 1986). Cucumbers were treated with Guthion® 50 WP at a rate of 0.5 lb. a.i./acre. Workers entered the treated area one day after the application. DFR and hand exposure samples were taken simultaneously. Dermal exposure to the rest of the body was not monitored. Air samples were taken from workers' breathing zone to determine inhalation exposure. Average hand (glove dosimeters) and inhalation exposures for 10 workers were 2023 ± 447 µg/hr and 3.8 ± 1.4 µg/hr, respectively. Average hand exposure based on 5 workers' ethanol hand rinses was 179 ± 36 µg/hr. The average of 8 DFR samples was 1.1 ± 0.3 µg/cm^2. The transfer factor based on residues found in gloves was 1839 cm^2/hour, and based on residues found in hand rinse is 163 cm^2/hr.

Potential head, forearm, hand, and respiratory exposure of apple thinners was monitored at 1, 2, 6, and 9 days following an air blast application of AZM at 2 lb. a.i./acre (Davis *et al*., 1983). Hand exposure was monitored by using gloves or an ethanol hand washes. Gloves showed AZM residues 4.5-fold greater than residues found in ethanol wash. Head and neck exposure was assumed to be 14% of forearm exposure, based on previous work by the same investigators. Apple thinners' exposure is shown in Table 11.

Table 11

Apple Thinners' Head, Forearm, Hand, and Respiratory Exposure to Azinphos-Methyl Residues[a]

Days After Application	DFR Value	Head, Neck	Forearm	Hand[b]	Respiratory	Total Dermal Exposure	Transfer Factor[c]
	(µg/cm^2)	(µg/hr)					(cm^2/hr)
1	1.7	270	1900	1300	49	3470	2040
2	1.9	440	3100	1800	78	5340	2810
6	1.4	190	1300	830	31	2320	1660
9	1.4	140	980	960	18	2080	1490

a - Data from study of Davis et al., 1983.
b - Ethanol hand rinse.
c - Based on dermal exposure to head, neck, forearm, and hand.
DFR - Dislodgeable foliar residue.

In a controlled trial, two groups of workers (thinners) were monitored for AZM exposure (Richards *et al*., 1978). One group (8 men) of workers entered a peach orchard that was treated with AZM wettable powder at a rate of 2.5 lb. a.i./100 gal/acre. Workers entered the treated orchard when mean DFR reached no greater than 2.58 ±0.74 µg/cm^2, presumably 9 days after AZM application. However, leaf disc samples taken for this purpose were frozen before analysis. The other group (7 men) started working in a peach orchard treated with a non-cholinesterase inhibitor (Galecron®). RBC and plasma ChE activity, and urinary dialkyl phosphate metabolites of these workers were measured pre-exposure and during routine thinning operation. RBC and plasma ChE measurements were taken on three separate days before exposure for the baseline and each day during the exposure. Plasma or RBC ChE activity was no less than 83.4% of the mean three-day baseline for workers in either group and during the five days of monitoring. Dimethylphosphate (DMP) and dimethylphosphorothionate (DMTP), the primary urinary metabolites of AZM, were not detected in pre-exposure or control urinary samples (MDL of 0.1 µg/mL). Five days' mean DMTP and DMP were 14.1 $\pm$ 6.2 ppm and 15.1 $\pm$ 6.8 ppm per day, respectively. Since a single urine sample was taken each day from each worker, and urinary inorganic phosphate interferes with the complete recovery of the dialkyl phosphates, no attempt was made to quantify daily DMP and DMTP excretion.

Hand exposure of workers limb propping a peach orchard 17 days after an AZM application was monitored (Maddy and Meinders, 1987). Hand exposure was 15.7 $\pm$ 4.0 µg/8-hours' work for three workers with cloth gloves and 60.0 µg/8-hours' work for one worker with no gloves. The orchard was treated at a rate of 1 lb. AZM/acre. The DFR on the day of monitoring was measured at 0.77 µg/cm^2. No AZM was detected (MDL = 0.2 ppb) in any air samples taken at workers breathing zone.

Table 12 is a summary of field worker exposure studies showing the daily dermal exposure and estimated transfer factors. The estimated dermal transfer factors, Absorbed Daily Dosages, and Annual Average Daily Dosages for field workers performing different tasks are shown in Table 12. The exposure to field workers harvesting vegetables or berries is also included in Table 12. Their estimate of exposure was based on AZM dislodgeable foliar residues observed on cucumbers (Knarr, 1986) and an average dermal transfer factor of 237 cm^2/hour for strawberry harvesters wearing rubber latex gloves as normal work practice (Krieger *et al*., 1990).

Table 12

Summary of Azinphos-Methyl Field Worker Exposure Studies
and the Estimated Dermal Transfer Factors

Job Description	Crop	Entry After Application (days)	Dislodgeable Foliar Residue (µg/cm^2)	DDE (mg/day)	Transfer Factor (cm^2/hr)
Harvester[a]	Peach	32, 52	0.48, 0.64	13.0, 15.6[b]	3525, 3038
Harvester[c]	Peach	50, 74	1.00, 0.37	22.8, 22.0[b]	2850, 7430
Harvester[d]	Nectarine	52	0.31	10.1[b]	4072
Harvester[a]	Apple	43	0.64	1.7[e]	360
Harvester[f]	Cucumber	1	1.10	1.4[g]	163
Thinner[a]	Peach	31	0.49	13.0[b]	3315
Thinner[h]	Apple	1-9	1.4-1.9	16.6-42.7[i]	1490-2810
Propper[a]	Peach	31	0.50	0.70[b]	174
Propper[j]	Peach	17	0.77	0.06[g]	10

a - Spencer et al., 1993.
b - Based on work clothing of long-sleeved shirt, long-legged pants, and shoes.
c - Spencer et al., 1991.
d - Schneider et al., 1990.
e - Gloves were worn, as a normal practice, in addition to clothing described in footnote b.
f - Knaar, 1986.
g - DDE (daily dermal exposure)based on hand exposure only.
h - Davis et al., 1983.
i – DDE based on head, forearm, and hand exposure only.
j – Maddy and Meinders, 1987.

McCurdy *et al*. (1994) monitored the exposure of 20 field workers entering a peach orchard 30 days after an AZM application (1.5 lb a.i./acre). Workers performed harvesting, thinning, and propping for 21 days in a 44-day period. RBC and plasma cholinesterase activities, urinary metabolites of AZM, and dermal exposure of these workers were monitored. Monitoring was conducted during the day one (propping and thinning), day two (harvesting), day three (harvesting), and day 44 (harvesting). DFR samples were taken during the first three days of monitoring, and ranged from 0.32 to 0.96 μg/cm^2. RBC cholinesterase activity, when compared to the baseline, for all workers decreased 7% during the initial 3 days of exposure and 19% over the 44-day period. Plasma cholinesterase activity decreased 9% during the initial 3 days of exposure and 12% over the 44-day period. Median dermal exposures were 364 ug/person for proppers (n = 6), 10,690 μg/person for thinners (n = 4), and 13,600 μg/person for harvesters (n = 10). Median urinary metabolite (alkylphosphates) levels were 3.8 μmoles/day for thinners and 1.2 μmoles/day for proppers. Median urinary metabolite levels for harvesters, derived from the figures provided in the report, were approximately 5 and 7 μmoles/day on day two and day three, respectively.

Table 13

Field Workers' Estimated Azinphos-Methyl Absorbed Daily Dosage (ADD)

Job Description	Crop	DFR at Reentry (14 days)	Transfer Factor	ADD[a]
		(μg/cm^2)	(cm^2/hr)	(μg/kg/day)
Harvester	Peach/Nectarine	0.96[b]	4,180[c]	80.4
Harvester	Apple	0.70	4,180[c]	58.6
Harvester	Orange	0.61[d]	4,180[e]	51.1
Thinner	Peach/Nectarine	1.17	3,315[e]	77.7
Thinner	Apple	0.70	3,315[e]	46.5
Propper	Peach/Nectarine	1.17	174[e]	4.1
Propper	Apple	0.70	174[e]	2.4
Harvester	Vegetables/Berries	0.9[f]	237[g]	4.3

a - Based on a dermal absorption of 19%, body weight of 75.9 kg, 8-hour workday (Thongsinthusak et al., 1993), and work clothing of long- sleeved shirt, long-legged pants and shoes.
b - DFR (dislodgeable foliar residue) at 21 days after application (preharvest interval for peach/nectarine).
c - Mean calculated from Specer et al., 1993; Spencer et al., 1991; and Schneider et al., 1990.
d - DFR at 30 days after application (reentry for citrus).
e - Specer et al., 1993.
f - Based on DFR of 1.1 μg/cm^2 on cucumber one day after application, DFR of 0.9 μg/cm^2 5 days after application by following the dissipation pattern that was observed in peaches.
g - A transfer factor of 237 cm^2/hr for berry harvesters (Krieger *et al*., 1990).

Using the dermal exposure data and assuming 19% dermal absorption, the ADD for proppers, thinners, and harvesters can be estimated to be 0.9, 26.7, and 34 μg/kg/day, respectively. A dermal transfer factor of 1770 to 5312 cm^2/hr will result for harvesters, based on the dermal exposure of 13,600 μg/person/day and DFR values of 0.32 to 0.96 μg/cm^2.

Schneider *et al.* (1994) monitored the exposure of peach harvesters entering treated orchards 51 days after AZM application and working 10 of the next 17 days. DFR collected during the study period ranged from 0.8 to 1.7 µg/cm^2. Dermal exposure monitoring, conducted during the first three days of harvest, showed a mean dermal exposure of 32 mg/person/day (n = 41). Urinary biomonitoring during the second, third, fourth, and fifth days of entry showed 3.2, 2.6, 4.7, and 6.2 mg/g creatinine alkylphosphates metabolites (DMP + DMTP), respectively, with a mean value of 4.2 mg/g creatinine. Mean creatinine value was 1.4 g/L with 90% of the 24-hour urine samples having a volume of greater than 700 mL. There was no difference in urinary metabolite levels between the harvesters monitored via dermal exposure and those harvesters providing 24-hour voids for biomonitoring. There was no significant difference in butyrylcholinesterase values between the harvesters and the control group. Harvesters had significantly lower acetylcholinesterase values than the control group, while no significant difference was found with the pre-exposure values.

Based on the mean dermal exposure of 32 mg/person/day and mean DFR of 1.3 µg/cm^2 observed by Schneider *et al*. (1994), an ADD of 80 µg/kg/day and a transfer factor of 3080 cm^2/hr can be calculated for peach harvesters.

The exposure estimates between the above-mentioned two studies vary almost three fold. The fact that the higher exposure estimate based from Schneider *et al.* (1994) is for workers entering treated peach orchards at a later time after the application than for McCurdy *et al*. (1994) provide further distance between these two estimates of exposure. It is interesting to observe the difference in the DFR values between these two studies, keeping in mind that McCurdy *et al*. (1994) study was conducted at the same location as that of Schneider *et al*., only a year before. This is not surprising as other DFR studies for AZM at the same location but different years have shown the same variation (Spencer *et al*., 1993; Richards *et al*., 1978). However, the DFR seem to be the driving factor in worker exposure; and the transfer factors derived from these two studies are similar and support the more conservative transfer factor used in Table 13 for harvesters.

No exposure is expected during field work in cotton, as the use on cotton has steadily declined during the past five years to zero in 1997 and 1998. The REI for grapes is 21 days. Grapes are not a major use crop compared to nut and fruit trees. Pesticide use data show that there are some uses on grapes mainly in Riverside County during the dormant season, when few work activities take place. The illness report shows some illness cases involving fruit tree pruners. Fruit tree pruning is normally performed during the dormant season. However, these illnesses occurred during May and July, indicating that the work task may have actually been removing some leaves and cutting suckers, which can be described as summer pruning. In the absence of a dermal transfer factor available for summer pruners, the exposure during this work activity can conservatively be estimated from the exposure during thinning. The exposure to thinners has already been shown.

Kraus *et al*., (1977) monitored the exposure to thinners, irrigators, and foremen entering treated peach orchards 12 to 18 hours after AZM application. It was shown that the exposure to irrigators was comparable to the exposure of foremen but minimal when compared to that of thinners. McCurdy *et al*. (1994) studied the exposure of workers performing thinning, propping, and irrigating peach orchards 30 days after AZM application. These investigators showed that the exposure to irrigators was minimal when compared to that of proppers and thinners.

Field Worker Repeated Exposure:

Azinphos-methyl is used in California almost all year long, but the majority of the applications occur during the 6 to 7 months between March and September (DPR, 1999a, 1999b, 2000). It appears that field workers are intermittently exposed between March and September. Workers may enter treated fields during March and April for thinning. In some areas, workers perform some early harvesting in May and June. In other areas, thinning occurs in July and August. Workers enter treated fields during August and September for harvest. It is highly unlikely that workers would be continuously (every day) exposed to azinphos-methyl dislodgeable residues from March through September. It would be an extreme overestimation to assume workers would enter azinphos-methyl-treated orchards exclusively every time they entered a field for work activity between March and September. It should be noted that approximately 75% of the total yearly use of azinphos-methyl is applied to nut crops such as almonds, pistachios, and walnuts that are mechanically harvested. Only the remaining 25% of the total use is on all other label-listed crops, including vegetables (DPR, 1999a, 1999b, and 2000). Field workers, however, could enter AZM-treated fields for several consecutive days and could be exposed to AZM residues repeatedly (every day) for several days. Again, it is a worst case scenario to assume that a worker will enter AZM-treated fields at the expiration of REI for several consecutive days.

Generally, the ADD is an estimate of such repeated exposure. In the case of AZM, however, human dermal absorption data suggest that some of the absorbed residues may remain in the body more than 24 hours and is carried over to the next day. Based on urinary excretion half-life of 24 hours after dermal administration of AZM in humans (Thongsinthusak *et al*., 1999), it is believed that the AZM body burden may increase after repeated exposure. Tables 14 (a) and 14 (b) show that body burden after several days of repeated exposure could reach up to 200% of a single day's exposure. At this level, the body burden reaches its steady state even if the exposure continues.

The transfer factors that were used to estimate dermal exposure to field workers were based on the dermal exposure and dislodgeable foliar residue values observed in several AZM studies (Table 12). In one of these studies (Schneider *et al*., 1990), dermal exposure was calculated from the biomonitoring results, showing AZM equivalents following several days of repeated exposure. The biomonitoring results from day 6 of exposure (the highest exposure value) were used to calculate dermal exposure. Dermal exposure was estimated from reverse calculation based on the human dermal absorption rate (see dermal absorption section). The transfer factor based on this study is somewhat less but very close to the average transfer factor that was calculated based on several studies. If we were to estimate harvesters' repeated exposure based on this study, the estimate of exposure would change very little. Therefore, the health conservative assumptions that were already taken into account (in this case, the selection of the highest exposure value after repeated exposure) and the estimated ADDs for harvesters in Table 13 are representative of the estimate of repeated exposure. However, the percent body burden of harvesters in this study can be determined and the estimate of field workers' ADD in Table 13 may be adjusted to represent body burden after repeated exposure.

In order to determine the percent body burden of harvesters in Schneider *et al*. (1990) after repeated exposure, their actual exposure scenario was applied to the scheme developed in Tables 14(a) and 14(b). In this study, workers started harvesting on day 52 post-application. Table 15 shows the percent body burden of harvesters after repeated exposure. On day 6 of exposure (day 57 post-application), body burden seems to be at 165% of a single day's exposure. Tables 14(a) and 14(b) show that daily maximum body burden after several days of repeated exposure does not exceed 200% of a single day's exposure. Therefore, the estimated ADD for harvesters in Table 13 may be assumed to be at 83% of the maximum body burden following repeated exposure.

Another study used to calculate the transfer factor for harvesters in Table 12 also contains biomonitoring results following repeated exposure for harvesters (Spencer *et al*., 1993). Transfer factors calculated based on these biomonitoring data produced similar or even lower estimates of exposure when compared to transfer factors calculated based on dermal dosimetry data.

Generally, dosimetry exposure monitoring overestimates exposure when compared to biomonitoring. Using biomonitoring data to calculate harvester repeated exposure results in estimates of exposure that are similar to or lower than those estimated from dosimetry data. However, a correction factor of 100/83 or 1.2 to the estimates of ADD in Table 13 for field workers can be applied for quantitative representation of body burden following repeated exposure.

Table 14(a)

Theoretical Azinphos-Methyl Body Burden of a Repeatedly Exposed Individual Expressed as a Percentage of Absorbed Daily Dosage[a]

Exposure day	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	Percentage of Azinphos-Methyl													
1	100	50	25	12.5	6.25	3.125	1.563	0.781	0.391	0.195	0.098	0.049	0.024	0.012
2		100	50	25	12.5	6.25	3.125	1.563	0.781	0.391	0.195	0.098	0.049	0.024
3			100	50	25	12.5	6.25	3.125	1.563	0.781	0.391	0.195	0.098	0.049
4				100	50	25	12.5	6.25	3.125	1.563	0.781	0.391	0.195	0.098
5					100	50	25	12.5	6.25	3.125	1.563	0.781	0.391	0.195
6						100	50	25	12.5	6.25	3.125	1.563	0.781	0.391
7							100	50	25	12.5	6.25	3.125	1.563	0.781
8								100	50	25	12.5	6.25	3.125	1.563
9									100	50	25	12.5	6.25	3.125
10										100	50	25	12.5	6.25
11											100	50	25	12.5
12												100	50	25
13													100	50
14														100
Cumulated Body Burden (% ADD)	100	150	175	187.5	193.75	196.88	198.44	199.22	199.61	199.80	199.90	199.95	199.98	199.99

a - Urinary excretion half-life of azinphos-methyl after topical administration in human volunteers is 24 hours (Thongsinthusak *et al*., 1999)
ADD - Absorbed daily dosage.

Table 14(b)

Theoretical Azinphos-Methyl Body Burden of an Individual Exposed Five Days a Week Expressed as a Percentage of Absorbed Daily Dosage[a]

Exposure Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	Percentage of AZM													
1	100	50	25	12.5	6.25	3.125	1.563	0.781	0.391	0.195	0.098	0.049	0.024	0.012
2		100	50	25	12.5	6.25	3.125	1.563	0.781	0.391	0.195	0.098	0.049	0.024
3			100	50	25	12.5	6.25	3.125	1.563	0.781	0.391	0.195	0.098	0.049
4				100	50	25	12.5	6.25	3.125	1.563	0.781	0.391	0.195	0.098
5					100	50	25	12.5	6.25	3.125	1.563	0.781	0.391	0.195
Saturday	No work	No work	No work	No work	No work	No work	No work	No work	No work	No work	No work	No work	No work	No work
Sunday	No work	No work	No work	No work	No work	No work	No work	No work	No work	No work	No work	No work	No work	No work
8								100	50	25	12.5	6.25	3.125	1.563
9									100	50	25	12.5	6.25	3.125
10										100	50	25	12.5	6.25
11											100	50	25	12.5
12												100	50	25
Saturday	No work	No work	No work	No work	No work	No work	No work	No work	No work	No work	No work	No work	No work	No work
Sunday	No work	No work	No work	No work	No work	No work	No work	No work	No work	No work	No work	No work	No work	No work
Cumulated Body Burden (% ADD)	100	150	175	187.5	193.75	96.88	48.44	124.22	162.11	181.05	190.53	195.26	97.63	48.82

a - Urinary excretion half-life of azinphos-methyl after topical administration in human volunteers is 24 hours (Thongsinthusak *et al.*, 1999)
ADD – Absorbed daily dosage.

Table 15

Azinphos-Methyl Repeated Exposure to Harvesters Based on Schneider *et al.*, 1990 and Their Daily Body Burden[a]

Day[b]	1	2	3	4	5	6
52	100	50	25	12.5	6.25	3.125
53		No exposure	No exposure	No exposure	No exposure	No exposure
54			100	50	25	12.5
55				No exposure	No exposure	No exposure
56					100	50
57						100
% Body Burden	100.0	50.0	125.0	62.5	131.3	165.6

a - Workers were exposed on days 52, 54, 56, and 57 post application. Exposure on day 57 (1.52 mg/day) was used in the exposure assessment to calculate a transfer factor. {Based on urinary excretion $t_{1/2}$ after topical administration in human of 24 hrs (Thongsinthusak *et al*, 1999)}.

b - Post application.

Mixer/Loader/Applicator Repeated Exposure:

Approximately 95% of total yearly use in California is applied to fruit and nut trees. As mentioned above, AZM is used mainly during the 6 to 7 months between March and September. While workers handling AZM during the application could be exposed to AZM repeatedly for several days, it seems to be a worst case scenario to assume that the same workers would be handling AZM at the maximum application rate repeatedly for several days. The estimates of ADD for handlers in Table 8 are based on the product label maximum application rate. These ADDs were adjusted for maximum application rate, assuming that exposure increases linearly with increases in the application rate. The ADDs were also normalized for a full 8-hour day, assuming that the exposure increases linearly with increases in duration of exposure. Normalizing daily exposure from less than a full day of exposure monitoring can significantly overestimate the exposure that occurs during one workday (Spencer *et al.*, 1991; Franklin *et al.*, 1981).

While the estimates of ADD for handlers in Table 8 may be overestimated due to standard assumptions, these estimates can be adjusted to show body burden following repeated exposure. To estimate body burden for handlers following repeated exposure, a correction factor of 2 (200%) may be applied to the estimates of ADD in Table 8. This is, again, based on the assumption that the body burden reaches its steady state (200% of a single day's exposure) after several days of repeated exposure, as shown in Table 14. The estimates of daily body burden, expressed as DBB, for AZM handlers and field workers following repeated exposure are shown in Table 16.

Table 16

Estimates of Azinphos-Methyl Daily Body Burden for Handlers and Field Workers Following Repeated Exposure

Work Task	Site	ADD[a]	DBB[b]
M/L/A electrostatic	Orchards	22.6 - 44.7	45.2 - 89.4
M/L/A air blast	Orchards	39.0 - 49.3	78.0 – 98.6
Pilot	Aerial applications	9.8	19.6
M/L	Aerial applications	9.5	19.0
Applicator	Ground boom	3.3	6.6
M/L	Ground boom	1.0	2.0
Applicator	Airblast	39.4	78.8
M/L	Airblast	0.5	1.0
Harvester	Peach/nectarine	80.4	96.5
Harvester	Apple	58.6	70.3
Harvester	Orange	51.1	61.3
Thinner	Peach/nectarine	77.7	93.2
Thinner	Apple	46.5	55.8
Propper	Peach/nectarine	4.1	4.9
Propper	Apple	2.4	2.9
Harvester	Vegetables/berries	4.3	5.2

a - Absorbed daily dosage (ADD) after a single day's exposure.

b - Daily body burden (DBB) after repeated exposure was based on correction factors of 2 for handlers and 1.2 for field workers.

<u>Seasonal and Chronic Occupational Exposure:</u>

As mentioned earlier, azinphos-methyl is used in California almost all year long, but the majority of the applications occur during the 6 to 7 months between March and September (DPR, 1999a, 1999b, 2000). It appears that field workers are intermittently exposed between March and September. Seasonal or chronic (annual) exposure for field workers may be estimated based on approximately 90 workdays in a season or in a year, picking peaches (Edmiston *et al.*, 1999). It is important to note that there are some uncertainties associated with this scenario. First, it is assumed that a field worker works in AZM-treated fields eight hours a day for 90 days during the season. Second, it is assumed that the same worker enters AZM-treated field as soon as the REI expires, consistently, during those 90 days. These assumptions tend to be conservative.

Although AZM is also applied during the dormant season, the total amount applied is minute compared to the total yearly use. Therefore, the season for exposure to handlers also seems to be mainly during the 6 to 7 months between March and September. However, handlers are also intermittently exposed during the season. The frequency of exposure to handlers during a season is assumed to be much less than those of field workers. In Kern County, which has the highest yearly use (nearly 140,000 lb or approximately 30% of the total yearly use in California), it will take 1,000 workdays to apply 67% of the total use by airblast application. There are approximately 300 certified applicators, 250 licensed applicators, and 20 certified pilots in Kern County. Assuming 50 applicators will be involved in the ground application of AZM in Kern

County, each applicator will spend 20 days in a season applying AZM. The remaining 33% by air will only take 10 workdays for four pilots to apply. Seasonal or annual exposure to ground applicators and aerial applicators may be estimated based on 20 and 10 days of exposure, respectively, during a season or a year. These estimates are based on an application rate of 2 lb a.i./acre, an airblast applicator treating 50 acres/day, and a pilot treating 500 acres/day (Haskell, 1998). It seems relevant to mention the U.S. EPA recently reduced total annual application to some crops by 25%. This could reduce the frequency of application and, therefore, the frequency of exposure to AZM applicators.

Table 17

Estimates of Azinphos-Methyl Annual Average Daily Dosage for Handlers and Field Workers

Work Task	Site/Application method	ADD[a]	SADD[b]	AADD[c]
M/L/A electrostatic	Orchard	22.6 - 44.7	2.15 - 4.26	1.24 - 2.45
M/L/A air blast	Orchard	39.0 - 49.3	3.71 - 4.70	2.14 - 2.70
Pilot	Aerial applications	9.8	0.47	0.27
M/L	Aerial applications	9.5	0.45	0.26
Applicator	Ground boom	3.3	0.31	0.18
M/L	Ground boom	1.0	0.10	0.05
Applicator	Airblast	39.4	3.75	2.16
M/L	Airblast	0.5	0.05	0.03
Harvester	Peach/nectarine	80.4	34.5	19.82
Harvester	Apple	58.6	25.1	14.45
Harvester	Orange	51.1	21.9	12.60
Thinner	Peach/nectarine	77.7	33.3	19.16
Thinner	Apple	46.5	19.9	11.47
Propper	Peach/nectarine	4.1	1.8	1.01
Propper	Apple	2.4	1.0	0.59
Harvester	Vegetable/berry	4.3	1.8	1.06

a - Absorbed daily dosage (AADD) after a single day's exposure.
b - Seasonal average daily dosage (SADD): based on 10, 20, and 90 days of exposure in a 7-month (210-day) season for aerial applicators, ground applicators, and field workers, respectively.
c - Annual average daily dosage (AADD): based on 10, 20, and 90 days of exposure in a year for aerial applicators, ground applicators, and field workers, respectively.

<u>Non-occupational Exposure:</u>
AZM is used exclusively on agricultural crops. There are no residential or home garden uses. However, Simcox *et al*., (1995) found low levels of residues (1 to 88 ug/m^2 carpet) in the carpet dust of residential dwellings near agricultural areas where AZM is applied. At these levels, no significant non-dietary exposure is expected to the general population.

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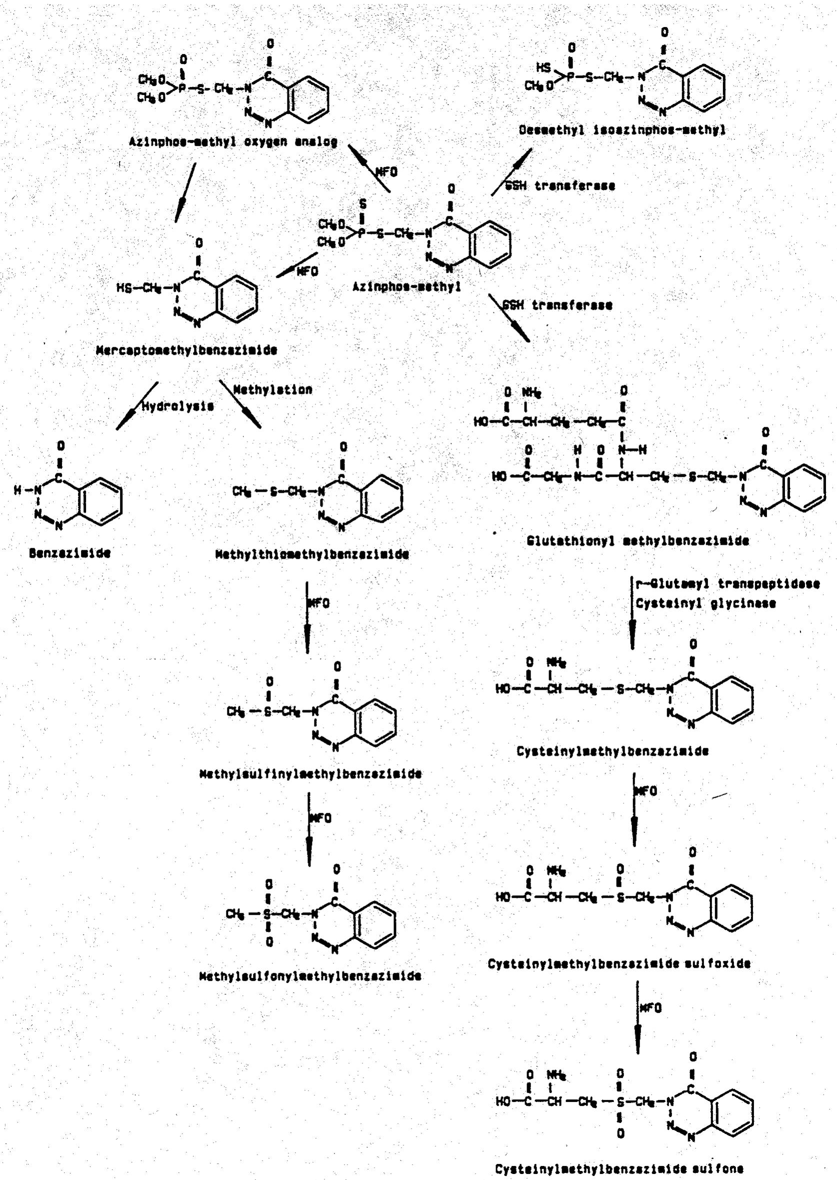
Figure 1

Proposed Metabolic Pathway of Azinphos-methyl in Rats (Reference 10)



Appendix A

Pesticide Handers Exposure Database (PHED)

Subset Specifications and Summary Statistics for:
Pilot, mixer/loader, airblast applicator, and ground boom applicator

DATA ANALYSIS SECTION: File/Subset Selection

Name: AZMPILOT.APPL

Pilot

<< specifications >> Page 1 of 2

Subset Specifications:

With Cab Type Equal to 3 (closed cockpit)
Subset originated from AZMPILOT.APPL
With Dermal Grade Uncovered Equal to "A" "B"
With Hand Grade Equal to "A" "B"
With Application Method Equal to 5 (fixed wing) or Equal to 6 (rotary wing)
Subset originated from APPL.FILE

Record I.D.	Dermal Grade Uncovered	Hand Grade	Application Method Code	Total AI Applied (lb)	Total Number of Acres	Cab Type Code
1001*B*02	A	A	5	1568.7000	835.0000	3
1001*B*03	A	A	5	852.1800	756.0000	3
1001*B*04	A	A	5	1191.5000	1057.0000	3
1001*F*Ol	A	A	5	1531.1000	815.0000	3
1001*F*02	A	A	5	1429.7000	761.0000	3
1001*F*03	A	A	5	681.9700	605.0000	3
1001*F*04	A	A	5	1196.0000	1061.0000	3
1014*BB*02	B	B	5	12.0000	200.0000	3
1014*BB*03	B	B	5	12.0000	200.0000	3
1014*BB*04	B	B	5	12.0000	200.0000	3
1014*BB*05	B	B	5	12.0000	200.0000	3
1014*BB*06	B	B	5	12.0000	200.0000	3
1001*B*Ol	A	A	5	1531.1000	815.0000	3
0422*A*Ol	A	B	5	300.0000	100.0000	3
0422*A*02	A	B	5	300.0000	100.0000	3
0447*BB*l	A	B	5	32.0000	160.0000	3
0447*BB*2	A	B	5	32.0000	160.0000	3
0447*BB*3	A	B	5	32.0000	160.0000	3
1014*AA*Ol	B	B	5	12.0000	200.0000	3
0447*AA*l	A	B	5	24.0000	120.0000	3
0447*AA*2	A	B	5	32.0000	160.0000	3
0447*AA*3	A	B	5	24.0000	120.0000	3
1014*AA*03	B	B	5	12.0000	200.0000	3
1014*AA*02	B	B	5	12.0000	200.0000	3
1014*AA*04	B	B	5	12.0000	200.0000	3
1014*AA*05	B	B	5	12.0000	200.0000	3
1014*AA*06	B	B	5	12.0000	200.0000	3
1014*BB*Ol	B	B	5	12.0000	200.0000	3

SUMMARY STATISTICS FOR CALCULATED DERMAL EXPOSURES

SCENARIO: Long pants, long sleeves, and no gloves

		MICROGRAMS	PER LB AI SPRAYED			
PATCH LOCATION	DISTRIBUTIO N TYPE	Median	Mean	Coefficient of Variation	Geometric Mean	Obs.
HEAD (ALL)	Other	0.13	0.4689	190.9362	0.2178	28
NECK.FRONT	Other	0.015	0.0413	164.4068	0.0239	28
NECK.BACK	Other	0.011	0.033	181.8182	0.0169	28
UPPER ARMS	Other	0.291	0.3274	44.4411	0.3117	16
CHEST	Other	0.355	0.355	0	0.355	14
BACK	Other	0.355	0.355	0	0.355	14
FOREARMS	Other	0.121	0.1452	35.124	0.139	10
THIGHS	Other	0.382	0.382	0	0.382	14
LOWER LEGS	Other	0.238	0.2975	54.6555	0.273	16
FEET	Lognormal	0.393	0.4803	88.8195	0.3311	12
HANDS	Lognormal	2.1658	10.1422	228.5707	3.0559	26
TOTAL DERM	5.285	4.4568	13.0278		5.4613	
INHALATION	Lognormal	0.0165	0.0229	98.69	0.014	16
COMBINED	5.299	4.4733	13.0507		5.4753	

95% C.I. on Mean: Dermal: [-269.0653, 295.1209]
95% C.I. on Geometric Mean: Inhalation: (.0015, .12861
Inhalation Rate: 14 Liters/Minute
Number of Records: 28
Data File: APPLICATOR
Subset Name: AZMPILOT.APPL
Dermal exposure with gloves = 13.0 - (10.1 * 90%) = 3.9 µg/lb a.i.

DATA ANALYSIS SECTION: File/Subset Selection

Name: AZMWSP.MLOD

Mixer/Loader

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Subset Specifications:

With Outdoor Equal to "X”
Subset originated from TEMP.NAME.MLOD
With Packaging Type Equal to 4 (water soluble packet)
Subset originated from MLOD.FILE

Record I.D.	Dermal Grade Uncovered	Hand Grade Uncovered	Solid Type code	Package Code	Mix Procedure Code	Total AI Applied (lb)	Site outdoor
0517*ML*08	A	D	1	4	1	3.0000	x
0518*ML*02	A	B	1	4	1	0.8000	x
0518*ML*03	A	B	1	4	1	1.2000	x
0518*ML*04	A	B	1	4	1	1.2000	x
0518*ML*05	A	B	1	4	1	0.8000	x
0518*ML*06	A	B	1	4	1	0.8000	x
0438*JH*Ol	A		1	4	1	6.2500	x
0437*AR*Ol	B	B	1	4	1	9.0000	x
0438*JH*02	A	A	1	4	1	6.2500	x
0438*JH*03	A	A	1	4	1	6.2500	x
0517*ML*05	A	D	1	4	1	1.5000	x
0517*ML*06	A	D	1	4	1	1.5000	x
0437*DD*02	B	B	1	4	1	9.0000	x
0437*JF*03	B	B	1	4	1	9.0000	x
0518*ML*Ol	A	B	1	4	1	0.8000	

SUMMARY STATISTICS FOR CALCULATED DERMAL EXPOSURES

SCENARIO: Long pants, long sleeves, gloves

		MICROGRAMS PER LB AI MIXED				
PATCH LOCATION	DISTRIUTION TYPE	Median	Mean	Coefficient of Variation	Geometric Mean	Obs.
HEAD (ALL)	Lognormal	1.3	3.51	165.0541	1.1942	15
NECK.FRONT	Lognormal	0.15	0.423	155.9811	0.1734	15
NECK.BACK	Lognormal	0.088	0.2933	167.61	0.0978	15
UPPER ARMS	Lognormal	2.91	2.619	17.2127	2.5837	6
CHEST	Lognormal	1.5975	1.8046	83.2317	1.1207	12
BACK	Lognormal	1.5975	1.8046	83.2317	1.1207	12
FOREARMS	Lognormal	1.21	1.089	17.2176	1.0743	6
THIGHS	Lognormal	2.674	4.9023	204.1674	1.6636	12
LOWER LEGS	Lognormal	0.952	1.19	86.1261	0.7092	12
FEET						0
HANDS	Other	0.0625	0.963	149.9169	0.1991	9
TOTAL DERM	9.8001	12.5415	18.5988		9.9367	
INHALATION	Lognormal	0.1279	1.6647	201.9703	0.1794	15
COMBINED:	9.9795	12.6694	20.2635		10.1161	

95% C.I. on Mean: Dermal: [-190.8906, 228.0882]
95% C.I. on Geometric Mean: Inhalation: (.0018, 18.0785]
Inhalation Rate: 14 Liters/Minute
Number of Records: 15
Data File: MIXER/LOADER
Subset Name: AZMWSP.MLOD

DATA ANALYSIS SECTION: File/Subset Selection

Name: AZMAIRBLAST.APPL

Airblast applicator

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Subset Specifications:

With Cab Type Equal to 1
With Dermal Grade Uncovered Equal to "A” "B"
With Hand Grade Equal to “A” "B"
With Application Method Equal to 1
Subset originated from APPL.FILE

Record I.D.	Dermal Grade Uncovered	Hand Grade Uncovered	Applicatio n Method Code	Total AI Applied (lb)	Total Number of Acres	Cab Code	Site Outdoors
0435*LD*Ol	B	A	1	0.9300	10.0000	1	x
0460*F*Ol	A	A	1	3.7500	20.0000	1	x
0460*F*03	A	A	1	3.7500	20.0000	1	x
0460*B*Ol	A	A	1	3.7500	20.0000	1	x
0460*B*03	A	A	1	3.7500	20.0000	1	x
0460*A*04	A	A	1	2.8100	15.0000	1	x
0518*SP*Ol	A	B	1	0.8000	6.4000	1	x
0518*SP*02	A	B	1	0.8000	6.4000	1	x
0518*SP*03	A	B	1	1.2000	9.6000	1	x
0518*SP*04	A	B	1	1.2000	9.6000	1	x
0518*SP*05	A	B	1	0.8000	6.4000	1	x
0432*RG*Ol	A	A	1	0.0700	2.5000	1	x
0432*RG*02	A	A	1	0.1200	3.7000	1	x
0434*GD*Ol	B	B	1	0.1400	12.5000	1	x
0434*GD*02	B	B	1	0.1000	12.5000	1	x
0460*E*02	A	A	1	2.8100	15.0000	1	x
0460*E*04	A	A	1	2.3400	12.5000	1	x
0460*E*06	A	A	1	2.8100	15.0000	1	x
0460*A*02	A	A	1	2.8130	15.0000	1	x
0460*A*05	A	A	1	2.8100	15.0000	1	x
0518*SP*06	A	B	1	0.8000	6.4000	1	x
0435*JK*Ol	B	A	1	1.2400	12.6000	1	x
0435*JK*02	B	A	1	1.2100	12.6000	1	x
0460*F*05	A	A	1	3.7500	20.0000	1	x
0460*B*06	A	A	1	3.7500	20.0000	1	x

SUMMARY STATISTICS FOR CALCULATED DERMAL EXPOSURES

SCENARIO: Long pants, long sleeves, and gloves

PATCH LOCATION	DISTRIBUTION TYPE	MICROGRAMS PER LB AI SPRAYED Median	Mean	Coefficient of Variation	Geo. Mean	Obs.
HEAD (ALL)	Lognormal	593.84	1271.2304	114.7723	369.0357	23
NECK.FRONT	Lognormal	33.765	55.4936	121.7479	17.9167	21
NECK.BACK	Lognormal	15.367	38.202	141.4392	11.3228	23
UPPER ARMS	Lognormal	21.0975	71.4841	214.556	19.1152	20
CHEST	Lognormal	8.52	29.1242	155.5253	11.1965	25
BACK	Lognormal	5.325	12.1552	121.4122	6.5403	25
FOREARMS	Lognormal	7.381	9.5792	115.5138	4.9374	18
THIGHS	Lognormal	27.122	55.772	197.8737	17.5502	23
LOWER LEGS	Lognormal	14.994	20.706	119.5253	8.3523	23
FEET					0	
HANDS	Lognormal	10.6667	8.5261	74.1769	2.4288	18
TOTAL DERMAL	468.3959	738.0782	1572.2728		468.3959	
INHALATION	Lognormal	1.6014	5.8126	232.9353	1.2868	25
COMBINED	469.6827	739.6796	1578.0854		469.6827	

95% C.I. on Mean Dermal: [-17504.3198, 20648.8654]
95% C.I. on Geometric Mean: Inhalation: [.0301, 55.0533]
Inhalation Rate: 14 Liters/Minute
Number of Records: 25
Data File: APPLICATOR
Subset Name: AZMAIRBLAST.APPL

DATA ANALYSIS SECTION: File/Subset Selection

Name: AZMBOOM.APPL

Ground Boom Applicator

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Subset Specifications:

With Application method Equal to 2
With Dermal Grade Uncovered Equal to “A" "B"
With Hand Grade Equal to "A” "B"
With Cab Type Equal to 1
Subset originated from APPL.FILE

Record I.D.	Dermal Grade Uncovered	Hand Grade	Site outdoors	Application Method Code	Total AI Applied (lb)	Cab Code	Total Number of Acres
1025*AA*Ol	B	A	x	2	90.0000	1	57.0000
1025*GG*Ol	B	A	x	2	21.0000	1	23.0000
0427*H*Ol	A	B	x	2	12.4000	1	10.0000
0427*F*03	A	B	x	2	6.0000	1	5.0000
0437*JF*Ol	B	B	x	2	9.0000	1	6.4000
0437*TS*02	B	B	x	2	9.0000	1	6.4000
1008*A*04	A	A	x	2	17.0300	1	10.3800
1008*A*Ol	A	A	x	2	24.3200	1	14.8300
1008*A*02	A	A	x	2	14.2900	1	8.7150
1008*A*03	A	A	x	2	17.3300	1	10.5700
1008*A*05	A	A	x	2	18.8500	1	11.5000
1025*BB*Ol	B	A	x	2	124.0000	1	61.0000
1025*HH*Ol	B	A	x	2	27.0000	1	29.0000
0465*D*l	A	A	x	2	60.0000	1	20.0000
0465*J*l	A	A	x	2	60.0000	1	20.0000
0465*K*l	A	A	x	2	60.0000	1	20.0000
0465*L*l	A	A	x	2	60.0000	1	20.0000
1025*CC*Ol	B	A	x	2	108.0000	1	38.0000
1025*II*Ol	B	A	x	2	23.5000	1	25.0000
0437*RT*03	B	B	x	2	9.0000	1	6.4000
0438*PA*Ol	A	A	x	2	6.2500	1	5.0000
0438*PA*02	A	A	x	2	6.2500	1	5.0000
0438*PA*03	A	A	x	2	6.2500	1	5.0000
0430*BH*Ol	B	A	x	2	1.8100	1	21.6000
0465*E*l	A	A	x	2	60.0000	1	20.0000

0465*F*l	A	A	x	2	60.0000	1	20.0000

SUMMARY STATISTICS FOR CALCULATED DERMAL EXPOSURES

SCENARIO: Long pants, long sleeves, and no gloves

PATCH LOCATION	DISTRIBUTION TYPE	MICROGRAMS PER LB AI SPRAYED Median	Mean	Coefficient of Variation	Geometric Mean	Obs.
HEAD (ALL)	Lognormal	0.91	2.5584	135.6629	0.9209	25
NECK.FRONT	Lognormal	0.2175	1.4198	193.4287	0.249	20
NECK.BACK	Lognormal	0.132	0.9209	208.2962	0.1602	21
UPPER ARMS	Lognormal	0.873	1.5928	104.8405	0.96	19
CHEST	Other	0.71	1.5827	121.7792	0.8873	24
BACK	Other	0.71	1.775	110.6479	0.9972	24
FOREARMS	Lognormal	0.363	4.0758	364.3947	0.5167	19
THIGHS	Other	0.382	0.7216	86.8764	0.5688	18
LOWER LEGS	Other	0.238	0.4879	78.2947	0.3912	20
FEET						0
HANDS	Lognormal	6.5323	50.876	179.5501	9.4044	26
TOTAL DERM	14.2512	11.0678	66.0109		15.0557	
INHALATION	Lognormal	0.2441	0.7917	172.2117	0.322	26
COMBINED	14.5732	11.3119	66.8026		15.3777	

95% C.I. on Mean: Dermal: [-1066.7833, 1198.8051]
95% C.I. on Geometric Mean: Inhalation: [.0206, 5.0235]
Inhalation Rate: 14 Liters/Minute
Number of Records: 26
Data File: APPLICATOR
Subset Name: AZMBOOM.APPL