AUSTRALIAN PESTICIDES AND VETERINARY MEDICINE AUTHORITY

NATIONAL REGISTRATION SCHEME

FOR AGRICULTURAL AND VETERINARY CHEMICALS

AUSTRALIA

CHEMICALS REVIEW PROGRAM

OCCUPATIONAL HEALTH AND SAFETY ASSESSMENT

OF

AZINPHOS METHYL

SUPPLEMENTARY EXPOSURE DATA

Prepared by the

OFFICE OF THE CHEMICAL SAFETY

of the

Department of Health and Ageing

Canberra

Report prepared November 2005

TABLE OF CONTENTS

LIST OF TABLES

GLOSSARY OF TERMS AND ABBREVIATIONS

ai	Active ingredient
bw	Body weight
cm^3	Cubic centimetre
g	Gram
ha	Hectare
h	Hour
kg	Kilogram
L	Litre
m^2	Square metre
m^3	Cubic metre
mg	Milligram
min	Minute
ml	Millilitre
oz	Ounce
μg	Microgram

APVMA	Australian Pesticides and Veterinary Medicines Authority
ChE	Cholinesterase
DFR	Dislodgeable foliar residue
DoHA	Department of Health and Ageing
EC	Emulsifiable concentrate
CRP	Chemical Review Program
MOE	Margin of exposure
NOEL	No Observed Effect Level
OCS	Office of Chemical Safety
OHS	Occupational Health and Safety
PPE	Personal protective equipment
PVC	Polyvinyl chloride
RBC	Red blood cell
WP	Wettable powder

1 EXECUTIVE SUMMARY

Azinphos-methyl is used to control pests such as codling moth, light brown apple moth, oriental fruit moth, pear and cherry slug in a range of fruit (eg apple, pear, nectarine, peach, apricot, grape, citrus and berry) orchards. Azinphos-methyl products are applied by mechanized sprayers (air blast, air shear) or by hand-held sprayers. Workers may be occupationally exposed to azinphos methyl during mixing, loading, and applying the pesticide, or to foliar residues during harvesting or pruning some days or weeks after application.

A previous occupational health and safety review of azinphos-methyl (Jan, 2005) concluded that the use of currently-registered azinphos-methyl products may pose an unacceptable risk to worker safety, and recommended that the APVMA consider immediate cancellation of uses where suitable alternatives already existed, and a phase-out period for all other uses. The recommendation was based on scientific evidence of unacceptably high worker exposure and concurrent inhibition of cholinesterase activity in blood during the harvesting of fruit treated with azinphos-methyl.

Additional studies have now been submitted to the APVMA and have been evaluated in this review. Biomonitoring and DFR studies were conducted to investigate the extent of worker exposure during various agricultural tasks. The exposure data in the studies were used to determine the occupational risk to workers during mixing/loading, application and post-application activities. The risk is determined by a margin of exposure (MOE), which is a measure of how close the likely occupational exposure comes to the NOEL observed in an appropriate animal or human study. The risk assessment used an internal (NOEL) dose of 0.25 mg/kg bw/day from a 4-week human dietary study. A MOE of 10 or more was considered to be acceptable.

Acceptable MOEs were obtained for airblast spray applicators using a closed cab system or for those wearing waterproof clothing, protective chemical resistant gloves and a respirator. However, the supplementary data submission assessed in this review did not contain any data on application by hand-held equipment, which the previous review had concluded would result in toxicologically unacceptable operator exposure. Therefore, azinphos-methyl application by hand-held equipment is not supportable.

Post-application activities (thinning and harvesting) in blueberry crops and in orchards resulted in low worker exposures indicating low risk to workers during these activities. Based on the supplementary data, re-entry intervals of one day have been recommended for blueberries and fruit and nut trees and 14 days for kiwi fruit. The REI for grapes is 14 days for all activities except grape girdling and cane turning. An enhanced REI of 44 days has been recommended for grape girdling and cane turning, because workers will be more heavily exposed to foliar residues of azinphos-methyl when performing these activities. Amendments have been made to the existing Safety Directions for registered products that are still supported.

2 INTRODUCTION

Azinphos-methyl is an organophosphate chemical used in crop protection. In Australia, products containing azinphos-methyl are used to control pests such as codling moth, light brown apple moth, oriental fruit moth, pear and cherry slug in a range of fruit (eg apple, pear, nectarine, peach, apricot, grape, citrus and berry) orchards.

A previous OCS occupational health and safety review, completed in January 2005, concluded that there were inadequate MOEs for workers applying azinphos-methyl or tending and harvesting crops treated with the chemical. The OCS recommended that the use of products containing azinphos-methyl should be discontinued. In response to the findings of the review, Bayer CropScience Pty Ltd has submitted new occupational exposure studies to support the continued use of azinphos-methyl products in Australia. This report provides a summary of the studies and a determination of occupational risk to workers handling azinphos-methyl products and performing post-application activities in areas treated with azinphos-methyl products.

3 MEASURED OCCUPATIONAL EXPOSURE

Krolski ME (2004) Azinphos-methyl – Biological monitoring of applicators following airblast treatment of orchard crops using open and closed cab equipment. Bayer CropScience Study Numbers GU264704 and GU264705 Report Number 201054. Bayer Research Park, Stilwell, KS USA.

Study and observations: The purpose of the study was to determine the extent of exposure to azinphos-methyl in workers mixing/loading/applying GUTHION 50 WP (500 g/kg azinphos-methyl, in water soluble packaging) to orchard crops using airblast sprayers. The study was designed to fulfil the requirements of the US EPA Series 875: "Occupational and Residential Exposure Test Guidelines". A total of 30 mixing/loading/application field trials were conducted at separate locations, 15 trials were performed using closed cab equipment and 15 were performed using open cab and protective PPE equipment. Details of the type of cabins are not provided and it is not clear if they were fitted with appropriate filtering devices to protect against chemicals.

Applicators in open cabs sprayed 17 – 127 pounds GUTHION 50 WP (3.8 kg – 28.8 kg azinphos-methyl) on 13.7 – 119 acres of orchard (5.55 – 48 hectares) with an average application rate of 0.9 lb ai/acre (1 kg ai/ha), and spent an average seven hours (4:50 – 11:55 hours) over the course of a typical day. Applicators in closed cabs sprayed 40 – 104 pounds GUTHION 50 WP (9.07 – 23.6 kg azinphos-methyl) on 19.7 – 59.84 acres of orchard (8 – 24 hectares) with an average application rate of 0.844 lb ai/acre (0.95 kg ai/ha), and spent an average eight hours (6:15 – 11:39 hours).

Personal protective equipment: During mixing/loading, workers wore long-sleeved shirt, long pants, chemical resistant gloves (butyl rubber, nitrile rubber or PVC), a chemical resistant apron (butyl rubber, nitrile rubber, PVC), protective eyewear and shoes and socks. Applicators in the open cab trials wore TYVEK overalls over long-sleeved shirt and long pants and chemical resistant gloves, chemical resistant footwear, socks, chemical resistant headgear and protective eyewear. A respirator with an organic vapour-removing cartridge with a prefilter approved for pesticides was also used. Applicators in the closed cab wore long-sleeved shirt, long pants and shoes plus socks.

Biological monitoring: Methylsulfonylmethylbenzazimide (MSMB), a metabolite of azinphos-methyl, excreted mostly in the urine of persons exposed to azinphos-methyl was used as a marker to measure total absorbed azinphos-methyl during end-use and post-application activities. The total urine output for each 24-hour period was collected from each worker performing mixing/loading/application. The urine collection started in the morning of the day before the application started (-1 day; control sample). Subsequently, 24-hour urine samples were collected over the next five days (Day-0 to Day 4). From the results of a dermal pharmacokinetic study with human volunteers, it was known that 90% of the total radioactivity excreted in urine was eliminated within 5 days (Selim, 1999). The total volume of each 24-hour urine sample was measured, mixed by shaking and then duplicate 50-mL sub-samples were transferred to separate containers and sent to laboratories for analysis.

Inhalation exposure monitoring: The potential azinphos-methyl inhalation exposure of each worker was measured using an OVS tube connected to a pump calibrated at an airflow rate of 2 L/min. The OVS tube was attached to the worker’s belt and air-samples were collected by operating the pump over the entire workday, including during breaks. No differentiation was made between mixing/loading and application as every worker carried out all these activities.

Field recovery: Assessment of the stability of residues in urine samples as well as in the inhalation exposure sampling tubes under field, storage and transit conditions was carried out. The stability of the metabolite in an acidic medium was assessed by fortifying urine from unexposed persons with MSMB. Field recovery and blank samples were prepared and treated in the same manner as the test samples.

Analytical methods: For each re-entry activity, the urine samples were analysed for MSMB residue and the OVS tube samples were analysed for azinphos-methyl and azinphos-methyl oxon using high-pressure liquid chromatography-triple stage quadrupole mass spectrometry (lc-ms/ms). They were analysed as analytical sets composed of laboratory control samples, laboratory fortification samples, field control samples, field fortification samples and field samples. The MSMB residue in the urine and the azinphos-methyl and azinphos-methyl oxon residue on the OVS tube from workers were corrected to 100% recovery based on the recoveries of the field fortification samples. Blood samples were analysed for plasma and red blood cell cholinesterase activity.

The amount of MSMB measured was directly corrected for the differences in molecular weight between azinphos-methyl (317.3 g/mol) and MSMB (239.0 g/mol) and is expressed in azinphos-methyl equivalents. Additionally, the residue data for each sample was corrected to 100% based on the recovery of the fortified urine samples. Calculation of the internal dose of azinphos-methyl based on the amount of MSMB in urine was performed by correcting for the fraction of the absorbed dose of azinphos-methyl that was identified as MSMB in urine in a previous work in which MSMB represented 8.2% of the absorbed dose of azinphos-methyl (Lunchick 2003).

The amount of azinphos-methyl sprayed and the total area treated by open and closed cab tractors are provided in Table 1. The applicators in open cabs sprayed an average 11.3 kg azinphos-methyl in 7 h 12 minutes and applicators in the closed cabs sprayed an average 14.3 kg azinphos-methyl in 8 h 13 minutes. Application rates for open cab and closed cab workers were standardised to an 8 h-work day (12.55 kg and 13.92 kg, respectively per 8 h). The exposure for each volunteer resulting from mixing/loading and application of azinphos-methyl was then corrected to the average amount of azinphos-methyl sprayed in a 8 h work day.

Table 1: Amount of azinphos-methyl mixed/loaded and applied using airblast with open and closed cabs

	Open cab/Waterproof PPE			Closed cab		
Volunteers	**Exposure period* (h)**	**Total area treated (ha)**	**Total azinphos-methyl sprayed (kg)**	**Exposure period* (h)**	**Total area treated (ha)**	**Total azinphos-methyl sprayed (kg)**
1	9:43	20	15.87	7:48	12.9	10.9
2	11:55	48	28.8	7:20	12.1	10.2
3	9:16	12.9	15.85	9:50	20.2	17.0
4	10:49	14.5	15.2	8:18	20.2	17.0
5	5:32	9.61	7.2	8:26	15.5	11.3
6	4:50	8.26	10.0	8:11	14.5	13.6
7	6:02	5.55	3.85	8:44	18.2	16.3
8	7:07	9.7	10.9	8:29	18.2	20.4
9	5:50	6.5	7.2	6:46	13.0	14.8
10	6:14	8.1	9.1	8:30	20.2	18.2
11	6:27	8.1	9.1	7:03	8.0	9.1
12	5:59	8.1	9.1	9:20	20.2	14.1
13	6:04	8.1	9.1	11:39	24.2	23.6
14	6:10	8.1	9.1	6:39	8.1	9.1
15	5:56	8.1	9.1	6:15	8.1	9.1
Arithmetic Mean	**7:12**	**12.24**	**11.3**	**8:13**	**15.6**	**14.3**

*Time taken to mix/load and spray total amount of the active

Findings:

Urine sampling was conducted for five days following exposure and urinary MSMB residues were used to determine the internal dose of azinphos-methyl [pharmacokinetic studies with human volunteers showed that 90% of the total radioactivity excreted in urine occurred within 5 days (Selim, 1999)]. Calculated exposure ranged between 0.047 and 0.534 µg/kg azinphos-methyl handled/kg bw in volunteers using open cab application equipment (mean = 0.2 µg/kg azinphos-methyl handled/kg bw) and between 0.002 to 0.171 µg/kg azinphos-methyl handled/ kg bw in volunteers using closed cab application equipment (mean = 0.04 µg/kg azinphos-methyl handled/kg bw) (Table 2). The average potential inhalation exposure was 0.35 µg/kg azinphos-methyl handled/kg bw for mixer/loader/applicators using open cab equipment and 0.02 µg/kg azinphos-methyl handled/kg bw using closed cab equipment (Table 3).

Table 2: Systemic concentrations of azinphos-methyl calculated from urinary MSMB

	Open Cab/Waterproof PPE			Closed Cab		
Volunteers	**Total MSMB excreted (µg)***	**Calculated systemic azinphos-methyl dose (µg)****	**Internal azinphos-methyl dose (µg/kg handled/kg bw)†**	**Total MSMB excreted (µg)***	**Calculated systemic azinphos-methyl dose (µg)****	**Internal azinphos-methyl dose (µg/kg handled/kg bw)†**
1	7.74	94.4	0.065	1.346	16.4	0.014
2	27.08	330.3	0.121	13.03	159.0	0.171
3	0.35	4.27	0.003	6.991	85.3	0.049
4	29.86	364.3	0.285	0.306	3.7	0.002
5	14.38	175.4	0.249	1.421	17.3	0.022
6	20.58	251.1	0.380	4.001	48.8	0.031
7	2.19	26.8	0.089	6.554	80.0	0.067
8	16.38	199.8	0.213	1.804	22.1	0.014
9	2.53	30.9	0.052	0.346	4.2	0.004
10	8.35	101.9	0.159	4.081	49.8	0.028
11	19.23	234.6	0.343	0.842	10.3	0.015
12	34.23	417.7	0.534	9.542	116.4	0.087
13	21.84	266.4	0.348	6.712	81.9	0.038
14	4.20	51.3	0.069	2.037	24.9	0.039
15	2.64	32.2	0.047	1.705	20.8	0.027
Arithmetic Mean			**0.2**			**0.04**

*Total MSMB excreted from day 0 to day 4.

**Azinphos-methyl residues were calculated by dividing the measured MSMB residue value by the percent recovery for the corresponding field recovery and then multiplying the result by 12.2 to correct for the fraction of the internal azinphos-methyl dose represented by MSMB in urine.

† Actual bodyweight of operators used in calculation.

Table 3: Inhalation exposure during mixing/loading/application of Guthion 50 WP

Volunteers	Open Cab/Waterproof PPE			Closed cab		
	Measured azinphos-methyl equivalents (µg) *	Inhaled dose (µg) **	Inhaled dose (µg/kg azinphos-methyl handled/kg bw)†	Measured azinphos-methyl equivalents (µg) *	Inhaled dose (µg) **	Inhaled dose (µg/kg azinphos-methyl handled/kg bw)†
1	18.23	264.4	0.183	0.689	10.0	0.009
2	17.40	252.3	0.092	1.13	16.3	0.018
3	14.58	211.4	0.147	1.68	24.5	0.014
4	26.84	389.2	0.305	0.79	11.4	0.007
5	5.84	84.7	0.120	2.87	41.7	0.052
6	21.94	318.1	0.482	4.21	61.0	0.039
7	17.04	247.1	0.823	1.89	27.4	0.023
8	10.51	152.4	0.167	1.06	15.4	0.009
9	Sample lost			0.29	4.3	0.004
10	29.15	422.7	0.334	1.31	18.9	0.010
11	31.03	449.9	0.659	0.45	6.60	0.010
12	21.22	307.6	0.393	1.04	15.0	0.011
13	30.07	435.9	0.574	7.06	102.3	0.048
14	15.10	219.0	0.293	0.92	13.4	0.021
15	19.12	277.2	0.406	1.04	15.1	0.019
Arithmetic Mean			**0.35**			**0.02**

*Sum of azinphos-methyl and azinphos-methyl oxon expressed as azinphos-methyl equivalents.

**Residue adjusted for average human respiration rate (29 L/min) compared to collection rate (2 L/min)

† Actual bodyweight of operators used in calculation.

Comment: The total internal azinphos-methyl dose was found to be low in open and closed cab applicators indicating that the PPE worn was adequate in protecting workers. Comparison of the data from mixer/loader/applicators using open cab and closed cab equipment indicated that closed cab reduced total dermal and inhalation exposure five-fold and potential inhalation exposure 15-fold, even though applicators in the closed cab wore less PPE than those in open cab (long-sleeved shirt and long pants as compared to TYVEK overalls over long-sleeved shirt and long pants, respirator and chemical resistant gloves, footwear and headgear worn by open cab workers). Excretion of MSMB in the urine was higher on Day 0 and Day 1 for operators of open cab equipment when compared to the closed cab workers; however by the third day following exposure, MSMB levels in urine were similar in both groups. By the fourth day following exposure, levels were at or below background, indicating that azinphos-methyl is cleared from the body fairly quickly.

The highest application rate for orchards in Australia is 0.98 kg azinphos-methyl per hectare. Relative to the usual Australian work rate of 15-20 ha per 8 h day (rate advised by APVMA) that is considered to be representative for most crops the work rate described in this trial was slightly lower, ie 13.75 ha per 8 h day. However, this slight difference is not expected to impact significantly on the MOE for product spraying (ie. application). Potentially a more significant impact on the mixing/loading MOE might be anticipated because the product used in this study was a wettable powder formulation packaged in water-soluble sachets. This is likely to result in a slight underestimate of the overall MOE for azinphos-methyl mixing/loading/application. The extent of exposure to active constituent from mixing/loading azinphos-methyl products therefore could not be estimated from this study.

Fischer DR (2004a) Guthion 50WP – Biological monitoring of post-application workers during manual thinning and harvesting of apples. Bayer CropScience Study Number GU264701; Report Number 201042. Bayer Research Park, Stilwell, KS USA.

Study and observations: The objective of this study was to determine the potential dermal and inhalation exposure to azinphos-methyl and change in blood cholinesterase activity of workers performing manual thinning and harvesting of apples following airblast spray application of azinphos-methyl.

Two apple field trials, one in New York and one in Oregon were included in the study. GUTHION 50 WP (a wettable powder formulation containing 50% azinphos-methyl and packaged in water soluble packets) was applied in both trials according to label specifications. The application rate was determined using the target rate (pounds ai/acre) and the amount of spray required for full coverage of large trees for dilute spray application (eg. 300 or 400 gallons per acre). All ‘pounds/acre’ values have been converted to ‘kg/hectare’ in this report.

For the New York trial, six foliar airblast applications were made at a rate of 0.275 lb ai/acre (0.31 kg ai/ha). The first three applications were made 10 days apart; the fourth application was made 53 days after the third application (34 days prior to the commercial harvest) followed by the fifth and sixth applications at 10-day intervals each. The re-entry activity, harvesting apples, occurred fourteen days after the last application. Fifteen workers, all males, harvested apples by hand for 8 hours (including tea and lunch breaks) according to normal practice.

For the Oregon trial, three foliar airblast spray applications of Guthion 50 WP were made at a rate of 0.47 lb ai/acre (0.527 kg ai/ha). The second application was made 15 days after the first application and the third application was made 75 days after the second application (14 days prior to the commercial harvest). Fourteen days after the first application, fifteen male workers entered the treated area and performed thinning of apple crop. A second group of fifteen workers carried out apple harvesting fourteen days after the third and final application.

The workers wore no personal protective equipment, including gloves, during any of the re-entry activities. Each worker individually chose and wore clothing typical of what they normally wore when performing agricultural work. Ladders were used for thinning or harvesting the apples from the top portions of the trees.

In the New York trial, rainfall occurred throughout the trial period; rainfall between the first application and the harvest was 11.44 inches. In the Oregon trial, rainfall between the first application and thinning was 0.02 inches and rainfall between the first application and harvesting was 0.78 inches.

Biological monitoring: Methylsulfonylmethylbenzazimide (MSMB), a metabolite of azinphos-methyl excreted in urine, was used as a marker to estimate the total absorbed azinphos-methyl. Total urine output was collected from each worker during each 24-hour period starting one day prior to the re-entry activity through to four days after the re-entry activity. Two millilitre blood samples were also collected 3 days and 1 day prior to the re-entry activity, on the day of the re-entry activity and 4 days following re-entry activity to monitor ChE activity in workers. Urine and blood samples collected one day prior to the re-entry activity served as controls.

Inhalation exposure monitoring: The potential azinphos-methyl inhalation exposure of each worker was measured using an OVS tube connected to a pump calibrated at an airflow rate of 2 L/min. The OVS tube was attached to the worker's belt and air samples were collected by operating the pump over the entire workday, including during breaks.

Field recovery: Assessment of the stability of residues in urine samples under field, storage and transit conditions was carried out by fortifying urine from unexposed persons with MSMB. Field recovery and blank samples were prepared and treated in the same manner as the test samples.

Analytical methods: For each re-entry activity, the urine samples were analysed for MSMB residue and the OVS tube samples were analysed for azinphos-methyl and azinphos-methyl oxon using high-pressure liquid chromatography-triple stage quadrupole mass spectrometry (lc-ms/ms). Samples were analysed as analytical sets composed of laboratory control samples, laboratory fortification samples, field control samples, field fortification samples and field samples. The MSMB residue in the urine and the azinphos-methyl and azinphos-methyl oxon residue on the OVS tube from workers were corrected to 100% recovery based on the recoveries of the field

Table 4: Cumulative total MSMB residues in urine and internal azinphos-methyl dose calculated from the MSMB

Volunteers	Total MSMB excreted* (µg)			Internal Azinphos-methyl** (µg)			Internal azinphos-methyl (µg/kg bw)		
	New York[a]	Oregon[b]		New York	Oregon		New York	Oregon	
	Harvest	Thinning	Harvest	Harvest	Thinning	Harvest	Harvest	Thinning	Harvest
1	34.88	6.89	20.10	425.1	84.1	246.0	4.19	1.09	3.63
2	33.04	12.40	30.23	403.5	151.3	368.0	4.04	2.36	4.81
3	22.85	16.78	30.44	279.2	204.6	371.0	3.75	3.15	5.81
4	7.17	9.36	89.77	87.5	114.2	1095.0	1.34	1.65	13.27
5	41.72	9.48	74.55	509.2	115.6	910.0	5.88	1.30	12.61
6	29.39	10.27	27.78	359.0	125.2	339.0	4.95	2.08	4.48
7	17.45	9.88	18.07	213.0	120.5	220.0	2.52	1.97	3.68
8	23.08	10.98	49.69	282.3	134.0	605.0	0.74	1.64	9.35
9	25.43	3.29	19.50	310.2	40.2	2380	3.93	0.51	3.75
10	94.61	15.33	42.40	1154.0	187.0	517.3	9.65	2.74	7.60
11	20.27	6.07	32.07	247.0	74.1	390.0	3.34	1.12	5.23
12	20.14	9.83	39.03	245.0	120.0	475.5	2.53	1.62	5.96
13	14.50	23.81	63.55	177.0	290.6	775.3	2.53	4.21	10.05
14	8.03	4.43	21.91	98.0	65.0	267.0	1.76	0.77	3.70
15	20.84	10.32	19.15	254.0	125.8	233.4	4.18	2.00	2.81
Arithmetic Mean	**27.6**	**10.6**	**38.55**	**336.2**	**129.4**	**470.3**	**3.7**	**1.9**	**6.4**

*Total MSMB excreted from Day 0 to Day 4.
**Azinphos-methyl residues were calculated by first dividing the measured MSMB residue value by the percent recovery for the corresponding field recovery and then multiplying the result by 12.2 to adjust for the fraction of the internal azinphos-methyl dose represented by MSMB in urine.
[a]Six applications of 0.31 kg ai/ha azinphos-methyl were made and workers entered the orchards 14 days after the last application.
[b]Three applications of 0.527 kg ai/ha azinphos-methyl were made and workers entered the orchards 14 days after the first application for thinning and 14 days after the third application for harvesting.

fortification. Blood samples were analysed for plasma and red blood cell cholinesterase activity.

The total MSMB residue excreted during each sampling interval was normalized to the worker's body weight. The internal azinphos-methyl dose was calculated by correcting for the fraction of the absorbed dose of azinphos-methyl that was identified as MSMB in urine in a previous work in which MSMB represented 8.2% of the absorbed azinphos-methyl (Lunchick 2003). The results of azinphos-methyl exposure following post-application activities are summarised in Tables 4-7.

Table 5: Daily excretion of azinphos-methyl metabolites by workers harvesting and thinning apples following azinphos-methyl application

Interval	Azinphos-methyl equivalents calculated from MSMB excreted in urine[a] (µg/kg body weight)		
	New York	Oregon	
	Harvest	Thinning	Harvest
Day 0	0.751	0.292	1.49
Day 1	1.460	0.839	2.60
Day 2	0.960	0.428	1.31
Day 3	0.534	0.233	0.728
Day 4	0.198	0.089	0.323
Total (5 days)	**3.90**	**1.88**	**6.45**

[a]Arithmetic mean of internal azinphos-methyl dose calculated from MSMB excreted each day following re-entry activity.

Table 6: Potential azinphos-methyl inhalation exposure in workers thinning and harvesting apples following azinphos-methyl application

Re-entry Activity	Average azinphos-methyl inhalation exposure (µg)[a]	Average azinphos-methyl inhalation exposure (µg/kg bw)[b]
Harvesting (New York)	76.6	0.979
Thinning (Oregon)	48.3	0.69
Harvesting (Oregon)	268	3.71

[a]Arithmetic mean of potential azinphos-methyl inhalation exposure from each re-entry activity (n=15 workers). Measured azinphos-methyl equivalents at 2 L/min was extrapolated to an average human breathing rate of 29 L/min. Total exposure time was ~8 h. [b]Inhalation exposure per kg bw

Table 7: Percent change in plasma and red blood cell ChE activity in workers thinning and harvesting apples following azinphos-methyl application

Re-entry Activity	Average percent change in ChE Activity[a]			
	Day 0 Blood sample		Day 4 Blood sample	
	Plasma	Red Blood Cell	Plasma	Red Blood Cell
Harvesting (New York)	-8	1	1	2
Thinning (Oregon)	-8	-2	1	-1
Harvesting (Oregon)	-6	0	5	-1

[a]Arithmetic mean of percent change in ChE activity in 15 workers. The % change in activity was based on the average ChE activity in two control samples collected 3 days and 1 day prior to re-entry activity

Findings: The azinphos-methyl internal dose was highest for the harvest workers in the Oregon trial, with excretion of azinphos-methyl equivalents starting at an average of 1.49 µg/kg bw on the first day of re-entry, increasing to a maximum of 2.60 µg/kg bw one day following re-entry, and decreasing to 0.323 µg/kg bw four days following re-entry (Table 5). For harvesters in New York, the internal dose of azinphos-methyl was lower than that observed in the Oregon trial (excretion of azinphos-methyl equivalents was 0.75 µg/kg bw on Day 0, and 1.46 µg/kg bw one day following re-entry). It is noted that, though the amount of azinphos-methyl applied in the New York trial was nearly half the amount used in the Oregon trial, 6 applications were made in New York compared to only three in Oregon. The total amount of azinphos-methyl applied in the two orchards before the workers re-entered the orchards for harvesting was therefore similar. The azinphos-methyl internal dose was lowest for the apple thinning workers (excretion of azinphos-methyl equivalents was 0.292 µg/kg bw on Day 0, and 0.839 µg/kg bw one day following re-entry).

Similarly, the potential azinphos-methyl inhalation exposure was higher for harvesters (0.98 or 3.71 µg/kg bw) compared to workers thinning the apples (0.69 µg/kg bw) (Table 6).

The average percent change in plasma ChE activity immediately following re-entry ranged between –6% to –8% for the two re-entry activities (Table 7). No inhibition of ChE activity was noted 4 days after the re-entry activities. Changes in red blood cell ChE activity were minimal immediately following the three re-entry activities (Day 0) or 4 days later.

Comment: The calculated internal dose of azinphos-methyl was higher in volunteers harvesting apples in the Oregon trial as compared to those in the New York trial. The results also showed that volunteers harvesting apples were exposed to higher amounts of azinphos-methyl residue than those engaged in the thinning activity. The potential inhalation exposure in the two activity groups also confirmed these results.

Application rates in the present study (0.31 kg ai/ha and 0.527 kg ai/ha) were significantly lower than those recommended for the Australian situation (0.98 kg/ha). In addition, heavy rainfall in the New York trial between the first application and harvesting (11.44 inches) may have washed off some of azinphos-methyl residue from the foliage resulting in lower exposure during post-application activities. This is also reflected in the low exposure values (total and inhalation) in the New York harvesters compared to Oregon harvesters.

Beedle EC and Kraai MJ (2004a) GUTHION 50 WP – Dislodgeable foliar residue on apple tree foliage. Bayer Corp. Study Number GU25AP01, Bayer Corp. Report Number 201101, Bayer Research Park, Stilwell, KS USA.

Study and observations: Three apple trials, one each in New York, California and Oregon were conducted to determine the amount of azinphos-methyl that can be dislodged from apple foliage following airblast application of GUTHION 50 WP. At the New York and Oregon sites, treated plots were divided into three subplots, each containing one row of four trees. At the California trial, two adjacent rows of 14 trees each were divided into three consecutive sampling subplots (eight trees per sampling subplot with an un-sampled border tree at each end). Application rates were calculated according to the foliar size of the trees. A 400 GPA (gallons per acre) necessary for full coverage of large trees was used to calculate the amount of azinphos-methyl to be applied at each site. Thus the application rate was 0.275 lb ai/acre (0.32 kg ai/ha) in the New York trial, 0.57 lb ai/acre (0.64 kg ai/ha) in the California trial and 0.47 lb ai/acre (0.53 kg ai/ha) in the Oregon trial. Six applications of GUTHION were made in the New York trial, while three applications each were made in California and Oregon trials.

Azinphos-methyl application: Of the total six applications made in the New York trial, the first three applications were made at 10-day intervals; the fourth application was made 53 days after the third application (34 days prior to the commercial harvest) followed by the fifth and sixth applications at 10 days intervals each. For the California and Oregon trials, three applications were made. The second application at both sites was made 15 days after the first application. However, the third application was made at different time intervals at the two sites. In the California trial, the third application was made 40 days after the second application (14 days prior to the normal harvest) and in the Oregon trial it was done 75 days after the second application (14 days prior to the commercial harvest). Rainfall occurred throughout the sampling period in New York (14.1 inches), while very little occurred in Oregon (1.4 inches) and none occurred in California.

A sample (40 one-inch-diameter leaf punches) was collected from each of the three subplots to provide three replicate sampling at each sampling interval shown in Table 8. Leaf punches were taken from the potential worker contact zones including upper, middle and low portions of the crop foliage and interior and exterior portions of the crop foliage. Control leaf punches were collected prior to the first application.

Residue analysis: Azinphos-methyl residues were dislodged from the leaf punches using 0.01% Aerosol OT. One to 1.5 mL aliquots from the dislodging solution were analysed for azinphos-methyl and azinphos-methyl oxon by liquid chromatography/mass spectrometry (LC/MS). Measured values of azinphos-methyl and azinphos-methyl oxon were corrected to 100% recovery based on the average recoveries of azinphos-methyl and azinphos-methyl oxon from the field recovery samples. The individual analyte residues [azinphos-methyl and azinphos-methyl oxon (in azinphos-methyl equivalents)] were summed up to give a total azinphos-methyl residue value.

Summary of azinphos-methyl dislodgeable residue data in apple trees for New York, California and Oregon trials are provided in Table 8.

Table 8: Dislodgeable foliar residue (azinphos-methyl + azinphos-methyl oxon) in apple tree foliage

New York		**California**		**Oregon**	
Sample No. (DAT)*	**DFR (µg/cm^2)**	**Sample No. (DAT)***	**DFR (µg/cm^2)**	**Sample No. (DAT)***	**DFR (µg/cm^2)**
1^{st} Appl		**1^{st} Appl**			
0	0.616	0	0.75	0	1.46
Rainfall on Day 3,4, 7, 8 and 9		1	0.84	1	1.41
9	0.051	2	1.01	2 (rainfall)	1.18
2^{nd} Appl		3	0.92	3	1.00
0	0.658	5	0.78	5	0.77
Rainfall on Day 1, 2, 3, 5, 6, 7 and 8		7	0.80	7	0.60
9	0.079	10	0.66	10	0.44
3^{rd} Appl		14	0.51	14	0.27
0	0.580	**2^{nd} Appl**			
1	0.537	0	1.83	0	1.35
2	0.501	1	1.53	1	0.95
3	0.368	2	1.44	2	1.06
Rainfall on Day 4,5, 6, 7 and 8		3	1.37	3	1.06
6	0.181	5	1.28	5	0.83
7	0.187	7	1.06	7	0.72
10	0.126	10	0.97	10	0.54
14 (rainfall)	0.106	14	0.87	14	0.61
Rainfall on Day 19				Rainfall on Day 15	
21 (rainfall)	0.072	21	0.74	21	0.18
Rainfall on Day 22, 23, 24, 25 and 26		28	0.48	28	0.18
28	0.024	35	0.44	35	0.16
Rainfall on Day 29, 30				Rainfall on 6 more days before the 3^{rd} application	
35 (rainfall)	0.016	**3^{rd} Appl**			
Rainfall on Day 36, 37, 38, 41, 46, 47, 48, 50 and 51		-1	0.45	-1	0.04
52	<0.015	0	1.59	0	1.03
4^{th} Appl		1	1.31	1	0.89
0	0.530	2	1.29	2	0.98
Rainfall on Day 1, 2, 3, 8		3	1.25	3 Rainfall on Day 4	0.92
9	0.118	5	1.09	5	0.93
5^{th} Appl		7	0.99	7	0.85
0	0.584	10	0.86	10	0.69

Rainfall on Day 8		14	0.71	14 Rainfall on Days 18 & 19	0.75
9	0.215	21	0.62	21	0.47
6th Appl		28	0.48	28	0.33
0	0.736			Rainfall on Day 31	
1 (rainfall)	0.659	35	0.39	35	0.33
3	0.298				
Rainfall on Day 4					
5 (rainfall)	0.249				
7	0.216				
Rainfall on Day 8					
10	0.217				
14	0.215				
Rainfall on Day 16,18, 19					
21	0.105				
Rainfall on Day 22, 25,26					
28 (rainfall)	0.073				
Rainfall on Days 31 to 35					
35 (rainfall)	0.040				

Values are means of three observations. The measured azinphos-methyl and azinphos-methyl oxon residues were corrected to 100% recovery.
*DAT = Days after treatment

Findings: In the New York trial, the average corrected azinphos-methyl DFR immediately after each of the six applications was around 20% of the amount applied. The DFR declined after each application and was less than the LOQ of 0.015 µg/cm^2 52 days after the third application (Table 8). Fourteen days after the sixth application, the DFR was 0.2 µg/cm^2 (1% of the total applied). At this time re-entry workers were also monitored for exposure to azinphos-methyl exposure during a commercial harvest of apples. The DFR continued to decline and was 0.04 µg/cm^2 35 days after the sixth application (Table 8). Linear regression analysis of the azinphos-methyl DFR on apple leaves indicated a half-life of 8 days after the third application and 10 days after the sixth application.

In California, the average corrected azinphos-methyl DFR immediately after each of the three applications varied between 12 and 28% of the amount applied. The DFR declined to 0.39 µg/cm^2 35 days after the third and final application (2% of the total applied) (Table 8). The half-life of the azinphos-methyl DFR on apple leaves was 20 days in California.

In the Oregon trial, the average corrected total azinphos-methyl DFR immediately after each of the three applications varied between 5 and 27% of the amount applied. Fourteen days after the third application, the DFR was 0.75 µg/cm^2 (5% of the total applied) (Table 8). At this time re-entry workers were also monitored for exposure to azinphos-methyl exposure during a commercial harvest of apples. The DFR continued to decline and was 0.33 µg/cm^2 35 days after the third (final) application (2% of the total applied). Half-life of azinphos-methyl DFR in Oregon was 6, 15 and 20 days after the first, second and third applications.

Calculation of transfer coefficient

The DFR can potentially be dislodged from both surfaces of leaves and workers entering treated areas can be exposed to the DFR. The Transfer Coefficient (TC), a ratio of dermal exposure to the DFR, indicates the amount of DFR that can be transferred to workers as a function of post-application activity. Appropriate TC (based on post-application activity and type of crop) is used to estimate worker exposure from DFR. TC values were calculated from the DFR data obtained in this study and the dermal exposure values derived from the previous study (Table 4) as both studies used identical application rates and were performed under similar conditions. TC values are presented in Table 9.

Table 9: Transfer coefficients calculated from DFR values

Days post application	Re-entry activity	Total internal azinphos-methyl dose (µg)[a]	Mean potential inhalation exposure (µg)[b]	Mean dermal exposure to azinphos-methyl (µg/8 h day)[c]	Dislodgeable foliar residue (µg/cm²)	Transfer coefficient (cm²/h)[d]
Apple						
14 (New York)	Harvesting	336.2	76.6	865.3	0.215	503
14 (Oregon)	Thinning	129.4	48.3	270.3	0.269	126
14 (Oregon)	Harvesting	470.3	268	674.3	0.747	113

[a]Calulated from total MSMB excreted in urine from Day 0 to Day 4 (5 days); Table 4.
[b]See Table 6. [c]Internal azinphos-methyl dose due to dermal exposure was first calculated as the difference of the total internal azinphos-methyl dose and the potential inhalation dose. This value was then converted to dermal exposure using a dermal absorption factor of 30% for azinphos-methyl e.g (336.2-76.6) x 100/30 = 865.3 µg/8 h day. [d]TC (cm^2/h) = Dermal exposure (µg/h) /DFR (µg/cm^2).

Comment: Application rates in the present study (0.31 kg ai/ha and 0.53 kg ai/ha) were similar to those recommended for the Australian situation (0.5 - 0.98 kg/ha). Heavy rainfall in the New York trial between the first application and harvesting (11.4 inches) may have washed off a significant amount of azinphos-methyl residue from the foliage resulting in lower exposure during post-application activities. DFR values from the New York trial have not been used for risk assessment.

It should be noted that the TC values in Table 9 were not calculated from actual dermal exposures but derived as a difference of the total internal azinphos-methyl dose and the 'potential' inhalation dose (see legend for calculation details).

Fischer DR (2004b) Guthion 50WP – Biological monitoring of post-application workers during manual handling of blueberries. Bayer CropScience Study Number GU264702; Report Number 201043. Bayer Research Park, Stilwell, KS USA.

Study and observations: The objective of this study was to determine the potential dermal and inhalation exposure to azinphos-methyl and the potential change in blood cholinesterase activity of workers harvesting blueberries following airblast spray application of azinphos-methyl.

The study was designed to fulfil the requirements of the US EPA Series 875: "Occupational and Residential Exposure Test Guidelines". Two foliar airblast spray applications of GUTHION 50 WP were made to the blueberry bushes in Michigan, 10 days apart, at a target rate of 0.75 lb ai/acre (0.84 kg ai/ha). Fifteen workers (10 males and 5 females) were monitored for azinphos-methyl exposure following the harvesting of blueberries 7 days after the last application. The harvest period was 8 hours, including tea and lunch breaks. The workers wore painter caps and normal clothing, but no extra PPE. Rainfall (0.4 inches) occurred 1.25 hours after the first application and 13.5 hours (0.35 inches) after the second application and throughout the trial period. Rainfall between the first application and the blueberry harvest was 0.95 inches.

Biological monitoring: Methylsulfonyl methylbenzazimide (MSMB), a metabolite of azinphos-methyl excreted in urine, was used as a marker to estimate the total absorbed azinphos-methyl. Total urine output was collected from each worker during each 24-hour period starting one day prior to the re-entry activity through four days after the re-entry activity. Two millilitre blood samples were collected 3 days and 1 day prior to the re-entry activity, on the day of the re-entry activity and 4 days following re-entry activity to monitor ChE activity in workers. Urine and blood samples collected one day prior to the re-entry activity served as controls.

Inhalation exposure monitoring: The potential azinphos-methyl inhalation exposure of each worker was measured using an OVS tube connected to a pump calibrated at an airflow rate of 2 L/min. The OVS tube was attached to the worker's belt and air-samples were collected by operating the pump over the entire workday, including during breaks.

Field recovery: Assessment of the stability of residues in urine samples under field, storage and transit conditions was carried out by fortifying urine from unexposed persons with MSMB. Field recovery and blank samples were prepared and treated in the same manner as the test samples.

Analytical methods: The urine samples were analysed for MSMB residue and the OVS tube samples were analysed for azinphos-methyl and azinphos-methyl oxon using high-pressure liquid chromatography-triple stage quadrupole mass spectrometry (lc-ms/ms). They were analysed as analytical sets composed of laboratory control samples, laboratory fortification samples, field control samples, field fortification samples and field samples. The MSMB residue in the urine and the azinphos-methyl and azinphos-methyl oxon residue on the OVS tube from workers were corrected to 100% recovery based on the recoveries of the field fortification. Blood samples were analysed for plasma and red blood cell cholinesterase activity.

The total MSMB residue excreted during each sampling interval was normalized to worker's body weight. The internal dose of azinphos-methyl was calculated by correcting for the fraction of the absorbed dose of azinphos-methyl that was identified as MSMB in urine in a previous work in which MSMB represented 8.2% of the absorbed dose of azinphos-methyl (Lunchick 2003).

Findings: The results of azinphos-methyl exposure following post-application activities are summarised in Tables 10-13.

Table 10: Azinphos-methyl residues in urine and calculated internal azinphos-methyl dose in workers harvesting blueberries

Volunteers	Total MSMB excreted* (µg)	Internal azinphos-methyl** (µg)	Internal azinphos-methyl (µg/kg bw)
1	16.5	201	1.90
2	43.2	528	7.00
3	11.2	137	1.55
4	21.5	262	3.93
5	14.8	181	2.11
6	109.5	1327	14.8
7	41.6	507	7.88
8	96.9	1183	11.96
9	13.7	168	2.36
10	6.6	81	1.16
11	55.4	676	6.93
12	12.6	153	3.20
13	16.7	204	2.33
14	8.8	107	1.41
15	16.7	204	2.30
Arithmetic Mean	**32.4**	**395**	**4.7**

*Sum of MSMB excreted from Day 0 to Day 4 (Actual value minus the blank).
**Azinphos-methyl residues were calculated by first dividing the measured MSMB residue value by the percent recovery for the corresponding field recovery, and then multiplying the result by 12.2 to adjust for the fraction of the internal azinphos-methyl dose represented by MSMB in urine.

Table 11: Daily excretion of azinphos-methyl metabolites by workers harvesting blueberries following application of Guthion 50 WP to blueberry bushes

Days after the re-entry activity	Excretion of azinphos-methyl equivalents calculated from MSMB excreted in urine[a] (µg/kg body weight)		
	Males	**Females**	**All workers**
0 Day	0.78	1.57	1.04
1 Day	1.18	2.08	1.48
2 Days	1.24	1.45	1.31
3 Days	0.69	0.64	0.67
4 Days	0.18	0.26	0.21
Total (5 days)	**4.1**	**6.0**	**4.7**

[a]Average calculated azinphos-methyl internal dose on Day 0 to Day 4 (n=15 workers). Two applications of 0.84 kg /ha azinphos-methyl were made and workers entered the bushes 7 days after the last application.

Table 12: Potential inhalation exposure to azinphos-methyl in workers harvesting blueberries 7 days after azinphos-methyl application by airblast

Workers	Average azinphos-methyl inhalation exposure (µg)[a]	Average azinphos-methyl inhalation exposure (µg/kg bw)
Males	83.2	1.11
Females	118.0	1.40
All workers	94.7	1.2

[a]Average potential azinphos-methyl inhalation exposure for male and female workers (n=15). Total azinphos-methyl measured on the OVS tubes while sampling at 2 L/min was extrapolated to an average human breathing rate of 29 L/min. Total exposure time was ~8 hours.

Table 13: Percent change in plasma and red blood cell ChE activity in workers harvesting blueberries 7 days after azinphos-methyl application by airblast

Workers	Average percent change in ChE Activity[a]			
	Day 0 Blood sample		Day 4 Blood sample	
	Plasma	Red Blood Cell	Plasma	Red Blood Cell
Males	-4	-3	1	-5
Females	-4	-11	0	-7
All workers	-4	-6	0	-5

[a]Average percent change in ChE activity in male and female workers (n=15).
The % change in activity was based on the average ChE activity in two control samples collected 3 days and 1 day prior to re-entry activity

Findings: The excretion of azinphos-methyl equivalents increased from 1.04 µg/kg bw (Day 0) to 1.48 µg/kg bw on Day 1 (Table 11). For most workers, the maximum excretion occurred 1 day following re-entry. By Day 4, excretion had decreased to an average 0.2 µg equivalents/kg bw. The azinphos-methyl internal dose was slightly higher in female volunteers than in males (6.0 vs 4.1 µg/kg bw), probably reflecting their lower body weight.

Similarly, the potential azinphos-methyl inhalation exposure was higher for the female volunteers (1.4 µg/kg bw; Table 12) than for the male volunteers (1.1 µg/kg bw). The average potential azinphos-methyl inhalation exposure for all 15 volunteers was 1.2 µg/kg bw. The average percent decrease in plasma ChE activity immediately following re-entry was very low (-4%) in both male as well as female volunteers (Table 13). There was no significant change 4 days following the re-entry activity. The decrease in the red blood cell ChE activity was also low and about the same at Day 0 and Day 4.

Comment: The application rate of azinphos-methyl in this trial was similar to that used in Australia. However, due to the rainfall soon after the first and second applications, and one and three days before harvest, a substantial amount of the active may have been washed off the leaves and the exposures reported in the study are likely to be an underestimation of the potential exposures in the absence of rainfall.

Beedle EC and Kraai MJ (2004b) GUTHION 50 WP – Dislodgeable foliar residue on blueberry plant foliage. Bayer Corp. Study Number GU25BU01, Bayer Corp. Report Number 201060, Bayer Research Park, Stilwell, KS USA.

Study and observations: Two trials were conducted to evaluate azinphos-methyl dislodgeable foliar residue (DFR) on blueberry plant leaves immediately after application of azinphos-methyl and at additional sampling intervals after the final application.

Azinphos-methyl application: Two applications of Guthion 50 WP at the rate of 0.75 lb ai/acre (0.84 kg ai/ha) were made in blueberry bushes at two trial locations, Maine and Michigan. The second application at both sites was made 10 days after the first application. Treatment plots in both trial locations consisted of sufficient blueberry bushes to provide the necessary samples. In the Maine trial, the sampling area was divided into three subplots containing blueberry plants scattered throughout each subplot. In the Michigan trial the sampling areas contained three rows of blueberry bushes with 10 bushes in each row (sub-plot). Guthion 50 WP was applied by airblast equipment at both locations. At the Michigan site 0.4 inches rainfall occurred 1.25 hours after the first application and 0.35 inches rainfall occurred 13.5 hours after the second application. Rainfall also occurred throughout the trial period.

DFR samples at Maine and Michigan sites were collected immediately after the first treatment (0 DA1T), 10 days after the first treatment (10 DA1T), immediately after the second treatment (0 DA2T) and 1, 2 3, 5, 7, 11, 15, 21, 28 and 35 days after the second treatment. The '10 DA1T' sample, in both trials, was also considered as the pre-treatment sample (control) with respect to the second treatment.

For the Maine trial, each DFR sample consisted of 158 half-inch diameter leaf punches (total double-sided leaf surface area of 400 cm^2). For Michigan trial, 40 1-inch diameter leaf punches were taken for each sample (total double-sided leaf surface area of 400 cm^2). One sample was collected from each of the three subplots to provide three replicate sampling at each sampling interval. Leaf punches were taken from the potential worker contact zones including upper, middle and low portions of the crop foliage and interior and exterior portions of the crop foliage. Control leaf punches were collected prior to the first application.

Residue analysis: Azinphos-methyl residues were dislodged from the leaf punches using 0.01% Aerosol OT. One to 1.5 mL aliquots from the dislodging solution were analysed for azinphos-methyl and azinphos-methyl oxon by liquid chromatography/mass spectrometry (lc/ms-ms). Measured values of azinphos-methyl and azinphos-methyl oxon were corrected to 100% recovery based on the average recoveries of azinphos-methyl and azinphos-methyl oxon in field recovery samples. The individual analyte residues [(azinphos-methyl and azinphos-methyl oxon (in azinphos-methyl equivalents)] were summed up to give a total azinphos-methyl residue value.

Summary of azinphos-methyl dislodgeable residue data in blueberry bushes for Maine and Michigan trials are provided in Table 14.

Table 14: Dislodgeable foliar residue (azinphos-methyl + azinphos-methyl oxon) in blueberry tree foliage

Maine Trial		Michigan Trial	
Sample No. (DAT)*	**Dislodgeable foliar residue (azinphos-methyl + oxon) (µg/cm^2)**	**Sample No. (DAT)***	**Dislodgeable foliar residue (azinphos-methyl + oxon) (µg/cm^2)**
1st Appl		**1st Appl**	
0 (rainfall)	1.61	0 (rainfall)	1.04
Rainfall on Days 3, 8 and 9		10	0.34
10	0.60		
2nd appl		**2nd appl**	
0 (rainfall)	1.82	0	1.47
1 (rainfall)	0.84	1 (rainfall)	0.82
2 (rainfall)	0.59	2	0.83
3 (rainfall)	0.85	3 (rainfall)	0.76
Rainfall on Day 4		Rainfall on Day 4	
5 (rainfall)	0.59	5	0.76
7 (rainfall)	0.77	7 (rainfall)	0.61
Rainfall on Day 8			
10 (rainfall)	-	10	0.64
11	0.56	11	-
13	-	13	0.55
15	0.68	15	-
21	0.59	21	0.49
Rainfall on Day 23, 26		Rainfall on Day 26	
28	0.57	28	0.35
Rainfall on Day 32		34	0.32
35	0.32	35	

Values are means of three observations. The measured azinphos-methyl and azinphos-methyl oxon residues were corrected to 100% recovery
*DAT = Days after treatment

Findings: The average corrected total azinphos-methyl DFR on blueberry leaves immediately after the first and second applications of GUTHION 50 WP in the Maine trial were 1.6 µg/cm^2 (19% of the application rate) and 1.8 µg/cm^2 (23% of the application rate and 11% of the total applied from the two applications), respectively (Table 14). Thirty-five days after the second application the average DFR had declined to 0.32 µg/cm^2.

In the Michigan trial, the average corrected total azinphos-methyl DFR on blueberry leaves immediately after the first and second applications were 1.04 µg/cm^2 (12% of the application rate) and 1.5 µg/cm^2 (17% of the application rate and 9% of the total applied from the two applications), respectively (Table 14). Thirty-four days after the second application the average DFR declined to 0.32 µg/cm^2 (2% of total applied).

A logarithmic regression analysis of the azinphos-methyl residue dissipation at each trial location was conducted to calculate the dissipation half-life of azinphos-methyl. The half-life of azinphos-methyl on blueberry leaves following two applications was 27 days at the Maine site and 20 days at the Michigan site. A TC of 270 was calculated using the worker exposure data obtained in a study run concurrently at these two sites to estimate exposure to workers harvesting blueberries.

Comment: In both trials (Maine and Michigan), rainfall occurred soon after the first and second applications and on different days during the trials. This may have affected the amount of azinphos-methyl residue present on the leaves, and therefore led to under-estimation of a true half-life of the azinphos-methyl on blueberry plant.

Fischer DR (2004c) Guthion 50WP – Biological monitoring of post-application workers during harvesting of walnuts. Bayer CropScience Study Number GU264703; Report Number 201044. Bayer Research Park, Stilwell, KS USA.

Study and observations: The objective of this study was to determine the potential dermal and inhalation exposure to azinphos-methyl and the potential change in blood cholinesterase activity of workers harvesting walnuts following airblast spray application of azinphos-methyl.

The study was designed to fulfil the requirements of the US EPA Series 875: "Occupational and Residential Exposure Test Guidelines". For the trial, a single spray application of GUTHION 50 WP was made to 23.6 acres of walnut trees at an application rate of 2 lb ai/acre (2.24 kg ai/ha). Fifteen male workers were monitored for azinphos-methyl exposure following the harvesting of walnuts 30 days after the azinphos-methyl application. The harvest period was 8 hours, including tea and lunch breaks, which is considered to be a typical workday for this activity. Very little rainfall (0.17 inches) occurred between the product application and the walnut harvest, and none within 24 hours of the application.

Workers 1 and 2 (shakers) operated shaker machines (huge robotic arm attached to a tractor) to shake each walnut tree rapidly for 10 seconds to cause the walnuts to fall from the tree. Workers 3 and 4 (sweepers) swept the walnuts to the middle of the tree rows using tractor mounted sweeping machines (blowers). The rest of the workers used rakes to remove small tree limbs and to move walnuts near the tree trunks that were not blown by the sweeper machine. All workers wore painter caps and normal clothing, but no extra PPE. Type N95 dust masks were made available to each worker. However, not all workers used the mask.

Biological monitoring: Methylsulfonylmethylbenzazimide (MSMB), a metabolite of azinphos-methyl excreted in urine, was used as a marker to estimate the total absorbed azinphos-methyl. Total urine output was collected from each worker during each 24-hour period starting one day prior to the re-entry activity through to four days after the re-entry activity. Two millilitre blood samples were collected 3 days and 1 day prior to the re-entry activity, on the day of the re-entry activity and 4 days following re-entry activity to monitor ChE activity in workers. Urine and blood samples collected one day prior to the re-entry activity served as controls.

Inhalation exposure monitoring: The potential azinphos-methyl inhalation exposure of each worker was measured using an OVS tube connected to a pump calibrated at an airflow rate of 2 L/min. The OVS tube was attached to the worker's belt and air-samples were collected by operating the pump over the entire workday, including during breaks.

Field recovery: Assessment of the stability of residues in urine samples under field, storage and transit conditions was carried out by fortifying urine from unexposed persons with MSMB. Field recovery and blank samples were prepared and treated in the same manner as the test samples.

Analytical methods: For each re-entry activity, the urine samples were analysed for MSMB residue and the OVS tube samples were analysed for azinphos-methyl and azinphos-methyl oxon using high-pressure liquid chromatography-triple stage quadrupole mass spectrometry (lc-ms/ms). They were analysed as analytical sets composed of laboratory control samples, laboratory fortification samples, field control samples, field fortification samples and field samples. The MSMB residue in the urine and the azinphos-methyl and azinphos-methyl oxon residue on the OVS tube from workers were corrected to 100% recovery based on the recoveries of the field fortification. Blood samples were analysed for plasma and red blood cell cholinesterase activity.

The total MSMB residue excreted during each sampling interval was normalized based on the worker's body weight. The internal dose of azinphos-methyl was calculated by correcting for the fraction of the absorbed dose of azinphos-methyl that was identified as MSMB in urine in a previous work in which MSMB represented 8.2% of the absorbed dose of azinphos-methyl (Lunchick 2003).

Findings: The results following Guthion 50WP applications are presented in Tables 15-18.

Table 15: Daily excretion of azinphos-methyl metabolites by workers harvesting walnuts following application of GUTHION 50 WP to walnut trees

Interval	**Excretion of azinphos-methyl equivalents calculated from MSMB excreted in urine[a] (µg/kg body weight)**			
	Shakers[b]	**Sweepers[c]**	**Rakers[d]**	**All Workers**
Day 0	0.017	0.024	0.116	0.090
Day 1	0.087	0.168	0.417	0.340
Day 2	0.024	0.042	0.173	0.136
Day 3	0.017	0.030	0.097	0.078
Day 4	0.011	0.011	0.041	0.033
Total (5 days)	**0.16**	**0.27**	**0.84**	**0.68**

[a]Average calculated azinphos-methyl excretion from each re-entry activity at each time interval. Volunteers entered the orchards 30 days after a single application of 2.24 kg ai/ha.
[b]Average calculated azinphos-methyl excretion by volunteers 1 and 2 who used shakers.
[c]Average calculated azinphos-methyl excretion by volunteers 3 and 4 who used sweepers.
[d]Average calculated azinphos-methyl excretion by volunteers 5 and 15 who used rakes to sweep fruit and broken branches

Table 16: Azinphos-methyl residues in urine and calculated internal azinphos-methyl dose in workers harvesting walnuts

Volunteers	Total MSMB excreted* (µg)	Internal azinphos-methyl** (µg)	Internal azinphos-methyl (µg/kg bw)
1	0.53	6.49	0.084
2	1.97	24.0	0.228
3	2.09	25.5	0.282
4	1.94	23.7	0.267
5	2.83	34.4	0.389
6	2.53	65.3	0.545
7	7.33	89.5	1.250
8	9.12	111.3	1.168
9	10.37	126.4	2.178
10	8.67	96.1	1.060
11	3.19	39.0	0.405
12	4.34	52.8	0.599
13	9.02	110.0	1.020
14	2.43	29.7	0.375
15	1.533	18.7	0.289
Mean	**4.5**	**56.9**	**0.7**

*Total MSMB excreted from Day 0 to Day 4. **Azinphos-methyl residues were calculated by first dividing the measured MSMB residue value by the percent recovery for the corresponding field recovery and then multiplying the result by 12.2 to adjust for the fraction of the internal azinphos-methyl dose represented by MSMB in urine.

Table 17: Potential azinphos-methyl inhalation exposure in workers harvesting walnuts 30 days after application of azinphos-methyl by airblast spray

Re-entry Activity	Average potential azinphos-methyl inhalation exposure (µg)[a]	Average potential azinphos-methyl inhalation exposure (µg/kg bw)
Shakers	31.5	0.37
Sweepers	39.8	0.45
Rakers	121.0	1.5
All Workers	98.0	1.2

[a]Average potential azinphos-methyl inhalation exposure for workers from each re-entry activity. Total azinphos-methyl measured on the OVS tubes while sampling at 2 L/min was extrapolated to an average human breathing rate of 29 L/min. Total exposure time was ~8 hours.

Table 18: Percent change in plasma and red blood cell ChE activity in workers harvesting walnuts 30 days after application of azinphos-methyl

Rentry Activity	Average percent change in ChE Activity*			
	Day 0 Blood sample		Day 4 Blood sample	
	Plasma	Red Blood Cell	Plasma	Red Blood Cell
Shakers	-8	-4	5	3
Sweepers	-3	-1	-2	-2
Rakers	-5	-2	1	-3
All Workers	-5	-2	1	-2

*Average percent change in plasma and RBC ChE activity in volunteers engaged in harvesting walnuts. The % change in activity was based on the average ChE activity in two control samples collected 3 days and 1 day prior to re-entry activity

Findings: The maximum excretion of azinphos-methyl equivalents occurred 1 day following re-entry for all workers (0.340 µg/kg bw; Table 15) and decreased to less than one-tenth within four days (0.03 µg/kg bw). The azinphos-methyl internal dose was highest for volunteers raking the fruit and broken twigs and lowest for volunteers shaking the trees by mechanical shakers. Similarly, the potential azinphos-methyl inhalation exposure was highest in rakers (1.5 µg/kg bw) and lowest in shakers (0.37 µg/kg bw; Table 17).

The mean percent change in plasma ChE activity immediately following re-entry was very low for each re-entry activity (-8% maximum, Table 17). The precent change in red blood cell ChE activity was insignificant for all work activities either immediately following the re-entry activity or 4 day later.

Comment: The calculated azinphos-methyl internal dose and the potential inhalation exposure were highest for the workers performing raking activity and lowest for workers performing the shaking activity. This is expected as workers performing raking activity used rakes and also their hands to move small tree limbs from the ground prior to sweeping the walnuts using mechanical sweepers. The application rate of azinphos-methyl in this trial was much higher (2.2 kg ai/ha) than the highest application rate in Australia (0.98 kg ai/ha). Azinphos-methyl is not registered for use on walnuts in Australia but is sprayed on macadamia nut trees, for which mechanical harvesting techniques are used.

Harbin AM and Kraai MJ (2004) GUTHION 50 WP – Dislodgeable foliar residue on sweet cherry tree foliage. Bayer Corp. Study Number GU25CH01, Bayer Corp. Report Number 201061, Bayer Research Park, Stilwell, KS USA.

Study and observations: Two trials, one in Michigan and one in Oregon, were conducted to determine the amount of azinphos-methyl residue (sum of azinphos-methyl and azinphos-methyl oxon) that can be dislodged from cherry foliage following airblast application of GUTHION 50 WP to sweet cherry trees. In both trials the plots contained one row of 12 trees and were divided into three subplots of four trees each.

Azinphos-methyl application: In the Michigan trial, two applications were made, fourteen days apart, at the rate of 0.76 lb ai/acre (0.84 kg ai/ha) (highest label rate). In the Oregon trial, the first application of 0.32 lb ai/acre (0.36 kg ai/ha) was made followed, after 15 days, with a second application of 0.45 lb ai/acre (0.50 kg ai/ha).

DFR samples were collected from each of the three subplots to provide three replicate sampling at each sampling interval. Each sample consisted of 40 one-inch-diameter leaf punches with a total double-sided surface area of 400 cm^2. Leaf punches were taken from the potential worker contact zones including upper, middle and low portions of the crop foliage and interior and exterior portions of the crop foliage. Control leaf punches were collected prior to the first application. Samples at both trials were collected immediately after the first treatment (0 day after first treatment [0 DA1T]), 14 days after the first treatment (14 DA1T), immediately after the second treatment (0 DA2T) and 1, 2 3, 5, 7, 10, 15, 21, 28 and 35 days after the second treatment. In both trials, the '14 DA1T' sample was also considered as the pre-treatment with respect to second treatment. Rainfall occurred at the Michigan site throughout the trial period; during the time between the first application and the last sampling, 4.95 inches of rainfall occurred. At the Oregon site, rainfall occurred twice during the trial, with a total rainfall of 0.45 inches during the whole trial period.

Residue analysis: Azinphos-methyl residues were dislodged from the leaf punches using 0.01% Aerosol OT. One to 1.5 mL aliquots from the dislodging solution were analysed for azinphos-methyl and azinphos-methyl oxon by liquid chromatography/mass spectrometry (lc/ms-ms). Measured values of azinphos-methyl and azinphos-methyl oxon were corrected to 100% recovery based on the average recoveries of azinphos-methyl and azinphos-methyl oxon from the field recovery samples. The individual analyte residues [(azinphos-methyl and azinphos-methyl oxon (in azinphos-methyl equivalents)] were summed up to give a total azinphos-methyl residue value. A summary of the measured dislodgeable azinphos-methyl residues in cherry trees for the Michigan and Oregon trials is provided in Table 19.

Table 19: Dislodgeable foliar residue (azinphos-methyl + oxon) in sweet cherry tree foliage

Michigan Trial		**Oregon Trial**	
Sample No. (DAT)*	**Dislodgeable foliar residue (azinphos-methyl + oxon) (µg/cm^2)**	**Sample No. (DAT)***	**Dislodgeable foliar residue (azinphos-methyl + oxon) (µg/cm^2)**
1st Appl		**1st Appl**	
0 (rainfall)	1.08	0	0.47
Rainfall on days 1, 2, 3, 5, 7		Rainfall on Day 2	
14	0.16	14	0.15
2nd Appl		**2nd Appl**	
0	1.17	0	0.68
1 (rainfall)	0.97	1	1.49
2	0.84	2	0.60
3	0.79	3	0.62
5	0.67	5	0.47
7	0.64	7	0.44
Rainfall on day 9			
10 (rainfall)	0.35	10	0.38
Rainfall on day 11			
15	0.12	15 (rainfall)	0.33
Rainfall on days 17, 18, 19			
21 (rainfall)	0.09	21	0.25
Rainfall on days 23, 24			
28 (rainfall)	0.02	28	0.18
Rainfall on days 33, 34		Rainfall on Day 34	
35 (rainfall)	0.01	35	0.06

Values are means of three observations. The measured azinphos-methyl and azinphos-methyl oxon residues were corrected to 100% recovery.
*DAT = Days after treatment

Findings: In the Michigan trial, the average corrected azinphos-methyl DFR on cherry leaves immediately after the first application was 1.08 µg/cm^2 (13% of the application rate) and declined to 0.16 µg/cm^2 (2% of the application rate) 14 days later (Table 19). Immediately following the second application, azinphos-methyl DFR was 1.17 µg/cm^2 (14% of the application rate and 7% of the total applied). Fifteen days after the second application, corresponding to a normal commercial cherry harvest, the total azinphos-methyl DFR had declined to 0.12 µg/cm^2 (1% of total applied). The total azinphos-methyl DFR continued to decline and was 0.01 µg/cm^2 35 days after the second application (Table 19).

The dissipation of azinphos-methyl DFR in the Oregon trial was very similar to that of the Michigan trial (to 13% and 4% of the first application rate immediately and 14 days after the first application, and to 14% of the second application rate immediately after the second application). Fifteen days after the second application, corresponding to a normal commercial cherry harvest, the total azinphos-methyl DFR had declined to 0.33 µg/cm^2 (4% of total applied). The total azinphos-methyl DFR continued to decline and was 0.06 µg/cm^2 35 days after the second application.

A logarithmic regression analysis of the total azinphos-methyl residue dissipation at each trial location was conducted to calculate the dissipation half-life of azinphos-methyl. The half-life of total azinphos-methyl DFR on cherry leaves following two applications was 5 days at the Michigan site and 12 days at the Oregon site

Comment: In the Michigan trial, rainfall occurred immediately after the first and second applications and throughout the trial. DFR data from this trial therefore may not reflect the true half-life of azinphos-methyl on cherry tree foliage. In the Oregon trial, the amount of azinphos-methyl applied is less than that recommended for the Australian situation. However the data can still be used to calculate the likely exposure of the re-entry workers to foliar residues of azinphos-methyl.

Duah FK, Kraai MJ and Murphy JJ (2004) GUTHION 50 WP – Dislodgeable foliar residue on hairy-leaf, needle-leaf, smooth-leaf and waxy-leaf ornamentals. Bayer CropScience. Study Number GU25HL01, GU25NL01, GU25SL01, GU25WL01, Bayer Corp. Report Number 201046, Bayer Research Park, Stilwell, KS USA.

Study and observations: This study was conducted to measure total DFR of azinphos-methyl on nursery stock with different leaf types at various times after four applications of GUTHION 50 WP. Nursery plants with varying leaf characteristics such as hairy leaf (strawberry plant), needle leaf (yew plant), smooth leaf (peach trees) and waxy leaves (swamp white oak) were used in the study. The treated plots were 10 x 180 feet for the hairy, needle and wax leaf testing and 10 x 330 feet for the smooth leaf testing. The treated plots each contained three subplots to allow for three replicate sampling at each time interval. Four applications were made to each type of plant at 10 to 11 days intervals. Applications were made with tractor-mounted boom sprayer at an application rate of 1 lb ai/acre (1.12 kg ai/ha).

Leaf punch samples (40 one-inch-diameter leaf punch) were collected prior to and immediately after each application as well as at additional sampling intervals after the fourth application. For the needle leaves, 50-70 needles, giving a total estimated area of 400 cm^2 (calculated based on surface area-to-weight factor), were used as one sample.

Table 20: Dislodgeable foliar residue (azinphos-methyl + azinphos-methyl oxon) on needle-leaf and hairy-leaf ornamentals

Needle Leaf		Hairy Leaf	
Sample No. (DAT)^	**Dislodgeable foliar residue (azinphos-methyl + azinphos-methyl oxon) (µg/cm^2)***	**Sample No. (DAT)^**	**Dislodgeable foliar residue (azinphos-methyl + azinphos-methyl oxon) (µg/cm^2)***
1st Appl		**1st Appl**	
0	3.33	0	1.41
Rainfall on Days 0-2, 8, 9		Rainfall on Day 3	
10	0.56	10	0.02
2nd Appl		**2nd Appl**	
0	3.11	0	0.88
Rainfall on Days 7, 10		Rainfall on Day 7	
11	0.04	11	0.10
3rd Appl		**3rd Appl**	
0	3.02	0	1.16
Rainfall on Days 2, 4-6			
11	0.02	11	0.01
4th Appl		**4th Appl**	
0	3.07	0	1.27
1	0.91	1 (rainfall)	1.14
2	0.28	2	1.08
3	0.36	3	1.02
4	0.27	4	1.04
5	0.27	5	1.23
Rainfall on Day 6			
7	0.10	7	0.58
		Rainfall on Day 9	
10	0.05	10	0.56
Rainfall on Day 14		Rainfall on Days 12, 13	
15	<0.015	15	0.02
Rainfall on Days 19, 20		Rainfall on Days 17, 18, 20	
21	<0.015	21	<0.015
Rainfall on Day 26		Rainfall on Days 25, 26	
28	<0.015	28	<0.015
35	<0.015	35	<0.015

*Values are means of three observations. The measured azinphos-methyl and azinphos-methyl oxon residues were corrected to 100% recovery.
^DAT = Days after treatment

During the time between first application and the last sampling, 6.4 to 11.6 inches rainfall occurred. Summary of azinphos-methyl dislodgeable residue data in hairy-leaf, needle-leaf, smooth-leaf and waxy-leaf ornamentals are provided in Table 20.

Table 21: Dislodgeable foliar residue (azinphos-methyl + azinphos-methyl oxon) on smooth-leaf and waxy-leaf ornamentals

Smooth Leaf		Waxy Leaf	
Sample No. (DAT)	**Dislodgeable foliar residue (azinphos-methyl + oxon) (µg/cm²)***	**Sample No. (DAT)**	**Dislodgeable foliar residue (azinphos-methyl + oxon) (µg/cm²)***
1st Appl		**1st Appl**	
0	1.65	0	1.71
Rainfall on Day 3		Rainfall on Day 1, 3, 4	
10	0.45	10 (Rainfall)	0.07
2nd Appl		**2nd Appl**	
0	2.42	0 (Rainfall)	1.19
Rainfall on Day 7			
11	0.06	11	0.22
3rd Appl		**3rd Appl**	
0	1.52	0	0.78
Rainfall on Day 1		Rainfall on Day 2	
11	0.07	11	0.02
4th Appl		**4th Appl**	
0	1.17	0	1.58
1	0.77	1	0.20
2	0.17	2	0.12
3	0.30	3	0.15
4	0.24	4	0.10
5	0.21	5	0.13
7	0.07	7	0.07
Rainfall on Day 9		Rainfall on Day 8	
10	0.06	10	0.05
Rainfall on Days 12, 13			
15	0.02	15	0.03
Rainfall on Days 18, 19		Rainfall on Day 17, 20	
21(rainfall)	<0.015	21(Rainfall)	0.02
		Rainfall on Day 24, 25	
28	<0.015	28	0.01
Rainfall on Day 34		Rainfall on Day 30, 32, 33	
35	<0.015	35	0.005

*Values are means of three observations. The measured azinphos-methyl and azinphos-methyl oxon residues were corrected to 100% recovery.
*DAT = Days after treatment

Findings: As a proportion of the application rate, the average corrected total azinphos-methyl DFRs measured immediately after each of the four applications ranged from 26 to 29% for hairy leaves, 8 to12% for needle leaves, 10 to 23% for smooth leaves and 7 to 15% for waxy leaves (Tables 20 and 21). For all leaf types, however, the average corrected total azinphos-methyl DFR was <10% of the total product applied (from four applications). The needle leaves lost the chemical more rapidly than other leaf types. At Day 10 the hairy leaves retained the most amount of the chemical. The residues in all leaf types declined rapidly after each application and were <0.015 $\mu g/cm^2$ at 35 days after the fourth application (Tables 20 and 21). Linear regression analyses of the disintegration of residues over time indicated a half-life of 3.4 to 5.6 days for all leaf types.

Comment: In most leaf types there was a dramatic decline of residues on the first two days after application and thereafter the residues declined gradually. The reason for this trend is not known. The post-application activity in these types of nursery plants is not known apart from transferring the plants for re-planting which could be considered as light activity in terms of exposure to tree foliage.

4 OCCUPATIONAL RISK ASSESSMENT

Biomonitoring studies were conducted to measure occupational exposure of farm workers to azinphos-methyl during mixing/loading/application of azinphos-methyl products and performing post-application activities (thinning, harvesting). Exposure data from these studies were used to estimate risk to workers handling azinphos-methyl products and entering areas treated with azinphos-methyl for post-application activities. Dislodgeable foliar residues were also measured to calculate the half-life of azinphos-methyl on foliage and to estimate the minimum time (days) after application at which workers can re-enter treated areas with acceptable risk. The risk assessment used an internal (NOEL) dose of 0.25 mg/kg bw/day from a 4-week human dietary study and a dermal absorption rate of 30% for azinphos-methyl (Selim, 1999). Given that a human NOEL was used to estimate risk, a margin of exposure (MOE) of 10 or more is considered to be acceptable.

4.1 Exposure assessment

Exposure to azinphos-methyl was calculated from the total MSMB excreted in urine for five days following Guthion 50 WP application or after performing a post-application activity. Guthion 50 WP is a wettable powder formulation of azinphos-methyl and is packed in water-soluble sachets. This type of packaging is considered to reduce exposure during mixing/loading to negligible levels. All exposure to azinphos-methyl reported in the mixing/loading/application study is therefore considered to have occurred only during application of dilute spray.

Potential inhalation exposure was calculated from the azinphos-methyl and azinphos-methyl oxon residues measured in personal samplers calibrated at 2 L/min air flow rate and extrapolated to the human respiratory rate of 29 L/min, 8 hours per day.

Plasma and RBC ChE activity was measured in post-application workers on the day of re-entry (post-application activity) and four days later. DFR values were used to estimate potential dermal exposure to azinphos-methyl residues in the re-entry workers. This estimation employed the use of surrogate TC values for thinning and harvest activities in some crops. The half-life of azinphos-methyl on foliage, which is an indicator of the persistence of a chemical, was also calculated using the DFR data.

4.2 Risk from end-use exposure

The mixer/loader/applicator exposure study indicated low exposure to workers applying azinphos-methyl by airblast technique. MOEs were acceptable for applicators using a closed cab as well as those using open cabs and wearing extra PPE (Tyvek overalls over a long-sleeved shirt and long pants, chemical resistant gloves, chemical resistant headgear and protective eyewear and a respirator) (Table 22). Comparison of MOEs for applicators in open and closed cabs revealed that closed cabs provided five times more protection that the open cabs, although applicators in closed cabs did not wear any extra PPE. Closed cabs were also more effective in reducing inhalation exposure. Potential inhalation exposure, determined by the OVS tubes was fifteen fold lower in closed cabs compared to that in open cabs (Table 3).

This study however used a product packed in water-soluble sachets. Therefore, risk from mixing and loading the SC formulation product available to Australian workers could not be estimated.

Table 22: Total exposure to azinphos-methyl and MOE during mixing/loading and application of Guthion 50 WP

Application situation	Internal azinphos-methyl dose (µg/kg ai /kg bw)*	Total internal dose per day (µg/kg bw/day)**	MOE
Open cab	0.2	4.0	63
Closed cab	0.04	0.8	313

*Values taken from Table 2.
**Based on 20 kg ai handled per day

4.3 Risk from post application activities

The submitted exposure studies have demonstrated that workers re-entering treated crops or orchards will be exposed to azinphos-methyl via the dermal and inhalation routes. The most probable sources of exposure will be from manual contact with treated fruit and foliage, and inhalation of dusts upon which the chemical has become deposited. In this section of the report, REIs have been calculated, based where possible on the measured exposure of American workers harvesting apples, walnuts and blueberries.

The calculations assume that:

- the half-life of azinphos-methyl DFRs on fruit trees is 20 days under conditions of little or no rainfall, based on the most prolonged half-life value of DFRs in apple trees recorded by Beedle and Kraai (2004a).

- the half-life of azinphos-methyl DFRs on blueberry bushes is 27 days, based on the most prolonged half-life value recorded on blueberries by Beedle and Kraai (2004b).

• in the same crop the MOE is inversely related to DFR level (i.e. if DFR level is halved, the MOE is doubled).

• in respect of DFRs on fruit trees, the gradient of the logDFR (and logMOE) vs time plot is log2 – log1 ÷ 20 = 0.01505/day

• in respect of DFRs on blueberry bushes, the gradient of the logDFR (and logMOE) vs time plot is log2 – log1 ÷ 27 = 0.01115/day

• azinphos-methyl DFR level = $10^{[\log I] + \text{ or } - [\text{gradient X } \Delta T]}$ where I is the reference DFR level and ΔT is the number of days over which the change in DFR level is being measured. Readers should note that the equation can be used to calculate DFRs *before* the reference level was measured, as well as after.

Pome fruits

Fischer (2004a) determined that apple harvesters in Oregon absorbed a mean dose of 6.45 µg azinphos-methyl/kg bw after working for 8 hours in an orchard treated three times by airblast at 0.527 kg active/ha. The workers' MOE was 39 relative to the Australian OHS NOEL of 0.25 mg/kg bw/d.

The first two applications were performed at 14-day intervals but the final treatment occurred 75 days after the second and 14 days prior to harvest. The azinphos-methyl DFR level immediately prior to the final treatment was 0.040 µg/cm^2, which is low enough for the third application to be considered as being independent from the first two treatments. The REI was 14 days after the third treatment, when azinphos-methyl DFR levels had declined to 0.747 µg/cm^2, or 72.6% of the 1.029 µg/cm^2 measured immediately after the third treatment (Beedle and Kraai, 2004a). This measured decline in DFR level over 14 days is in fairly close agreement with the theoretical decline to 62% of initial levels, assuming a half-life of 20 days, estimated from the equation:

$$10^{[\log 100] - [0.01505 \text{ X } 14]} = \mathbf{61.6}\%$$

In Australia, azinphos-methyl may be applied to pome fruits up to three times during summer at 14- or 21-day intervals. The highest application rate is 0.98 kg active/ha. However, this is used only for control of some beetle and weevil pests by butt and soil spray, which would create far less potential for worker exposure than by full cover spray because residues would not be deposited on the fruit or foliage. The normal application rate for full cover spraying (the method used for most pests) is 0.49 kg/ha, although some labels recommend a first spray at 0.74 kg/ha for control of woolly aphids. Therefore, the REI for pome fruits will be based on a worst-case assumption of a full cover treatment at 0.74 kg/ha followed by two treatments at 0.49 kg/ha, performed at 14-day intervals.

If the American exposure data are adjusted to the highest Australian foliar application rate of 0.74 kg/ha, the MOE for harvesters 14 at days post-application would be:

$$(0.527 \div 0.735) \text{ X } 39 = \mathbf{28}$$

The MOEs throughout the application cycle would range between 12 and 28, as shown in the following table:

Application	Day	DFR as % of initial level	MOE
1 (0.74 kg/ha)	0	**100**	$10^{[\log 28] - [0.01505 \times 14]}$ = **17**
	14	(From text above) **62**	(From text above) **28**
2 (0.49 kg/ha)	14	62 + 66* = **128**	100 ÷ 128 X 17 = **13**
	28	$10^{[\log 128] - [0.01505 \times 14]}$ = **79**	100 ÷ 79 X 17 = **22**
3 (0.49 kg/ha)	28	79 + 66* = **145**	100 ÷ 145 X 17 = **12**

*0.49 is 66% of 0.74

Therefore, given that there is an acceptable MOE of 12 at the time of peak DFR level, the REI for pome fruits may be set at one day, to ensure that workers are exposed only to dry residues of azinphos-methyl (the conditions under which the exposure study was performed).

Stone fruits and citrus

Australian product labels recommend that azinphos-methyl be applied by full cover spray at 0.49 kg/ha to citrus and stone fruits (including cherries and plums) at 21- to 28-day intervals. The available information suggests that two or more applications may be required per growing season but there is no indication of the maximum number of treatments that would occur. Therefore, the REI for stone fruits will be based on a worst-case assumption of four full cover treatments at 0.49 kg/ha, performed at 21-day intervals.

If the American exposure data for apple harvesters are adjusted to the highest Australian application rate of 0.49 kg/ha, the MOE for harvesters at 14 days post-application would be:

(0.527 ÷ 0.49) X 39 = **42**

Using the same methods shown above, the MOEs throughout the application cycle would range between 14 and 54, as illustrated in the following table:

Application	Day	DFR as % of initial level	MOE
1 (0.49 kg/ha)	0	**100**	$10^{[\log 42] - [0.01505 \times 14]}$ = **26**
	14	(From text above) **62**	(From text above) **42**
	21	$10^{[\log 100] - [0.01505 \times 21]}$ = **48**	100 ÷ 48 X 26 = **54**
2 (0.49 kg/ha)	21	48 + 100 = **148**	100 ÷ 148 X 26 = **18**
	42	$10^{[\log 148] - [0.01505 \times 21]}$ = **71**	100 ÷ 71 X 26 = **37**
3 (0.49 kg/ha)	42	71 + 100 = **171**	100 ÷ 171 X 26 = **15**
	63	$10^{[\log 171] - [0.01505 \times 21]}$ = **83**	100 ÷ 83 X 26 = **31**
4 (0.49 kg/ha)	63	83 + 100 = **183**	100 ÷ 183 X 26 = **14**

Therefore, given that there is an acceptable MOE of 14 at the time of peak DFR level, the REI for stone fruits and citrus may be set at one day, to ensure that workers are exposed only to dry residues of azinphos-methyl.

Lychees

Lychees are treated at 0.38 kg azinphos-methyl/ha, most frequently by airblast or airshear. Application may occur as dictated by pest numbers or on a two to three week schedule during the period when pests are normally active. The shorter interval is used during wet weather or severe infestations. Therefore, the REI for lychees will be based on a worst-case assumption of four full cover treatments at 0.38 kg/ha, performed at 14-day intervals.

If the American exposure data for apple harvesters are adjusted to the Australian application rate on lychees of 0.38 kg/ha, the MOE for harvesters 14 at days post-application would be:

$$(0.527 \div 0.38) \text{ X } 39 = \mathbf{54}$$

Using the same methods shown above, the MOEs throughout the application cycle would range between 15 and 54, as illustrated in the following table:

Application	Day	DFR as % of initial level	MOE
1 (0.38 kg/ha)	0	**100**	$10^{[\log 54] - [0.01505 \text{ X } 14]}$ = **33**
	14	(From text above) **62**	(From text above) **54**
2 (0.38 kg/ha)	14	62 + 100 = **162**	100 ÷ 162 X 33 = **20**
	28	$10^{[\log 162] - [0.01505 \text{ X } 14]}$ = **100**	**33**
3 (0.38 kg/ha)	28	100 + 100 = **200**	100 ÷ 200 X 33 = **17**
	42	$10^{[\log 200] - [0.01505 \text{ X } 14]}$ = **123**	100 ÷ 123 X 33 = **27**
4 (0.38 kg/ha)	42	123 + 100 = **223**	100 ÷ 223 X 33 = **15**

Therefore, given that there is an acceptable MOE of 15 at the time of peak DFR level, the REI for lychees may be set at one day, to ensure that workers are exposed only to dry residues of azinphos-methyl.

Blueberries

Fischer (2004b) determined that blueberry harvesters in Michigan absorbed a mean dose of 4.72 µg azinphos-methyl/kg bw after working for 8 hours in an orchard treated twice by airblast at 0.841 kg active/ha. The workers' mean MOE was 53 relative to the Australian OHS NOEL of 0.25 mg/kg bw/d.

The two applications were performed at 10-day intervals. The azinphos-methyl DFR level immediately prior to the second treatment was 0.344 µg/cm^2. Immediately after the second treatment, DFR levels rose to 1.47 µg/cm^2, of which a net 1.126 µg/cm^2 (or 76%) was attributable to the additional deposition of active. Therefore, the second application can not be considered as independent from the first application. Harvesting was undertaken 7 days after the second treatment, when azinphos-methyl

DFR levels had declined to 0.610 µg/cm^2, or 41.4% of the 1.47 µg/cm^2 measured immediately after the second treatment (Beedle and Kraai, 2004b).

Possibly due to rainfall, this measured decline in DFR level over 7 days is approximately double the theoretical decline to 84% of initial levels, assuming a 27-day half life (from blueberries growing in Maine) and estimated from the equation:

$$10^{[\log 100] - [0.01115 \times 7]} = \mathbf{83.6}\ \%$$

Consequently, the American DFR and exposure data must be adjusted to compensate for (i) the accelerated DFR losses caused by rainfall and (ii) the contribution of residues remaining from the first application. The first adjustment is made by multiplying the observed MOE by the ratio of the predicted and observed decreases in DFR levels, as follows:

$$56 \times (41.4 \div 83.6) = \mathbf{28}$$

and the second adjustment is effected by dividing the corrected MOE by the fraction of DFRs contributed by the second application:

$$28 \div 0.76 = \mathbf{37}$$

In Australia, azinphos-methyl may be applied to blueberries at a rate of 0.49 kg/ha. Product labels recommend application at 14-day intervals after flowering, whereas information from growers suggests that three applications at monthly intervals may be performed. It is unclear whether all growers adopt the latter treatment regime, or whether some utilise the label treatment interval. Therefore, the REI for blueberries will be based on a worst-case assumption of three treatments at 0.49 kg/ha, performed at 14-day intervals.

If the American exposure data are adjusted to the Australian application rate of 0.49 kg/ha, the MOE for harvesters at 7 days post-application would be:

$$(0.84 \div 0.49) \times 37 = \mathbf{63}$$

The MOEs throughout the application cycle would range between 24 and 75, as shown in the following table:

Application	**Day**	**DFR as % of initial level**	**MOE**
1 (0.49 kg/ha)	0	**100**	$10^{[\log 63] - [0.0\ 1115\ \times 7]}$ = **53**
	7	(From text above) **84**	(From text above) **63**
	14	$10^{[\log 84] - [0.01115\ \times 7]}$ = **70**	$10^{[\log 63] + [0.01115\ \times 7]}$ = **75**
2 (0.49 kg/ha)	14	70 + 100 = **170**	100 ÷ 170 X 53 = **31**
	28	$10^{[\log 170] - [0.01115\ \times 14]}$ = **119**	100 ÷ 119 X 53 = **45**
3 (0.49 kg/ha)	28	119 + 100 = **219**	100 ÷ 219 X 53 = **24**

Therefore, given that there is an acceptable MOE of 24 at the time of peak DFR level, the REI for blueberries may be set at one day, to ensure that workers are exposed only to dry residues of azinphos-methyl.

Macadamias

Macadamia trees are treated at 0.38 kg azinphos-methyl/ha, most frequently by airblast or airshear. Application may occur as dictated by pest numbers or on a two to three week schedule during the period when pests are normally active. The shorter interval is used during wet weather or severe infestations. Therefore, the REI for macadamias will be based on a worst-case assumption of four full cover treatments at 0.38 kg/ha, performed at 14-day intervals.

Macadamia nut harvesting is usually performed mechanically after the fruits have fallen onto the ground, and the fruits are also de-husked by machine. Therefore, there is little opportunity for workers to make contact with azinphos-methyl residues on treated foliage or fruit. Although macadamia trees are not shaken to dislodge fruit, macadamia harvest is closely equivalent to the harvesting practices used for walnuts in the USA, and the study of Fischer (2004c) may be used to estimate exposure of persons operating mechanical harvesters.

Fischer (2004c) monitored the urinary excretion of an azinphos-methyl metabolite in (mechanical) tree shakers, (mechanical) blower operators and (manual) rakers who worked for eight hours in a walnut grove sprayed 30 days previously at 2.24 kg/ha. The respective doses of azinphos-methyl absorbed by the three groups of workers were 0.156, 0.275 and 0.844 µg/kg bw. DFR levels were not measured. Relative to the Australian OHS NOEL of 0.25 mg/kg bw/d, the respective MOEs would have been 1603, 909 and 296. Data from the shaking and blowing machine operators are the most relevant to Australian harvester operators, and the worst-case MOE of 909 will be used for exposure estimation.

If the American exposure data are adjusted to the Australian application rate on macadamias of 0.38 kg/ha, the MOE for harvesters at 30 days after a single application would be

$$(2.24 \div 0.38) \text{ X } 909 = \mathbf{5358}$$

and if the half-life of azinphos-methyl on walnut trees is the same as on apples (20 days), the MOE immediately post-application would be

$$10^{[\log 5358] - [0.01505 \text{ X } 30]} = \mathbf{1895}$$

The MOEs throughout the application cycle would therefore range between 850 and 3056 (see next table).

Application	**Day**	**DFR as % of initial level**	**MOE**
1 (0.38 kg/ha)	0	**100**	From text above = **1895**
	14	$10^{[\log 100] - [0.01505 \text{ X } 14]}$ = **62**	100 ÷ 62 X 1895 = **3056**
2 (0.38 kg/ha)	14	62 + 100 = **162**	100 ÷ 162 X 1895 = **1170**
	28	$10^{[\log 162] - [0.01505 \text{ X } 14]}$ = **100**	**1895**

3 (0.38 kg/ha)	28	100 + 100 = **200**	100 ÷ 200 X 1895 = **948**
	42	$10^{[\log 200] - [0.01505 \times 14]}$ = **123**	100 ÷ 123 X 1895 = **1541**
4 (0.38 kg/ha)	42	123 + 100 = **223**	100 ÷ 223 X 1895 = **850**

Therefore, given that there is a highly acceptable MOE of 850 at the time of peak DFR level, the REI for walnuts may be set at one day, to ensure that workers are exposed only to dry residues of azinphos-methyl.

Vine crops

Azinphos-methyl may be applied to grape and kiwi fruit vines at 0.49 kg/ha against scale insects and moths. Labels recommend a treatment interval of three to four weeks but it is unclear how many treatments would be required during a growing season. A worst-case treatment schedule of four applications at 21-day intervals will therefore be assumed.

Data on azinphos-methyl foliar residues on grapevines are available from the study of Knarr (1987). Only limited information was provided with respect to the experimental methods. Two trials were run, using “50WP” and “2S” formulations in Woodland and Chualar, CA. The vines were treated (apparatus unknown) with a total of 72 oz azinphos-methyl/acre (approximately 5 kg/ha) over a season. DFR levels were measured approximately an hour after the final treatment and 1, 2, 5, 7, 14, 21, 28 and 35 days later. Linear regression plots (ln µg DFR/cm^2 vs time) were then calculated. The following results were obtained:

2S formulation: Intercept = 1.95 Slope = -0.0331 Correlation = -0.82
50 WP formulation: Intercept = 2.06 Slope = -0.0232 Correlation = -0.56

Because of uncertainty over the number and timing of the azinphos-methyl treatments that were applied to the vines, the actual DFR levels will not be used in this exposure assessment. However, the above data may be used to estimate the half-life of DFRs on vine leaves. In the case of the 50WP formulation, the initial DFR level was $e^{2.06}$ = 7.846 µg/cm^2. After one half-life, the DFR level would decline to 3.923 µg/cm^2, the natural log of which is 1.37. The half-life can be obtained from the equation

[ln initial DFR – ln final DFR] ÷ slope = t½ ie [2.06 – 1.37] ÷ 0.0232 = **29.7** days

Applying the same method to the regression data for the 2S formulation yields a half-life estimate of **20.9** days.

Both values are in fairly close agreement with each other and the half-lives of azinphos-methyl DFRs on apples and blueberries. Due to the lack of information on climate or other variables that may have affected the behaviour of DFRs in Knarr (1987), the more conservative half-life value of 30 days will be used for exposure assessment purposes. When using regression equations based on log10-transformed DFR values, the slope associated with a 30-day half-life will be

$$\log 2 - \log 1 \div 30 = 0.01003$$

and will be used for consistency with the previous methods for calculating REIs into other crops.

No reliable exposure studies are available covering workers tending or harvesting vine crops treated with azinphos-methyl. However, it is recognised that worker exposure to pesticides on vine / trellis crops is heavier than occurs from fruit trees. Compared with default transfer coefficients of around 3000 for tree fruit harvesting, the US EPA uses default values of 10 000 for grape girdling and cane turning and 5000 for harvesting, leaf pulling, pruning, thinning, training and tying grapes and other vine crops. From this, it may be inferred that at a given application rate, worker exposure from harvesting grapes and kiwi fruit will be approximately 1.67-fold higher than corresponding activities when harvesting tree fruits, while grape girdling and cane turning would entail exposures 3.33-fold greater.

If the initial DFR value on vine crops is the same as on stone fruit and citrus trees treated at the same rate/ha, the MOE for all activities except grape girdling and cane turning immediately post-application would be

$$26 \div 1.67 = \mathbf{15.6}$$

The MOEs throughout the application cycle would range between 26 and 7.2, as illustrated in the following table.

Application	**Day**	**DFR as % of initial level**	**MOE**
1 (0.49 kg/ha)	0	**100**	**16**
	21	$10^{[\log 100] - [0.01003 \times 21]}$ = **62**	100 ÷ 62 X 16 = **26**
2 (0.49 kg/ha)	21	62 + 100 = **162**	100 ÷ 162 X 16 = **9.9**
	42	$10^{[\log 162\ ] - [0.01003 \times 21]}$ = **98**	100 ÷ 98 X 16 = **16**
3 (0.49 kg/ha)	42	98 + 100 = **198**	100 ÷ 198 X 16 = **8.1**
	63	$10^{[\log 198] - [0.01003 \times 21]}$ = **122**	100 ÷ 122 X 16 = **13**
4 (0.49 kg/ha)	63	122 + 100 = **222**	100 ÷ 222 X 16 = **7.2**

The MOE would regain the minimum acceptable value of 10 on the 14th day after the final application, as estimated from the following equation:

$$(\log 10 - \log 7.2\ ) \div 0.01003 = \mathbf{14.2}$$

Therefore, the REI for kiwi fruit and grapes (all activities except grape girdling and cane turning) should be set at 14 days unless additional information is made available which would permit refinement of the exposure estimate used above.

The MOEs associated with grape girdling and cane turning would be halved relative to the values shown above, and it would take

$$(\log 10 - \log 3.6) \div 0.01003 = \mathbf{44} \text{ days}$$

after the final application for the MOE to increase to the minimum acceptable value of 10. Consequently, the REI for grape girdling and cane turning should be 44 days unless additional information is made available which would permit refinement of the exposure estimate. If entry into treated kiwi fruit or grape crops is required prior to the relevant REIs, workers should wear chemical resistant gloves and cotton overalls buttoned to the neck and wrist (or equivalent clothing).

5 DISCUSSION

An earlier OHS risk assessment of azinphos-methyl (OCS 2005) indicated a need to reduce exposure during mixing/loading and application for a number of end use situations. Therefore, wide-neck containers and appropriate chemical-resistant gloves and boots were recommended for mixing/loading. No PPE was considered adequate to afford adequate protection during application of azinphos methyl products. However, submitted chemical specific exposure data (Maasfeld, 1999) indicated that engineering controls, such as the use of an enclosed tractor cab fitted with charcoal filter (to filter incoming air), could provide adequate protection during application.

The post-application exposure for workers entering treated areas was assessed from data provided in chemical-specific re-entry and surrogate studies. Most of the chemical specific studies provided DFR data but in two studies the blood ChE activity among hand harvesters was measured. A risk assessment of possible post-application activities indicated that the MOE was not acceptable for many post-application activitites, including hand pruning and hand harvesting of pome and stone fruit, blueberries, kiwis, macadamias and lychees. The risk assessment was supported by the observation that several hand harvesters had significant reductions in RBC and plasma ChE activity despite wearing gloves. This was thought to be the result of the persistence of azinphos methyl residues on the foliage.

In the present re-assessment of several new biomonitoring and DFR studies that were completed in 2004 and submitted to support the use of azinphos methyl products the recommendations made in the earlier assessment for mixing/loading and application remain appropriate. The submitted studies measured occupational exposure to azinphos-methyl during mixing/loading and application of azinphos-methyl product (Guthion 50 WP) and when thinning and harvesting berries, nuts and fruit from one to four weeks post-application.

Guthion 50 WP used in these studies is a wettable powder formulation, whereas the azinphos-methyl products available in Australia are flowable or suspension concentrate formulations. In addition, Guthion 50 WP is packaged in water-soluble sachets, which results in considerably reduced worker exposure to the chemical during mixing and loading the product for application. For the above reasons, exposure, and hence the risk to workers during mixing and loading could not be quantified from these studies.

None of the additional studies considered in this evaluation provided data on the exposure of operators applying azinphos-methyl by hand-held equipment. Therefore, there are no grounds for revising the conclusion of the previous occupational health and safety review, that worker exposure from manual application will be unacceptably high (OCS 2005).

For post-application activities, such as thinning and harvesting, urinary biomonitoring showed that MOEs (when adjusted for the Australian application rates and OHS NOEL) were higher than 10 in all crops studied, indicating low risk to workers during these activities. Workers entered the treated areas seven days following azinphos-methyl application for harvesting blueberries, 14 days post-treatment for thinning/harvesting apples, and 30 days post-treatment for walnut harvesting.

The orchard workers were probably exposed to azinphos-methyl residues via dermal contact and inhalation. It is worth noting that exposure to azinphos-methyl residue through the inhalation route for harvesters was almost the same as that for spray applicators using open cabs (see Tables 3 and 6). Explanation for such high inhalation exposure for harvesters was not provided.

However, workers in the newly-submitted studies did not experience toxicologically significant ChE depression, in contrast to the findings of the re-entry exposure studies evaluated in the previous OCS review. The anti-ChE toxicity noted in the earlier studies probably occurred because very high application rates of azinphos-methyl were used, which were up to eight times greater than the rates recommended for registered Australian products and the rates used in the current American exposure studies.

Significant rainfall was reported at some trial sites between the time of application and re-entry activities. This may have resulted in the reduction in DFR values (wash off from the leaves) and consequently in underestimation of exposure for workers harvesting fruit in these trials. This is evident in the apple harvesting study in the New York trial (Beedle and Kraai, 2004a) where rainfall occurred throughout the trial. Half-life of azinphos-methyl in this trial was calculated as eight days as compared to 20 days in California where little rainfall occurred. DFR half-life and exposure data from the most severely rain-affected trial sites were not considered for risk assessment, or were adjusted to compensate for the effects of rainfall.

When adjusted for the application rates and treatment schedules recommended for Australian azinphos-methyl products, the MOEs for workers re-entering blueberry, macadamia and citrus, pome-, stone-fruit crops have been assessed as acceptable. REIs have been set at one day for these crops. However, a relatively prolonged REI of 14 days has been recommended for kiwi fruit and grapes (applying to all activities except grape girdling and cane turning, for which a 44-day REI is required). This is due to the lack of reliable data on exposure of persons tending and harvesting vine crops, and the high default transfer coefficients associated with these activities. The REIs applying to vine crops could be re-considered if additional information on use pattern, foliar residues or worker exposure becomes available.

6 FIRST AID INSTRUCTIONS

Existing first aid instructions for azinphos methyl as they appear in the First Aid Instruction and Safety Directions (FAISDs) Handbook are as follows:

Code	***First Aid Instruction***
a	If poisoning occurs, contact a doctor or Poisons Information Centre. *Phone Australia* 131126
h	If swallowed, give one atropine tablet every 5 minutes until dryness of the mouth occurs – if poisoned by skin absorption or through lungs, remove any contaminated clothing, wash skin thoroughly and give atropine tablets as above. Get to a doctor or hospital quickly

First Aid Instructions ‘h’, which relates to the treatment of OP poisoning with atropine following oral, dermal and inhalational exposure has now been deleted from the FAISD handbook and replaced with the following instruction, which also incorporates the Poisons Information Centre contact details conveyed in instruction ‘a’:

Code	***First Aid Instruction***
m	If swallowed, splashed on skin or in eyes, or inhaled, contact a Poisons Information Centre (Phone Australia 131 126) or a doctor at once. Remove any contaminated clothing and wash skin thoroughly. If swallowed, activated charcoal may be advised. Give atropine if instructed.

Therefore, First Aid Instructions ‘a’ and ‘h’ should be removed from all commercial azinphos methyl product labels and replaced with statement ‘m’.

7 SAFETY DIRECTIONS

The current safety directions (including PPE) for WP or SC products containing less than 350 g/kg azinphos-methyl are as follows:

Azinphos-methyl WP 350 g/kg or less, SC 350 g/L or less	
Very dangerous, particularly the concentrate	100, 101
Product and spray are poisonous if absorbed by skin contact or inhaled or swallowed	120, 121, 130, 131, 132, 133
May irritate the eyes and skin	161, 162, 164
Repeated exposure may cause allergic disorders	180
Repeated minor exposure may have a cumulative poisoning effect	190
Avoid contact with eyes and skin and clothing	210, 211, 212
Do not inhale dust (WP), vapour (SC) or spray mist	220, 221, 222, 223
When opening the container, preparing spray and using the prepared spray: wear cotton overalls buttoned to the neck and wrist and a washable hat, and elbow-length PVC gloves and full facepiece respirator [NB: comment, not for label: this category includes air-purifying respirator] with combined dust and gas cartridge	279, 280, 281, 282, 290, 292, 294, 301, 303
If clothing becomes contaminated with product or wet with spray remove clothing immediately	330, 331, 332

Azinphos-methyl WP 350 g/kg or less, SC 350 g/L or less	
If product on skin, immediately wash area with soap and water	340, 342
After use and before eating, drinking or smoking, wash hands, arms and face thoroughly with soap and water	350
After each day's use, wash gloves and respirator (and if rubber wash with detergent and warm water), and contaminated clothing	360, 361, 364, 366
Obtain an emergency supply of atropine tablets 0.6 mg	373

The recommended revised safety directions are summarised below. Only SC formulations are registered in Australia. As all azinphos methyl products are in Schedule 7 of the SUSDP, the SD statement "very dangerous" duplicates the signal heading already contained on the product label and so can be deleted.

A previous quantitative OHS risk assessment has indicated that mixer/loaders handling SC products need to wear waterproof clothing over one layer of their own clothing, impervious footwear and elbow length PVC gloves. Eye protection should also be worn, given that the OCS toxicology review of azinphos-methyl concluded that SC products are expected to be slight to moderate eye irritants. It is also recommended that wide neck containers be used for packing the SC products, to minimise dermal exposure when pouring the concentrate.

Based on the findings of the currently-reviewed operator exposure studies, it is recommended that if workers are protected by a closed cab fully equipped with appropriate filters during application, their exposure will be acceptable if they wear overalls buttoned to the neck and wrist and normal enclosed footwear. However, applicators should also have access to gloves and waterproof clothing (similar to that for mixing/loading) to protect themselves if maintenance during application is required (eg. to clear a blocked spray nozzle). This should be located outside the cab but protected from contamination (ie. in a waterproof container). Suitable wash equipment also needs to be available to wash the hands to minimise any subsequent contamination of the tractor cab.

Workers applying the product who are not protected with an enclosed cab should wear PPE similar to that used by those participating in the US exposure studies evaluated in this report. The required PPE would comprise overalls, protective waterproof clothing including a hood or waterproof hat, elbow-length PVC gloves, respirator and water resistant footwear.

Therefore, the FAISD Handbook should be modified by amending the current entry for WP or SC products containing 350 g/kg azinphos-methyl or less, as follows:

Azinphos-methyl SC 350 g/L or less	
Product and spray are poisonous if absorbed by skin contact or inhaled or swallowed	120, 121, 130, 131, 132, 133
Will irritate the eyes and skin	161, 162, 164
May irritate the nose and throat	160, 163
Repeated exposure may cause allergic disorders	180
Repeated minor exposure may have a cumulative poisoning effect	190
Avoid contact with eyes and skin and clothing	210, 211, 212
Do not inhale vapour or spray mist	220, 222, 223

Azinphos-methyl SC 350 g/L or less	
When opening the container and preparing spray, wear cotton overalls buttoned to the neck and wrist (or equivalent clothing), protective waterproof clothing, elbow-length PVC gloves, water resistant footwear and face shield or goggles	279, 280, 281, 290, 292b, 291, 294, 298b, 299
When using the prepared spray (open cab), wear cotton overalls buttoned to the neck and wrist (or equivalent clothing), protective waterproof clothing including a hood or waterproof hat**,** elbow-length PVC gloves, water resistant footwear and half facepiece respirator with combined dust and gas cartridge	279, 282 [open cab], 290, 291c*, 292b, 294, 298b, 300, 303
When using the prepared spray (closed cab fitted with charcoal filters), wear cotton overalls buttoned to the neck and wrists (or equivalent clothing).	279, 282 [closed cab fitted with charcoal filters], 290, 292b
If clothing becomes contaminated with product or wet with spray remove clothing immediately	330, 331, 332
If product on skin, immediately wash area with soap and water	340, 342
If product in eyes, wash it out immediately with water	340, 343
After use and before eating, drinking or smoking, wash hands, arms and face thoroughly with soap and water	350
After each day's use, wash gloves and respirator (and if rubber wash with detergent and warm water), face shield or goggles and contaminated clothing	360, 361, 364, 365, 366
Obtain an emergency supply of atropine tablets 0.6 mg	373

* Proposed new FAISD Handbook standard statement

The entries referring to WP formulations should be deleted as they are no longer appropriate.

8 RECOMMENDATIONS

The following recommendations are made in respect to the four SC azinphos-methyl products currently registered in Australia.

1. The OCS recommends that the APVMA can be satisfied that the continued use of products containing up to 350 g/L azinphos-methyl in SC formulation, when applied other than by hand-held spray equipment and used on in accordance with label instructions and the following amended safety directions, would not pose an undue risk to worker safety.

2. First Aid Instructions 'a' and 'h' should be removed from all commercial azinphos methyl product labels and replaced with statement 'm'.

   If swallowed, splashed on skin or in eyes, or inhaled, contact a Poisons Information Centre (Phone Australia 131 126) or a doctor at once. Remove any contaminated clothing and wash skin thoroughly. If swallowed, activated charcoal may be advised. Give atropine if instructed

3 The following amended Safety Directions, which will be included in the FAISD Handbook, should be included on the product labels.

Amended entry

Azinphos-methyl SC 350 g/L or less	
Product and spray are poisonous if absorbed by skin contact or inhaled or swallowed	120, 121, 130, 131, 132, 133
Will irritate the eyes and skin	161, 162, 164
May irritate the nose and throat	160, 163
Repeated exposure may cause allergic disorders	180
Repeated minor exposure may have a cumulative poisoning effect	190
Avoid contact with eyes and skin and clothing	210, 211, 212
Do not inhale vapour or spray mist	220, 222, 223
When opening the container and preparing spray, wear cotton overalls buttoned to the neck and wrist (or equivalent clothing), protective waterproof clothing, elbow-length PVC gloves, water resistant footwear and face shield or goggles	279, 280, 281, 290, 292b, 291, 294, 298b, 299
When using the prepared spray (open cab), wear cotton overalls buttoned to the neck and wrist (or equivalent clothing), protective waterproof clothing including a hood or waterproof hat**,** elbow-length PVC gloves, water resistant footwear and half facepiece respirator with combined dust and gas cartridge	279, 282 [open cab], 290, 291c*, 292b, 294, 298b, 300, 303
When using the prepared spray (closed cab fitted with charcoal filters), wear cotton overalls buttoned to the neck and wrists (or equivalent clothing).	279, 282 [closed cab fitted with charcoal filters], 290, 292b
If clothing becomes contaminated with product or wet with spray remove clothing immediately	330, 331, 332
If product on skin, immediately wash area with soap and water	340, 342
If product in eyes, wash it out immediately with water	340, 343
After use and before eating, drinking or smoking, wash hands, arms and face thoroughly with soap and water	350
After each day's use, wash gloves and respirator (and if rubber wash with detergent and warm water), face shield or goggles and contaminated clothing	360, 361, 364, 365, 366
Obtain an emergency supply of atropine tablets 0.6 mg	373

* Proposed new FAISD Handbook standard statement

Note: Applicators using a vehicle with enclosed cab should also have access to gloves and waterproof clothing (similar to that for mixing/loading) to protect themselves if maintenance during application is required. This should be located outside the cab but protected from contamination (ie. in a waterproof container). Suitable wash equipment also needs to be available to wash the hands to minimise any subsequent contamination of the tractor cab.

Delete entries

Azinphos methyl - WP over 350 g/kg and Azinphos-methyl – WP 350 g/kg or less

4. The supplementary data considered in this review does not include studies on exposure of workers applying azinphos-methyl by hand-held apparatus. Consequently, there are no grounds for amending the previous review's

finding that workers applying azinphos-methyl by this method are likely to experience unacceptably high exposure. Application of azinphos-methyl by hand-held apparatus should therefore be discontinued.

5. The following re-entry intervals are recommended for the following crops:

Crop	**Re-entry interval (days)**
Blueberries, pome fruits, stone fruits (including plums and cherries), citrus, lychees and macadamias	1
Kiwi fruit and grapes (all activities except grape girdling and cane turning)	14
Grapes (grape girdling and cane turning)	44

6. **Precautionary statement**

“If re-entry is necessary during a designated re-entry interval, wear cotton overalls buttoned to the neck and wrist (or equivalent clothing) and chemical resistant gloves. Clothing must be laundered after each day’s use”.

7 REFERENCES

Beedle EC and Kraai MJ (2004a) GUTHION 50 WP – Dislodgeable Foliar Residue on Apple Tree Foliage, Bayer Corp. Study Number GU25AP01, Bayer Corp. Report Number 201101, Bayer Research Park, Stilwell, KS USA.

Beedle EC and Kraai MJ (2004b) GUTHION 50 WP – Dislodgeable Foliar Residue on Blueberry Plant Foliage, Bayer Corp. Study Number GU25BU01, Bayer Corp. Report Number 201060, Bayer Research Park, Stilwell, KS USA.

Duah FK, Kraai MJ and Murphy JJ (2004) GUTHION 50 WP – Dislodgeable Foliar Residue on Hairy-leaf, Needle-leaf, Smooth-leaf and Waxy-leaf Ornamentals, Bayer CropScience. Study Number GU25HL01, GU25NL01, GU25SL01, GU25WL01, Bayer Corp. Report Number 201046, Bayer Research Park, Stilwell, KS USA.

Fischer DR (2004a) Guthion 50WP – Biological Monitoring of Post-application Workers During Manual Thinning and Harvesting of Apples, Bayer CropScience Study Number GU264701; Report Number 201042. Bayer Research Park, Stilwell, KS USA.

Fischer DR (2004b) Guthion 50WP – Biological Monitoring of Post-application Workers During Manual Handling of Blueberries, Bayer CropScience Study Number GU264702; Report Number 201043. Bayer Research Park, Stilwell, KS USA.

Fischer DR (2004c) Guthion 50WP – Biological Monitoring of Post-application Workers During Harvesting of walnuts, Bayer CropScience Study Number GU264703; Report Number 201044. Bayer Research Park, Stilwell, KS USA.

Harbin AM and Kraai MJ (2004) GUTHION 50 WP – Dislodgeable Foliar Residue on Sweet Cherry Tree Foliage, Bayer Corp. Study Number GU25CH01, Bayer Corp. Report Number 201061, Bayer Research Park, Stilwell, KS USA.

Knarr RD (1987) Re-entry intervals for azinphos-methyl, oxydemeton-methyl, disulfoton and anilazine Study Number 95094 Mobay Corporation, Corporate Occupational and Product Safety, Kansas City, MO USA.

Krolski ME (2004) Azinphos-methyl – Biological Monitoring of Applicators Following Airblast Treatment of Orchard Crops using Open and Closed Cab Equipment, Bayer CropScience Study Numbers GU264704 and GU264705 Report Number 201054. Bayer Research Park, Stilwell, KS USA.

Lunchick C (2003) Assessment of pharmacokinetic data to identify a biomarker for the biological monitoring of azinphos-methyl. Bayer CropSciences Report No. 200575.

Maasfeld W (1999): Determination of Exposure during Mixing/loading and Application of Gusathion WP 25 in High Crops, Bayer AG, Crop Protection Development, Institute for Metabolism Research and Residue Analysis, D-51368 Leverkusen, In Germany, Report No. MR-121/99, Report Date, April 15, 1999.

OCS (2005) Occupational health and Safety Assessment of Azinphos-methyl Office of Chemical Safety, Department of Health and Ageing, Canberra Revised – January 2005

Selim S (1999) Absorption, Excretion, Balance and Pharmacokinetics of ^{14}C Radioactivity After Single Dose Dermal Application of Three Dose Levels of ^{14}C Labelled Guthion to Healthy Volunteers, XBL study no: 98052, Pharma Bio-Research Code PBR-963691, Bayer Corporation, 17745 South Metcalf, Stilwell, KS 66085.