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EXISTING CHEMICALS REVIEW PROGRAM

OCCUPATIONAL HEALTH AND SAFETY ASSESSMENT

OF

DIAZINON

DRAFT REPORT

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The Agricultural and Veterinary Chemicals Section
Chemicals Assessment Division

of the

The National Occupational Health and Safety Commission

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GLOSSARY OF TERMS AND ABBREVIATIONS

AAAA	Aerial Applicator Association of Australia
ai	Active ingredient
bw	Body weight
d	Day
mg	Milligram
g	Gram
kg	Kilogram
m^2	Square metre
ha	Hectare
L	Litre
mL	Millilitre
ACPH	Advisory Committee on Pesticides and Health
AChE	Anticholinesterase activity
ADI	Acceptable Daily Intake
ChE	Cholinesterase
CNS	Central Nervous System
CR	Chemical Review
DETP	Diethylthiophosphate
DMTP	Dimethylthiophosphate
DHAC	Department of Health and Aged Care
EC	Emulsifiable concentrate
EMG	Electromyography
GPS	Geographic Positioning Systems
LOEL	Lowest Observed Effect Level
MAFF	Ministry of Agriculture, Fisheries and Food
ME	Microencapsulated
NOEL	No Observable Effect Level
NOHSC	National Occupational Health and Safety Commission
NRA	National Registration Authority for Agricultural and Veterinary Chemicals
OHS	Occupational health and safety
OP	Organophosphorus pesticide
O,O-TEPP	Tetraethyl-pyrophosphate
O,S-TEPP	Monothiono-tetraethyl pyrophosphate
POEM	Predictive Operator Exposure Model
PPE	Personal protective equipment
PQ	Performance questionnaires
RBC	Red blood cell
REP	Restricted-entry Period
RfD	Reference Dose
SCOT	Standing Committee on Toxicity
S,S-TEPP	SulfoTEPP
WHP	Withholding Period
WP	Wettable powder

1. INTRODUCTION

Diazinon is an organophosphate (OP) insecticide, currently registered in Australia in a range of veterinary and agricultural products. It is used as an ectoparasiticide in large animals and an insecticide in agricultural situations. The chemical is a contact insecticide with anticholinesterase (AChE) activity. Diazinon products are also registered for use by pest control operators and home garden/home veterinary uses.

Diazinon is one of the agricultural and veterinary chemicals identified as candidates for priority review under the National Registration Authority for Agricultural and Veterinary Chemicals' (NRA's) Chemical Review.

In conducting the occupational health and safety (OHS) review, the National Occupational Health and Safety Commission (NOHSC) obtained information from the following sources: the Department of Health and Aged Care (DHAC) Review of Diazinon, industry submissions, NRA performance questionnaires (PQs) initiated as part of the review of diazinon, NRA Agriculture Report on diazinon, overseas reviews and the published literature.

2. HAZARD OVERVIEW

The information presented in this section derives from the DHAC report "Review of the Mammalian Toxicology and Metabolism/Toxicokinetics of Diazinon" (DHAC, 1999), unless otherwise noted.

2.1 Metabolism and excretion

Diazinon administered orally to rats was almost completely absorbed from the GI tract. Approximately 3% of the administered dose was measurable in the faeces, with a substantial portion of this dose derived from biliary excretion. Excretion studies indicated that most of the absorbed diazinon was present in urine as metabolites within 24 hours of administration. A half-life of 2.86 hrs in plasma was determined for diazinon, indicating that it is rapidly excreted from circulation.

2.2 Toxic endpoints relevant to the occupational health and safety assessment

Ideally, the toxicology end point(s) used in the OHS risk assessment should be established in the relevant species (ie. humans) by the route most appropriate for occupational exposure (ie. dermal). In the absence of human data, animal data may be used as surrogate, however, the variability in sensitivity between species is accounted for in the risk assessment (Section 5). Where dermal toxicology studies are not available or are inappropriate, oral studies may be used. Correction is made in the risk assessment to account for the protection afforded by skin, ie dermal penetration factor (Section 2.3).

The toxicological profile of diazinon is typical of organophosphate anti ChE (AChE) pesticides. Clinical symptoms are similar in humans and experimental species. Female animals are more sensitive to diazinon induced ChE inhibition, however, the inherent instability of diazinon causes an increase in toxicity in both sexes.

Acute toxicity

Technical diazinon was of moderate acute oral and dermal toxicity in mammals, the degree of toxicity dependent on the presence or absence of a stabiliser. The oral LD_{50} of stabilised diazinon ranged from 300-1350 mg/kg bw in a variety of vehicles, whilst the oral LD_{50} of non-stabilised diazinon ranged from 76-466 mg/kg bw. The acute dermal toxicity of stabilised diazinon was 876->2150 mg/kg bw (in rats). Diazinon was of low acute inhalation toxicity in rats with an inhalation LC_{50} of between 3100 and 5500 mg/m^3 (whole body exposure) and >5437 mg/m^3 (nose-only exposure). It was a slight eye and skin irritant in rabbits and a skin sensitiser in guinea pigs.

The acute oral toxicity of the diazinon products varied with LD_{50} ranging from 293->5050 mg/kg bw. Dermal toxicities were low (LD_{50} >1000 mg/kg bw). The microencapsulated formulations had very low acute oral toxicity (LD_{50} >5000 mg/kg bw) and low dermal toxicity (LD_{50} >2000 mg/kg bw). Generally, the products were slight eye and skin irritants, but not skin sensitisers.

Toxic impurities

Although fresh diazinon has only moderate toxicity, the presence of small quantities of impurities increases its toxicity significantly. This increased toxicity with “aging” was determined to occur in the presence of oxygen and a small volume of water. Under these conditions highly toxic tetraethyl-pyrophosphate (O,O- TEPP or TEPP), monothiono-tetraethyl pyrophosphate (O,S-TEPP) and dithiono-tetraethyl pyrophosphate (S,S-TEPP or sulfo-TEPP) are formed. These impurities may be formed either during manufacture or as breakdown products during storage. It is established that S,S-TEPP and O,S-TEPP are approximately 300- and 2500-fold respectively more toxic than the parent compound. In the presence of large volumes of water, biologically inactive diethyl phosphate is the predominant breakdown product.

Water, oxygen, and presumably temperature are the major factors that promote the formation of the toxic impurities. Therefore, the inherent ability of the product container to prevent the entry of water and air as well as the frequency of opening of lid/cap are factors likely to determine the formation of these impurities. Many currently registered diazinon products contain epoxidised soybean oil as a stabiliser, introduced immediately after manufacture, in an attempt to minimise the formation of impurities. [However, the DHAC determine that this additive may not be sufficient to reliably prevent the formation of toxic by-products]. In addition, results of an Australian study supported by the NRA reported that 26 of 169 (15%) diazinon formulations within the label-stated expiry date contained unacceptably high concentrations of S,S-TEPP and O,S-TEPP.

Repeat dose toxicity

Cholinesterase inhibition is the primary target of diazinon toxicity. Following is a summary of No-Observable-Effect-Levels (NOELs) based on ChE inhibition, relevant for the OHS assessment.

Table 1: Diazinon; Summary of NOELs (mg/kg bw/day) for ChE inhibition relevant to the OHS assessment

Species and route	Duration of study	Plasma ChE	Red cell ChE	Brain ChE
Rat, oral	3 months	0.01	0.1	1.5
Rat, oral	3 months	0.1	>0.4	>0.4
Rat, oral	3 months	0.03	0.04	0.06
Rat, oral	3 months	0.017	0.017	1.9
Dog, oral	3 months	0.0034	0.02	0.02
Human, oral	37 or 43 days	0.020	>0.025	-

Source: DHAC, 1999

As evident from Table 1, inhibition of plasma ChE occurred at lower doses than inhibition of RBC ChE and Brain ChE. However, it is of note that the Lowest-Observable-Effect-Level (LOEL) established in animal studies was not much lower than 0.02 mg/kg/day, the NOEL for humans (LOELs not presented in this report).

In the only human study in which a NOEL was established, groups of 3 adult male volunteers were dosed orally for either 37 days at 0.02 mg/kg/day or 43 days at 0.025 mg/kg/day. Treatment at the lower dose resulted in non-significant inhibition of plasma and RBC ChE. The higher dose resulted in significant change in mean plasma ChE but no significant change in RBC ChE activity. Following cessation of dosing, plasma ChE returned to full activity by approximately day 61.

The current acceptable daily intake (ADI) of 0.001 mg/kg bw/day was derived from a NOEL of 0.1 mg/kg bw/day, based on plasma ChE inhibition observed in a 3-month rat study. The toxicology review identified a validated human study (refer above) that had a lower NOEL (0.02 mg/kg/day) based on the same endpoint. The Advisory Committee for Pesticides and Health (ACPH) reviewed the toxicology database and determined that a 20-fold safety factor was acceptable, ie 10-fold for variability in human sensitivity and an additional 2-fold safety factor given closeness of the NOEL and LOEL (0.025 mg/kg/day) and the small group size (n=3) used to establish the NOEL in the human study.

Diazinon was not mutagenic in studies using various endpoints *in vitro* and *in vivo*. Rodent studies provided no evidence for carcinogenicity.

No teratogenic effects were observed in reproduction studies (in rats) or developmental studies (in rats, rabbits and pigs).

Other toxic effects of diazinon

Porphyrin Biosynthesis

An abnormally high incidence of porphyria cutanea tarda in humans was reported in parts of NSW, Australia. A possible relationship between this condition and exposure to diazinon in wool fat contacted during shearing was investigated in 1992 by the Standing Committee on Toxicity (SCOT). However, no clear causal relationship was found. It was determined that the reported incidents of porphyria cutanea tarda may have been caused by congenital low levels of liver uroporphyrinogen decarboxylase activity in the affected persons.

Pancreatitis

Pancreatic lesions and an increase in the secretion of amylase were observed in dogs exposed to diazinon. The DHAC determine that the formation of such pancreatic lesions is probable in humans following exposure to diazinon, as judged from *in vitro* data and several poisoning incidents where increased serum amylase was observed (when measured, refer to Section 2.4, Lee, 1989 and Ciba-Geigy Australia Ltd, 1995).

Neuropathy

In addition to clinical signs of acute diazinon poisoning, ingestion of the chemical has been reported to cause “Intermediate Syndrome”, a condition occurring 24 to 96 hours after exposure and characterised by muscular weakness affecting the neck, proximal limbs and respiratory muscles (cited in DHAC, Samal & Sahu 1990).

There have been no reported cases of delayed neuropathy following accidental or deliberate ingestion of diazinon.

Skin sensitisation

Several pesticides (including diazinon) were patch tested in 652 subjects to determine the frequency of irritation and allergic reactions. Diazinon did not produce either irritant or allergic reactions.

Discussion

The acute oral toxicity of diazinon is moderate with the primary target of toxicity being inhibition of ChE activity. Female animals appear to be more sensitive to diazinon induced ChE inhibition. However, the inherent instability of diazinon causes an increase in toxicity in both sexes. Inhibition of plasma ChE occurred at lower doses relative to inhibition of RBC and brain ChE in experimental species.

No human dermal studies were available for diazinon. The single human oral dosing study that established a NOEL, utilised a small number of subjects and two dosing regimes. The NOEL from this study was determined to be 0.02 mg/kg/day for plasma ChE inhibition. NOELs established in short-term rodent studies for plasma ChE inhibition ranged from 0.01 mg/kg/day to 0.1 mg/kg/day. A single canine study established a NOEL of 0.0034 mg/kg/day for the same end point. The LOELs for the short-term animal studies were not much lower than the NOEL from the human oral study. Given the uncertainty associated with correcting for dermal penetration of diazinon, the use of a human oral NOEL may overestimate the risk to workers where the primary exposure route is expected to be dermal.

However, in the absence of a human dermal study and considering all of the above, NOHSC used the NOEL of 0.02 mg/kg/day from a repeat dose human dietary study in the OHS risk assessment.

2.3 Dermal absorption

Dermal dosing of rats, dogs and sheep failed to establish a meaningful dermal absorption rate for diazinon. However, it is of note that of the total dose (in tetrahydrofuran) applied to rats in metabolic cages, 18% was present in the atmosphere as volatile after 144 hrs. Similarly, in the sheep study, the volatility of the preparation precluded an accurate assessment of the applied dose.

In vivo and *in vitro* studies using radio-labelled diazinon were conducted in humans to measure the percutaneous absorption rate of diazinon.

Radio labelled diazinon in acetone was applied to an area (10 cm^2) of the ventral forearm or abdomen to groups of six volunteers each. A third group of six volunteers had 14.7 g of radioactive diazinon in lanolin applied to the abdomen. The application area was left uncovered in all subjects for 24 hrs, after which time the area was washed in all treatment groups and the application site stripped repeatedly using adhesive tape 7 days later. For each volunteer the radioactivity in the surface wash, adhesive tape and 24-hour pooled urine (collected over 7 days) was measured. After adjusting for residual radioactivity at the application site, the cumulative 7-day urinary excretion radioactivity was calculated to be 2.2%, 1.8% and 1.6% for forearm (acetone), abdomen (acetone) and abdomen (lanolin) groups, respectively. A concurrently performed Rhesus monkey study had demonstrated that approximately 56% of an intravenous dose was excreted in the urine over 7 days. Assuming that pharmacodynamics is similar in humans and monkeys, the human percutaneous absorption rate for the three groups corrected for incomplete or other route excretion was estimated to be 3.8% (forearm, acetone), and 3.2% (abdomen, acetone) and 2.9% (abdomen, lanolin) respectively. The DHAC determine that if the quantity of diazinon remaining in contact with the skin for 24 hrs is uncertain (due to possible loss of approximately 95% of the applied dose through vapourisation or smearing on clothing), the reliability of this calculated absorption rate is in doubt.

In the same report, diazinon absorption was measured *in vitro* using two human cadaver abdominal skin samples (from 23- and 56-year cadavers) in flow-through cells. Radio labelled diazinon in acetone was applied on 1 cm^2 of skin samples in six separate cell for each donor. After 24 hours without occlusion and a buffered saline flow rate of 1.25 mL/hr, the samples were removed and washed to quantify residual surface radioactivity. Radioactivity remaining on the skin was determined by tissue solubilisation. The surface wash accounted for 48.3% and 34.6% respectively of total radioactivity for the 23- and 56-year cadaver skin specimens whilst the skin digest had 5.6% and 4.8% respectively. Radioactivity in the receptor fluid was 8.5% and 19.7% respectively. Therefore, total radioactivity recovered was 62.4% and 59.1% respectively. It was speculated that the balance radioactivity (approximately 40%) had evaporated over the duration of the study (Wester et al., 1993; also cited in DHAC, 1999).

There is no specific data relating to percutaneous absorption of the degradation products of diazinon. Several dog and cattle deaths have been reported following the use of out-of-date diazinon products. The DHAC determine that it can be inferred that significant amounts of these toxic degradation products can penetrate the skin at the same or greater rate than the parent compound.

Discussion

It should be noted that the dermal penetration process cannot be described adequately in terms of percentage absorption, since the amount penetrating will depend on the area of skin involved, the amount of pesticide present on the skin acting as a "driving force" for penetration, the duration of the presence on the skin as well as on many other aspects related to the worker (skin) and the work situation.

Based on systemic effects (depression of ChE activity) following dermal dosing, diazinon has been shown to be absorbed through the skin of animals and humans.

The human volunteer study (Wester et al., 1993) established the dermal absorption of diazinon to be in the range of 2.9% to 3.8%, depending on vehicle and site of application. However, several animal and human studies support the contention that a significant portion of the applied dose may be lost through volatilisation (refer above). The dermal penetration rate of toxic metabolites of diazinon is unquantified.

Considering all of the above, NOHSC adopted a conservative approach in selecting a dermal penetration rate of 4% for the OHS risk assessment.

2.4 Poisoning incidents and health effects related to occupational exposure

Eighteen workers at a mushroom farm were exposed to diazinon when the only entrance to the room was sprayed with the chemical. Within 15 minutes, 17 workers developed cholinergic symptoms, including headache, blurred vision, dizziness, fatigue, nausea and vomiting. Four of these workers were hospitalised and treated. Their plasma and RBC cholinesterase levels were at the lower end of the normal range. Two of these four workers felt nauseous and vomited shortly after returning to work 2 days later. Eight other workers sought medical advice within 48 hrs of exposure. Their ChE activity was determined at this time and 15 days later. In all cases plasma and RBC ChE activity increased between the two tests. If the ChE levels found at 15 days post-exposure were taken to be the normal for these workers, the mean inhibition of plasma and RBC ChE noted was 29% and 27% respectively. It is recognised that this may be an underestimate of ChE depression, as recovery of ChE activity is not likely to be complete within 15 days after exposure. The study authors recommend that where there are cholinergic signs and symptoms, no baseline ChE values for the individual and plasma ChE levels are at the lower end of normal, the worker should be kept from work and re-tested at the same laboratory 3-5 days later. Repeat testing should be performed at similar intervals until ChE activity returns to normal (Coye et al., 1987).

Two female horticultural workers were accidentally exposed to diazinon, when an open bottle in a storeroom spilled onto the back of one worker. As she changed her clothes, her companion mopped up the spilt pesticide with rags. Approximately 3 hrs later the worker who cleaned up the spill was admitted into hospital with giddiness, diarrhoea and vomiting, frothing at the mouth, cyanosis, tachypnoea and drowsiness. The history of pesticide exposure was not explained. Despite a clear chest x-ray the patient was treated for pulmonary disease, intubated and maintained on a respirator. Blood tests indicated disruption of the clinical chemistry. She improved, and was removed from the respirator. Later the same day she complained of epigastric pain and vomited. She was diagnosed as suffering from acute pancreatitis, with serum amylase levels increased approximately 10 fold over normal levels. Enzyme levels returned to normal over the next 3 days following treatment. The second worker developed cholinergic symptoms approximately 7 hr after exposure. She was admitted to hospital 4 hrs later and was treated for pesticide poisoning with atropine. Her plasma ChE levels was decreased by approximately 75% of the normal. ChE activity increased over the next 4 days, to be within 25% of normal values. Serum amylase levels were not determined in this worker. The study author concluded that considering the role of acetylcholine in stimulation of the acinar cells of the pancreas, the link between OP poisoning and pancreatitis is conceivable. However, it would appear that other risk factors for pancreatitis may also be involved, given that not all poisoning victims develop the symptoms of acute pancreatitis (Lee, 1989).

In an attempt to simulate worker exposure to diazinon when treating rice paddies, five male volunteers aged 44 to 55 years, stirred a dry granular formulation of 10% diazinon (formulation details not available) in a plastic bucket with one bare hand for a period of 30 minutes. At the same time the volunteers stood with bare feet in water containing diazinon at 1.7 ppm. At the end of the exposure period, each volunteer carefully washed his hands and feet with soap and water. No adverse health effects were reported. Plasma and RBC ChE activity was determined twice pre-test, 2 to 4 hrs- and 4 days post-test. Plasma ChE activity was inhibited from 17% to 27% within 4 hrs of exposure, compared to pre-exposure values. Inhibition of 9% to 14% of pre-exposure values were observed after 4 days. Erythrocyte ChE activity was unaffected by exposure to diazinon (Loosli, 1983).

The neurobehavioural function of pest control workers following short-term exposure to low levels of diazinon was investigated in California by Maizlish et al., (1987). Ninety nine volunteers undertook the application of diazinon through residential areas or were involved in supervision, pest-inspection or other non-pesticide related work. All volunteers were required to undertake a physical examination and complete a questionnaire, to identify any pre-existing disease, trauma, medication or other condition unrelated to pesticide exposure which may affect behavioural test performance. Diazinon granules (14%) were applied at 40 lbs/acre to the soil surface using a variety of application equipment, followed by watering in. Applicators wore disposable overalls, rubber boots and rubber gloves while in the treatment area. In addition, workers involved in loading machinery also wore wear face shields and full-face air purifying (cartridge type) respirators. Urinary levels of diazinon metabolites, diethylthiophosphate (DETP) and dimethylthiophosphate (DMTP) were measured pre- and post-shift in 46 applicators and 56 non applicators. A random sample of 19 workers' were also selected for the measurement of diazinon exposure using dermal badges, hand rinses and breathing zone air samplers. The median duration of pesticide application was 39 days before testing. Seven behavioural tests were undertaken by each volunteer, pre- and post-shift. The tests were selected on the basis of their sensitivity, reliability, ease of administration, subject acceptance and inclusion of CNS functions known to be affected by pesticide exposure. Post-shift median DETP concentration was 24 and 39 ppb for applicators and non-applicators, respectively. Median diazinon exposure was 2.1 and 0.03 mg, respectively. No adverse DETP-related changes in pre- and post-shift neurobehavioural function were found after adjusting for age, sex, education and alcohol intake. The prevalence of 18 symptoms possibly related to diazinon exposure was not increased among applicators. The study authors concluded that there was no evidence that short-term low level diazinon in a controlled pest control program (using PPE and working under supervision) caused any behavioural effects.

A 51-year-old male treated 3 cows with a commercial mixture containing malathion and diazinon in a closed shed. He was found unconscious several hours later and hospitalised. Neurological examination revealed increased muscle tone, neuromuscular excitability and non-response to all stimuli except pain. The patient also demonstrated a sinus tachycardia and a chest x-ray revealed a mild increase in heart size with increased pulmonary vasculature. Plasma ChE activity was inhibited by 75% relative to the normal values. The patient died on day 4 following a second cardio-respiratory arrest. A postmortem examination was conducted 4 hrs after death. Postmortem examination revealed diffuse haemorrhages in subarachnoid, intraventricular and cerebral cortical areas and autolysis at the base of the brain. Examination of the heart indicated moderate left ventricular hypertrophy, with no dilation or hypertrophy of the other cardiac chambers. Microscopic examination of intercostal muscle revealed mild pathologic changes including necrotic fibres, randomly scattered throughout the muscle tissue. These types of lesions were not seen in control samples. The neuromuscular ChE activity in the intercostal samples obtained from the patient with pesticide poisoning were approximately half those seen in control patients. The study authors report that necrosis had been seen previously in muscle tissue from patients dying of acute OP poisoning (Wecker et al., 1985).

The NSW State Coroner’s Office, Australia, reported on the death of a sheep farmer related to the use of a diazinon product. This 68-year-old sheep farmer used diazinon to treat sheep without wearing the protective clothing recommended on the product label. He presented the next day with peri-umbilical and upper abdominal pain, and diagnosed with acute haemorrhagic pancreatitis requiring intensive care. His condition deteriorated over time and he died of multi-organ failure two days after admission to hospital. On postmortem examination, the mid-portion of the pancreas was necrotic and adherent to the stomach, with extensive greenish-black discoloration of the peritoneal surface, and ischaemic necrosis of the small bowel and transverse colon. Three hundred mL of blood stained fluid was found in the peritoneal cavity. Incidental post-mortem finding included; left ventricular dilatation, extensive moderate atherosclerosis in the aorta, an early infrarenal abdominal aortic aneurysm, moderate emphysema and pulmonary oedema. The pleura contained 200 mL of serous fluid. Histopathological examination revealed the following; extensive necrosis of the pancreas and retro-peritoneal tissue, pulmonary oedema, saponificated lipid material in the arterial vessels, early tubular hyperplasia and vascular scaring of the kidney and centrivenous necrosis in the liver. Diazinon was not detected in the organs or tissues at this time. Blood ChE activity was 26 units (normal 80 to 150 units), which was consistent with OP exposure. The cause of death was determined to be severe acute haemorrhagic pancreatitis caused by exposure to diazinon, probably by the dermal route (Ciba-Geigy Australia Ltd, 1995).

Soliman et al., (1982) reported two cases of acute poisoning possibly related to diazinon transformation products, in Egypt. Two experienced sprayers with over 18 months experience in applying diazinon weekly by backpack, suffered acute toxicity after using a 60% diazinon EC formulation. The product was previously packaged in aluminium containers. The product handled by these workers was packed in tin-plated sheet steel. When preparing this batch of spray the workers noticed crystals in the storage container. The 33 year old male developed nausea, vomiting, muscular weakness and twitching in his arms and legs. His plasma ChE was inhibited by >20% (relative to unexposed males) on day eight after poisoning, with recovery at day 15. His RBC ChE activity was inhibited by >20% on day 18 and returned to control levels by day 28. The second worker, a 50 year old male, developed nausea and vomiting after a full day’s spraying. He later developed blurred vision, difficulty in breathing and severe headache, which lasted for three days. The symptoms abated within 3 days without medical intervention. Plasma ChE activity was inhibited by >20% (relative to unexposed males) on day ten after poisoning, with recovery at day 17. His RBC ChE activity was inhibited by >20% on day 17 and returned to control levels by day 20.

Examination of the crystals found in the container revealed the presence of large amounts of 2-isopropyl-4-methyl-6-hydroxypirimidine in two isometric forms. Small amounts of sulfotepp and monothiono-TEPP were detected. TEPP was not found. The study authors conclude that it is likely that these toxic metabolites resulted in the clinical signs observed.

Discussion

Several incident reports and volunteer studies were available for diazinon. These confirm the occurrence of cholinergic symptoms following occupational exposure to the chemical. Clinical symptoms were associated with inhibition of ChE activity. Plasma ChE appears to be more sensitive to inhibition by diazinon than RBC ChE. Severe inhibition of ChE may be associated with random necrosis of affected muscle fibres and cardiac and cerebrocortical abnormalities (Werker et al., 1985).

Acute pancreatitis has been reported following occupational exposure to diazinon in Australia and overseas (Lee, 1989 and Ciba Geigy, 1995). However, the DHAC determine that it is uncertain whether other risk factors contributed to the development of pancreatitis in these patients.

Acute poisoning has been related to the formation of toxic degradation products during storage (Soliman et al., 1982). The case report highlights the possible contribution of packaging material in the formation of toxic metabolites.

3. USE PROFILE

3.1 Prior to end use

Several formulations of diazinon are currently registered in Australia. The veterinary products include emulsifiable concentrates (EC) containing diazinon at 200 g/L, 96 g/L, 93.3 g/L, 80 g/L, 60 g/L, 3 g/L and 1g/L and powder formulations at 15 g/kg and 20 g/kg. The agricultural products include EC formulations containing diazinon at 800 g/L, 240 g/L and 200 g/L and microencapsulated (ME) formulations containing diazinon at 300 g/L and 240 g/L.

Some diazinon products are imported fully formulated whilst others are formulated in Australia. The EC formulations are packed in 200 mL, 250 mL, 5 L, 20 L and 25 L containers, whilst the powder formulations are packed in 500 g, 3 kg, 12.5 kg and 15 kg containers. The ear tags are packed in sachets containing 20 tags each.

This assessment does not address worker exposure and risk during manufacture/formulation. Individual premises, manufacturing/formulation processes and exposure control measures may vary within workplaces. However, they are expected to follow good manufacturing practices, and have adequate quality control and monitoring facilities.

Refer to Section 6 for details on Commonwealth/State/Territory occupational health and safety legislative requirements.

3.2 End use

The following information is based on products registered in Australia prior to the commencement of this review.

Information on the Australian use pattern of diazinon was obtained from registered product labels, NRA Agriculture Report and PQs obtained through the NRA covering Large Scale

Users (PQ No.1), Small Scale Users (PQ No.2), and State Chemical Co-ordinators (PQ No. 4). This information is summarised in Tables 2-9.

3.2.1 Use pattern

Diazinon is currently registered for a wide range of uses in Australian agriculture and animal treatment. It is of particular importance as an ectoparaciticide in sheep and cattle husbandry. As an agricultural chemical, it is registered as an insecticide for use in small yet significant industries. Diazinon is a major component of pest control and resistance management strategies across Australia.

The major use of diazinon in cattle is for control of buffalo fly through use of backrubbers, ear tags, hand sprayers and spray races. It is also used for the treatment of lice, blowfly and other parasites in sheep through plunge and shower dipping, jetting (hand and automatic), and backline treatment. Diazinon is approved for use in several species as a general wound dressing and for the control of lice and other parasites in pigs, dogs, goats and horses.

All commercial diazinon products recommend the use of protective clothing during mixing/loading and spray/solution application. The personal protective equipment specified varies depending on product and work activity.

Diazinon is widely available for use in pet care products and home garden situations. The OHS review does not include home garden and home veterinary uses of the chemical.

The use of diazinon products is permitted by the NRA in circumstances such as minor and/or emergency uses and for trial purposes. Current permit uses of the chemical are not evaluated in this report.

Table 2 - Use pattern of diazinon products (EC 800 g/L) in agricultural situations – vegetables

(additional information found in Table 6.1 of the NRA Review of Diazinon September 2002, Volume 1, Review Summary)

Crop/situation	Pest	Formulation type and concentration of ai in product	Application rate/dilution of product (concentration of ai in solution)	Comments
Vegetables (other than onions and mushrooms)	Aphid Grub White butterfly Caterpillar Moth Cutworms Wireworms Thrips Flies	EC 800 g/L	<u>Foliar boomspraying</u> 700 mL-1.4 L/ha <u>Foliar knapsack spraying</u> 5 mL-30 ml/15 L water (0.02%-0.16%)	Spray when necessary, usually at 7-14 day intervals Applied mainly by boom spray. Knapsack spraying used only when absolutely necessary (user information) Vary boom spray rate according to plant size Use higher rate for advanced crops Spray volume - high volume spraying a minimum of 250 – 500 L water per ha, low volume spraying 50 – 100 L water per ha In specific crops the spray is applied as a band on either side of the plants
Onions	Onion maggot Wireworms		<u>Foliar boom spray</u> 700 mL product/ha or 65 ml/100 L (0.052%) <u>Aerial application</u> 700 mL product/ha or 65 mL/100L	Apply by boom spray Spray volume - high volume spraying a minimum of 250 – 500 L water per ha, low volume spraying 50 – 100 L water per ha Standard closed filling/loading are in operation as per AAAA guidelines. The chemical would be pumped from a drum into a mixing tank from which it would then be transferred to the plane Spray volume 20-30 L/ha GPS navigation systems used while spraying

Mushrooms	Mushroom pests (various)		30 mL/10 L water/tonne of moist compost (after casing) (0.24%)	Treatment at spawning does not occur (NRA Agricultural Report) Labels specify spraying of chemical over top of casing Industry practices is to incorporate the chemical evenly into the peatmoss and limestone mixture during preparation of casing (NRA Agricultural Report) Not to be applied later than 14 days before harvest

Table 3:- Use pattern of diazinon products (EC 800 g/L) in agricultural situations – fruit

(additional information found in Table 6.1 of the NRA Review of Diazinon September 2002, Volume 1, Review Summary)

Crop/situation	Pest	Formulation type and concentration of ai in product	Application rate/dilution of product (concentration of ai in solution)	Comments
Fruit (other than bananas and pineapples	Scale Aphid Citrus bug Citrus leaf miner Grasshopper	EC 800 g/L	65 mL/100 L –1.3 L/ha 65 mL/100 L – 1.3 L/ha	Foliar boom spraying Representative parameters. Spray at 2-4 week intervals 2000 L/ha, 30 ha/day Airblast Representative parameters Spray at 2-4 week intervals 2000 L/ha, 30 ha/day
Bananas	Weevil borer Rust thrips		125 mL product/100 L water (0.1% ai)	Band application, applied by tractor-mounted spray 900 L/ha Variable work rate 8-10 ha/day on the largest farms. Most farms would be 6-8 ha/day Chemical applied as a 30% band, approximately 1 m wide, on either side of the plants. The inter-row is not treated Usually 2 applications per crop, 14 days apart
Pineapples	Scale Mealy bug		65 mL product/100 L (0.05% ai)	Boomspray Spray volume 3000 L/ha Maximum work rate 2-4 ha/day, ie 2 hours Maximum of 5 applications per year at 2-3 month intervals Spray pineapple plants thoroughly when scales or eggs are evident. s

Table 4:- Use pattern of diazinon products (EC 800 g/L and 200 g/L) in agricultural situations - field crops, lawns, nurseries

(additional information found in Table 6.1 of the NRA Review of Diazinon September 2002, Volume 1, Review Summary)

Crop/situation	Pest	Formulation type and concentration of ai in product	Application rate/dilution of product (concentration of ai in solution)	Comments
Field crops Pastures, cereals (including maze, sorghum), oilseed crops (including cotton), sugar cane, soybeans, rice	Leafhopper Aphid Grubs Australian Plague Locust Migratory locust Grasshoppers Brown plant hopper Bloodworm	EC 800 g/L	700 mLs^{-}1.4 L^{-}110 L water/ha (0.5%-1.0% ai) 700 mLs^{-}-1.4 L^{-}/22 L water/ha (2.5%-5.0% ai) 700 mLs^{-}-1.4 L/22 L water/ha (2.5%-5.0% ai)	Boom spray, 30 ha/day 50 ha/day Aerial 200 ha/day Misting machines 50 ha/day For locust control spray directly onto hopper bands and flying swarms Rice crops are sprayed either when pests are active or, at /within 24 hours of sowing. Apply spray when pests are present in damaging numbers Re-application is permitted as required. Application at 4 – 10 day intervals is permitted in specific crops and at particular stages of growth Higher application rates recommended for high pest pressure, dense crops and greater water depth (rice only)
Nursery plants	Aphids Thrips Mealy bugs Scale insects Plant bugs Beetles	EC 800 g/L	Dipping mixture 60 mL/100 L water (0.05% ai)	Knapsack and motorized equipment Thoroughly drench plant material with dipping mixture Common practice is to apply the spray mixture directly to the surface of the potting media
Ornamentals, potted plants	Fungus gnats	EC 800 g/L	2 mL/10 L (0.016% ai)	Product applied as drench.
Lawns (around trees, fences, walls)	Argentine ant	EC 800 g/L	600 mL/100 L water (0.48% ai) Minimum 1 L mixture/10 m^2 Maximum 400 L spray /day	Hand-held spraying
Lawns/Turf	Armyworms Cutworms African black beetle Couch flea beetle		600 mL/200 L or sufficient water (0.24%) 20 ha/day Spray over 1500 m^2 area	Boomspray Apply to nests and infested areas.

	Couch Tip-maggot			Spray base of trees, along foundation walls, fences, paths and garden beds Do not graze or cut for stock feed within 2 days of application Spray lawns on a grid pattern of $1m^2$
Lawns (around trees) Lawns	Argentine ant Cut worms Maggots Mites Mealybugs Beetles Grub	EC 200 g/L with liquid solvent	2.5 L/100 L water (0.5% ai) Use 1 L mixture/10 m^2 150 mL/10 L water (0.3% ai) Apply over 100 m^2	Apply to nests, infested areas such as base of trees, along foundation walls, fences, paths and garden beds Repeat if necessary in 10 days

Table 5: - Use pattern of diazinon products (EC 200 g/L, & 800 g/L) in agricultural situations - pest control/others

Situation	Pest	Formulation type and concentration of ai in product	Application rate/dilution (concentration of ai in spray)	Comments
Commercial and industrial buildings, ships, farm buildings including kennels, stables, and piggeries, garbage containers, refuse areas	Cockroaches Silver fish Beetles Fleas Flies Spiders Ants Bugs Mosquitoes	EC 800 g/L	Sprayer 6 mL/L water or kerosene (0.48% ai) Mister 15 mL/L water or kerosene (1.2% ai) Swingfog 60 mL/L fogging oil or distillate (4.8% ai)	Application to be made when pests are first seen. Re-treat when pests re-appear Product applied to crevices, cracks, floors, under carpets, ceilings, under eaves, sleeping areas of pets, walls and other areas of infestation using sprayers Spray volume: sprayers 1 L mixture should cover 20 m^2 of surface; misters - 1 L mixture should cover 50 m^2 of surface Product applied to ant trails. 1 L mixture should cover 10 m^2. Nests must be thoroughly saturated.
		EC 200 g/L	Sprayer 25 mL/L water or kerosene (0.5% ai) Mister 60 mL/L water or kerosene (1.2% ai) Swingfog 250 mL/L fogging oil or distillate (5% ai)	
Refuse areas, garbage	Maggots	EC 200 g/L	250 mL/100 L water (0.05% ai)	Apply to thoroughly penetrate refuse
Skins and hides	Skin and hide beetles	EC 800 g/L	6 mL/L water (0.48% ai) Skins/hides Apply 60 ml of mixture per hide Spraying of surrounding areas 5 L of mixture per 100 m^2	Used for fly control when preparing skins or hides for transport Pallets are sprayed before loading into containers to prevent build up of fly numbers Apply using atomiser, small sprayer or mister when necessary.

		EC 200 g/L	25 mL/L water (0.5% ai) Skins/hides Apply 60 ml of mixture per hide Spraying of surrounding areas Spray 5 L mixture/100 m^2	
Ponds, stagnant water	Mosquito larvae	EC 800g/L	Sprayer 125 mL/100 L water (0.1% ai) Mister 2 mL in diesel oil or kerosene per 100 m^2 Swingfog 180 mL in fogging oil or distillate/ha	Apply to breeding areas
		EC 200 g/L	Sprayer 500 mL/100 L water (0.1% ai) Mister 7 mL in diesel oil/kerosene/100 m^2 Swingfog 700 mL in fogging oil or distillate/ha	

Table 6: - Use pattern of microencapsulated diazinon products (ME 240 g/L & 300 g/L) in agricultural situations - pest control, turf

Situation	Pest	Formulation type and concentration of ai in product	Application rate/dilution (concentration of ai in spray)	Comments
Domestic and industrial buildings including food processing plants, aircraft, boats, ships, railway cars, buses, trucks and trailers and building perimeter treatment	Cockroaches Silverfish Ants Fleas Ticks Flies	ME 240 g/L	210-420 mL in 10 L water (0.5-1%)	Apply as a fine spray or by paint brush to areas where insects hide Repeat applications as necessary Window frames, screens, garbage tins and similar areas are to be treated with spot applications Foundations and walls are sprayed up to 1 m high and 2-3 m out from perimeter of building
Commercial and industrial buildings including kennels, stables, piggeries, refuse areas and garbage containers	Cockroaches Silverfish Ants Fleas Beetles Bugs	ME 300 g/L	20 mL/L water (0.6%)	Use atomiser or small sprayer Apply as a fine spray just to point of wetting surface, to areas where insects hide 1 L of mixture should cover approximately 20 m^2 Specially designs pack with squeeze action to minimise spillage during pouring
Turf	Stem weevil Black beetle Mole cricket Caterpillars	ME 240 g/L	30 mL-250 mL in 15 L water/100 m^2 (0.048%-0.4%)	Apply after mowing turf After application irrigate treated area with the equivalent of 2 mm water Repeat application when necessary

Table 7: - Use pattern of diazinon products in cattle, goats, pigs and horses using various application methods

Application method	**Host/Pest**	**Formulation type/concentration of ai in product**	**Application rate/dilution (concentration of ai in spray)**	**Comments**
Backrubber and rubbing posts	Cattle Buffalo fly	EC 200 g/L	500 mL product/10 L oil (1% ai)	Backrubbers are generally used during the fly season, ie 6 months of the year Re-treatment is carried out every 3 weeks The solution is either poured on the backrubber or the backrubber soaked in solution within a trough. Rubbing posts are filled with solution 11 L of oil mixture is used for initial treatment of backrubber. A further 2-4 L of the mixture is applied after 2 – 3 weeks Backrubbers are usually suspended at a height to enable cattle to rub the uppermost parts of their bodies against them Witholding period – 3 days
Ear tags		200 g/kg product 15 g diazinon per tag	One tag per ear of each animal	Herd treatment is required. Not to be used for calves <3 months of age Tags are applied when pests first appear. Tags are removed after 16 weeks, ie two sets of ear tags per fly season Applied using specialised tagging equipment and removed using side cutter 'Nil' witholding period for meat and milk
Hand spray – backline treatment	Cattle Buffalo fly	EC 200 g/L	400 mL product/100 L water (0.08%)	Apply 500 mL dilute solution per animal along backline Respray if necessary

Hand spray or spray race	<u>Cattle</u> Lice (high volume spraying and low volume spraying)	EC 200 g/L	High volume spraying 250 mL product/100 L water (0.05%) Low volume spraying 500 mL product/100 L water (0.1%)	Application rate is dependent on equipment 4 - 5L spray per animal for hand spraying and high volume spray units. 2 – 3 L spray per animals for low volume cattle sprayers Re-spray if required Ensure animal has complete coverage Product is not to be applied later than 3 days before slaughter
Hand spray	<u>Pigs & goats</u> Lice Mange (pigs only) <u>Horses</u> Flies & lice	EC 200 g/L	250 mL/100 L water (0.05%)	Spray or swab liberally as required Goats - repeat treatment 15 days after initial application to break lice life cycle Pigs - after initial application repeat treatment twice at 10 day intervals to break lice life cycle Witholding period for human consumption – 14 days pigs and goats, 3 days horses
Wound dressing	<u>Cattle & other animals</u> Fly strike	EC 1.0 g/L	Not applicable	Used as an insecticidal wound dressing for cuts and abrasions and protection against blowfly strike Applied to affected areas with brush or sprayer Not to be used < 3 days (cattle) or 14 days (other animals) before slaughter for human consumption
		Powder 15 g/kg 20 g/kg	Not applicable	Used in the treatment of dehorning wounds in cattle. Dust wound liberally using puffer, shaker tin or other suitable applicator, introduce into any cavities beneath the skin. Also dust area surrounding the wound. Not to be used < 3 days before slaughter for human consumption

Table 8: Use pattern of diazinon products in dogs and animal housing

Application method	**Situation/Pest**	**Formulation type/concentration of ai in product**	**Application rate/dilution (concentration of ai in spray)**	**Comments**
Hand spray	Animal sheds Flies	EC 200 g/L	250 mL/10 L water (0.5%)	Spray inner walls thoroughly & any other areas where flies settle Respray as necessary
	Dogs & dog kennels Ticks Fleas Mange, Mites Lice	EC 200 g/L EC 150 g/L EC 50 g/L EC 35 g/L	10 mL/4 L water (0.05) 25 mL/1 L water (0.5%) (kennel) 10 mL/3 L water (0.05%) 20-40 mL/1 L water (0.1-0.2%) 15 mL/1 L water (0.05%)	Rinse or sponge dog thoroughly with diluted product. Allow solution to dry on coat Daily inspection of the animal is to be maintained Rinse weekly as protection if ticks are active Repeat every 3 weeks or as required for flea treatment Spray kennel and surrounding area every 3 weeks or as required

Table 9: Use pattern of diazinon products in sheep using various application methods

Application Method	Pest	Formulation type and concentration of ai in product	Application rate /dilution of product (concentration of ai in solution)	Comments
Plunge dip	Lice Ked Blowfly Itchmite	EC 200 g/L	Initial charge 500 mL – 1 L per 1000 L water (0.01% -0.02% ai) Reinforcing 650 mL – 1.2 L of undiluted product when dip level falls by 500 L Topping up 250 mL – 500 mL per 500 L water (0.01% -0.02% ai)	Used by farmers and mobile dipping contractors Plunge dipping usually occurs once per year as flock treatment Sheep should be totally immersed twice in the dip solution and checked for effective wetting T-shaped poles are used to push sheep under the dip surface to ensure effective wetting in the back of the neck Sheep carrying < 2 weeks wool should not be dipped Work rate expected to be 300 sheep/hour (average) 500 sheep/hour (maximum) for 4 hours /day Average sump volume 2000 L Dip solution per sheep – 2 L WHP - 14 days before slaughtering for human consumption
		EC 80 g/L	Initial charge 2.5 L per 1000 L water (0.02% ai) Reinforcing 0.6 L – 1.2 L undiluted product when dip level falls by 200 L Topping up 1.5 L - 2 L per 500 L water (0.02% - 0.03% ai)	
		EC 60 g/L	Initial charge 2.5 L per 1000 L water (0.01% ai) Reinforcing 3.5 L undiluted product when dip level falls by 1000 L Topping up 5 L – 6 L per 1000 L water (0.03% ai)	

Conventional shower dip	Lice Blowfly Itchmite	EC 200 g/L	Initial charge 500 mL – 1 L per 1000 L water (0.01% - 0.02% ai) Reinforcing 250 mL – 500 mL of undiluted product when dip level falls by 200 L Topping up 250 mL- 500 mL per 500 L water (0.01% - 0.02% ai)	Shower dipping usually occurs once per year as flock treatment Sump capacity is usually around 2000 L Average number of sheep treated 1200 per day. Maximum of 2000 sheep treated per day Dip wash is discarded after treatment of 1000 sheep Dip is usually charged twice/day Sheep carrying < 2 weeks wool should not be dipped Also used in long wooled sheep. Thorough wetting of the sheep should be achieved as the length of the wool increases WHP - 14 days before slaughtering for human consumption
		EC 80 g/L	Initial charge 2.5 L per 1000 L water (0.02% ai) Reinforcing 1.2 L of undiluted product when dip level falls by 200 L Topping up 1.5 L per 500 L water (0.02% ai)	
		EC 60 g/L	Initial charge 2.5 L per 1000 L water (0.01% ai) Reinforcing 3 L of undiluted product when dip level falls by 500 L Topping up 3 L per 500 L water (0.03% ai)	
Continuous replenishment shower dip	Lice Ked Blowfly	EC 200 g/L	Initial charge 500 mL – 2 L per 1000 L water (0.01% - 0.04% ai)	
		EC 80 g/L	Initial charge 5 L per 1000 L water (0.04% ai)	
		EC 60 g/L	Initial charge 5 L per 1000 L water (0.03% ai)	

Spray race	Lice Ked	EC 200 g/L	500 mL per 1000 L water (0.01% ai)	Treatment is carried out usually once or twice per year Less effective than other methods of chemical application Sheep should be treated not more than 7 days after shearing Allows rapid treatment of sheep at an average of 1500 sheep/day, and occassionally up to 3000 sheep/day Jetting solution of approximately 4L per sheep Average spray tank size 2000 L WHP - 14 days before slaughtering for human consumption
Automatic jetting	Blowfly	EC 200 g/L	400 mL per 200 L water (0.04%)	
Hand jetting	Blowfly	EC 200 g/L	400 mL per 200 L water (0.04% ai)	Treatment carried out once per year Known to be the most effective method of applying jetting chemicals Use a jetting gun with nozzles or a hand wand/comb to apply the chemical at a pressure of 500-700 kPa directly into the fleece of the sheep Work rate approximately 500-700 sheep per day 5L spray/sheep 2000 L tank capacity WHP - 14 days before slaughtering for human consumption

Backline long wool treatment	Lice Blowfly	EC 96 g/L	5.25 mL – 10.5 mL undiluted product per sheep (9.6% ai) Application volume depends on pest and length of wool (higher rate for longer wool)	Treatment carried out once per year Product is packaged in 5 L containers Work rate 300 sheep per day Product is to be applied only with the recommended handgun applicator Apply as a single back band or as 2 parallel bands on back of sheep from pole to tail. The width of the band varies from 100 mm to 150 mm depending on pest Period of protection is up to 12 weeks for body and breech strike Sheep < 6 weeks off-shears should not be treated WHP – 14 days for slaughter for human consumption and 3 months for shearing
Backline off shears treatment	Lice	EC 93.3 g/L	1 part of product to 6 parts of water (0.15% ai) Apply approximately 3 mL per kg live weight	Average of 500 sheep treated per day Product is packaged in 20 L containers Average time spent treating each sheep is 10 seconds Applied as a single treatment only within 24 hours off shears Product is to be applied with the special spray-on applicator Applied as a single band from just above the ears along the backline to the butt of the tail Treated sheep should not be mixed with untreated sheep until 6 weeks after treatment WHP - 21 days before slaughter for human consumption
Wound dressing		EC 1 g/L	20 mL undiluted product per wound (0.1% ai)	Apply as required Shear or clip wool from affected area Saturate wound and surrounding wool Approximately 30 sheep may be treated per hour if required
		EC 3 g/L	1 L per 5 L water (0.06% ai)	
		EC 200 g/L	5 mL per 1 L water (0.1% ai)	

		PD 15 g/kg	Not relevant	Use as required
		PD 20 g/kg		Dust wound lightly and liberally using a suitable container or puffer after clipping or shearing the area infected Ensure the powder enters all crevices and cavities under the skin WHP - 14 days before slaughter for human consumption

3.2.2 Label restrictions
(refer amended information in Section 6.5.1 of the NRA Review of Diazinon September 2002, Volume 1, Review Summary)

Agricultural uses

The product labels recommend a withholding period (WHP) of 14 days before harvest and prohibit grazing or cutting for stock food within 2 days of application.

A specific Restricted Entry Period (REP) is not specified on product labels.

Veterinary uses

Cattle and other livestock

The WHP specified on diazinon veterinary product labels vary from "nil" to 28 days. Most products have a withholding period of 3 to 14 days before slaughter for human consumption.

The product label prohibits use on animals producing milk for human consumption or processing for human food.

Product labels do not carry specific re-handling restrictions.

Sheep

The product labels recommend a minimum WHP of 14-21 days before slaughter and not less than 2-3 months before shearing.

4. OCCUPATIONAL EXPOSURE ASSESSMENT

As detailed in Section 3.2.1, diazinon products are currently registered for agricultural and veterinary use, in a range of crops/animals/use situations. To facilitate the exposure assessment and risk assessment, rather than consider each individual use separately, exposure scenarios were developed, coded and grouped where possible. This allows maximisation of available data and simplifies the assessment.

End use exposure

Agricultural uses

Diazinon is registered for agricultural use as an EC formulation containing 800 g/L, 240 g/L and 200 g/L of the active ingredient, and as a ME formulation containing 300 g/L and 240 g/L of the active ingredient.

The main route of occupational exposure to diazinon is expected to be by skin contamination. Workers handling undiluted solvent-based product can be potentially exposed to solvent vapour during mixing/loading operations. Inhalation of spray mist may occur during spray application, particularly when using hand-held equipment.

Diazinon will be applied by the following methods: boom, airblast, knapsack or small sprayers, misters, fogging machines and aircraft.

The agricultural exposure scenarios identified for use of diazinon are (Code: ‘a’ denotes agricultural use).

(1a) Mixing/loading to support boom spraying of vegetables

(2a) Mixing/loading to support directed spraying of vegetables

(3a) Mixing/loading to support boom spraying of fruit

(4a) Mixing/loading to support butt spraying of bananas

(5a) Mixing/loading to support high volume application of fruit through air blast sprayers

(6a) Mixing/loading to support boom spraying of field crops

(7a) Mixing/loading to support aerial application of field crops

(8a) Mixing/loading to support dipping/drenching of nursery plants and ornamentals

(9a) Mixing/loading to support hand held spraying of lawns around trees, fences, walls

(10a) Mixing/loading to support boom spraying of lawns/turf

(11a) Mixing/loading to support hand-held spraying of commercial and domestic areas

(12a) Mixing/loading to support mister application in commercial and domestic areas

(13a) Mixing/loading to support fogging in commercial and domestic areas

(14a) Mixing/loading to support directed spraying of hides/skins and surrounding areas

(15a) Mixing/loading to support hand held spraying/misting/fogging of ponds, stagnant water

(16a) Mixing/loading to support hand spraying/misting/fogging of refuse areas and garbage

(17a) Boom spraying of vegetables

(18a) Directed spraying of vegetables using hand-held equipment

(19a) Incorporation into mushroom casing

(20a) Boom spraying of fruit

(21a) Butt spraying of bananas using tractor driven boom sprayers

(22a) High volume application of fruit using air blast sprayers

(23a) Boom spraying of field crops

(24a) Aerial application to field crops

(25a) Dipping/drenching of nursery plants and ornamentals

(26a) Hand-held spraying of lawns around trees, fences, walls

(27a) Boom spraying of lawns/turf

(28a) Hand-held spraying of commercial and domestic areas

(29a) Misting of commercial and domestic areas

(30a) Fogging of commercial and domestic areas

(31a) Directed spraying of hides /skins and surrounding areas using hand-held equipment

(32a) Hand-held spraying of ponds, stagnant water

(33a) Mister application of ponds, stagnant water

(34a) Fogging of ponds, stagnant water

(35a) Hand-held spraying of refuse areas and garbage

(36a) Misting of refuse areas and garbage

(37a) Fogging of refuse areas and garbage containers

Veterinary uses

Cattle (also pigs, goats, horses, dogs) and animal housing

Diazinon liquid formulations registered for use in cattle, goats, pigs, horses, dogs and animal housing contain the active ingredient at 200 g/L, 150 g/L, 50 g/L, 35 g/L and 1 g/L. Powder formulations containing 15 g/kg and 20 g/kg are registered as wound dressings, whilst the cattle ear tags contain 15 g diazinon per tag.

As buffalo fly treatment in cattle, diazinon is used as backrubbers/rubbing posts, ear tags, and backline treatment. For the control of lice, the chemical is applied as a spray using automatic or manual application equipment.

Workers involved in preparing backrubbers and filling rubbing posts may be exposed to diazinon products by skin contamination and inhalation of solvent vapour. Exposure during application of ear tags is only likely by the dermal route, however, exposure is not expected to be significant due to the slow release nature of the product and work activities undertaken during application of ear tags.

Hand spraying using a dilute solution of diazinon occurs during backline treatment for fly control, generalised spraying for lice control and treatment of animal housing. Alternatively, spray races may be used for lice control. Mixer/loader exposure will be through skin contact and inhalation of solvent vapour. Applicator exposure can occur via the dermal route and inhalation of spray mist.

Worker exposure during wound dressing may occur by the dermal route when using both liquid and powder formulations. Inhalation of dust is likely when dressing with powder formulations only. Some spray mist may be generated if sprayers are used for wound dressing.

The veterinary exposure scenarios identified for use of diazinon in **cattle, pigs, goats, horses, dogs and animal housing** are [Note: these scenarios are denoted by the code ‘c’]:

(1c)	Mixing/loading and preparing backrubbers/rubbing posts
(2c)	Application of ear tags
(3c)	Mixing/loading to support backline treatment of cattle
(4c)	Backline treatment of cattle
(5c)	Mixing/loading to support high volume spraying of cattle (also pigs, goats, horses)
(6c)	High volume spraying of cattle (also pigs, goats, horses)
(7c)	Mixing/loading to support low volume spraying of cattle
(8c)	Low volume spraying of cattle
(9c)	Wound dressing using liquid formulations
(10c)	Wound dressing using powder formulations
(11c)	Mixing/loading to support hand spraying of animal housing
(12c)	Hand spraying of animal housing

Sheep treatment

Several EC formulations containing 1 g/L, 3 g/L, 60 g/L, 80 g/L, 93.3 g/L, 96 g/L and 200 g/L diazinon and two powder formulations containing 15 g/kg and 20 g/kg containing diazinon are registered for use in sheep.

Sheep treatment using diazinon will be by the following methods: plunge and shower dipping, jetting (automatic and hand), backline and wound treatment.

Workers involved in plunge dipping and shower dipping of sheep are expected to handle large volumes of chemical. Mixer/loader exposure will be by skin contamination and inhalation of solvent vapour (diazinon has a low vapour pressure). Potential exposure during sheep dipping will be by the dermal route, due to the possibility of splashing during plunge dipping and the generation of large quantities of spray mist during shower dipping. Inhalation of spray mist is also possible, particularly during shower dipping. Dermal exposure is also possible for workers involved in removing sludge from the dip at the end of the treatment.

Sheep jetting may be conducted using automatic jetting, spray races or hand jetting equipment. Automatic jetting allows for rapid yet ineffective treatment, whilst hand jetting ensures more thorough wetting of the fleece. Mixer/loader exposure will be mainly through skin contamination whilst worker exposure during jetting will be by dermal and inhalation routes due to the generation of spray mist and proximity of worker to jetting equipment.

Backline long wool treatment utilises a small volume of undiluted product, whilst off-shears treatment is conducted using diluted product. The main route of worker exposure will be dermal due to the proximity of the worker to application equipment. Inhalation of solvent vapour may occur.

Occupational exposure during wound dressing will be mainly by the dermal route, when using liquid and powder formulations. Inhalation of dust is likely when handling powder formulations only.

The veterinary exposure scenarios identified for use of diazinon in **sheep** are [Note: sheep scenarios are denoted by the code 's']:

(1s)	Mixing/loading to support plunge and shower dipping
(2s)	Plunge and shower dipping
(3s)	Mixing/loading to support hand jetting
(4s)	Hand jetting
(5s)	Mixing/loading to support automatic jetting
(6s)	Automatic jetting
(7s)	Loading equipment for backline long wool treatment
(8s)	Backline long wool application
(9s)	Mixing/loading to support backline off shears treatment
(10s)	Backline off shears application
(11s)	Mixing/loading to support hand dressing using the EC formulation
(12s)	Hand dressing using the EC formulation
(13s)	Hand dressing using the powder formulation

4.1 Measured exposure studies

Smith, ML, Apthorpe L, Foster, G, (1998) Occupational Health and Safety Issues with Shower Dipping; and
Apthorpe L, Foster, G, Smith, ML (1998) Diazinon: A true blue dermal and inhalation exposure study for sheep dip workers

The study was conducted jointly by the National Occupational Health and Safety Commission and the NSW Agriculture Department.

Aim

The aim of the study was to assess sheep dip workers for diazinon exposure using dermal sampling and inhalable mist and vapour measurements. The exposure study was conducted simultaneously with a NSW Agriculture Department investigation into the efficacy of organophosphate lice treatments using modified shower dip design and method.

Study design

The study took place over 8 days in March 1997 and involved a total of four trained workers. Two diazinon products containing 200 g/L active ingredient, were used in accordance with label instructions. Over 3500 adult merino ewes and wethers of mixed age in 3-4 weeks wool were treated over the full duration of the study. The shower dip consisted of a three metre diameter corrugated iron enclosure with two sets of spray nozzles, one set located on the base of the dip, and the other on a rotating boom suspended at the top of the dip enclosure. The dipping solution was re-circulated and maintained at an optimal concentration of 100 ppm diazinon. The sump had a capacity of 1000 L. To assist in tracking the pesticide on the sheep (and worker contamination), a bright blue dye was added to the dip solution at a final concentration of 100g/1000L. The dye was added to the premix water before the chemical was added.

Two activities, dip operator and dip assistant, were studied each day. Over the trial period three of the four study subjects acted as dip operators and three as dip assistants. Both workers wore overalls, gum boots and hat. PVC gloves were used when handling the concentrate, cleaning the sump and handling treated sheep (when they chose to do so). Dedicated PVC gloves were worn on subsequent days except one that became contaminated on the inside. The dip operator measured the product into a two litre plastic measuring cylinder and added it to water in a premix bucket of approximately ten litre, controlled the dip valves and pump, tested and checked the equipment. The dip assistant was largely responsible for sheep handling, ie. timing the dip runs and herding sheep in and out of the dip. In addition, he helped the dip operator to measure out, premix and mix the concentrate (but was not in close contact with the concentrated liquid). Some task sharing occurred and both workers performed other general sheep dipping duties, including; sweeping manure from the dipwash liquid return, rescuing sheep from awkward or hazardous positions, hand dipping of lambs, effecting running repairs and cleaning up the dip site. Occasionally, other workers not monitored assisted in sheep handling but did not operate the dip. The sheep were subjected to a period of spray from the top nozzles followed by a period of exposure to the bottom nozzles. Up to 60 sheep were dipped simultaneously. The dip sump was drained and cleaned out daily.

On Day 3 of the trial, the dip was modified to reduce the amount of spray mist emanating from above. Black plastic sheeting was rigged to effectively heighten the sides of the dip. This visibly reduced the amount of spray arising from the dip. The plastic remained in place until the end of day eight. Dripping hoses and leakages from the walls of the dip were noted and rectified during the course of the study. Sampling time ranged from 168 to 340 minutes and included the trial treatment day, plus on occasion, extra dipping of sheep not included in the trial. The number of batches, the number of dip runs, and the dip time varied from 3-6 batches, 8-15 dip runs and 52-88 minutes respectively for the 8 days.

Worker exposure was separated into two days without plastic and the remaining (five) days with plastic. There were insufficient replicates to compare exposure between existing and modified dipping strategies.

Data collection and analysis

Both workers were monitored for dermal and inhalation exposure, as they carried out normal dipping activities. Cotton overalls were used to monitor outer dermal exposure. Penetration of pesticide through the fabric was measured using inner sampling pads, placed directly underneath the overalls. Sections of the outer fabric were cut from the cotton overalls from the following sites; lower legs (R & L), upper legs (R & L), forearms (R & L), upper arms (R & L), shoulders (R & L), chest and back. These patches were the same size as the inner patches. For inner dosimeters, workers wore dermal sampling pads attached to a velcro/elastic strap. The inner pads were made of adsorbent paper with an aluminium foil backing and stapled to fabric, to which the velcro strap was sewn. Pads were placed directly below the marked outer sampling areas of the overalls. Workers wore their own clothes beneath the coveralls, typically shorts and cotton shirt or T-shirt.

Hand exposure was measured using cotton gloves worn during all dipping activities. If the gloves became wet or soiled a new pair was issued. Dedicated cotton gloves were worn inside elbow-length PVC gloves during handling of the concentrate. Each set of gloves was analysed and the results summed. Exposure to the head was estimated using an absorbent pad attached to a hat. Foot exposure was measured from white cotton/nylon socks worn with normal footwear used during dipping activities.

Dermal exposure for both layers of sampling were estimated by extrapolating the loading on each sample patch (µg/cm^2/hour) to the total skin surface area (Spear, 1977), for the body region represented by the patch. Total body exposure comprised inner and outer exposure, hand and foot exposure and inhalation exposure. Actual exposure represented inner exposure, hand exposure and inhalation exposure. A dermal absorption of 4% was assumed when calculating the absorbed dose from dermal exposure.

Inhalation exposure (mist and vapour) was measured using personal samplers and based on the NIOSH method 5600 (NIOSH, 1994). The pump flow rates were set at 2L/min and average duration of each sample was 4 hrs. Airborne concentrations (mg/m^3) were converted to respiratory exposure (mg/hr) by multiplying by the breathing rate of 29 L/min (for male workers performing light work).

All samples were stored under refrigeration prior to analysis. Samples were analysed using gas chromatography.

Results

The dermal, inhalation and total absorbed doses of operator and assistant are summarised in Table 10.

Table 10: Dermal, inhalation and total absorbed doses of operator and assistant exposed to diazinon during open mixing/loading and shower dipping

Worker description	Dermal absorbed dose[1,3] (mg/hr)	Inhalation dose[2,3] (mg/hr)	Total absorbed dose[3] (mg/hr)
Operator	0.031 (range 0.003-0.253)	0.013 (0.005-0.042)	0.048 (0.008-0.295)
Assistant	0.036 (0.012-0.106)	0.008 (0.003-0.018)	0.047 (0.025-0.118)
All samples	0.034	0.010	0.048

	(0.003-0.253)	(003-0.042)	(0.008-0.295)

Note: Table 10 consists of the geometric mean of readings over the full trial (eight days). These data do not separate the results prior to and after erection of plastic sheeting

1 Dermal absorption of diazinon is estimated at 4% of summed inner patches and hands
2 Inhalation absorption of diazinon is estimated at 100%
3 The geometric mean was used in the estimation of absorbed dose (dermal and inhaled)

The total absorbed dose (made up of dermal and inhalation dose) was similar for both operator and assistant (0.048 and 0. 047 mg/hr, respectively). Inhalation exposure was a small component of total exposure (approximately 20%), with levels ranging between 0.003 and 0.042 mg/hr. The exposure standard for diazinon (0.1 mg/m^3) was not exceeded in any sample.

Percent distribution of diazinon per body part indicated that the source of exposure differed for the two workers. Most of the operator's exposure occurred on the hip, upper and lower legs (results not presented). The study authors concluded that this was mainly due to plumbing leaks and splashing, which occurred when the dip operator adjusted valves, measured the concentrate, mixed the dip wash solution and monitored pump operations standing directly beside the dip enclosure. Exposure to the upper body was mainly due to overspray from the shower dip, especially when the lower jets were operating. The operator's lower body exposure decreased after major plumbing leaks were repaired after day two. Exposure to the upper body was reduced by the addition of the plastic sheet to block the overspray (on day 3). The barrier also reduced the dip operator's inhalation exposure.

The assistant's main dermal exposure was also on the upper and lower legs. Significant exposure occurred when a treated sheep became caught in the open wire mesh of the exit gate and required handling. Exposure for the assistant also occurred from splashing when hand dipping lambs that were too small for shower dipping.

Hand exposure was comparatively low due to the use of PVC gloves when handling the concentrate and wet sheep. Foot contamination was minimal as most workers wore waterproof boots. Slightly higher levels were obtained from the socks of the single operator who wore leather boots. Inner dermal patches indicated that penetration through the cotton overalls was minimal.

Total exposure was highest for dip operator prior to erection of plastic sheeting barrier (28.7 mg/hr) compared to 3.8 mg/hr after sheeting was erected. This change was reflected in both dermal and inhalation exposure. Contamination was reduced across all body parts [range 61% (arms) to 92% (head)] and by the inhalation route. The effect of adding the plastic was more variable for the dip assistant although still substantially protective. After the plastic was erected, both operator and assistant had similar exposures.

Actual exposures shows the same trend, where exposures without plastic were 4.1 mg/hr for dip operator and 0.8 mg/hr for the assistant. After plastic was erected, the respective values for operator and assistant were 0.3 mg/hr and 0.6 mg/hr.

Exposure to the body of the dip operator was reduced by 93% - 95% by wearing overalls. Overalls provided the assistant with 71% - 83% protection.

Discussion

The study results indicated the following:

- *(i)* *measurable dermal and inhalation worker exposure occurred during shower dipping activities;*
- *(ii)* *improvements in shower dip design reduced worker exposure; eg. increasing dip wall height, relocation of switching valves;*
- *(iii)* *general tasks associated with dipping such as running repairs and sheep rescue, can contribute substantially to total exposure; and*
- *(iv)* *appropriate PPE provides substantial skin protection.*

Insufficient information was available on the total number of sheep treated per day and the total hours spent on dipping activities per day. Therefore, it is unclear whether the work rate in this study is representative of current Australian work practices.

4.2 Predicted exposure

The UK Predictive Operator Exposure Model (POEM) is a descriptive model based on databases of operator exposure field studies. POEM provides surrogate exposure values, which are derived from the levels determined in several field studies for each of several different scenarios. Exposure calculations are divided into two parts; contamination from handling the concentrated product and contamination during actual application of the dilute spray. The model assumes that the level and distribution of potential dermal contamination are mainly dependent on the handling techniques used while preparing the pesticide product for use, the type of application equipment employed and the work practices of the individual operator.

In this model, exposure during mixing/loading is assumed to be confined to the hands only, and no respiratory exposure is assumed to occur during mixing/loading. Dermal (hands, trunk and legs) and inhalation exposure is assumed during spray application.

In using POEM, it is necessary to make assumptions in order to estimate the actual exposure from potential exposure. These assumptions may be based on laboratory or field data, but in the absence of data, conservative estimates have to be made.

The use of exposure values derived from predictive models (such as POEM), involve the use of conservative assumptions for unknowns and a range of values for a particular method of spraying. Such modelling is internationally accepted as the first step in a tiered risk assessment (Tier 1).

A suitable model does not exist within the UK POEM to estimate worker exposure during animal treatments. However, applicable handler exposure estimates may be obtained using POEM for mixer/loaders for a range of application methods and applicators using hand held equipment. Given the registered uses of diazinon, it is assumed that these exposure estimates will provide a reasonable frame of reference to allow rough assessment of risk to workers mixing, loading and applying diazinon. The approach is especially relevant for use patterns where there is potential for significant worker exposure.

Predictive modelling was used to estimate worker exposure to diazinon, where possible. The parameters and assumptions used for diazinon are provided in Table 11. Model default values were used for parameters not specified.

Table 11: Use pattern parameters used in the agricultural exposure assessment

(The following table has been amended. Refer Table 6.1 in the NRA Review of Diazinon September 2002, Volume 1, Review Summary)

Crop/situation, formulation	Application method	Application rate/dilution, other relevant parameters	Work rate (ha/6 hour spraying)	Spray volume (L/ha)	Application frequency/comments
Vegetables EC 800 g/L	Boomspray	700 mL/ha(1) 1.4 L/ha(2)	30 ha/day(4) 50 ha/day(5)	High volume spraying 500 L/ha (6) 1000 L/ha (7)	Apply at 7-14 day intervals
	Hand held	30 mL/15 L water(1) 15 L knapsack volume(3)	0.25 ha/day (4)	400 L/ha(5)	Small areas treated, occasional spraying
Mushroom casing EC 800 g/L	Incorporation into casing	30 mL/10 L water/tonne of compost(1)	Intermittent activity of short duration		Applied in casing when pests are present
Fruit EC 800 g/L	Boomspray	65 mL/100L(1) 1.3 L/ha	30 ha/day(4)	2000 L/ha(1)	Foliar boom spraying in pineapples Representative parameters Spray at 2-4 week intervals
	Knapsack	125 mL/100L(1) 0.5 L/day	1 ha/day(4)	400 L/day(4)	Hand spraying in bananas spray applied at base of each plant Maximum parameters
	Airblast	65 mL/100L(1) 1.3 L/ha	30 ha/day(4)	2000 L/ha(4)	Representative parameters Generally applied at 2-4 week intervals
Field crops EC 800 g/L	Boomspray	700 mL/ha(1) 1.4 L/ha(2)	30 ha/day(4) 50 ha/day(5)	110L/ha(6)	Representative and maximum exposures estimated
	Aerial	700 mL/ha(1) 1.4 L/ha(2)	200 ha/day(4)	22 L/ha(6)	Not frequently used for locust or grasshopper control
	Misting machines	700 mL/ha(1) 1.4 L/ha(2)	50 ha/day(4)	22 L/ha(6)	Repeat applications permitted to control other pests
Nursery plants Ornamentals EC 800 g/L	Drench	20 - 60 mL/100L(1) application rate not available	Not available Dependent on extent of nursery	Not available	Applied as necessary Plants generally drenched 24 hours prior to loading and transfer
Lawns (around trees, fences, walls) EC 800 g/L	Hand-held spraying	600 mL/100 L(1) water 6 L/ha	0.4 ha/day	1 L mixture/10 m^2 area(1) Maximum of 400 L spray/day(5)	Apply when necessary Area to be treated is variable Hand spray likely in small areas
Lawns/turf EC 800 g/L	Boomspray	600 mL/200 L water(1) 4 L/ha	20 ha/day(4) 2 hours spraying	200 L sprayed over 1500 m^2 area(1) 1333 L spray/ha	Maximum exposures estimated

Lawns/turf ME 240 g/L	Hand-held spraying	250 mL/15 L water(2) (max) 25 L product/ha	0.25ha/day	15 L/100 m^2 area(2) Maximum of 400 L spray/day(5)	
Commercial and domestic areas EC 800 g/L Commercial and domestic areas ME 240 g/L ME 300 g/L	Hand-held spraying	6mL/L water(1) 3 L product/ha or 270 mL product/day 210 mL/10 L water(1) 10.5 L product/ha or 945 mL product per day 20 mL/L water(1)	6 x 150 m^2 sites per day (default) or 0.09 ha/day	1 L spray per 20 m^2 of surface(1) or 500 L/ha	Representative exposures estimated Apply when pests first appear Re-apply when pests reappear
Skins and hides EC 800 g/L	Hand-held sprayers	6 mL product/L of water(1)	Not available	60 mL of mixture per hide(1) 5 L mixture per 100 m^2 surrounding area(1)	Spray when necessary, particularly before packaging and transport
Ponds, stagnant water EC 800 g/L	Hand-held sprayers	125 mL/100 L water(1)	Not available	Not available	When necessary
Refuse areas, garbage EC 800 g/L	Hand-held sprayers	6mL/L water(1)	Not available	Not available	Apply when pests first appear Thoroughly penetrate refuse

(1) label recommended application rate/dilution considered to be representative for most crops by particular application method
(2) label recommended application rate considered to be maximum for most crops by particular application method
(3) default used in the absence of information
(4) default value used in the absence of information and estimated to be representative for most crops
(5) default value used in the absence of information and estimated to be the maximum area to be treated by this application method
(6) label recommended spray volume considered to be representative for most crops
(7) label recommended spray volume considered to be maximum for most crops

Worker exposure was estimated for the following agricultural exposure scenarios (identified in Section 4):

Scenarios (1a) and (17a) Mixing/loading and boom spraying of vegetables (Estimates 1a to 6a)

Scenarios (3a) and (20a) Mixing/loading and boom spraying of fruit (Estimates 9a to 12a)

Scenarios (6a) and (23a) Mixing/loading and boom spraying of field crops (Estimates 17a to 20a)

Scenarios (10a) and (27a) Mixing/loading and boom spraying of lawns/turf (Estimates 25a and 26a)

using the Vehicle Mounted (with cab) Hydraulic Nozzles (V-nozzle) model from POEM. The results of the POEM Estimates are provided in Attachment 1.

Worker exposure was estimated for the following agricultural exposure scenarios (identified in Section 4):

Scenarios (2a) and (18a) Mixing/loading and directed spraying of vegetables using hand-held equipment (Estimates 7a & 8a)

Scenarios (4a) and (21a) Mixing/loading and butt application of bananas (Estimates (13a & 14a)

Scenarios (9a) and (26a) Mixing/loading and hand-held spraying of lawns around trees, fences, walls (Estimates 23a & 24a)

Scenarios (11a) and (28a) Mixing/loading and hand-held spraying of commercial and domestic areas (Estimates 27a & 28a)

using the Hand Held Outdoors Hydraulic Nozzles (H-Nozzle) model and Vehicle Mounted (with cab) Hydraulic Nozzles (V-nozzle –for bananas) from POEM. The results of the POEM Estimates are provided in Attachment 2.

Worker exposure was estimated for the following agricultural exposure scenarios (identified in Section 4)

Scenarios (5a) and (22a) Mixing/loading and airblast spraying of fruit (Estimates 15a & 16a)

using the Vehicle Mounted (without cab) Air-Assisted Application Volume 500 L/ha Upwards Air-Blast High Volume (V-500). The results of the POEM Estimates are provided in Attachment 2.

Cattle, pigs, goats, horses and animal housing

Table 12: Use pattern parameters used in exposure assessment - cattle, pigs, goats, horses, animal housing

Application method	Product dilution	Representative parameters	Formulation type/concentration of active ingredient (ai)	Comments
Back rubber/rubbing post	500 mL product/10 L oil (1% ai)	Not applicable	EC 200 g/L	Used during the 6 month fly season Rubbers/posts charged every 2 - 3 weeks
Ear tags	-	One tag per ear per animal	200 g/kg product 15 g per tag	Herd treatment Tags replaced after 16 weeks, ie two sets per season
Backline treatment	400 mL product/100 L water (0.08%)	500 mL per animal 100 cattle per day[a] 2000 L tank volume	EC 200 g/L	Herd treatment Re-treatment permitted if required
Hand spray or spray race[b]	High volume spraying 250 mL product/100 L water (0.05%) Low volume spraying 500 mL product/100 L water (0.1%)	High volume spraying 4-5 L per head Low volume spraying 2-3 L per head Hand spray - 100 cattle per day	EC 200 g/L	High volume spraying is conducted either using hand sprayers or spray races Low volume spraying is conducted using spray races Re-treat if required

		Spray race – 500 cattle per day[c] 2000 L tank volume		
Wound dressing	Used undiluted	-	EC 1.0 g/L PD 15 g/kg PD 20 g/kg	Use as required
Animal housing – hand spraying	250 mL/10 L water (0.5%)[d]	Expected to be of short duration depending on extent of area to be treated[e]	EC 200 g/L	Use may be intermittent (approximately every 3 weeks) or irregular Variable use pattern parameters

(a) a representative number of 100 cattle assumed to be treated per day by hand spray. Note hobby farmers may treat smaller numbers of animals, whilst large dairy operations may treat more animals by this method
(b) Cattle treatment considered as worst-case to cover hand spraying of pigs, goats and horses. Note the dilution is independent of species
(c) 500 head of cattle considered to be representative of herd size in Australia
(d) worst case – maximum concentration used in animal housing
(e) an estimate of area to be treated 100 m^2 , 400 mL per 10 m^2 and 2 hours spraying time (default values used in the absence of information on work rates)

Exposure estimates for the following exposure scenarios (identified in Section 4):

Scenario (4c) Backline treatment of cattle (Estimates 1c and 2c)

Scenarios (5c & 6c) Mixing/loading and high volume spraying of cattle, pigs, goats and horses (Estimates 3c and 4c)

Scenario (7c) Mixing/loading to support low volume spraying of cattle (Estimates 5c to 8c)

were estimated using the Hand-held Hydraulic Nozzles (H-nozzle) model from POEM. The results of the POEM estimates are provided in Attachment 2.

Exposure estimates for:

Scenarios (11c & 12c) Mixing/loading and hand spraying of animal housing (Estimates 9c and 10 c)

were estimated using the Hand-held Outdoor Rotary Disc Atomiser: Low Level Application (H-RDA Low) and Hand-held Outdoor Rotary Disc Atomiser: High Level Application (H-RDA High) models from POEM, for low level and high level applications respectively. The results of the POEM estimates are provided in Attachment 3.

Sheep treatment

Table 13: Use pattern parameters used in exposure assessment - sheep

Application method	Product dilution	Representative parameters	Formulation type/concentration of active ingredient (ai)	Comments
Plunge dip,	500 mL/1000 L (0.01%)	3500-4000 sheep/day 2 L dip solution per sheep 3500-4000 L sump volume **(information to be confirmed)**	EC 200 g/L	Plunge dipping usually occurs once per year Flock treatment is anticipated Sump is emptied and refilled several times per day
Shower dip	500 mL/1000 L	1200 sheep/day (average)	EC 200 g/L	Shower dipping usually occurs

	(0.01%)	2000 sheep/day (maximum) 2 L dip solution per sheep 2000 L sump volume		once per year Flock treatment is anticipated Similar dilutions for charging and topping up
Hand jetting	400 mL/200 L (0.4%)	500 sheep/day (average) 700 sheep/day (maximum) 5 L jetting solution per sheep 2000 L spray tank (average)	EC 200 g/L	Usually carried out once or twice per year Flock treatment anticipated
Automatic jetting	500 mL/1000 L (0.4%)	1500 sheep/day (average) 3000 sheep/day (maximum) 4L jetting fluid per sheep 2000 L spray tank (average)	EC 200 g/L	Recommended for the control and treatment of blowfly strike, mostly in long wool
Spray races	500 mL/100 L (0.01%)		EC 200 g/L	Used once per year as off-shears/short wool treatment
Backline (long wool)	9.6% active ingredient Product used undiluted-	10 mL product per sheep (maximum rate) 300 sheep per day Application time 2 hrs per day	EC 96 g/L	Expected to be once per year
Backline (off shears)	1 part of product to 6 parts of water (0.15% ai)	Apply approximately 3 mL solution per kg live weight Sheep body weight 60 kg (average) 500 sheep per day Mixing tank 100 L or more	EC 93.3 g/L	Expected to be once per year
Wound dressing	5 mL/1 L (0.1%) 1 L/5 L (0.06%) 20 mL (undiluted) Applied directly as a powder	Approximately 30 sheep could be treated in 1 hour	EC 200 g/L EC 3 g/L EC 1 g/L PD 15 g/kg PD 20 g/kg	Sheep treated as necessary

Exposure estimates for the following exposure scenarios (identified in Section 4):

Scenario (1s) Mixing/loading to support plunge and shower dipping (Estimates 1s to 8s)

Scenario (5s) Mixing/loading to support automatic jetting (Estimates 17s to 20s)

were estimated using the Vehicle Mounted (with cab) Hydraulic Nozzles (V-nozzle) model from POEM. The results of the POEM estimates are provided in Attachment 2.

Exposure estimates for the following exposure scenarios (identified in Section 4):

Scenarios (3s & 4s) Mixing/loading and hand jetting (Estimates 9s to 16s)

Scenarios (7s & 8s)	Loading/application to support backline treatment of long wool (Estimates 21s & 22s)
Scenarios (9s & 10s)	Mixing/loading/application to support backline off shears treatment (Estimates 23s & 24s)

were estimated using the Hand-held Hydraulic Nozzles (H-nozzle) model from POEM. The results of the POEM estimates are provided in Attachment 2.

From modelling, estimates were derived for daily absorbed dermal dose for mixer/loaders and applicators, daily absorbed inhalation dose for applicators only and daily total absorbed dose for both worker categories. These values were used to estimate Margins of Exposure (MOE) for each of the exposure scenarios identified earlier.

End use exposure overview

No suitable measured exposure data were available to estimate worker exposure during the agricultural uses of diazinon products. A worker exposure study was submitted which identified worker exposure during shower dipping only which was conducted in accordance with Australian work practices. The study provides measure of exposure but cannot be linked to current Australian work practices and therefore has limitations (refer to Section 4.1 for details). In an attempt to estimate potential worker exposure for the various scenarios identified in Section 4, NOHSC used predictive modelling where possible. It should be noted that the use of exposure data from predictive models using default assumptions, is likely to overestimate risk.

A qualitative risk assessment was conducted for scenarios where no suitable data or models were available.

Table 14 summarises the caveats and parameters specific for each scenario and presents dermal and inhalation doses.

Table 14: Agricultural uses (vegetables) of EC diazinon (800 g/L), exposure scenarios, caveats, parameters and absorbed doses

Exposure scenario	Application rate (g ai/ha) Spray volume (L/ha) Work rate (ha/d) (1)	Equipment PPE/clothing	Data source/model (Estimate No)	Daily absorbed dermal dose(2) (mg/kg/d)	Daily absorbed inhalation dose(3) (mg/kg/d)	Daily total absorbed dose (mg/kg/d) (4)	Comments
				Mixer/loaders			
Scenario (1a) Mixing/loading, to support boom spraying, vegetables	700 mL product/ha (560 g ai/ha) Spray volume 500 L/ha (high volume spraying) Work rate 30 ha/d (default)	**Open mixing/loading** **PPE** - gloves	**POEM**				Representative application rates, spray volumes and work rates for high volume boom spraying
		5 L non-specific design container	Estimate 1a	0.053	NM	0.053	Hand exposure only estimated
		5 L wide neck containers	Estimate 2a	0.003	NM	0.003	
		20 L non-specific design containers	Estimate 3a	0.053	NM	0.053	
		20 L wide neck container	Estimate 4a	0.005	NM	0.005	
	1.4 L product/ha (1120 g ai/ha) 1000 L spray /ha (maximum spray volume) work rate 50 ha/day (maximum, default)	**Open mixing/loading** **PPE** – gloves	**POEM**				Maximum application rate, spray volume and work rate for high volume boom spraying
		5 L non-specific design container	Estimate 5a	0.149	NM	0.149	Worst case exposures estimated Hand exposure only estimated
		20 L non-specific design container	Estimate 6a	0.107	NM	0.107	

Scenario (2a) Mixing/loading to support directed spraying of vegetables	30 mL product/15 L knapsack (0.16% ai) Rate per ha not available 400 L spray/ha (default) 0.25 ha/d (default)	**Open mixing/loading** **PPE** – gloves 5 L non-specific design container 5 L wide neck container	 Estimate 7a Estimate 8a	 0.011 0.001	 NM NM	 0.011 0.001	Hand-held spraying is only conducted in small areas and when necessary Default work rates and spray volumes used in the absence of data Hand exposure only estimated
				Applicators			
Scenario (17a) Boom spraying, vegetables	700 mL product/ha (representative) 1.4 L product/ha (maximum) Spray volume 500 L/ha (representative) 1000 L spray /ha (maximum) Work rate 30 ha/d (representative) 50 ha/d (maximum)	**Closed cab tractor** **PPE** - Overalls (or long pants and long sleeved shirt), gloves	**POEM** Estimates 1a – 6a	 0.005	 0.001	 0.006	Representative and maximum application rates, spray volumes and work rates Default values used in the absence of data Hand and body exposure estimated
Scenario (18a) Directed spraying of vegetables using hand held equipment	30 mL product/15 L knapsack (0.16% ai) Rate per ha not available 400 L spray/ha (default) 0.25 ha/d (default)	**Hand held sprayers** **PPE** - Overalls (or long pants and long sleeved shirt), gloves	**POEM** Estimates 7a and 8a	 0.018	 0.001	 0.019	Hand-held spraying is only conducted in small areas and when necessary Default work rates and spray volumes used in the absence of data Hand and body exposure estimated

(1) Label recommended application rate and spray volume, considered to be representative or maximum for most crops. Default work rate used in the absence of information

(2) Daily absorbed dermal dose (mg/kg/d) = surface contamination (mL/operation or mL/hour) x number of operations or duration of exposure (hours) x concentration of ai in spray (mg/mL) x penetration through clothing/protective clothing (%) x dermal penetration (%)÷ average body weight (kg)
(3) Daily absorbed inhalation dose (mg/kg/d) = inhalation exposure (mL/hour) x concentration of active ingredient in spray (mg/mL) x duration of spraying (hours) x inhalation absorption (%)÷ average body weight (kg)
(4) Daily total absorbed dose (mg/kg/d) = Daily absorbed dermal dose (mg/kg/d) + Daily absorbed inhalation dose (mg/kg/d) * NM – not measured

Table 15: Agricultural uses (fruit) of EC diazinon (800 g/L), exposure scenarios, caveats, parameters and absorbed doses

Exposure scenario	Application rate (g ai/ha) Spray volume (L/ha) Work rate (ha/d) [(1)]	Equipment PPE/clothing	Data source/model (Estimate No)	Daily absorbed dermal dose[(2)] (mg/kg/d)	Daily absorbed inhalation dose[(3)] (mg/kg/d)	Daily total absorbed dose (mg/kg/d) [(4)]	Comments
				Mixer/loaders			
Scenario (3a) Mixing/loading, to support boom spraying, fruit	65 mL/100 mL (0.05% ai) 1.3 L product/ha Spray volume 2000 L/ha Work rate 30 ha/day (default)	**Open mixing/loading** **PPE** - gloves 5 L non-specific design container 5 L wide neck containers 20 L non-specific design containers 20 L wide neck container	**POEM** Estimate 9a Estimate 10a Estimate 11a Estimate 12a	0.085 0.004 0.053 0.005	NM NM NM NM	0.085 0.004 0.053 0.005	Representative application rates, spray volumes and work rates for high volume boom spraying Default values used in the absence of data Hand exposure only estimated
Scenario (4a) **(see Table 6.4 in the NRA Review of Diazinon September 2002, Volume 1, Review Summary)**	125 mL/100 L (0.1%) 8-10 ha/day 900 L/ha	**Open mixing/loading** **PPE** – gloves 20 L non-specific design container 20 L wide neck container	**POEM** Estimate13a Estimate 14a	0.023 0.002	NM NM	0.023 0.002	Maximum application rate, spray volume and work rate for high volume boom spraying Worst case exposures estimated Hand exposure only estimated Considering the small volume of product required per day, only 5 L containers were modelled Spray preparation expected to occur in large volume tank, i.e. 1 mixing/loading operation per day

Scenario (5a) Mixing/loading to support air blast spraying, fruit	65 mL/100 L (0.05% ai) 1.3 L product/ha Spray volume 2000 L/ha (default) Work rate 30 ha/day (default)	**Open mixing/loading** **PPE** – gloves 5L non specific design container 20 L non specific design container	Estimate 15 a Estimate 16a	0.085 0.053	NM NM	0.085 0.053	Default work rates and spray volumes used in the absence of data Hand exposure only estimated

				Applicators			
Scenario (20a) Boom spraying, fruit	65 mL/100 L (0.05% ai) 1.3 L product/ha Spray volume 2000 L/ha Work rate 30 ha/day	**Closed cab tractor** **PPE** - Overalls (or long pants and long sleeved shirt), gloves	**POEM** Estimates 9a–12a	0.002	0.001	0.003	Representative application rates, spray volumes and work rates modelled Default values used in the absence of data Hand and body exposure estimated
Scenario (21a) Butt application for bananas using tractor-driven boomsprayers **(see Table 6.4 in the NRA Review of Diazinon September 2002, Volume 1, Review Summary)**	125 mL/100 L (0.1% ai) 900 L/ha Work rate 8-10 ha/day	**PPE** - Overalls (or long pants and long sleeved shirt), gloves	**POEM** Estimates 13a–14a	0.004	0.001	0.005	
Scenario (22a) High volume application of fruit using air blast sprayers	1.3 L product/ha Spray volume 2000 L/ha Work rate 30 ha/day	**Vehicle without cab** **PPE** - Overalls (or long pants and long sleeved shirt), gloves	**POEM** Estimates 15a-16a	0.030	0.003	0.033	Representative application rates, spray volumes and work rates modelled Default values used in the absence of data Hand and body exposure estimated

(1) Label recommended application rate and spray volume, considered to be representative or maximum for most crops. Default work rate used in the absence of information
(2) Daily absorbed dermal dose (mg/kg/d) = surface contamination (mL/operation or mL/hour) x number of operations or duration of exposure (hours) x concentration of ai in spray (mg/mL) x penetration through clothing/protective clothing (%) x dermal penetration (%)÷ average body weight (kg)
(3) Daily absorbed inhalation dose (mg/kg/d) = inhalation exposure (mL/hour) x concentration of active ingredient in spray (mg/mL) x duration of spraying (hours) x inhalation absorption (%)÷ average body weight (kg)
(4) Daily total absorbed dose (mg/kg/d) = Daily absorbed dermal dose (mg/kg/d) + Daily absorbed inhalation dose (mg/kg/d)

* NM – not measured

Table 16: Agricultural uses (field crops) of EC diazinon (800 g/L), exposure scenarios, caveats, parameters and absorbed doses

Exposure scenario	**Application rate (g ai/ha)** **Spray volume (L/ha)** **Work rate (ha/d)** (1)	**Equipment PPE/clothing**	**Data source/model (Estimate No)**	**Daily absorbed dermal dose**(2) **(mg/kg/d)**	**Daily absorbed inhalation dose**(3) **(mg/kg/d)**	**Daily total absorbed dose (mg/kg/d)** (4)	**Comments**
			Mixer/loaders				
Scenario (6a) Mixing/loading, to support boom spraying, field crops	700 mLs product/ha Spray volume 110 L/ha Work rate 30 ha/day (default)	**Open mixing/loading** **PPE** - gloves 20 L non-specific design container 20 L wide neck container	**POEM** Estimate 17a Estimate 18a	 0.053 0.005	 NM NM	 0.053 0.005	Representative application rates, work rates, and minimum spray volume for high volume boom spraying Default values used in the absence of data Hand exposure only estimated Considering the volume of product required per day, only 20 L containers were modelled
Scenario (6a) Mixing/loading, to support boom spraying, field crops	1.4 L product/ha Spray volume 110 L/ha Work rate 50 ha/day (default)	**Open mixing/loading** **PPE** – gloves 20 L non-specific design container 20 L wide neck container	**POEM** Estimate 19a Estimate 20a	 0.107 0.011	 NM NM	 0.107 0.011	Maximum application rate, work rate, and minimum spray volume for high volume boom spraying Hand exposure only estimated Considering the volume of product required per day, only 20 L containers were modelled Default values used in the absence of data

Scenario (7a) Mixing/loading to support aerial application, field crops	700 mLs product/ha Spray volume 22 L/ha 200 ha/day (default)	**Open mixing/loading** **PPE** – gloves 20 L non-specific design container	Estimate 21a	0.187	NM	0.187	Representative and maximum exposures estimated Hand exposure only estimated Considering the volume of product required per day, only 20 L containers were modelled Default values used in the absence of data
	1.4 L product/ha Spray volume 22 L/ha 200 ha/day (default)	**Open mixing/loading** **PPE** – gloves 20 L non-specific design container	Estimate 22a	0.373	NM	0.373	
				Applicators			
Scenario (23a) Boom spraying, field crops	700 mLs product/ha Spray volume 110 L/ha Work rate 30 ha/day	**Closed cab tractor** **PPE** - Overalls (or long pants and long sleeved shirt), gloves	**POEM** Estimates 17a–18a	0.022	0.005	0.027	Representative and maximum exposures estimated Default values used in the absence of data Hand and body exposure estimated
	1.4 L product/ha Spray volume 110 L/ha Work rate 50 ha/day		Estimates 19a-20a	0.044	0.010	0.054	

(1) Label recommended application rate and spray volume, considered to be representative or maximum for most crops. Default work rate used in the absence of information

(2) Daily absorbed dermal dose (mg/kg/d) = surface contamination (mL/operation or mL/hour) x number of operations or duration of exposure (hours) x concentration of ai in spray (mg/mL) x penetration through clothing/protective clothing (%) x dermal penetration (%)÷ average body weight (kg)
(3) Daily absorbed inhalation dose (mg/kg/d) = inhalation exposure (mL/hour) x concentration of active ingredient in spray (mg/mL) x duration of spraying (hours) x inhalation absorption (%)÷ average body weight (kg)
(4) Daily total absorbed dose (mg/kg/d) = Daily absorbed dermal dose (mg/kg/d) + Daily absorbed inhalation dose (mg/kg/d) * NM – not measured

Table 17: Agricultural uses (lawns around trees, fences, walls and lawns/turf) of EC diazinon (800 g/L), exposure scenarios, caveats, parameters and absorbed doses

Exposure scenario	Dilution Application rate Spray volume (L/ha) Work rate (ha/d) (1)	Equipment PPE/clothing	Data source/model (Estimate No)	Daily absorbed dermal dose(2) (mg/kg/d)	Daily absorbed inhalation dose(3) (mg/kg/d)	Daily total absorbed dose (mg/kg/d) (4)	Comments
				Mixer/loaders			
Scenario (9a) Mixing/loading, to support hand held spraying, lawns around trees	600 mL/100 L water 1 L spray/10 m^2 Work rate 0.4 ha/day 6 L product/ha or 2.4 L/day Spray volume 1000 L/ha or 400 L/day (default)	**Open mixing/loading** **PPE** – gloves 5 L non-specific design container 5 L wide neck container	**POEM** Estimate 23a Estimate 24a	0.011 0.001	NM NM	0.011 0.001	Maximum application rates, spray volumes and work rates Hand exposure only estimated Considering application equipment and quantity of product required per day only 5 L containers were modelled Spray preparation expected to take place in a large spray tank (approx. 400 L) ie. only 1 mixing/loading operations per day
Scenario (10a) Mixing/loading to support boom spraying, lawns/turf	600 mL/200 L water 200 L spray/1500 m^2 4 L product/ha Spray volume 1333 L/ha Work rate 20 ha/day	**Open mixing/loading** **PPE** – gloves 20 L non-specific design container 20 L wide neck container	**POEM** Estimates 25a Estimate 26a	0.107 0.011	NM NM	0.107 0.011	Worst case exposures estimated Hand exposure only estimated Twenty litre containers were modelled given the volume of product expected to be used per day.
				Applicators			

Scenario (26a) Hand held spraying, lawns around trees	6 L product/ha Spray volume 1000 L /ha Work rate 0.4 ha/day 4 hours spraying (default)	**Hand held sprayers** **PPE** - Overalls (or long pants and long sleeved shirt), gloves	**POEM** Estimates 23a–24a	0.106	0.006	0.112	Maximum application rates, spray volumes and work rates Default values used in the absence of data Hand and body exposure estimated
Scenario (27a) Boom spraying, lawns/turf	4L product/ha 200 L spray/1500 m^2 Spray volume 1333 L/ha Work rate 20 ha/day 2 hours spraying (default)	**Closed cab tractor** **PPE -** Overalls (or long pants and long sleeved shirt), gloves	Estimates 25a-26a	0.003	0.001	0.004	Maximum application rates, spray volumes and work rates Default values used in the absence of data Hand and body exposure estimated

Table 18: Agricultural uses (commercial and domestic) of EC diazinon (800 g/L), exposure scenarios, caveats, parameters and absorbed doses

Exposure scenario	Application rate Spray volume (L/ha) Work rate (ha/d) [(1)]	Equipment PPE/clothing[(1)]	Data source/model (Estimate No)	Daily absorbed dermal dose[(2)] (mg/kg/d)	Daily absorbed inhalation dose[(3)] (mg/kg/d)	Daily total absorbed dose (mg/kg/d) [(4)]	Comments
Mixer/loaders							

Scenario (11a) Mixing/loading, to support hand-held spraying, commercial and domestic areas	6 mL/L water 3 L product/ha or 270 mL product per day 1 L spray/20 m^2 or 500 L spray/ha Work rate 6 x 150 m^2 sites per day (default) or 0.09 ha/day	**Open mixing/loading** **PPE** – gloves 5 L non-specific design container 5 L wide neck container	**POEM** Estimate 27a Estimate 28a	0.011 0.001	NM NM	0.011 0.001	Representative application rates, spray volumes and work rates for knapsack spraying of household pests Default values used in the absence of data Hand exposure only estimated Given that the volume of product required per day is small, only 5 L containers were modelled
				Applicators			
Scenario (28a) Hand held spraying, commercial and domestic areas	3 L product/ha or 270 mL product per day 1 L spray/20 m^2 or 500 L spray/ha Work rate 6 x 150 m^2 sites per day (default) or 0.09 ha/day 2 hrs spraying time (default)	**Hand held sprayers** **PPE -** Overalls (or long pants and long sleeved shirt), gloves	**POEM** Estimates 27a–28a	0.053	0.003	0.056	Representative application rates, spray volumes and work rates Default values used in the absence of data Hand and body exposure estimated Workers are expected to prepare spray solution in a large tank (>100 L)

(1) Label recommended application rate and spray volume, considered to be representative or maximum for most crops. Default work rate used in the absence of information
(2) Daily absorbed dermal dose (mg/kg/d) = surface contamination (mL/operation or mL/hour) x number of operations or duration of exposure (hours) x concentration of ai in spray (mg/mL) x penetration through clothing/protective clothing (%) x dermal penetration (%)÷ average body weight (kg)
(3) Daily absorbed inhalation dose (mg/kg/d) = inhalation exposure (mL/hour) x concentration of active ingredient in spray (mg/mL) x duration of spraying (hours) x inhalation absorption (%)÷ average body weight (kg)
(4) Daily total absorbed dose (mg/kg/d) = Daily absorbed dermal dose (mg/kg/d) + Daily absorbed inhalation dose (mg/kg/d)

* NM – not measured

Table 19: Veterinary uses of EC diazinon (200 g/L) in cattle and animal housing, exposure scenarios, caveats, parameters and absorbed doses

Exposure scenario, concentration of active ingredient in product	**No. of animals treated, application dose and dip/spray volume, sump volume**	**Equipment PPE/clothing[(1)]**	**Data source/model, Estimate No**	**Daily absorbed dermal dose[(2)] (mg/kg/d)**	**Daily absorbed inhalation dose[(3)] (mg/kg/d)**	**Daily total absorbed dose (mg/kg/d) [(4)]**	**Comments**
			Mixer/loaders				
Scenario (3c) Mixing/loading to support backline treatment of cattle EC 200 g/L	100 cattle per day (representative) 500 mL spray solution per animal 400 mL per 100L water 50 L spray solution per day 200 mL product per day 2000 L sump volume (average)	**Open mixing/loading** 5L non specific design container 5 L wide neck container	**POEM** Estimate 1c Estimate 2c	 0.003 Nil	 NM NM	 0.003 Nil	Only hand exposure measured Exposure estimates considered representative of larger farms and dairy operations Only 5 L containers modelled considering the small volume of product required per day
Scenario (5c) Mixing/loading to support high volume spraying of cattle EC 200 g/L	100 cattle per day (representative) 5 L per animal 250 mL per 100L water 500 L spray solution per day 1.25 L product per day 2000 L sump volume (average)	**Open mixing/loading** 5L non specific design container 5 L wide neck container	**POEM** Estimate 3c Estimate 4c	 0.003 Nil	 NM NM	 0.003 Nil	Only hand exposure measured Exposure estimates considered representative of larger farms and dairy operations Only 5 L containers modelled considering the small volume of product required per day Cattle treatment considered worst case due to larger number of animals treated and greater surface area to be treated

Scenario (7c) Mixing/loading to support low volume spraying of cattle EC 200 g/L	500 cattle per day (representative) 3 L per animal 500 mL per 100L water 1500 L spray solution per day 7.5 L product per day 2000 L sump volume (average)	**Open mixing/loading** 5L non specific design container 5L wide neck container 20L non specific design container 20 L wide neck container	Estimate 5c Estimate 6c Estimate 7c Estimate 8c	0.005 Nil 0.007 0.001	NM NM NM NM	0.005 Nil 0.007 0.001	Only hand exposure measured Exposure estimates considered representative of larger farms and dairy operations The number of mixing/loading operations is determined by container size
Scenario (11c) Mixing/loading to support hand spraying of animal housing EC 200 g/L	Area of 100 m^2 treated per day (default) 2 hours spraying time per day (default) 250 mL product per 10 L water 400 mL solution per 10 m^2 (default)	**Open mixing/loading** 5L non specific design container 5L wide neck container	Estimate 9c Estimate 10c	0.003 Nil	NM NM	0.003 Nil	Only hand exposure estimated Representative default values used in the absence of use pattern information Only 5 L containers modelled considering the small volume of product required per day
Applicators							
Scenario (6c) High volume spraying of cattle	100 cattle per day (representative) 5 L per animal 250 mL per 100L water 500 L spray solution per day 1.25 L product per day 2000 L sump volume (average)	**Hand-held sprayers** **PPE -** cotton overalls (or equivalent clothing) and gloves	Estimate 3c	0.017	0.001	0.018	Hand and body exposures estimated Exposure estimates considered representative of larger farms and dairy operations Cattle treatment considered worst case due to larger number of animals treated and greater surface area to be treated
		Hand-held sprayers **PPE** -cotton overalls (or equivalent clothing), waterproof clothing and gloves	Estimate 4c	0.004	0.001	0.005	

Scenario (12c) Hand spraying of animal housing	Area of 100 m^2 treated per day (default) 2 hours spraying time per day (default) 250 mL product per 10 L water 400 mL solution per 10 m^2 (default)	**Hand-held sprayers – Low level spraying** **PPE** - cotton overalls (or equivalent clothing) and gloves	Estimate 9c	0.024	0.002	0.026	Hand and body exposures estimated Low and high level applications anticipated Representative default values used in the absence of use pattern information
		Hand-held sprayers – High level spraying **PPE -** cotton overalls (or equivalent clothing), waterproof clothing and gloves	Estimate 10c	0.008	0.002	0.010	

(1) Although product safety directions recommend the use of extensive PPE during mixing/loading (overalls, gloves, apron, water-proof footwear, respirator) only gloves were modelled as POEM only estimates hand exposure during mixing/loading. The protection afforded by the additional PPE cannot be quantified using POEM. The clothing scenario modelled is appropriate for applicators
(2) Daily absorbed dermal dose (mg/kg/d) = surface contamination (mL/operation or mL/hour) x number of operations or duration of exposure (hours) x concentration of ai in spray (mg/mL) x penetration through clothing/protective clothing (%) x dermal penetration (%)÷ average body weight (kg)
(3) Daily absorbed inhalation dose (mg/kg/d) = inhalation exposure (mL/hour) x concentration of active ingredient in spray (mg/mL) x duration of spraying (hours) x inhalation absorption (%)÷ average body weight (kg)
(4) Daily total absorbed dose (mg/kg/d) = Daily absorbed dermal dose (mg/kg/d) + Daily absorbed inhalation dose (mg/kg/d) * NM – not measured

Table 20: Veterinary uses of EC diazinon in sheep (200 g/L), exposure scenarios, caveats, parameters and absorbed doses

Exposure scenario concentration of active ingredient in product	No. of animals treated, application dose and dip/spray volume, sump volume	Equipment PPE/clothing[(1)]	Data source/model, Estimate No	Daily absorbed dermal dose[(2)] (mg/kg/d)	Daily absorbed inhalation dose[(3)] (mg/kg/d)	Daily total absorbed dose (mg/kg/d) [(4)]	Comments
Scenario (1s) Mixing/loading to support plunge and shower dipping, 200 g/L product	1200 sheep per day (average) 2000 sheep per day (maximum) 1.2 L product/day (average) 2 L product/day (maximum) 2 L dip solution per sheep 2400L total dip wash per day (average) 4000L total dip wash per day (maximum) 2000 L sump volume (average)	**Open mixing/loading** 5 L wide neck container 5 L non-specific design container 20 L wide neck container 20 L non-specific design container PPE – Cotton overalls (or equivalent clothing) and gloves	**POEM** Estimate 1s (average) and 3s (maximum) Estimate 2s (average) and 4s (maximum) Estimate 5s (average) and 7s (maximum) Estimate 6s (average) and 8s (maximum)	Nil 0.005 0.001 0.013	NM NM NM NM	Nil 0.005 0.001 0.013	Only hand exposure measured Exposure estimates considered representative of average and maximum flock sizes Representative concentration of active ingredient in dip wash (100 ppm)
Scenario (3s) Mixing/loading to support hand jetting, 200 g/L product	500 sheep per day (average) 700 sheep per day (maximum) 5 L product/day (average) 7 L product/day (maximum) 5 L jetting solution per sheep 2500L jetting fluid per day (average) 3500L jetting fluid per day (maximum) 2000 L sump volume (average)	5 L wide neck container 5 L non-specific design container 20 L wide neck container 20 L non-specific design container PPE – as for Scenario (1s)	Estimate 9s (average) and 11s (maximum) Estimate 10s (average) and 12s (maximum) Estimate 13s (average) and 15s (maximum) Estimate 14s (average) and 16s (maximum)	Nil 0.005 0.001 0.013	NM NM NM NM	Nil 0.005 0.001 0.013	Exposure estimates considered representative of average and maximum flock sizes Only hand exposure estimated

Scenario (5s) Mixing/loading to support automatic jetting, 200 g/L product	1500 sheep per day (average) 3000 sheep per day (maximum) 30 L product/day (average) 60 L product/day (maximum) 4 L jetting fluid per sheep 6000L jetting fluid per day (average) 12000L jetting fluid per day (maximum) 2000 L sump volume (average)	20 L wide neck container 20 L non-specific design container	Estimate 17s (average) Estimate 19s (maximum) Estimate 18s (average) Estimate 20s (maximum)	0.002 0.004 0.02 0.04	NM NM NM NM	0.002 0.004 0.02 0.04	Due to the large volumes of product required, it is anticipated that 20 L containers will be used more frequently than 5 L containers Exposure estimates considered representative of average and maximum flock sizes Hand exposure only measured Sump volume is expected to determine the number of operations required
Scenario (7s) Loading equipment for backline long wool treatment, 96 g/L product	300 sheep per day 10 mL product (undiluted) per sheep 3 L product per day 5 L backpack	5 L non specific design container 5L wide neck container	Estimate 21s Estimates 22s	0.001 Nil	NM NM	0.001 Nil	Product packed in 5 L containers Backpack of 5 L capacity Maximum application rate modelled, therefore worst case exposure estimated Application period expected to be 2 hrs per day
Scenario (9s) Mixing/loading to support backline off-shears treatment, 93 g/L product	500 sheep per day 3 mL product per kg live weight Average weight of sheep 60 kg Dilution 1 part product: 6 parts water 15 L product per day 90 L dilute solution per day	20 L non specific design container 20L wide neck container	Estimate 23s Estimate 24s	0.003 Nil	NM NM	0.003 Nil	Product packed in 20 L containers Backpack of 5 L capacity The rate of shearing is expected to be the limiting factor for work rate Application period expected to be 2 hrs per day

Applicators							
Scenario (4s) Application by hand jetting, 200 g/L product	500 sheep per day (average) 700 sheep per day (maximum) 5 L product/day (average) 7 L product/day (maximum) 5 L jetting solution per sheep 2500L jetting fluid per day (average) 3500L jetting fluid per day (maximum) 2000 L sump volume (average)	**Hand-held sprayers** PPE – Cotton overalls (or equivalent clothing) and gloves	Estimates 9s – 12s, 14s and 16s	0.013	0.001	0.014	Maximum spray concentration Hand and body exposure estimated Exposure estimates considered representative of average and maximum flock sizes
		Hand-held sprayers PPE – Cotton overalls (or equivalent clothing) gloves and waterproof clothing	Estimates 13s and 15s	0.003	0.001	0.004	

(1) Although product safety directions recommend the use of extensive PPE during mixing/loading (overalls, gloves, apron, water-proof footwear, respirator) only gloves were modelled as POEM only estimates hand exposure during mixing/loading. The protection afforded by the additional PPE cannot be quantified using POEM. The clothing scenario modelled is appropriate for applicators
(2) Daily absorbed dermal dose (mg/kg/d) = surface contamination (mL/operation or mL/hour) x number of operations or duration of exposure (hours) x concentration of ai in spray (mg/mL) x penetration through clothing/protective clothing (%) x dermal penetration (%)÷ average body weight (kg)
(3) Daily absorbed inhalation dose (mg/kg/d) = inhalation exposure (mL/hour) x concentration of active ingredient in spray (mg/mL) x duration of spraying (hours) x inhalation absorption (%)÷ average body weight (kg)
(4) Daily total absorbed dose (mg/kg/d) = Daily absorbed dermal dose (mg/kg/d) + Daily absorbed inhalation dose (mg/kg/d) * NM – not measured

Exposure scenario, concentration of active ingredient in product	Concentration of dip solution	Equipment PPE/clothing	Data source	Daily absorbed dermal dose (mg/hr)	Daily absorbed inhalation dose (mg/hr)	Daily total absorbed dose (mg/hr)	Comments
Mixer/loader/applicator							
Scenarios (1s) and (2s) Mixing loading to support shower dipping and shower dipping	Dip concentration 100 ppm diazinon	**Open mixing/loading Shower dipping** PPE – overalls, hat, gloves (during certain activities), boots	Measured exposure study (Apthorpe L, Foster, G, Smith, M (1998)	0.034	0.010	0.048	Gloves worn only during mixing/loading, cleaning sump and handling treated sheep

4.3 Post-application exposure

Agricultural uses

No measured exposure data or dislodgeable foliar residue data were provided. Diazinon product labels do not specify a REP for agricultural situations.

Exposure may occur in agricultural and horticultural crops when workers re-enter treated crops to check pest kills, irrigate, weed, prune, thin or harvest crops. The type of activity, timing and frequency of re-entry activities is dependent on crop type. Potential worker exposure will be determined by the amount of chemical applied, interval between spraying and re-entry, nature and duration of the particular re-entry activity, density of foliage and spacing of crops, and environmental factors that affect the breakdown of residues.

Harvesting of agricultural and horticultural crops may be either a mechanical or a manual activity. Mechanical harvesting is not of OHS concern as no worker exposure is anticipated. Manual harvesting can result in exposure, and will depend on the quantity of residues present at the time of harvest and work practices. Timing for harvesting is governed by the WHP for harvest. This ranges from 10-14 days for vegetables to 2-14 days for field crops. In general, broadacre crops are harvested mechanically. Some vegetables and fruits may be harvested manually.

It is uncommon for pest control operators to re-enter buildings post-treatment, except in exceptional circumstances. Registered product labels to not include a restriction on re-entering enclosed areas after treatment with diazinon.

It is reasonable to assume that workers will be required to engage in post application activities in nurseries and greenhouses. Potential worker exposure will be determined by factors listed for agricultural/horticultural crops (refer above). Of particular concern is the impact of enclosed areas, such as delayed drying of spray, closely packed plants resulting in extensive contact with treated foliage and the lack of adequate ventilation.

Information from processors of skins/hides indicated that the predominant use of diazinon in the industry is to spray the pallets containing the hides, prior to export. Contact with treated pallets is not anticipated. Application of diazinon to individual skins/hides is rarely, if ever, required.

No post application occupational exposure is anticipated in lawns, ponds or stagnant waterways, and refuse areas or garbage dumps.

Veterinary uses

Cattle

Diazinon product labels do not carry specific re-handling restrictions. Post-application exposure is likely for persons who may come in contact with treated cattle shortly after application. No exposure data were available to assess the risk from such contact. However, normal husbandry practices do not require workers to re-handle treated cattle.

A withholding period of 3-14 days (depending on application method) is recommended before slaughter for human consumption. Considering the WHP and work practices in Australian abattoirs, potential worker exposure during slaughter and subsequent handling of carcasses is not expected to be significant.

Sheep

No specific re-handling restriction is indicated on product labels. Post-application exposure may occur in workers handling treated sheep (eg for drenching, vaccination, marking, mulesing, crutching etc), shearers and other wool handlers. Some product labels recommend a WHP of 2-3 months before shearing. A separate NRA review to consider this concern is currently underway.

5. OCCUPATIONAL RISK ASSESSMENT

The occupational risk assessment takes into consideration the hazard of the chemical as determined by toxicology testing (Section 2), its use pattern in Australia (Section 3) and worker exposure for each exposure scenario (Section 4).

In order to adequately determine the risk associated with the use of diazinon, MOE were calculated by comparing the most appropriate NOEL with exposure data obtained from measured exposure studies and predictive modelling. A qualitative risk assessment was conducted where a suitable model was not identified.

The main adverse health effect of diazinon exposure is ChE inhibition. The most appropriate NOEL to assess short-term and longer-term occupational risk to workers was determined to be 0.02 mg/kg/d, established in a 37-43 day human dietary study (Section 2.2). A dermal absorption adjustment of 4% was used in the risk assessment (Section 2.3). No correction was made for inhalation absorption, as 100% absorption was assumed (Section 2).

A human NOEL is used to estimate risk. However, the study in which this NOEL was determined (a) utilised only three subjects per dose and (b) tested two dose levels only, thereby increasing the uncertainty of the results. Therefore, MOE of approximately 20 or more are considered to be acceptable, to account for intra-species (10x) variability and small number of subjects and the closeness of the NOEL to the LOEL (2x).

In general, diazinon products are slight skin and eye irritants in experimental animals. These topical effects may manifest in workers who come in contact with these products. The potential for topical effects when in contact with the working strength solutions is likely to be governed by the concentration of the product in the spray/solution in each case.

In estimating the risk to workers handling diazinon products, it is assumed that workers wear appropriate PPE, as specified on product labels.

For all uses of liquid diazinon formulations significant risk was identified associated with open pouring from narrow necked containers. Adoption of wide-necked containers for all open pouring applications will substantially reduce the risk of exposure to concentrate.

5.1 Risk from end use exposure

. *Vegetables*

Diazinon is registered for use in a range of vegetable crops as a foliar spray. Vegetables can be treated with diazinon at 7-14 day intervals if required, depending on pest pressure. It is anticipated that in most instances mixing/loading and spray application will be carried out by the farmer or farm employee.

Workers are required to open containers, measure the required quantity of product and mix it with the appropriate amount of water often within the spray tank of the application equipment. Diazinon application in vegetables usually takes place using boom sprayers. Information from regular users indicates that occasionally, hand-held equipment (such as knapsack sprayers) may be used. It is expected that hand spraying will occur when spot spraying is required or the area to be treated is small. The amount of chemical applied as a foliar spray depends on plant size, with higher rates being used for advanced crops. In all crops, the concentration of the active constituent in the spray is low (maximum of 0.5%). Product labels indicate that both high and low volume foliar spraying may take place.

The use pattern of diazinon in vegetables varies between crops/uses. At the most, worker exposure for the following exposure scenarios is likely to be intermittent, particularly when pest pressure is high.

Scenarios (1a) and (17a) Mixing/loading and ground spraying of vegetables using boom sprayers

Scenarios (2a) and (18a) Mixing /loading and directed spraying of vegetables using hand-held equipment

Table 21: Risk associated with open mixing/loading, boom and knapsack spraying of vegetables

Scenario and description of container/equipment	Daily absorbed dermal dose (mg/kg/d)	Daily absorbed inhalation dose (mg/kg/d)	Daily total absorbed dose (mg/kg/d)	MOE(1)
Scenario (1a) Mixing/loading, to support boom spraying, vegetables, 5 L non specific container	Representative exposure 0.053	NM	Representative exposure 0.053	<1
	Maximum exposure 0.149		Maximum exposure 0.149	<1
Scenario (1a) Mixing/loading, to support boom spraying, vegetables, 5L wide neck container	Representative exposure 0.003		Representative exposure 0.003	6

Scenario (1a) Mixing/loading, to support boom spraying, vegetables, 20 L non specific containers	Representative exposure 0.053		Representative exposure 0.053	<1
	Maximum exposure 0.107		Maximum exposure 0.107	<1
Scenario (1a) Mixing/loading, to support boom spraying, vegetables, 20 L wide neck containers	0.005		0.005	4
Scenario (2a) Mixing/loading, to support hand held spraying, vegetables, 5 L non specific container	0.011		0.011	2
Scenario (2a) Mixing/loading, to support hand held spraying, vegetables, 5 L wide neck container	0.001		0.001	20
Scenario (17a) Boom spraying, vegetables, closed cabs, wearing cotton overalls and gloves	0.005	0.001	0.006	3
Scenario (18a) Directed spraying of vegetables using hand held equipment, wearing cotton overalls and gloves	0.018	0.001	0.019	1

Source: POEM
(1) MOE = NOEL (0.02 mg/kg/d) ÷ daily total absorbed dose (mg/kg/d)

Predictive modelling indicated a health risk for mixer/loaders when open pouring from 5 L and 20 L containers, except when handling 5 L wide neck containers and mixing for hand spraying. MOE were low across a range of exposure parameters, ie. representative and maximum.

Worker exposure during boom spraying was determined for closed cabs (the model available for boom sprayers). Workers in open tractor may be exposed to greater quantities of spray mist. It was assumed that application of diazinon products would take place over a six hour period (default). Farmers using more efficient equipment would cover a greater area, hence two work rates were modelled. Results from using the model indicate an unacceptable risk for applicators in closed cabs. However, a 10 fold shift could be acceptable given the conservative assumptions used in the model.

Hand spraying in vegetables is expected to occur only as spot sprays or where small areas require treatment. Default work rates were used in order to obtain a rough estimate of potential worker exposure during hand spraying. Model results indicate the risk to be unacceptable during hand spraying of vegetables wearing cotton overalls and gloves, ie. label specified PPE. However, as in the above, a 10 fold shift could be acceptable given the conservative assumptions used in the model.

(See additional para on Vegetables in Section 6.5.1 of the NRA Review of Diazinon September 2002, Volume 1, Review Summary)

Mushrooms

Scenario (19a) Incorporation into mushroom casing

Although product labels recommend the use of diazinon in mushrooms at spawning or after casing, current cultural practice in the mushroom industry is to incorporate the chemical into casing. Drenching of mushroom beds is not a registered use of diazinon. Several chemicals are currently available for use in mushroom housing. Industry practice is to use physical barriers for the control of mushroom pests. When periodic pest monitoring indicates economically damaging numbers, diazinon is incorporated into the next batch of casing.

In commercial enterprises, approximately 50 batches of mushrooms are grown per year, with new casing prepared for each batch. Workers are required to mix the required amount of diazinon and water, the mixture being added to dry peatmoss/limestone (casing). The casing is applied evenly as a 4-5 cm thick layer over the compost. The quantity of product handled at any time will depend on the extent of the mushroom beds to be treated. It is also noted that the concentration of the active constituent in the prepared solution is low (0.24%). The process of mixing is usually mechanized. In addition, workers wear label specified protective clothing during these activities.

Worker exposure during incorporation of the chemical in mushroom casing could not be quantified. However, worker exposure during this activity is unlikely to be significant due to the:

- concentration of the chemical in the prepared solution;
- infrequent or intermittent nature of the activity;
- protective clothing recommended on product labels; and
- mechanised mixing of chemical into peatmoss.

According to information provided by the mushroom industry, workers would not be exposed to diazinon following the treatment of the mushroom casing as no contact is made with the treated casing. There is a minimum interval of 14 days between application of diazinon to the mushroom beds and the start of harvesting. During that interval, the room is closed and the only entry is to monitor carbon dioxide levels or to water the beds. There is no reason for workers entering the room to come in contact with the mushroom beds. At harvesting pickers would wear rubber gloves and long sleeves while hand picking mushrooms.

Based on the information provided, and considering that:

- diazinon is not sprayed, but used as a casing treatment
- workers will not be handling the treated casing during other agricultural activities, such as monitoring for carbon dioxide or watering
- harvesting of mushrooms does not occur prior to 14 days post-treatment;

Onions

The information provided by the onion industry indicate that treatment with diazinon is conducted by ground or aerial application early in the crop stage. Application rates of diazinon are 70 mL/ha or 65 mL/100 L water, with spray volume ranging from 200-300 L/ha. Mixing is usually done in spray vats, with the chemical added to the vat when part full, with some form of agitation to ensure adequate mixing. Boomspray ground rigs are used for ground application.

Aerial applications are only conducted in situations, where it is too wet to gain access using groundrig applications (eg. clay soil). Standard closed filling/loading systems are in operation as per AAAA (Aerial Applicator Association of Australia) guidelines. The chemical would be pumped from a drum into a mixing tank from which it would then be transferred to the plane. All aerial operators in the onion producing areas utilize GPS navigation systems.

Recent information confirms that application of diazinon directly to soil, for treatment of seedling maggot is not a current practice. It is recommended that this use is deleted from labels.

. ***Fruit***

Diazinon products are registered in fruit as a foliar spray (boom and airblast) and as a butt spray for bananas, applied as a band application by tractor-mounted spray. It is anticipated that mixing/loading and spray application will most likely be conducted by the owner/operators or farm employee.

Diazinon products may be applied to fruits either infrequently or at approximately 2-4 week intervals, depending on pest pressure. Therefore, the following scenarios can result in intermittent or irregular worker exposure.

Scenarios (3a) and (20a) Mixing/loading and boom spraying of fruit

Scenarios (5a) and (22a) Mixing/loading and high volume air blast spraying of fruit

Mixing/loading in Australian orchards and vineyards is most common by the open pour method. It is anticipated that the required quantity of product and water will be mixed in the spray tank of the airblast or boom sprayer.

Vehicle mounted sprayers may be of the closed cab variety or open tractors. It is noted that the concentration of diazinon in the prepared spray solution is low (maximum 0.1%) across the range of fruit crops.

Table 22: Risk associated with open mixing/loading, boom, and air blast spraying of fruit

Scenario and description of container/equipment	Daily absorbed dermal dose (mg/kg/d)	Daily absorbed inhalation dose (mg/kg/d)	Daily total absorbed dose (mg/kg/d)	MOE[(1)]
Scenario (3a) Mixing/loading, to support	0.085	NM	0.085	<1

boom spraying, fruit 5 L non specific containers				
Scenario (3a) Mixing/loading, to support boom spraying, fruit, 5L wide neck containers	0.004	NM	0.004	5
Scenario (3a) Mixing/loading, to support boom spraying, fruit, 20 L non specific containers	0.053	NM	0.053	<1
Scenario (3a) Mixing/loading, to support boom spraying, fruit, 20 L wide neck containers	0.005	NM	0.005	4
Scenario (5a) Mixing/loading to support high volume air blast application, fruit, 5 L non specific design container	0.085	NM	0.085	<1
Scenario (5a) Mixing/loading to support air blast application, fruit, 20 L non specific design container	0.053	NM	0.053	<1
Scenario (20a) Boom spraying, fruit, closed cabs, wearing cotton overalls and gloves	0.002	0.001	0.003	7
Scenario (22a) High volume air blast application, fruit, open cabs, wearing cotton overalls and gloves	0.030	0.003	0.033	<1

(1) MOE = NOEL (0.02 mg/kg/d) ÷ daily total absorbed dose (mg/kg/d)

The risk to mixer/loaders open pouring from 5 L and 20 L containers was unacceptable under the parameters modeled. MOE were low for applicators applying the spray using boom and airblast equipment. MOE were highest (7) for applicators in closed cabs, reflecting the protection afforded by engineering controls (closed cabs). The additional protection afforded by pesticide filters could not be quantified.

Discussion

Based on the output from the model alone, the risk for most scenarios was unacceptable, for both mixer/loaders and applicators. However, the MOE for boom and airblast spraying may overestimate risk due to:

- *intermittent use of the chemical (at most) in fruit crops, with intervening exposure free periods; and*

- *the increasing use of closed cab boom and airblast sprayers with pesticide filters. The additional protection afforded by filters could not be quantified.*

Scenarios (4a) and (21a) Mixing/loading and butt spraying of bananas using tractor-driven boomsprayers

Information provided by the banana industry indicated that the industry uses diazinon as a 'butt spray', applied as a band application by tractor mounted boom spray. No hand spraying or foliar spraying is currently carried out using diazinon, and it is recommended that these instructions are deleted from labels. As no worker exposure data were provided for butt spraying of bananas, NOHSC used the UK POEM model to estimate exposure, results of which are outlined in Table 23.

Table 23: Risk associated with butt spraying of bananas, using tractor-driven boom spraying equipment

Method of application	Daily absorbed dermal dose (mg/kg bw/d)	Daily absorbed inhalation dose (mg/kg bw/d)	Daily total absorbed dose (mg/kg bw/d)	MOE (NOEL/Exposure)
Scenario (4a) Mixing/loading, to support butt application using 20 L non specific containers	0.023	NM	0.023	<1
Scenario (4a) Mixing/loading, to support butt application using 20 L wide-neck containers	0.002	NM	0.002	10
Scenario (21a) Butt application using tractor-driven boom sprayers	0.004	0.001	0.005	4

NM: not measurable

A NOEL of 0.02 mg/kg bw/day from a human study was used to calculate the MOE. Predictive modelling indicated unacceptable MOE for mixer/loaders (MOE <1), using the non-specific design container where hand contamination was 0.5 mL for a 20 L container. However, acceptable MOE (MOE 10), was obtained when a wide-neck container with hand contamination of 0.05 mL was used, for a 20 L container. A MOE of 4 was obtained for workers applying diazinon as a butt application.

Under normal circumstances a MOE of 4 would be considered low using a human NOEL, however, NOHSC considers the risk for workers is likely to be minimal, given that:

- the frequency of application is only 2 applications per crop;
- no hand spraying is involved;
- closed cab tractors with the inclusion of air-conditioning and pesticide filters are used for spraying, which would provide added protection as well as worker comfort; and
- containers designed to minimise spillage, eg wide neck containers are used for mixing/loading.

Therefore, NOHSC concludes that the use of diazinon for butt spraying of bananas only is acceptable provided the above criteria are observed, and in addition that:

- control measures outlined in the National Occupational Health and Safety Commission (1994) *Control of Workplace Hazardous Substances* [NOHSC:1005(1994), 2007(1994), Australian Government Publishing Service, Canberra, are observed;

- the products are used in accordance with label instructions.

. ***Field crops***

Diazinon is registered for use in pastures and other field crops by boom, mister or aerial application. Information obtained from users indicates that though diazinon is registered for control of locusts and grasshoppers in various field crops, it is rarely, if ever used. Other chemicals are generally used in preference to diazinon.

It is anticipated that mixing/loading and spray application will be carried out by the farmer or farm employee using boomsprayers or misting machines. Aerial spraying by farmers is unlikely. Accredited operators usually conduct aerial spray operations.

Worker exposure may occur during mixing/loading, spraying, cleaning equipment, or in the event of spills. Exposure to spray mist can be minimised by flying against the direction of the spray mist (aerial spraying) and using closed cab equipment (ground spraying). Misting machines can result in significant exposure if workers are required to remain in the vicinity.

It is noted that aerial spraying and misting utilise more concentrated solutions (2.5% - 5% ai) than boom spraying (0.5% - 1%a ai). Rice is treated at greater dilutions by both aerial and ground equipment (maximum 0.56% ai).

Diazinon products are generally applied when pests are first noticed and may be re-applied at 10-14 day intervals, if necessary. Higher application rates are recommended for high pest pressure and dense crops. Rice crops can be treated at or within 24 hours of sowing by aircraft or ground application and treatment repeated when necessary.

Considering all of the above, worker exposure from the use of diazinon in field crops is likely to be irregular or at most intermittent.

Scenarios (6a) and (23a) Mixing/loading and boom spraying of field crops

Scenarios (7a) and (24a) Mixing/loading to support aerial application of field crops

Table 24: Risk associated with open mixing/loading and boom spraying of field crops

Scenario and description of container/equipment	**Daily absorbed dermal dose (mg/kg/d)**	**Daily absorbed inhalation dose (mg/kg/d)**	**Daily total absorbed dose (mg/kg/d)**	**MOE(1)**
Scenario (6a) Mixing/loading, to support boom spraying, field crops 20 L non specific design containers	Representative exposure 0.053	NM	Representative exposure 0.053	<1
	Maximum exposure 0.107		Maximum exposure 0.107	<1
Scenario (6a) Mixing/loading, to support boom spraying, field crops, 20L wide neck containers	Representative exposure 0.005		Representative exposure 0.005	4

20L wide neck containers	Maximum exposure 0.011		Maximum exposure 0.011	<2
Scenario (7a) Mixing/loading, to support aerial spraying, field crops, 20L non specific design container	Representative exposure 0.187		Representative exposure 0.187	<1
	Maximum exposure 0.373		Maximum exposure 0.373	<1
Scenario (23a) Boom spray application, field crops, closed cabs, wearing cotton overalls and gloves	Representative exposure 0.022	Representative exposure 0.005	Representative exposure 0.027	<1
	Maximum exposure 0.044	Maximum exposure 0.010	Maximum exposure 0.054	<1

(1) MOE = NOEL (0.02 mg/kg/d) ÷ daily total absorbed dose (mg/kg/d)

Exposures were estimated for mixer/loaders handling 20 L containers only, as it is unlikely that workers will use 5L containers given the quantity of product required per day. Representative and maximum exposures were determined where appropriate. Based on an acceptable MOE of 20, the MOE obtained from using the model for open mixing/loading to support ground and aerial spraying of field crops were low (<10 fold), irrespective of container design.

Model results indicate that the MOE for applicators in closed cab boom sprayers were low across the range of application rates (representative and maximum). It is reasonable to assume that exposure and therefore risk will be greater for applicators in open tractors. Aerial applicator exposure could not be estimated using POEM as no suitable model exists. Aerial applicators are adequately trained, follow best practice guidelines, are located in closed cabins and operate against spray drift. Therefore potential exposure is not likely to be extensive. Flaggers will only be used during night spraying, when Geographic Positioning Systems (GPS) cannot be utilised. They are expected to operate from enclosed vehicles and follow best practice guidelines.

. *Discussion*

Worker exposure was estimated using predictive modelling where possible, in the absence of measured exposure data. Taking into account the wide variation in field sizes for the crops under consideration, representative and maximum parameters were modelled where relevant. Based on the model results alone, the risk to mixer/loaders (supporting ground and aerial spraying) by the open pour method were unacceptable. MOE were low for applicators in closed cab ground sprayers. On balance, the risk to aerial spray applicators is expected to be acceptable.

The MOE calculated from predictive modelling are likely to overestimate risk due to the following reasons:

- *The infrequent use of diazinon for locust or grasshopper control;*
- *When used in field crops use is most likely to be irregular or at most intermittent, with intervening exposure free periods;*

- *Ground applicators in broadacre crops generally use closed cab tractors with air-conditioning and pesticide filters. The additional protection afforded by pesticide filters could not be quantified; and*
- *Mixing/loading for aerial applications is usually by a closed method such as closed filling/loading systems or dry coupling.*

. ***Nursery plants and ornamentals (refer amended version Section 6.5.2 in the NRA Review of Diazinon September 2002, Volume 1, Review Summary)***

Diazinon is used for the treatment of various pests in nursery plants and ornamentals, particularly as a quarantine measure prior to interstate transfer. It is used as a dilute solution (0.02% - 0.05% ai) and applied as a drench or dip. Information from State authorities and the nursery industry suggest that diazinon is an important chemical in the control of pests in ornamentals and potted plants (NRA Agriculture Report).

Greenhouse/nursery workers are expected to measure out the required quantity of product and prepare the solution in a large spray vat. Drenching of plants may be by dipping or flooding of beds. The solution may be applied via an existing irrigation system or via hand-held equipment. Treatment may be carried out in several situations including fully or partially enclosed greenhouses and outdoors.

Product labels specify a dilution only. The quantity of product and solution required per treatment and potential worker exposure, will depend on:
(a) the number and size of plants to be treated,
(b) extent of greenhouse;
(c) application method ie. irrigation through a fixed system or hand spraying;
(d) indoor or outdoor use and if indoor, the design of the greenhouse (ie. ventilation).

Inadequate information on use pattern and work practices was available to quantitatively estimate potential worker exposure. It is anticipated that dipping/drenching of plants and ornamentals will occur on a needs basis. Hence worker exposure will be mainly irregular, with intermittent exposure possible in large commercial establishments.

Scenarios (8a) and (25a) Mixing/loading and dipping/drenching of nursery plants and ornamentals

. *Discussion*

No measured exposure data were available for drenching or dipping of plants. Inadequate information was available to determine potential worker exposure during this use with any degree of confidence. However, worker exposure and risk is not expected to be significant due to:

- *The relatively infrequent use of diazinon in nursery plants and ornamentals;*
- *The high dilution of the solution (maximum 0.05% ai);*

- *That worker exposure during flooding via irrigation systems is unlikely to be significant as it is an automatic delivery system and generation of spray mist is not likely;*
- *Application using hand-held equipment is likely to utilise coarse spraying rather than fine spraying. Coarse droplets are less prone to drift.*

. ***Lawns/turf and around trees, walls, fences, garden beds***

Diazinon products (EC and ME formulations) are registered for the control of ants, worms, bugs and beetles in lawns (also around trees, fences, walls) and in turf. This is not expected to be a major use of diazinon products, with information from users indicating that other chemicals are used in preference. Application to large areas of lawn/turf is likely to occur by boom spraying. For the control of pests around trees, fences, walls etc, the likely method of application is via hand-held equipment. Application to turf is likely to be undertaken by the farmer, whilst spraying for ant/bug control along trees, fences etc may be undertaken by owner/operators, council workers or professional pest controllers.

Both formulations are applied at similar concentrations (maximum of 0.5% diazinon in the spray). Therefore, potential worker exposure is only determined quantitatively for the 800 g/L EC formulation. Worker exposure may occur while mixing and loading the product, applying spray, cleaning equipment and in the event of spills.

It is anticipated that diazinon will be applied when pests first appear. Product labels permit repeat applications, if necessary. Therefore, potential worker exposure for the following scenarios may be either infrequent or intermittent. Given that diazinon is not the chemical of choice for this use pattern, regular (several times per week) exposure is not anticipated.

Scenarios (9a) and (26a) Mixing/loading and hand held spraying of lawns (around trees, fences, walls)

Scenarios (10a) and (27a) Mixing/loading and boom spraying of lawns/turf

Table 25: Risk associated with open mixing/loading, boom and hand-held spraying of lawns (around trees, fences, walls) and lawns/turf

Scenario and description of container/equipment	Daily absorbed dermal dose (mg/kg/d)	Daily absorbed inhalation dose (mg/kg/d)	Daily total absorbed dose (mg/kg/d)	MOE(1)
Scenario (9a) Mixing/loading, to support hand-held spraying, lawns around trees, 5 L non specific design container	0.011	NM	0.011	2
Scenario (9a) Mixing/loading, to support hand-held spraying, lawns around trees, 5L wide neck container	0.001	NM	0.001	20
Scenario (10a) Mixing/loading, to support boom spraying, lawns/turf, 20	0.107	NM	0.107	<1

L non specific design container				
Scenario (10a) Mixing/loading, to support boom spraying, lawns/turf 20 L wide neck container	0.011	NM	0.011	2
Scenario (26a) Hand-held spraying of lawns around trees, wearing cotton overalls and gloves	0.106	0.006	0.112	<1
Scenario (27a) Boom spraying, lawns/turf, closed cabs, wearing cotton overalls and gloves	0.003	0.001	0.004	5

(1) MOE = NOEL (0.02 mg/kg/d) ÷ daily total absorbed dose (mg/kg/d)

Predictive modelling indicated unacceptable risk to all categories of workers, except those open mixing/loading from 5 L wide neck containers to support hand spraying around trees and other structures. MOE were also inadequate for applicators in closed cabin boom sprayers.

. *Discussion*

No measured exposure data were available for this use of diazinon. Predictive modelling was used as a first tier assessment to gauge potential worker exposure. The risk to workers open mixing/loading and applicators hand spraying were determined to be unacceptable in most cases. The risk to applicators in closed cabs was lower, yet unacceptable. These MOE are likely to overestimate risk due to the following reasons:

- *Diazinon is not a first line chemical for the control of insects in lawns and turf. When it is used, the frequency and extent of use is unlikely to be significant. Use is expected to be predominantly infrequent, with intervening exposure free periods.*

- *Boom sprayers generally use closed cab tractors with air-conditioning and pesticide filters. The additional protection afforded by pesticide filters could not be quantified.*

- *The potentially higher exposure scenario, ie. hand spraying, is not expected to be extensive or intense.*

. ***Commercial and domestic areas***

Diazinon is one of several chemicals used for general pest control in domestic and commercial establishments. Alternatives are preferred in these situations due to odour and reported adverse reactions in household pets (NRA Agriculture Report). Several diazinon products (EC 800 g/L, EC 200 g/L, ME 240 g/L and ME 300 g/L) are registered for use as hand sprays, mists and fogs. Hand spraying utilises the most dilute solution (approximately 0.5% ai), whilst misting (1.2% ai) and fogging (4.8% ai) utilise more concentrated solutions. Use of diazinon for pest control is usually conducted by trained and accredited pest control operators.

Product labels recommend application when pests are first noticed and re-treatment when pests reappear. Workers may be exposed to diazinon when mixing the product (with kerosene or water as required) and hand spraying or application using a brush. Worker exposure during misting and fogging will only occur if they are required to remain in the area. Although hand spraying utilises a more dilute solution than misting or fogging, worker exposure is estimated for this use scenario because:

(a) it can result in significant worker exposure due to the proximity of the operator to the application equipment;
(b) hand spraying is expected to be more prevalent due to easier access into cracks and crevices, under floors etc;
(c) a greater volume of spray is utilised during hand spraying than misting (1 L mixture per 20 m^2 for hand spraying and 1L mixture per 50 m^2 for misting);

Considering that diazinon is not a first line chemical for general pest control, worker exposure for the following exposure scenarios is most likely to be irregular or at most intermittent.

Scenarios (11a- 13a) and (28a – 30a) Mixing/loading and hand-held spraying/misting/fogging of commercial and domestic areas

Table 26: Risk associated with hand-held spraying of commercial and domestic areas

Scenario and description of container/equipment	Daily absorbed dermal dose (mg/kg/d)	Daily absorbed inhalation dose (mg/kg/d)	Daily total absorbed dose (mg/kg/d)	MOE[(1)]
Scenario (11a) Mixing/loading, to support hand-held spraying, commercial and domestic areas, 5 L non specific design container	0.011	NM	0.011	2
Scenario (11a) Mixing/loading, to support hand-held spraying, commercial and domestic areas, 5 L wide neck container	0.001	NM	0.001	20
Scenario (28a) Hand-held spraying of commercial and domestic areas, wearing cotton overalls and gloves	0.053	0.003	0.056	<1

(1) MOE = NOEL (0.02 mg/kg/d) ÷ daily total absorbed dose (mg/kg/d)

The risk to mixer/loaders was unacceptable when handling containers of standard design and acceptable when open pouring from wide neck containers. The risk to hand sprayers wearing cotton overalls and gloves was unacceptable. It is noted that due to inadequate use pattern information, defaults were used to estimate potential worker exposure.

. *Discussion*

In the absence of measured data, worker exposure was estimated using POEM for hand-held application only. This model cannot be used to estimate exposure during fogging and misting. The risk to mixer/loaders open pouring from standard containers and applicators using hand-held equipment was unacceptable. These MOE may overestimate risk due to:

- *Infrequent or intermittent (at most) use of diazinon for general pest control with intervening exposure-free periods;*
- *The use of default values in the absence of Australian use pattern information.*

In addition, it is of note that diazinon products will be mainly used for general pest control by trained and accredited pest control operators.

It is anticipated that exposure estimates for hand spraying will equate or exceed potential worker exposure during misting and fogging. It is not possible to quantitatively estimate exposure for these use scenarios due to the lack of data and suitable models.

The risk assessment was conducted for the EC formulations of diazinon. The two ME formulations registered for pest control utilise a similar concentration of active ingredient in the spray solution. POEM cannot be used to estimate exposure to microencapsulate formulations. Therefore, exposure values obtained for the EC product, are used as surrogate for the ME products.

. Skins and hides

Diazinon is one of a number of chemicals used for the control of skin and hide beetles. Current management practices undertaken by processors make infestation of hides with beetles rare. However, diazinon is still used for fly control, especially when preparing skins or salted hides for export. Pallets are sprayed before they are loaded into containers to prevent fly numbers from building up during shipment (NRA Agriculture Report).

A dilute solution containing diazinon at 0.48% is applied to skins and/or surrounding areas including pallets, using hand-held sprayers, atomisers or misters. Worker exposure may occur during mixing/loading and spraying. It is not possible to quantify potential worker exposure during this activity due inadequate information on use and work practices.

Therefore, worker exposure during the following use scenarios is most likely to be irregular or intermittent.

Scenarios (14a) and (31a) Mixing/loading to support directed spraying of hides/skins and surrounding areas using hand-held equipment

. Discussion

Inadequate use pattern information was available to accurately determine worker exposure for this use pattern. No measured exposure data were available. Predictive modelling could not be *used due to the lack of relevant use pattern information. However, worker exposure and risk is likely to be acceptable due to*:

- *current management practices minimising beetle infestation of skins;*
- *diazinon being one of many chemicals registered for this use;*
- *if used at all, regular and extensive spraying is not anticipated.*

. ***Ponds, Stagnant water***

Diazinon EC products are registered as hand sprays, mists and fogs for the control of mosquito larvae in ponds and stagnant waterways. No further information was available and it is considered a relatively minor use of the chemical. For hand spraying, a 0.1% solution of diazinon in water is applied to breeding areas. The recommended diluent for misting and fogging is either diesel or kerosene.

It is anticipated that council workers and pest control operators will be the most likely end users. Worker exposure is possible during mixing/loading and application. Given that hand spraying requires the applicator to remain in close proximity to the application equipment, this may result in significant worker exposure. Exposure during misting and fogging operations will depend on the requirement to remain in the area.

It is not possible to quantify the extent of use of diazinon for mosquito control, council workers may apply the chemical over a few consecutive days. However, regular and frequent exposure is not anticipated for the following scenarios.

Scenarios (15a) and (32a – 34a) Mixing/loading and hand-held spraying/ misting/fogging of ponds, stagnant water

. *Discussion*

No measured exposure data were available. An estimate of potential worker exposure could not be made due to inadequate use pattern information. However, worker exposure and risk is likely to be acceptable due to:

- *The relatively infrequent use of diazinon;*
- *The dilution of the solution (maximum 0.1% ai).*

. ***Refuse areas and garbage containers***

Diazinon is registered for use in pest control around garbage and refuse dumps. No further information was available and it is expected to be a minor use of the chemical. It is reasonable to assume that council workers will be the most likely users and that application will be more likely in the summer when pest pressure is high.

Product labels recommend thorough penetration of refuse with a dilute solution (maximum 0.5%) when pests are first seen and re-application as required. Sprayers, mister or foggers may be used, however, it is anticipated that hand spraying will be the preferred method of application to ensure good coverage and penetration. It is possible that workers may be exposed to diazinon during mixing/loading and spray application.

It is not possible to accurately determine the extent of diazinon use in garbage dumps with the information available. However, it is unlikely that diazinon products will be used to any great extent. Therefore, worker exposure for the following scenarios is expected to be irregular.

Scenarios (16a) (35a – 37a) Mixing/loading and hand-spraying/misting/fogging of refuse areas and garbage

. *Discussion*

Insufficient use pattern information was available to determine potential worker exposure while treating refuse areas and garbage. No measured worker exposure data was available. However, worker exposure and risk is likely to be acceptable due to:

- *The relatively infrequent use of diazinon;*
- *The high dilution of the solution (0.05% - 0.5% ai).*

. ***Treatment of animal housing***

Diazinon liquid products are registered for fly control in dog kennels and other animal housing. Product labels recommend spraying inner walls, other surfaces where flies settle and the ground surrounding the kennel/building with a dilute solution of diazinon, every three weeks. Re-spraying is expected to be more common during the hot summer months when pest pressure is high.

Workers are required to prepare a 0.5% solution of diazinon and open mixing/loading is anticipated in most cases. Spraying of animal housing will be via hand-held application equipment, including knapsack sprayers or hose and wand attached to motorised sprayer.

The amount of chemical handled per day will be determined by the area to be treated. Inadequate information was available to determine the extent of diazinon use in animal housing in Australia.

The following exposure scenarios are expected to result in irregular or intermittent worker exposure, particularly during the fly season.

Scenarios (11c) and (12c) Mixing/loading and hand spraying of animal housing

Table 27: Risk associated with open mixing/loading and hand spraying of animal housing

Scenario and description of container/equipment	Daily absorbed dermal dose (mg/kg/d)	Daily absorbed inhalation dose (mg/kg/d)	Daily total absorbed dose (mg/kg/d)	MOE[(1)]
Scenario (11c)	0.003	NM	0.003	7

Mixing/loading to support hand spraying of animal housing, 5L non specific design containers				
Scenario (11c) Mixing/loading to support hand spraying of animal housing, 5L wide neck containers	Nil	NM	Nil	*
Scenario (12c) Low level hand spraying wearing cotton overalls and gloves	0.024	0.002	0.026	<1
Scenario (12c) High level hand spraying wearing water-proof clothing, cotton overalls and gloves	0.008	0.002	0.010	2

Source: POEM

(1) MOE = NOEL (0.02 mg/kg/d) ÷ daily total absorbed dose (mg/kg/d)
* MOE could not be determined as no dermal or inhalation absorption occurred using the 5 L wide-neck container

Predictive modelling indicated unacceptable risk to mixer/loaders open pouring from containers of non specific design. The risk to these workers when handling wide neck containers was acceptable.

The MOE for applicators were inadequate for high and low level hand spraying. It is established that high level spraying results in higher worker exposure than low level spraying. It is of note that the risk during high level spraying was unacceptable despite the additional protection of water-proof clothing over cotton overalls.

. *Discussion*

Inadequate use pattern information was available to accurately estimate the extent of use of the chemical in animal housing. In the absence of measured exposure data, POEM was used as a rough estimate of potential worker exposure during mixing/loading and hand spraying of animal housing.

The risk was determined to be unacceptable for mixer/loaders handling non-specific design containers and applicators involved in low level and high- level spray application. It is of note that additional skin protection, namely water-proof clothing over cotton overalls, was considered during high-level spray application.

It is established that worker exposure can be significant during hand spraying, particularly high level spraying. Significant quantities of spray mist may be generated, resulting in dermal and inhalation exposure. Potential exposure will be determined by the:

- *position of the operator in relation to spray equipment;*
- *extent of the area treated;*
- *level of spraying, ie high level or low level spraying; and*
- *ventilation within enclosed animal housing.*

Based on the low MOE determined when predictive modeling was used, and the lack of adequate information, NOHSC considers the risk to workers using diazinon to treat animal housing unacceptable

Veterinary Applications (some of the information provided below has been amended and appears in Section 6.5.3 of the NRA Review of Diazinon September 2002, Volume 1, Review Summary)

. *Backrubbers and rubbing post*

Diazinon products are used in backubbers or rubbing posts as a cheap, yet effective and labour saving method of buffalo fly control. The requirement for these methods of control extend through the six month buffalo fly season, during which time backrubbers are charged at approximately three weekly intervals. Cattle farmers are required to prepare a solution containing 500 mL product per 10 L oil (1% ai in solution). The backrubber is either soaked in solution within a trough or the oil mixture poured onto it. Rubbing posts are generally filled with the oil solution. The treated backrubbers are suspended from trees or posts, at a height that will enable cattle to rub the uppermost areas of their bodies against them. The number of backrubbers/rubbing posts charged at any one time would depend on the herd size and extent of the farm. Therefore, the following exposure scenario is expected to result in intermittent exposure, particularly over the fly season.

Scenario (1c) Mixing/loading and preparing backrubbers or rubbing posts

Worker exposure may occur during mixing/loading and treatment of backrubbers/rubbing posts. Label safety directions require workers to wear cotton overalls buttoned to the neck and wrist (or equivalent clothing), elbow-length gloves and water-resistant footwear, when opening the container and preparing the solution. Considering concentration of the chemical in the mixture, work practices and protective clothing recommended for use, skin contamination is not expected to be significant. Preparation of backrubbers will be an outdoor activity, hence, inhalation of product vapour is not of concern.

. *Discussion*

Measured exposure data were not available for preparation of backrubbers/rubbing posts. Inadequate use pattern information was available to determine the extent of use of diazinon by this method. However, considering:

- *the duration of the buffalo fly season (six months of the year);*
- *the intermittent nature of worker exposure during backrubber preparation;*
- *the dilution of the chemical in the prepared solution (1%);*
- *work practices within the industry: and*
- *the protective equipment specified on product labels,*

worker exposure is expected to be neither frequent nor extensive.

. *Ear tags*

Diazinon ear tags are formulated for the controlled (slow) release of active constituent onto the surface of the tag and then onto the animal. It is an effective and labour saving method of control favoured by many Australian farmers. Considering the nature of the pest, herd treatment is required. Tags provide approximately 16 weeks protection, therefore two sets will be required per season. Farmers are expected to apply ear tags to each ear of animals over 3 months of age. The number of tags handled and the duration of potential worker exposure will be dependent on herd size. On average, this activity is expected to take place over one or two days. Removal of old tags and re-application will be required after approximately 4 months. Therefore, the following exposure scenario is expected to result in infrequent worker exposure.

Scenario (2c) Application of ear tags

Diazinon ear tags are packed in sachets of 20 tags with corresponding buttons. They are applied using a specialised hand-held applicator (plier). The tag is attached by means of a pin through the ear, with the pin secured in place by a button. Worker exposure may occur during application of the tags, particularly through hand contamination. However, extensive contact with tags is not required and label safety directions specify the use of rubber gloves when handling the product. The solid form of the product minimises inhalation exposure to diazinon.

. *Discussion*

Measured exposure data were not available and existing models are not appropriate to estimate worker exposure during application of ear tags. Herd treatment is anticipated. However, considering the:

- *duration of protection afforded by each set of eat tags (approximately 16 weeks);*
- *infrequent nature of worker exposure;*
- *presentation of the product, ie designed for slow release of diazinon over time and no potential for inhalation exposure;*
- *packaging of the product (20 tags per sachet);*
- *specialised application equipment: and*
- *requirement to wear gloves when handling tags,*

potential worker exposure is not expected to be significant.

. *Backline treatment*

Diazinon is registered as a backline treatment for buffalo fly control in cattle. The product is mixed with water, to form a solution containing 0.08% diazinon. The spray is applied along the backline using hand-held equipment, at a rate of 500 mL per animal. It is possible that workers may use knapsacks, trigger packs or engine-powered equipment connected to a hose and hand wand.

Backline treatment will only be required during the buffalo fly season. Herd treatment is conducted in order to maximise fly control. Product labels permit re-treatment although a re-treatment interval is not specified. Considering normal husbandry practice, frequent backline application of diazinon products is not anticipated. Therefore, the following exposure scenarios will be intermittent or infrequent, as well as seasonal.

Scenarios (3c) and (4c) Mixing/loading and backline treatment of cattle

Table 28: Risk associated with open mixing/loading to support backline treatment of cattle

Scenario and description of container/equipment	Daily absorbed dermal dose (mg/kg/d)	Daily absorbed inhalation dose (mg/kg/d)	Daily total absorbed dose (mg/kg/d)	MOE[(1)]
Scenario (3c) Mixing/loading to support backline treatment of cattle 5L non specific design container	0.003	NM	0.003	7
Scenario (3c) Mixing/loading to support backline treatment of cattle 5L wide neck container	Nil	NM	Nil	*

Source: POEM
(1) MOE = NOEL (0.02 mg/kg/d) ÷ daily total absorbed dose (mg/kg/d)
* MOE could not be determined as no dermal or inhalation absorption occurred using the 5 L wide-neck container

Predictive modelling was used to obtain a rough estimate of worker exposure during open mixing/loading. MOE determined using model results were inadequate when handling containers of non-specific design and adequate when pouring from wide neck containers.

Spray applicators apply a solution containing 0.08% diazinon along the backline of each animal. Considering that each animal requires only one pass (occasionally two passes) along the midline, ie. not continuous application, worker exposure was not estimated using POEM. Potential worker exposure may be calculated theoretically for this activity. The NOEL of 0.02 mg/kg/day is equivalent to skin contamination with 37.5 mL of the prepared solution (assuming 60 kg body weight, 0.08% dilution of active in spray, 4% dermal penetration of diazinon, no safety factor applied).

Product safety directions recommend the use of cotton overalls (or equivalent clothing), gloves and water-resistant footwear when opening the container and preparing spray. Workers have a choice of protective clothing during spray application, ie. either cotton overalls (or equivalent clothing) and gloves, <u>or</u> protective waterproof clothing [or cotton overalls (or equivalent clothing) and PVC or rubber apron], gloves and water-resistant footwear, if excessive splashing or contamination is likely.

. *Discussion*

No measured exposure data were available for this use pattern. Predictive modelling used as a rough estimate of potential mixer/loader exposure, indicated a concern when handling containers of standard design. However, these MOE may overestimate the risk due to:

- *backline treatment is expected to be conducted over one or two consecutive days until all animals are treated;*
- *the period between treatments is expected to be exposure free;*
- *the likelihood of spillage, therefore, hand contamination, when open pouring into a large mixing tank is expected to be less than when open pouring into a smaller spray tank for agricultural use (as POEM is designed to estimate).*

Predictive modelling was not used to estimate exposure during backline spraying. Theoretical calculations indicated that skin contamination with a moderate quantity of spray was required to equate to the NOEL used in the OHS risk assessment. This reflects the high dilution of the chemical in the spray solution. It is acknowledged that this is a conservative calculation (given the frequency of diazinon backline treatment), no safety factor was applied and the distribution of contamination could not be determined.

. Manual and automatic spraying of cattle (and other animals)

Manual (hand spraying) or automatic spraying of diazinon products is conducted for lice control in cattle, pigs, goats and horses. **High volume** spraying utilises hand held sprayers or automatic spray races and **low volume** spraying (cattle only) utilises automatic spray races.

For high volume spraying, the concentration of active ingredient in the spray solution and work practices are identical across species. Low volume spraying is only undertaken for lice control in cattle. This review considers only cattle treatment by hand-held/automatic spraying as a worst case scenario. Herd treatment is anticipated to control the spread of lice infestation.

High volume spraying utilises a 0.05% solution of diazinon, irrespective of application equipment. Four to five litres of spray solution is applied per animal. Potential worker exposure during high volume hand spraying is expected to be greater than during automatic spraying. The proximity of the applicator to the spray equipment is expected to result in greater dermal and inhalation exposure, particularly from spray mist. Therefore, only high volume hand spraying is assessed in this review (worst case scenario).

Workers are required to prepare the dilute solution in a large (motorised) mixing tank, using mainly the open pour method. Agitation of the tank mixture is mechanical. Most operators utilise hand-hand sprayers connected to the mixing tank by a hose. A few smaller operators may use knapsack equipment. The number of mixing operations is determined by the herd size and spray tank volume.

Thorough coverage of the animal is essential for effective lice control. Cattle are often restrained in a race for treatment. The applicator is required to stand in close proximity to the animal (either inside the race or just outside) and apply the solution by running the wand along the animal, making several passes to ensure adequate coverage. Therefore, hand spraying is labour intensive and has the potential to result in significant operator exposure.

Product labels neither limit the number of spray applications nor specify a re-treatment interval in cattle. However, re-spraying 10-14 days after initial treatment is recommended for some other species (ie. goats, pigs) in order to break the lice life cycle. Considering that herd treatment is conducted on most farms and the labour intensive nature of the activity, regular hand spraying of cattle is not anticipated. Therefore, the following exposure scenarios are expected to be intermittent activities.

Scenarios (5c) and (6c) Mixing/loading and high volume spraying of cattle

Table 29: Risk associated with open mixing/loading and high volume hand spraying of cattle, goats, pigs, horses

Scenario and description of container/equipment	Daily absorbed dermal dose (mg/kg/d)	Daily absorbed inhalation dose (mg/kg/d)	Daily total absorbed dose (mg/kg/d)	MOE[(1)]
Scenario (5c) Mixing/loading to support high volume spraying of cattle, 5L non specific design container	0.003	NM	0.003	7
Scenario (5c) Mixing/loading to support high volume spraying of cattle, 5L wide neck container	Nil	NM	Nil	*
Scenario (6c) High volume spraying of cattle, wearing cotton overalls and gloves	0.017	0.001	0.018	1
Scenario (6c) High volume spraying of cattle, wearing WPC, cotton overalls and gloves	0.004	0.001	0.005	4

Source: POEM

[(1)] MOE = NOEL (0.02 mg/kg/d) ÷ daily total absorbed dose (mg/kg/d)
* MOE could not be determined as no dermal or inhalation absorption occurred using the 5 L wide-neck container

Predictive modelling indicated that the risk to workers open mixing/loading from containers of non-specific design was unacceptable, whilst the risk from open pouring from wide neck containers was acceptable.

Label safety directions provide a choice of protective clothing for applicators. Cotton overalls and gloves are recommended under normal conditions of use. Additional PPE, namely water-proof clothing (or cotton overalls plus apron) and gloves are recommended when excessive splashing or contamination is likely. Both clothing scenarios were modelled. The risk to applicators using hand-sprayers was unacceptable when wearing cotton overalls and gloves. MOE were slightly higher, yet inadequate when wearing water-proof clothing (over overalls) and gloves.

It is noted that the exposure assessment was conducted assuming treatment of 100 head of cattle per day. This work rate may be in excess of the number of animals treated by 'hobby farmers'.

Low volume mechanical spraying of cattle is an alternative to hand spraying. It is a less labour intensive and rapid method of lice control, often carried out when large numbers of animals require treatment. Given the number of animals treated and the slightly higher concentration of active constituent used for low volume spraying, mixer/loaders will be required to handle larger quantities of chemical when compared with hand spraying.

Workers are required to prepare a 0.1% solution of diazinon in a large mixing tank. In addition to initial charging of the tank, periodic topping up may be required to maintain the concentration of the chemical in solution. It is likely that the initial mixture will be prepared at the beginning of the day and topped up as required. The number of mixing/loading operations will be determined by; (i) container size, (ii) volume of mixing tank and (iii) number of animals to be treated. The number of top up operations cannot be quantified.

As for high volume spraying, herd treatment is anticipated. Therefore, the following exposure scenarios are expected to result in intermittent worker exposure.

Scenarios (7c) and (8c) Mixing/loading and low volume spraying of cattle

Table 30: Risk associated with open mixing/loading to support low volume automatic spraying of cattle

Scenario and description of container/equipment	Daily absorbed dermal dose (mg/kg/d)	Daily absorbed inhalation dose (mg/kg/d)	Daily total absorbed dose (mg/kg/d)	MOE[(1)]
Scenario (7c) Mixing/loading to support low volume spraying of cattle, 5L non specific design container	0.005	NM	0.005	4
Scenario (7c) Mixing/loading to support low volume spraying of cattle, 5L wide neck container	Nil	NM	Nil	-
Scenario (7c) Mixing/loading to support low volume spraying of cattle, 20L non specific design container	0.007	NM	0.007	3
Scenario (7c) Mixing/loading to support low volume spraying of cattle, 20L wide neck container	0.001	NM	0.001	20

Source: POEM

(1) MOE = NOEL (0.02 mg/kg/d) ÷ daily total absorbed dose (mg/kg/d)

POEM estimates indicated that the risk was unacceptable for mixer/loaders handling 5L and 20L containers of non-specific design. The risk to workers handling wide neck containers of both sizes was acceptable.

A suitable model was not identified to estimate potential worker exposure during spray race operation. Workers are required to stand at the entrance to the race and control the flow of cattle at a rate that ensures adequate coverage of the animal. Although workers are not required to remain in close proximity to the spray nozzles, large amounts of spray mist can be generated, resulting in significant dermal and inhalation exposure. Based on a theoretical calculation, the

NOEL of 0.02 mg/kg/day is equivalent to skin contamination with 30 mL of the spray solution (assuming 60 kg body weight, 0.1% dilution of active in spray, 4% dermal penetration of diazinon, no safety factor applied). It is not possible to estimate the distribution of spray (therefore penetration through PPE) during this activity. In addition, exposure through inhalation of spray mist could not be quantified.

. *Discussion*

No measured exposure data were available to assess the risk to workers during hand-spraying and automatic spraying of cattle. Predictive modelling was used, where possible, to obtain a frame of reference for potential worker exposure. POEM could not be used to estimate operator exposure during automatic spraying.

MOE obtained for open mixing/loading were adequate when handling wide neck containers. The risk was unacceptable when open pouring from containers of non-specific design. These MOE may overestimate risk as:

- *farmers are more likely to treat the whole herd and only re-treat animals after a period of time: and*
- *the likelihood of spillage, therefore, hand contamination when open pouring into a large mixing tank is expected to be less than when open pouring into a smaller spray tank for agricultural use (as POEM is designed to estimate).*

It is anticipated that hand-spraying of cattle can result in significant operator exposure. Exposure is determined by the following:

- *proximity of operator to animal and application equipment;*
- *concentration of diazinon in the spray solution;*
- *the requirement for several passes of the equipment per animal to ensure thorough coverage;*
- *the number of animal treated; and*
- *the generation of spray mist, resulting in dermal and inhalation exposure.*

Although more animals may be treated using automatic spray races and low volume spraying utilises a slightly higher concentration of diazinon in the spray solution, operator exposure is expected to be greater during hand spraying than automatic spraying. Predictive modelling indicated unacceptable risk (MOE 1-4) from hand spraying, despite the added protection afforded by water-proof clothing (over cotton overalls) and gloves.

. *Wound dressing*

One liquid diazinon formulation containing 1 g/L active ingredient and two powder formulations containing 15 g/kg and 20 g/kg, are registered for wound dressing of cattle and other large animals. Both formulations are used undiluted.

The **liquid** product is applied as a disinfectant for cuts, abrasions and flystrike. Wound treatment is carried out as required and herd treatment is not likely. The undiluted product is applied to the wound and surrounding area, using a brush or pressure sprayer. **Powder** products are often used to treat de-horning wounds in cattle. The powder is dusted liberally on the wound, surrounding skin and introduced into cavities under the skin, using a puffer, shaker tin or other suitable applicator. Product labels do not specify a re-treatment interval or maximum number of applications per animal.

The number of animal treated at any one time will depend on the husbandry activity requiring wound dressing, ie. flystrike, cuts and de-horning wounds.

Therefore, the following exposure scenarios will result in either intermittent exposure, or regular exposure over a few consecutive days.

Scenarios (9c) and (10c) Wound dressing using EC and powder formulations

The quantity of product required per day cannot be quantified. However, it is noted that the concentration of diazinon in liquid and powder products is low (0.1% liquid and 1.5% - 2% powders). Most diazinon wound dressing product labels recommend that workers wear cotton overalls buttoned to the neck and wrist and gloves when using the product.

Some spray mist may be generated when using pressure sprayers to apply the liquid formulation. Generation of dust is likely when using powder formulations. Given that wound dressing is most likely to be an outdoor activity and that the products contain low concentrations of diazinon, exposure to the chemical by the inhalation route is not expected to be significant.

. *Discussion*

The extent of use of diazinon products for wound dressing could not be quantified, therefore, worker exposure and risk could not be accurately estimated. However, the risk is determined to be acceptable because:

- *the concentration of active constituent in the products is low;*
- *only affected areas are treated, therefore, the quantity of product required in each case will not be extensive;*
- *work practices and label recommended PPE will minimise exposure by skin contamination;*
- *outdoor application will minimise inhalation exposure to spray mist or dust;*
- *wound dressing with diazinon is unlikely to result in frequent exposure.*

.
Sheep treatment

. ***Plunge and shower dipping***

Plunge dipping is used to control lice, ked, itchmite and blowfly. Shower dipping, using either conventional shower dips or continuous replenishment shower dips, is used as an alternative to plunge dipping. Shower dipping off-shears minimises extra handling of sheep and achieves complete saturation of animals. Shower dipping can be used for long woolled sheep but thorough wetting of fleece must be ensured. Flock treatment with diazinon is anticipated, therefore, large numbers of sheep can be treated by these methods. Both application methods utilise similar concentrations of diazinon in the dip solution (0.01% - 0.02%).

In most instances, mixing/loading and dipping operations will be carried out by the farmer or farm employee. Mobile dipping may be conducted by contractors, particularly on small farms. Worker exposure is possible when measuring the product, initial charging of the dip, during periodic topping up (required to maintain an adequate concentration of the chemical in the dip), when dunking sheep and cleaning out the sump. Sheep are dunked twice in the dip solution using T-shaped poles. It is anticipated that the dip will be charged once or twice per day, depending on the sump capacity and the number of animals to be treated.

Information obtained from regular users indicated that flock treatment is carried out on farms approximately once per year. It is reasonable to assume that dipping operations will take place from one to a few consecutive days (2-3 days, particularly on large farms) until all sheep are treated. Therefore the following exposure scenarios will result in either regular exposure over a few days or infrequent exposure (where all animals can be treated in a day).

Scenarios (1s) and (2s) Mixing and loading, plunge dipping and shower dipping

Dipping contractors can be potentially exposed to diazinon over longer periods, as they move from farm to farm.

Table 31: Risk associated with shower dip applications from measured exposure data

Scenario and description of container/equipment	Absorbed dermal dose	Absorbed inhalation dose	Total absorbed dose	MOE (2)
Scenario 1 (s) and (2s) Mixing/loading (open pour) and shower dipping	0.034 mg/hr 0.0034 mg/kg/day(1)	0.010 mg/hr 0.001 mg/kg/day(1)	0.048 mg/hr 0.0048 mg/kg/day(1)	4

Source: Apthorpe et al., 1998

(1) Assuming a 6 hour shower dip operation and 60 kg body weight
(2) MOE = NOEL (0.02 mg/kg/day) ÷ daily total absorbed dose (mg/kg/day)

Table 32: Risk associated with open mixing/loading for plunge dip and shower dip applications using modelled exposure data

Scenario and description of container/equipment	Daily absorbed dermal dose (mg/kg/d)	Daily absorbed inhalation dose (mg/kg/d)	Daily total absorbed dose (mg/kg/d)	MOE(1)
Scenario 1 (s) Mixing/loading to support plunge and shower dipping, 5 L non-specific design container	0.005	NM	0.005	4
Scenario 1 (s) Mixing/loading to support plunge and shower dipping, 5 L wide neck container	Nil	NM	Nil	*
Scenario 1 (s) Mixing/loading to support	0.013	NM	0.013	1.5

plunge and shower dipping, 20 L non-specific design container				
Scenario 1 (s) Mixing/loading to support plunge and shower dipping, 20 L wide neck container	0.001	NM	0.001	20

Source: POEM
[(1)] MOE = NOEL (0.02 mg/kg/d) ÷ daily total absorbed dose (mg/kg/d)
* MOE could not be determined as no dermal or inhalation absorption occurred using the 5 L wide-neck container

Available measured exposure data indicated that the risk to workers performing open mixing/loading and shower dipping was unacceptable, under study conditions. These results are considered with caution because; (a) the work rate in the study may not be representative of Australian sheep dipping operations and (b) the dipping equipment being modified during the course of the study.

When using exposure estimates obtained from predictive modelling, MOE were inadequate for open mixing and initial charging using 5L and 20L containers of standard design. The risk to workers open mixing/loading from wide neck containers of both sizes was acceptable. Although it is reasonable to assume that several top-up and reinforcement operations will be required per a day, the exact number of operations cannot be determined, therefore worker exposure cannot be estimated during these activities.

Current industry practice is to use mechanical agitation of dips, therefore worker exposure is not anticipated during this activity. A suitable model was not available to estimate worker exposure during plunge or shower dipping. Splashing is common during plunge dipping of sheep, whilst large quantities of spray mist may be generated during shower dipping. Potential worker exposure during these activities could only be estimate theoretically. A NOEL of 0.02g/kg/day, is equivalent to skin contamination with 300 mL of the working strength solution per day (assuming 0.01% ai in solution, 4% dermal absorption and 60 kg body weight, no safety factor applied). However, it is not possible to estimate the distribution of contamination or penetration through PPE.

Studies conducted by the NSW Department of Agriculture indicated the following, in relation to plunge and shower dipping of sheep (NSW Agriculture, 1998):

- Engineering improvements in shower dip design minimised worker exposure from spray drift. For example:
  (a) raising the side of the dip surround;
  (b) re-location of control valves and pump for remote operation;
  (c) good equipment maintenance to reduce the need for running repairs during dip operation;
  (d) abandoning the bottom spray altogether and using high efficiency spray nozzles on top boom for a longer period of time; and
  (e) use of larger solid stream spray nozzles operating at lower pressure.

- Enclosing the exit gate during dipping to block the sheep's view to the outside during shower dipping. This changes the behaviour of the sheep within the shower dip and minimises the need to rescue trapped sheep, thereby reducing worker exposure during this activity.

- The concentration of diazinon in sludge from the bottom of the sump was found to be approximately three times the initial charging concentration of the dip. This indicates that diazinon was not only being stripped out of the dip wash but also binding to organic material and settling to the bottom of the sump. Therefore, worker exposure when cleaning the sump may be significant unless adequate precautions are taken, ie. adequate PPE and safe work practices.

Based on label safety directions, workers using the prepared dip solution are required to wear water proof clothing [alternatively cotton overalls buttoned to the neck and wrist (or equivalent clothing and PVC or rubber apron], elbow length PVC gloves, and water resistant footwear.

. *Discussion*

Some measured exposure data were available for workers performing mixing, charging and shower dipping only. These data indicated unacceptable risk to workers involved in combined functions. It is anticipated that the same worker(s) will perform mixing and dipping operations. However, the data may not reflect current Australian work practices Predictive modelling was used to obtain a rough estimate of worker exposure during mixing and charging of dips only. POEM could not be used to estimate worker exposure during dip/shower operation.

The MOE calculated for mixing/loading for plunge and shower dipping of sheep were inadequate when handling containers of standard design and acceptable for wide neck containers. It is recognised that these MOE were calculated using a NOEL from a repeat dose study. These MOE may overestimate risk due to:

- *Farmers generally using the chemical for no more than a few consecutive days for dipping activities. This will be followed by an exposure free period;*
- *The likelihood of spillage, therefore, hand contamination when open pouring into a large sump is expected to be less than when open pouring into a spray tank for agricultural uses (as POEM is designed to estimate).*

However, dipping contractors may be exposed to diazinon daily for longer periods, particularly during the shearing or fly season(s). Insufficient information was available to ascertain the duration of exposure of these workers.

It is generally accepted that actual operation of plunge and shower dips may result in significant worker exposure from spray mist or splashing. Worker exposure and risk during dipping activities could not be quantified. Exposure mitigation methods for plunge and shower dip operations have been investigated by State Agriculture authorities.

. ***Hand Jetting***

Sheep are jetted predominantly for the control of blowfly strike. Hand jetting is known to be the most effective method of applying jetting chemicals. It is a slow and labour intensive method of chemical application but is effective over long periods. Hand jetting is the preferred method of treatment where fly populations are large and/or sheep are struck (to ensure the whole wound is treated).

A single operator can effectively jet 500-700 sheep per day. Hand jetting is conducted using a "jetting gun" or wand, with a "comb-like" end, usually made up of 5 nozzles and a T-bar leading edge for opening fleece while jetting. The gun is connected to a motorised pressure tank (of approximately 2000 L capacity).

Worker exposure is possible during mixing/loading and jetting operations. Most often these activities are conducted by the farmer or farm employee. Workers are required to add the product and water into the pressure tank, which is agitated mechanically. The number of mixing/loading operations would depend on the number of animals to be treated and the capacity of the pressure tank.

One or two workers may be involved in hand jetting operations. Generally, the sheep are restrained in a race for jetting. The applicator is required to stand in close proximity to the animal to be treated, either inside the race or immediately outside, and thoroughly saturate the wool by running the comb along the fleece. The volume of jetting fluid applied would depend on the age of the animal, the length of the wool and the area to be treated. The pressure at which the fluid is applied is dependent on the length of wool, with lower pressure used for longer woolled sheep. Where two workers are involved, the second worker stands at the entrance of the spray race and ensures the smooth flow of sheep in the spray race.

The product labels neither limit the number of applications nor specify a re-treatment interval. However, information obtained from regular users indicated that jetting is generally carried out once per year. Large numbers of sheep may be jetted per day, requiring workers to handle large volumes of jetting fluid. However, the concentration of diazinon in the jetting fluid is low (0.04%). The following exposure scenarios will be infrequent or at most take place over a few consecutive days.

Scenarios (3s) and (4s) Mixing/loading and hand jetting

Table 33: Risk associated with open mixing/loading and hand jetting of sheep

Scenario and description of container/equipment/PPE	Daily absorbed dermal dose (mg/kg/d)	Daily absorbed inhalation dose (mg/kg/d)	Daily total absorbed dose (mg/kg/d)	MOE[(1)]
Scenario (3s) Mixing/loading to support hand jetting, 5 L wide neck container	Nil	NM	Nil	*
Scenario (3s) Mixing/loading to support hand jetting, 5 L non specific design container	0.005	NM	0.005	4
Scenario (3s)	0.001	NM	0.001	20

Mixing/loading to support hand jetting, 20 L wide neck container				
Scenario (3s) Mixing/loading to support hand jetting, 20 L non specific design container	0.013	NM	0.013	1.5
Scenario (4s) Application by jetting gun wear cotton overalls and gloves	0.013	0.001	0.014	1.4
Scenario (4s) Application by jetting gun wear water-proof clothing, cotton overalls and gloves	0.003	0.001	0.004	5

Source: POEM
(1) MOE = NOEL (0.02 mg/kg/d) ÷ daily total absorbed dose (mg/kg/d)
* MOE could not be determined as no dermal or inhalation absorption occurred using the 5 L wide-neck container

MOE obtained for open mixing/loading were low for both container sizes, except for 20 L wide neck containers. Only a few mixing/loading operations are anticipated due to the high dilution of product in the jetting fluid.

Two applicator clothing scenarios were modelled based on the options available to workers on product labels. The risk to applicators was unacceptable when wearing cotton overalls and gloves. The addition of water-proof clothing increased the MOE, however, the risk was still unacceptable.

Discussion

In the absence of measured exposure data, exposure estimates were obtained from the POEM for mixer/loaders and hand jetters of diazinon.

The risk to workers during mixing/loading (except from 20 L wide neck containers) and hand jetting was determined to be unacceptable. It is possible that the MOE calculated using a repeat dose NOEL may overestimate the risk to these workers due to:

- *The probability of one day or at most a few consecutive days jetting using diazinon;*
- *The likelihood of spillage, therefore, hand contamination when open pouring into a large pressure tank is expected to be less than when open pouring into a spray tank for agricultural uses (as POEM is designed to estimate).*

However, worker exposure during hand jetting may be substantial due to;

- *The large number of animals treated requiring workers to handle large volumes of jetting fluid;*
- *The probability of the same worker performing mixing/loading and jetting operations;*
- *The proximity of the applicator to the sheep and jetting gun;*
- *The concentration of diazinon in the jetting fluid is higher than dipping fluid; and*
- *The volume of solution required per animal is higher for hand jetting (5L) than dipping (2L);*

- *The low MOE for hand jetting (5) despite the additional protection afforded by water proof clothing.*

Automatic jetting

Automatic jetting races are used mainly for off-shears control of lice and ked. It is a relatively ineffective method of chemical treatment in sheep carrying wool as it results in uneven penetration and distribution of chemical. Automatic jetting races allow rapid treatment of sheep (1500 - 3000 sheep per day) and are of value in regions where flock sizes are large. It is anticipated that in most instances automatic jetting will be conducted by the farmer or farm employee(s).

Worker exposure is possible during mixing/loading and jetting of sheep. Automatic jetting utilises a higher concentration of diazinon (0.1%) in the jetting fluid in comparison with hand jetting. This factor combined with the greater number of animals treated by automatic jetting, requires workers to handle greater volumes of concentrated product than workers involved in hand jetting operations. As for hand jetting, workers are required to add the required quantity of product and water into a pressure tank which is agitated mechanically.

Application of jetting fluid is an automated process. Workers are required to remain in the vicinity of the spray race (in order to manoeuvre the sheep into the race) but not necessarily in close proximity to the spray nozzles or animal being jetted. However, worker exposure by the dermal and inhalation routes maybe significant due to the generation of spray mist.

The product labels do not recommend a jetting regime. Considering that automatic jetting is an off-shears treatment, it is reasonable to assume that it would take place once or twice per year, after shearing. Therefore, the following exposure scenarios are most likely to be infrequent or at most over a few consecutive days.

Scenarios (5s) and (6s) Mixing/loading and automatic jetting

Table 34: Risk associated with open mixing/loading to support automatic jetting

Scenario and description of container/equipment	Daily absorbed dermal dose (mg/kg/d)	Daily absorbed inhalation dose (mg/kg/d)	Daily total absorbed dose (mg/kg/d)	MOE[(1)]
Scenario (5s) Mixing/loading to support automatic jetting, 20 L wide neck container, average number of sheep treated	Average exposure 0.002	NM	Average exposure 0.002	10
	Maximum exposure 0.004		Maximum exposure 0.004	5
Scenario (5s) Mixing/loading to support automatic jetting, 20 L non specific design container,	Average exposure 0.02		Average exposure 0.02	1

average number of sheep treated	Maximum exposure 0.04		Maximum exposure 0.04	<1

Source: POEM

(1) MOE = NOEL (0.02 mg/kg/d) ÷ daily total absorbed dose (mg/kg/d)

MOE obtained for mixer/loaders supporting automatic jetting operations were low and the risk unacceptable irrespective of container design and treatment of average or maximum numbers of sheep. This reflects the large numbers of sheep treated per day and the slightly higher concentration of the chemical in the jetting fluid compared to hand jetting.

Predictive modelling could not be used to estimate worker exposure during automatic jetting. Workers can direct sheep into the jetting race by standing outside the entrance to the jetting area and away from the direction of spray mist. Therefore, potential worker exposure during automatic jetting is not likely to exceed applicator exposure during hand jetting.

Discussion

In the absence of measured exposure data, exposure estimates from the POEM were used to roughly estimate mixer/loaders exposure for automatic jetting. The model could not be used to estimate worker exposure during jetting operations.

The risk to workers was higher when mixing/loading to support automatic jetting than hand jetting. This reflects the rapid treatment of animals requiring workers to handle more product and jetting fluid and the higher concentration of chemical in the automatic jetting fluid. The risk to workers during mixing/loading was determined to be unacceptable irrespective of container design and average or maximum flock size. It is possible that the MOE calculated using a repeat dose NOEL may overestimate the risk to these workers due to:

- *The probability of workers undertaking automatic jetting only one day per season (or at most a few days) and a maximum of two applications per year with an long exposure free period between treatments; and*
- *The likelihood of spillage, therefore, hand contamination when open pouring into a large sump is expected to be less than when open pouring into a spray tank for agricultural uses (as POEM is designed to estimate).*

Workers are not required to stand in close proximity to the spray nozzles or animals when the jetting race is in operation. However worker contamination from spray mist is likely. Considering the PPE recommended on the product labels and work practices, potential worker exposure during automatic jetting (excluding mixing/loading) is unlikley to exceed potential contamination during hand jetting.

Backline treatment

Diazinon products are registered as a backline long wool treatment for the control of lice and blowfly and backline off shears treatment for the control of lice.

As a **long wool treatment** the product is applied undiluted using a special hand gun applicator. The application volume per sheep is dependent on the pest and length of wool. Worker exposure is possible when loading hand-gun from product container and application of undiluted product. Workers are likely to pour the product direct from the container into the backpack (usually 5 L in capacity) attached to the special applicator. The product is applied as a single or double band on the back of the sheep from pole to tail. Given that no dilution occurs and the product contains 96 g/L diazinon, spillage can result in significant worker exposure.

A single worker can treat approximately 300 sheep per day. Available information indicates that backline long wool treatment is conducted once per year. Workers may carry out backline treatments for a few consecutive days, when large numbers of animals require treatment. Therefore, worker exposure for the following exposure scenarios will be infrequent or at most occur over a few consecutive days per year.

Scenario (7s) and (8s) Loading equipment and backline long wool treatment

Refer to Table 34 for the risk associated with loading applicator for backline long wool treatment.

As **off-shears treatment**, the product is applied diluted to 0.15% active ingredient using a special spray-on applicator. Sheep are generally treated within 24 hours of shearing, therefore the rate of shearing is considered to be the limiting factor in the work rate for off shears treatment. Considering the lack of fleece, the application time per sheep is expected to be shorter than for long wool treatment. Depending on the rate of shearing an average of 500 sheep may be treated per day.

Worker exposure is possible during mixing/loading and application of the dilute solution. It is anticipated that workers will mix the required quantity of product and water in a large mixing tank. The dilute solution will be loaded into the backpack (or reservoir) attached to the spray applicator. Considering the dilution of the spray and average size of mixing tank, no more than one mixing operation is likely to be required per day. However, several loading operations will be required; the number depending on the capacity of the backpack and number of animals to be treated. Potential exposure during loading only could not be quantified. A single band of spray is applied from just above the ears along the backline to the butt of the tail.

Information obtained from users indicates that treatment is conducted once per year. Therefore, worker exposure for the following exposure scenarios will be infrequent or at most occur over a few consecutive days per year.

Scenario (9s) and (10s) Mixing/loading and backline off shears treatment

Table 35: Risk associated with open mixing/loading to support backline treatment of sheep

Scenario and description of container/equipment	Daily absorbed dermal dose (mg/kg/d)	Daily absorbed inhalation dose (mg/kg/d)	Daily total absorbed dose (mg/kg/d)	MOE[(1)]

Scenario (7s) Loading equipment for backline long wool treatment, 5 L non specific design container	0.001	NM	0.001	20
Scenario (7s) Loading equipment for backline long wool treatment, 5 L wide neck container	Nil	NM	Nil	-
Scenario (9s) Mixing/loading to support backline off shears treatment, 20 L non specific design container	0.003	NM	0.003	7
Scenario (9s) Mixing/loading to support backline off shears treatment, 20 L wide neck container	Nil	NM	Nil	-

Source: POEM

(1) MOE = NOEL (0.02 mg/kg/d) ÷ daily total absorbed dose (mg/kg/d)

Predictive modelling was used to obtain a rough estimate of worker exposure during mixing and loading operations. MOE obtained for all mixing and loading operations were adequate, except for mixing/loading to support backline off shears treatment from 20 L containers of non specific design.

POEM was not used to estimate applicator exposure during backline treatment, as these are not continuous application methods. Large numbers of animals may be treated, however, each animal requires only one or two bands of the diluted or undiluted product along the backline from a special applicator. It is noted that the use of undiluted product for long wool treatment may result in some applicator exposure, in case of any spillage. Potential worker exposure during this activity can only be estimated theoretically. The NOEL of 0.02 mg/kg/day is equivalent to skin contamination with 0.25 mL per day of the undiluted product used for long wool treatment and 20 mL per day of the diluted solution used for off shears treatment (assuming 60 kg body weight, 1:6 dilution for off shears treatment only, and 4% dermal penetration of diazinon, no safety factor applied).

Product safety directions for backline diazinon products recommend the use of cotton overalls, a washable hat, PVC or rubber apron, elbow-length PVC gloves and water resistant footwear, when opening the container, preparing the spray and using the prepared spray.

Discussion

No measured worker exposure data were available for backline treatment of sheep. POEM estimates were used as a first tier approach to obtain a rough estimate of potential worker exposure during mixing and loading operations only. The risk to mixer/loaders was acceptable in all but those workers pouring from 20 L containers of non specific design. It is noted that these MOE calculated using a NOEL from a repeat dose study, may overestimate the risk due to the probability of backline treatment being conducted once per year, with no more than a few consecutive days treatment per year.

Predictive modelling could not be used to estimate worker exposure during backline application. Theoretical calculations (not including a safety factor) indicate an OHS concern particularly when using the undiluted product.

Wound dressing

Three diazinon EC formulations (containing 1 g/L, 3 g/L and 200 g/L, respectively) and two powder formulations (containing 15 g/kg and 20 g/kg, respectively) are registered for wound dressing. The EC formulations are used diluted to 0.06% - 0.1% active ingredient. The powder formulations are applied dry.

Normal husbandry practices require farmers to carry out wound dressing following docking, of tails, mulesing, castrating, ear marking, vaccination and occasionally drenching. Wound dressing is also required in the presence of flystrike.

When using liquid formulations, the wool is clipped from the affected area and the wound and surrounding wool saturated with the dilute diazinon solution using a brush or sprayer. When using the powder formulation, the wool is clipped as for liquid application and the product dusted on liberally using a suitable puffer or container.

Product labels do not specify a re-treatment interval. It is anticipated that the number of animal treated at any one time may vary depending on the husbandry activity associated with wound treatment. For example, several sheep may be treated following docking, mulesing of flock, whilst only a few struck sheep may require dressing. It is common to have two workers in a team, one shearing the affected site and the other treating the wound. Available information indicated that approximately 300 sheep could be dressed per hour, provided the wool is already clipped.

Considering all of the above, the following exposure scenarios can result in either regular exposure (for a short period at a time) or intermittent exposure.

Scenarios (11s), (12s) Mixing loading and hand dressing using the EC formulation

Scenario (13s) Hand dressing using the powder formulation

The quantity of product and/or dilute solution required per day cannot be quantified. However, it is noted that the concentration of diazinon in two of the three EC formulations is low (0.1% and 0.3%). The prepared wound dressing solution contains no more than 0.1% diazinon. Similarly, the powder formulations contain 1.5% and 2% diazinon.

Label safety directions require workers using the liquid formulations containing 1 and 3 g/L diazinon to wear cotton overalls, gloves and water resistant footwear when mixing/loading and applying the dilute solution. The powder formulations recommend the use of overalls, gloves and water resistant footwear.

The use of pressurised sprayers to apply the liquid product may generate some spray mist. Powder formulations will generate dust. Considering that wound dressing will be conducted outdoors and the concentration of diazinon in the powder or solution is low, exposure to the chemical by the inhalation route is not expected to be significant.

Discussion

Potential exposure and risk to workers involved in wound dressing could not be quantified. However, the risk for these workers is likely to be acceptable because;

- *the concentration of diazinon in the products and/or dilute solution is low;*
- *the area requiring treatment is not expected to be extensive, therefore the quantity of dilute solution or powder required per sheep will not be large;*
- *work practices and PPE recommended on product labels will minimise skin contamination;*
- *outdoor application will provide a dilution effects and minimise inhalation exposure to the spray or dust;*
- *it is anticipated that the farmers will apply diazinon to wounds infrequently, with an exposure free period between treatments.*

5.1.1 Risk from exposure to degradation products

Appreciable quantities of two highly toxic degradation products of diazinon, namely O,S-TEPP and S,S-TEPP were detected in unopened off-the shelf products that were within the expiry date. On consideration of the toxicity of diazinon and its metabolites, the ACPH recommended that diazinon products currently available for agricultural use continue to be registered only where there was proven storage stability under a range of Australian climatic conditions. The Committee supported a proposal to include a warning statement on diazinon product labels to draw users attention to the possibility of an increased toxic hazard with use of the product after the expiry date (DHAC, 1999).

5.2 Risk from post-application exposure

Agricultural uses

No diazinon specific exposure data or dislodgeable foliar residue data were available. Diazinon product labels do not specify a REP for agricultural situations.

Dislodgeable foliar residue data and/or re-entry data were recommended in the initial draft diazinon review report to enable any uses to be retained.

Following the revised review NOHSC recommends the following re-handling statements:

"**Do not re-handle treated mushrooms within 14 days of spraying. If entry to treated areas is required for watering of beds, or monitoring of carbon dioxide, workers must avoid contact with treated casing**".

Re-entry to treated areas, both after ground or aerial applications for onion treatment is not necessary. The cultivation or spraying of weeds would be the only other practice likely to occur, but this would not be required due to the use of pre-emergent herbicide, i.e., additional weed control practices, and this would not be needed till later in the crop development. No hand weeding is carried out. Harvesting of onions is usually carried out 6 months after diazinon application. The current re-entry interval for onions is 2 days.

Based on the information provided, and considering that:

- re-entry to treated areas following ground or aerial application is not necessary;
- hand weeding is not carried out; and
- harvesting of onions is usually carried out 6 months after spraying,

Re-entry statement for onions:

"**Do not re-enter treated areas within 48 hours of spraying**".

Additional information provided by the Agricultural industry indicate that the major activity carried out after butt spraying would be harvesting of bananas. However, harvesting of bananas is unlikely to occur soon after spraying. Some limited crop monitoring for the purpose of disease management, ie. leaf inspection on a whole farm basis may occur.

Re-entry statement for bananas:

"Do not re-enter treated areas for purposes of crop monitoring, or other related activities, such as irrigation and scouting of immature/low foliage plants within 48 hours of spraying".

A re-entry interval for purposes of harvesting bananas is not required following butt application, as treatment is unlikely to be carried out close to harvest.

Information provided by the pineapple industry indicate that workers do not enter the treated areas for several days after treatment. Besides, due to the nature of the crop, i.e., spiky leaves, entry into treated areas is limited. Entry after application is likely to be to assess effectiveness of application, or for the application of other pesticides (eg. metalaxyl-M which is used for the control of phytophthora at 4-8 week intervals). Irrigation is normally from fixed sprinklers, with remotely-located controls. The current re-entry interval is 14 days.

Based on the information provided, and considering that:

- workers are not required to re-enter treated areas soon after spraying;
- entry into treated areas is limited due to the "spiky" nature of the crop; and

- harvesting of pineapples occurs at a much later stage (ie.18 months),

Re-entry statement for pineapples:

"**Do not re-enter treated areas within 14 days of spraying**".

Information provided by stakeholders indicates that rehandling of treated pots occurs mainly during interstate transfer, for quarantine purposes. Following treatment (drenching), plants are irrigated twice in a 24-hour period, using either overhead or inlaid irrigation systems, with approximately 20-30 mm delivered each time. Therefore, plants would be irrigated 3-4 times before re-handling. The current practice is that there is a period of 48 hours between drenching and re-handling. Contact with the chemical is unlikely as the chemical is not sprayed, but applied as a drench i.e., a coarse stream directed into the growing medium of the pot. The subsequent irrigations effectively incorporate the insecticide into the growing medium. It is therefore unlikely that workers would be exposed to chemical deposits. It is understood that contract farmers associated with retail outlets involved with shipment of plants, observe the same treatment and rehandling procedures.

Based on the information provided, and considering that:

- diazinon is used as a pot drench and not sprayed on foliage;
  very low pressure is used to ensure all the mixture is applied to the surface of the media;
- pots would be treated in situ; and
- the pots are irrigated twice in a 24-hour period,

Re-entry statements for nursery plants and ornamentals:

"**Do not re-enter treated areas, or handle treated pots within 48 hours of spraying**".

"**Pots should be irrigated thoroughly at least 3-4 times within the 48 hour period**."

"**If spraying has been conducted indoors, it is recommended that the enclosed areas are adequately ventilated before workers are allowed to enter.**"

It is also recommended that labels be updated to reflect use of diazinon as a pot drench only.

Re-entry statement for pest control operators:

"Do not re-enter until completely dry and adequately ventilated".

Re-entry statement for workers handling skins and hides:

"Workers are advised to wear gloves when handling skins and hides"

Veterinary uses

Cattle

Product labels do not include a re-handling restriction.

Considering normal animal husbandry practices, significant contact with treated cattle is not anticipated. Should exceptional circumstances require workers to handle treated animals, the risk from post application exposure is expected to be substantially lower than the risk to mixer/loaders and dip/spray operators.

Therefore, it is determined that post-application exposures do not appear to pose an unreasonable risk to workers handling treated animals, as long as contact is not permitted shortly after application of diazinon.

Sheep

No measured exposure data were available. Pesticide exposure for shearers and wool handlers was estimated using the following protocol developed by NOHSC: 'Guidelines for Conducting a Health Risk Assessment of Sheep Ectoparasiticides for Wool and Sheep Handlers' (NOHSC, June 1999).

The post application risk assessment was conducted for sheep assuming hand jetting due to:

- this being the most common and effective method of treating long wooled sheep;
- jetting utilises the highest concentration of active ingredient in solution for sheep carrying wool;
- the volume of fluid applied, ie the amount of active ingredient applied, per animal is greater than for plunge/shower dipping (alternative methods for treating long wooled sheep);
- a few product labels specify a withholding period of 2-3 months for shearing.

The following assumptions are used in the evaluation:

.	Maximum amount of fluid retained in the fleece	3 L[a]
.	Exposure to wool wax	23 g/day[b]
.	Weight of shearer	70 kg[c]
.	Dermal absorption rate	4%
.	Wool wax/yolk	13%[d]

The parameters used in the evaluation are as follows:

.	Concentration of diazinon in the product	200 g/L
.	Dilution of product	400 mL product/200 L water (0.04% ai)
.	Maximum application rate	5 L/sheep
.	NOEL	0.02 mg/kg/day[e]

(a) default volume assumed when more than this amount is applied per animal, used in the absence of trial data
(b) based on body surface area (front half of body = 9000 cm^2, WHO,1982) and the maximum amount of wool wax estimated to adhere to the skin (2.5 mg/cm^2), conservative estimate used in the absence of data to the contrary
(c) Note this value is different to the average body weight used in the end use risk assessment
(d) assuming all pesticide residues will be contained in the wool wax
(e) established in a repeat dose human dietary study for plasma ChE depression

Concentration of chemical applied was estimated using the following formula:

C = A x B
(C concentration in mg/L, where A mg/L represents the concentration of chemical in the formulated product; and B (%) the dilution factor)

C = 200 x 1000 mg/L x 0.04%
=80 mg/L

Residues in wool (mg/kg) were estimated using the following formula:

$\mathbf{R_{xmonths} = Y_{at\ treatment} \times C/z_{x\ months}}$
(where y is the volume of solution retained by the fleece, C is the concentration of chemical applied in mg/L, and Z the weight of wool at the time of treatment. Z kg of wool per sheep (for adult sheep), 12 months after shearing is 4.4 kg (used in the absence of data, may be an overestimate in instances where the 2-3 month WHP for shearing is observed).

R_{12} = 3 x 80/4.4 = 54.54 mg/kg

Pesticide exposure (mg/kg/day) was estimated using the following formula:

E = R (residue data)**/0.13** (wool wax/yolk) **x 0.023** (wool wax in kg) **x 1/70** (shearer weight in kg)

E = 54.54/0.13 x 0.023 x 1/70 = 0.1378 mg/kg/day

E = 0.1378 x 4/100 (percutaneous absorption rate) = 0.0055 mg/kg/day

On the basis of the risk assessment, the amount of diazinon absorbed by a shearer per day exceeds 1/20 of the NOEL.

<u>*Discussion*</u>

The following factors influence the amount of pesticide retained in the fleece:

- *the initial deposit of pesticide left on the sheep after treatment;*
- *the treatment regime; and*
- *subsequent distribution and dissipation of the pesticide.*

The main exposure to residues in wool for shearers and other wool handlers is through dermal absorption. It is assumed that all residues in wool are contained in the wool wax, therefore available for transfer to the handlers' skin. Factors which influence the extent of worker exposure include:

- *amount and distribution of pesticide residues in the fleece;*
- *area of skin exposed; and*
- *the rate of percutaneous absorption.*

Given that the amount of chemical absorbed by a shearer is greater than 1/20 of the NOEL, further refinement of the risk assessment is required.

It is noted that this evaluation is conducted assuming a single application of diazinon . Information available to date indicates that farmers apply ectoparasiticides more than once per season. It is reasonable to expect that repeat applications are likely to leave higher residues in the fleece at shearing than a single application.

A safe re-handling period for shearing could not be determined for diazinon based on available data.

6. OCCUPATIONAL CONTROLS

6.1 Hazard classification

Diazinon is listed in the National Occupational Health and Safety Commission (NOHSC) List of Designated Hazardous Substances (NOHSC, 1999). Substances containing diazinon are classified as harmful at concentrations greater than or equal to 25%.

The risk and safety phrases assigned to diazinon at concentrations greater than or equal to 25% are as follows:

<u>Risk phrases</u>

R22	Harmful if swallowed

<u>Safety phrases</u>

S24	Avoid contact with skin
S25	Avoid contact with eyes
S60	This material and its container must be disposed of as hazardous waste

S61	Avoid release to the environment. Refer to special instructions/safety data sheets

All agricultural EC and ME formulations of diazinon are determined to be hazardous substances based on the concentration of the active ingredient (200 g/L to 800 g/L).

The veterinary EC formulation of diazinon determined to be hazardous contains diazinon at 200 g/L. The other EC formulations containing diazinon at 1 g/L to 96 g/L are determined to be non-hazardous. The powder formulations containing diazinon at 15 g/kg and 20 g/kg are determined to be non-hazardous.

The National Model Regulations [NOHSC:1005(1994a)] and National Code of Practice [NOHSC:2007(1994a)] for the Control of Workplace Hazardous Substances apply to all hazardous substances, as defined in the national model regulations, and extend to all workplaces in which hazardous substances are used or produced and to all persons (consistent with the relevant Commonwealth/State/Territory occupational health and safety legislation) with potential for exposure to hazardous substances in those workplaces.

6.2 Safety directions

The safety directions for Diazinon in the Handbook of First Aid Instructions and Safety Directions (1998) are as follows:

Diazinon

BL 95 g/L or less with dibutyl phalate 720 g/L or less, with surfactants	
Product is poisonous if swallowed	120, 130, 133
Will irritate the eyes and skin	161, 162, 164
Repeated minor exposure may have a cumulative poisoning effect	190
Obtain an emergency supply of atropine tablets 0.6 mg	373
Avoid contact with eyes and skin.	210, 211
Do not inhale vapour or spray mist	220, 222, 223
When opening the container and preparing spray and using the prepared spray	279, 280, 281, 282
wear cotton overalls buttoned to the neck and wrist (or equivalent clothing) and a washable hat	290, 292a
and PVC or rubber apron and elbow-length PVC gloves	293, 294
and water resistant footwear	298b
If clothing becomes contaminated with product remove clothing immediately.	330, 332
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 contaminated clothing.	360, 361, 366

DU 20 g/kg or less except as specified below	
Repeated minor exposure may have a cumulative poisoning effect	190
Avoid contact with eyes and skin	210, 211
Do not inhale dust	220, 221
When using the product wear cotton overalls buttoned to the neck and wrist and washable hat	279, 283, 290, 292
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 contaminated clothing	360, 366
DU 20 g/kg or less 300 g pack	
Avoid contact with eyes and skin	210, 211
Wash hands after use	351
Ear tags 200 g/kg or less	
Product is poisonous if swallowed	120, 130, 133
Avoid contact with eyes and skin	210, 211
Repeated minor exposure may have a cumulative poisoning effect	190
Obtain an emergency supply of atropine tablets 0.6 mg	373
When using the product wear rubber gloves	279, 283, 290, 312
Wash hands after use	351
After each day's use, wash gloves	360, 361
EC ULV 200 - 800 g/L	
Product is poisonous if absorbed by skin contact or swallowed	120, 130, 131, 133
Repeated minor exposure may have a cumulative poisoning effect	190
Avoid skin contact with eyes and skin	210, 211
Do not inhale spray mist	220, 223
Obtain an emergency supply of atropine tablets 0.6 mg	373
When preparing spray and using the prepared spray	279, 281, 282
wear cotton overalls buttoned to the neck and wrist and a washable hat	290, 292
and elbow-length PVC gloves	294
and face shield or goggles	299
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 face shield and goggles and contaminated clothing	360, 361, 365, 366
EC 10 g/L or less	
Harmful if swallowed	129, 133
May irritate the eyes and skin	160, 162, 164
Repeated minor exposure may have a cumulative poisoning effect	190
Obtain an emergency supply of atropine tablets 0.6 mg	373

Avoid contact with eyes and skin	210, 211
When preparing spray and using the prepared spray	279, 281, 282
wear elbow-length PVC gloves	290, 294
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 contaminated clothing	360, 361, 366
EC 30 – 80 g/L in liquid hydrocarbons (other than xylene) 660 g/L or less, with surfactants	
Product is poisonous if swallowed	120, 130, 133
Will irritate the eyes and skin	161, 162, 164
Repeated minor exposure may have a cumulative poisoning effect	190
Obtain an emergency supply of atropine tablets 0.6 mg	373
Avoid contact with eyes and skin	210, 211
Do not inhale vapour or spray mist	220, 222, 223
When opening the container and preparing spray	279, 280, 281
wear cotton overalls buttoned to the neck and wrist(or equivalent clothing) and a washable hat	290, 292a
and elbow-length PVC gloves and water resistant footwear	294, 298b
When using the prepared spray	279, 282
wear protective waterproof clothing [or cotton overalls buttoned to the neck and wrist (or equivalent clothing) and a washable hat and PVC or rubber apron] and elbow-length PVC gloves and water resistant footwear	290, 291, [or 292a, 293], 294, 298b
If clothing becomes contaminated with product remove clothing immediately	330, 332
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 contaminated clothing	360, 361, 366
EC 50 g/L or less more than 10 g/L	
Product is poisonous if swallowed	120, 130, 133
Avoid contact with eyes and skin	210, 211
Do not inhale vapour	220, 222
Wash hands after use	351
EC 200 g/L or less in xylene	
Product is poisonous if swallowed	120, 130, 133
Will irritate the eyes and skin	161, 162, 164
Repeated minor exposure may have a cumulative poisoning effect	190
Obtain an emergency supply of atropine tablets 0.6 mg	373
Avoid contact with eyes and skin	210, 211
Do not inhale vapour or spray mist	220, 222, 223
When opening the container and preparing spray	279, 280, 281
wear cotton overalls buttoned to the neck and wrist (or	290, 292a

equivalent clothing) and a washable hat	
and elbow-length (nominate other specific material) gloves and water resistant footwear	295, 298b
When using the prepared spray	279, 282
wear protective waterproof clothing [or cotton overalls buttoned to the neck and wrist (or equivalent clothing) and a washable hat and PVC rubber apron]	290, 291, [or 292a, 293]
and elbow-length (nominate other specify material) PVC gloves	295
If clothing becomes contaminated with product remove clothing immediately	330, 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 contaminated clothing	360, 361, 366
EC 200 g/L or less, in liquid hydrocarbons 600 g/L or less, with surfactant 150 g/L or less, when packed as one part of a two-part product containing amitraz EC 125 g/L or less in the other part	
Product is poisonous if swallowed	120, 130, 133
Will irritate the eyes and skin	161, 162, 164
Repeated minor exposure may have a cumulative poisoning effect	190
Obtain an emergency supply of atropine tablets 0.6 mg	373
Avoid contact with eyes and skin	210, 211
Do not inhale vapour or spray mist	220, 222, 223
When opening the container and preparing the spray	279, 280, 281
wear cotton overalls buttoned to the neck and wrist (or equivalent clothing) and a washable hat	290, 292a
and elbow-length PVC gloves and water resistant footwear	294, 298b
When using the prepared spray	279, 282
wear protective waterproof clothing [or cotton overalls buttoned to the neck and wrist (or equivalent clothing) and a washable hat and PVC or rubber apron]	290, 291, [or 292a, 293],
and elbow-length PVC gloves and water resistant footwear	294, 298b
If clothing becomes contaminated with product remove clothing immediately	330, 332
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 contaminated clothing	360, 361, 366
EC 215 g/L or less in liquid hydrocarbons (other than xylene) 650 g/L or less, with surfactants	
Product is poisonous if swallowed	120, 130, 133
Will irritate the eyes and skin	161, 162, 164
Repeated minor exposure may have a cumulative poisoning	190

effect	
Obtain an emergency supply of atropine tablets 0.6 mg	373
Avoid contact with eyes and skin	210, 211
Do not inhale vapour or spray mist	220, 222, 223
When opening the container and preparing the spray	279, 280, 281
wear cotton overalls buttoned to the neck and wrist (or equivalent clothing) and a washable hat	290, 292a
and elbow-length PVC gloves and water resistant footwear	294, 298b
When using the prepared spray	279, 282
wear protective waterproof clothing [or cotton overalls buttoned to the neck and wrist (or equivalent clothing) and a washable hatand PVC or rubber apron]	290, 291, [or 292a, 293]
and elbow-length PVC gloves and water resistant footwear	294, 298b
When using the prepared spray	279, 282
wear cotton overalls buttoned to the neck and wrist (or equivalent clothing) and a washable hat	290, 292a
and elbow-length PVC gloves	294
If clothing becomes contaminated with product remove clothing immediately	330, 332
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 use and before eating, drinking or smoking, wash hands, arms and face thoroughly with soap and water	360, 361, 366
EC 250 g/L or less more than 50 g/L	
Avoid contact with eyes and skin	210, 211
Do not inhale spray mist	220, 223
When preparing spray and using the prepared spray	279, 281, 282
wear elbow-length PVC gloves	290, 294
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 contaminated clothing	360, 361, 366
EC SA 3 g/L or less, in liquid hydrocarbons (other than xylene) 660 g/L or less, with surfactants	
Product is poisonous if swallowed	120, 130, 133
Will irritate the eyes and skin	161, 162, 164
Repeated minor exposure may have a cumulative poisoning effect	190
Obtain an emergency supply of atropine tablets 0.6 mg	373
Avoid contact with eyes and skin	210, 211
Do not inhale vapour or spray mist	220, 222, 223
When opening the container and preparing the spray and using the prepared spray	279, 280, 281, 282
wear cotton overalls buttoned to the neck and wrist (or equivalent clothing) and a washable hat	290, 292a

and elbow-length PVC gloves and water resistant footwear	294, 298b
If clothing becomes contaminated with product remove clothing immediately	330, 332
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 contaminated clothing	360, 361, 366
HV AC ME 465 g/L or less	
Product may irritate the eyes and skin	120, 160, 162, 164
Avoid contact with eyes and skin	210, 211
Wash hands after use	351
HV EC 200 g/L or less	
Product is poisonous if absorbed by skin contact or swallowed	120, 130, 131, 133
Product will irritate the eyes and skin	120, 161, 162, 164
Avoid contact with eyes and skin	210, 211
Wash hands after use	351
HG EC 200 g/L or less	
Product is poisonous if absorbed by skin contact or swallowed	120, 130, 131, 133
Product will irritate the eyes, nose and throat and skin	120, 161, 162, 163, 164
Avoid contact with eyes and skin	210, 211
Wash hands after use	351
ME 240 g/L or less	
Avoid contact with skin	210, 164
When opening the container and preparing the spray and using the prepared spray	279, 280, 281, 282
wear elbow-length PVC gloves	290, 294
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	360, 361
PD 15 g/L or less and pyrethrin 1 g/kg or less	
Harmful if swallowed	129, 133
Repeated minor exposure may have a cumulative poisoning effect	190
Obtain an emergency supply of atropine tablets 0.6 mg	373
Avoid contact with eyes and skin	210, 211
Do not inhale dust	220, 221
When using the product	279, 283
wear cotton overalls buttoned to the neck and wrist (or equivalent clothing) and a washable hat	290, 292a
and elbow-length PVC gloves	294
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 contaminated clothing	360, 361, 366
SR Pet Collar	

Do not open inner envelope/pouch until ready for use	380
Do not allow children to play with collar	382
Wash hands after handling the collar	383

6.3 Information provision

6.3.1 Labels

Active constituent label

Technical grade diazinon is determined to be a hazardous substance. Therefore, it must be labelled in accordance with the NOHSC Code of Practice for the Labelling of Workplace Substances (NOHSC, 1994b)

Product labels

All diazinon product labels containing diazinon EC and ME at 200g/L or more, must include a reference to the MSDS for further information.

Refer to Section 7.2 for product labelling requirements arising from this review.

6.3.2 MSDS

The active ingredient and products containing diazinon at 200 g/L or more require MSDS in accordance with the NOHSC Code of Practice for the Preparation of Material Safety Data Sheets (NOHSC, 1994c)

6.4 Occupational exposure monitoring

6.4.1 Atmospheric monitoring

A NOHSC Exposure Standard of 0.1 mg/m^3, Time Weighted Average (TWA) with “Sk” skin notation has been assigned to diazinon (NOHSC, 1995a). (The notation Sk indicates that absorption through the skin may be a significant source of exposure). NOHSC has not established a Short-Term-Exposure-Limit (STEL) for diazinon.

6.4.2 Health surveillance

NOHSC has placed OP pesticides on the Schedule for Health Surveillance (Schedule 3 Hazardous Substances for which Health Surveillance is Required). Guidelines are available for monitoring OP pesticides (NOHSC, 1995b). The employer is responsible for providing health surveillance where estimates of workplace risk indicate surveillance.

Where health surveillance is required, the NOHSC guidelines recommend one, or preferably two pre-exposure tests at least 3 days apart, to establish baseline ChE activity (an average is used when two samples are obtained). It is also recommended that a period of 4 weeks elapse between last exposure to OP pesticides and testing to establish baseline levels.

The NOHSC guidelines require estimation of RBC and plasma ChE levels. It is preferable if testing is carried out in the latter half of the working day when OP pesticides are used. If a 20% depression in ChE activity is seen, the worker should be re-tested. If ChE levels fall by 40% or more, the worker should be removed from exposure to OP pesticides until such time as the level returns to baseline level.

7. REVIEW OUTCOMES

The following outcomes have been amended and recommendations provided in Section 6.6 of the NRA Review of Diazinon September 2002, Volume 1, Review Summary)

Diazinon is currently registered in a range of agricultural and veterinary situations. All registered uses were considered, exposure scenarios developed and grouped, where possible.

Chemical specific measured exposure data were limited to diazinon use in shower dipping of sheep only. Australian use pattern information was insufficient to conduct a quantitative risk assessment for some exposure scenarios. Given the lack of measured exposure data for a majority of uses, predictive modelling was used, where possible, as a first tier risk assessment. It is generally accepted that modelling tends to overestimate risk as each measure is by best practice methodology, defaulted to conservative. Overall, the risk from occupational exposure to diazinon was determined using model outputs (where available) and factoring in possible risk mitigating circumstances. The use of an oral NOEL in the absence of an appropriate human dermal NOEL and a conservative dermal absorption factor for diazinon may also overestimate risk.

The following uses of diazinon were of OHS concern: hand spraying in bananas, manual and automatic spraying of cattle, pest control in animal housing, hand jetting and backline long wool treatment of sheep. Concerns also exist for shearers and wool handlers and agricultural re-entry workers. Whilst continued use is supported in these instances, exposure mitigation methods are recommended and additional data required (refer to Section 7.3 for details).

Of the agricultural uses, the overall risk to workers is likely to be acceptable for the following scenarios, provided good agricultural practice is observed and products are used in accordance with label instructions: vegetables, fruits (except hand spraying of bananas), field crops, nursery plants/ornamentals (excluding use in enclosed greenhouses), lawns/turf, commercial and domestic pest control, hides/skins, ponds and stagnant waterways and garbage areas. Additional information on work practices and use patterns is required for the use of diazinon products in enclosed greenhouses.

When used as cattle treatments, the overall risk to workers is likely to be acceptable for the following scenarios, provided safe work practices are observed and products are used in accordance with label instructions: preparation of backrubbers/rubbing posts, application of ear tags and wound dressing. Additional controls, by way of more extensive personal protective equipment, are recommended during backline treatment of cattle.

The risk to workers using diazinon products as sheep ectoparaciticides is considered to be acceptable for the following scenarios provided safe work practices are observed and products are used in accordance with label instructions: off-shears backline treatment and wound dressing. Additional controls, by way of more extensive personal protective equipment, are recommended during plunge and shower dipping and automatic jetting.

Detailed outcomes for each use are presented below.

7.1 End use

. *Vegetables (including mushrooms)*

Diazinon products are registered for use, though not extensively used in vegetables and mushrooms. In vegetables, foliar spraying and soil treatment is recommended depending on crop. Incorporation of diazinon in mushroom casing is current industry practice.

No exposure data were available for this use. Model data were used where possible to obtain a frame of reference for potential worker exposure. Although the risk to many categories of workers was determined to be unacceptable based on predictive modelling, noting that:

(i) diazinon is one of many chemicals used in these crops and its use is essentially regional;
(ii) use of diazinon in these crops is expected to be infrequent or intermittent
(iii) hand spraying is unlikely to be extensive nor the favoured application method to treat large areas;
(iv) the maximum concentration of the active constituent in the spray/solution is 0.5%;
(v) many farmers use closed cab equipment fitted with pesticide filters and that the added protection afforded by such engineering controls was not quantified and;
(vi) mechanised processes in the mushroom industry and PPE minimise worker exposure,

it is concluded that the risk to workers involved in spraying of vegetables and mushroom casing will be acceptable under the following conditions:

(a) that exposure mitigation methods specified in Section 7.1.1 are instituted where applicable; and
(b) the products are used in accordance with label instructions.

. *Fruit*

In fruits, diazinon may be applied as a fruit or foliar spray, basal or bunch treatment or dip, applied through boom sprayers, air assisted sprayers and hand sprayers. No measured worker exposure data were available. Predictive modelling was used to estimate worker exposure where possible. Inadequate use pattern information was provided on dipping of pineapples and bunch spraying and bell injection (off label use) in bananas.

Worker exposure and risk was unacceptable in most cases. However, noting the:

(i) availability of alternative chemicals;
(ii) infrequent use of diazinon in fruits;
(iii) dilute nature of the spray and;
(iv) the current trend to use closed cab sprayers with pesticide filters,

the risk to workers from application of diazinon by **boom and airblast sprayers** is likely to be acceptable under the following conditions:

(a) that exposure mitigation methods specified in Section 7.1.1 are instituted where applicable; and
(b) the products are used in accordance with label instructions.

Of OHS concern was the potential risk, as evidenced by low MOE, for **hand spraying of bananas**. In addition, potential exposure during bunch spraying (using hand-held equipment) could not be adequately quantified due to the lack of information on use and work practices.

Noting the: (i) current trend to use diazinon in Queensland;
(ii) extent of commercial banana plantations;
(iii) proximity of the worker to the spray equipment and the labour intensive nature of the task;
(iv) lack of measured exposure data and;
(v) inadequate information on use and work practices,

it was concluded that the risk to workers during hand spraying of bananas (bunch spraying and basal spraying) could not be adequately quantified. Additional worker exposure data are required. Refer to Section 7.3 for data requirements.

. ***Field crops***

Diazinon is registered for use in broadacre crops for the control of locusts and other pests by ground and aerial spraying. However, it is a second line chemical in broadacre crops and rarely if ever used for locust and grasshopper control.

The risk to mixer/loaders and ground applicators was unacceptable based on predictive exposure data using representative and maximum parameters. As specified in Section 5.1, the MOE calculated using a NOEL from a repeat dose study may overestimate the risk. The risk to aerial operators could not be estimated quantitatively, however considering existing controls and training of professional aerial operators, the risk is expected to be minimal.

Given that: (i) diazinon is not the chemical of choice in the treatment of field crops;

(ii) ground spraying of broadacre crops will more likely utilise closed cab sprayers with air-conditioning and pesticide filters and;
(iii) the risk to aerial mixer/loaders and pilots is not expected to be significant,

the use of diazinon products in field crops is not expected be of OHS concern under the following conditions:

(a) that exposure mitigation methods specified in Section 7.1.1 are instituted where applicable; and
(b) the products are used in accordance with label instructions.

- ***Nursery plants and ornamentals***

Available information indicated that diazinon was a key chemical in the nursery industry, particularly as a quarantine measure prior to interstate transfer of plants. Inadequate information was available to determine the extent of diazinon use in the nursery industry and potential worker during this use.

Of particular concern would be the hand spraying of plants in enclosed spaces such as greenhouses. Further information on use and work practices is required in order to determine the risk to workers involved in treating nursery plants and ornamentals. Refer to Section 7.3 for data requirements.

Continued use of diazinon products for this use is supported pending provision of data. Exposure mitigation methods specified in Section 7.1.1 should be instituted, where applicable, during this period.

- ***Lawns – around trees, fences, walls/turf***

The use of diazinon in lawns and turf is but a minor use of the chemical. Exposure estimates obtained from predictive models were used to obtain an estimate of worker exposure in the absence of measured exposure data. It is noted that due to the lack of adequate information on use, default values were used in the calculations.

As indicated in Section 5.1, the risk to workers involved in this use is not expected to be significant under the following conditions;

(a) that exposure mitigation methods specified in Section 7.1.1 are instituted where applicable; and
(b) products are used in accordance with label instructions.

- ***Commercial and domestic areas***

Several diazinon formulations are available for general pest control of buildings. It may be assumed that diazinon products will be applied by registered pest control operators, therefore there is the potential for significant and repeated use. However, available information indicates that diazinon is not the preferred chemical in these situations.

No measured exposure data were available. Predictive modelling was used to estimate worker exposure during hand spraying. Potential exposure during misting and fogging could not be determined, but as indicated in Section 4.2, is expected to be equal to or less than hand spraying.

Two formulations of diazinon, namely EC and ME, are available for this use. Both formulations are to be used at similar concentrations for each application method. No suitable model was identified to determine exposure to the ME formulation. Exposure estimates obtained for the EC product are used as surrogate for ME products.

Noting that: (i) other chemicals are used in preference to diazinon for general pest control;
(ii) mixing/loading and chemical application will most likely be carried out by licensed pest control operators adequately trained in the use of organophosphates and;
(iii) the MOE obtained using exposure estimates from POEM may overestimate risk (refer to Section 4.2, for details);

it is concluded that on balance, the risk to workers is likely to be acceptable under the following conditions:

(a) that exposure mitigation methods specified in Section 7.1.1 are instituted where applicable; and
(b) products are used in accordance with label instructions.

. ***Skins and hides***

Diazinon is one of a number of chemicals that may be used for the control of skin and hide beetles. Information from processors indicated that the incidence of infestations is largely controlled by other management practices, therefore the requirement for chemical control is minimal. However, it may be used for fly control during export.

No exposure data were available for this use. Predictive modelling could not be carried out as information on work practices and use parameters was lacking. Given the fact that:

(i) beetle infestation of hides and skins is uncommon;
(ii) diazinon is one of many chemicals registered for this use;
(iii) the main use is expected to be for fly and;
(iv) extensive spraying is not anticipated,

it is concluded that the risk to workers during spraying of hides and skin is likely to be acceptable, under the following conditions:

(a) that exposure mitigation methods specified in Section 7.1.1 are instituted where applicable; and
(b) products are used in accordance with label instructions.

. ***Ponds, stagnant water***

The use of diazinon products in mosquito control is a relative minor use of the chemical. No measured exposure data were available and information on use pattern and work practices was scanty.

Considering that: (i) diazinon is not expected to be the major chemical in mosquito control;
(ii) a dilute solution (0.1% ai) is recommended for application to breeding sites and ;
(iii) regular use is not anticipated,

it is concluded that the use of diazinon products for mosquito control in waterways is likely to be acceptable, under the following conditions:

(b) that exposure mitigation methods specified in Section 7.1.1 are instituted where applicable; and
(b) products are used in accordance with label instructions.

. ***Refuse areas and garbage containers***

Diazinon use around garbage dumps and refuse is considered a minor use of the chemical. Limited information was available on the frequency and extent of use. Measured data were unavailable and worker exposure could not be quantified with the available use pattern information.

Considering the: (i) relatively minor and potentially irregular use of the chemical in garbage/refuse dumps;
(ii) concentration of active ingredient to be applied (maximum 0.5%);

worker exposure and risk is not expected to be significant provided:

(a) exposure mitigation methods specified in Section 7.1.1 are instituted where applicable; and
(b) products are used in accordance with label instructions.

Cattle treatment

. ***Backrubbers and rubbing posts***

Diazinon is incorporated in backrubbers and rubbing posts for buffalo fly control. Inadequate use pattern information was available to accurately determine the extent of use of the chemical by these methods in Australia.

No measured data were available and potential worker exposure during preparation of backrubbers and rubbing posts could not be adequately quantified. However;

Noting the: (i) frequency of use of the chemical will result in intermittent worker exposure rather than regular exposure;
(ii) low concentration of the chemical in the prepared solution;
(iii) normal work practices; and
(iv) PPE specified on product labels,

it is concluded that the risk to workers during preparation of backrubbers/rubbing posts is likely to be acceptable, under the following conditions:

(a) that exposure mitigation methods specified in Section 7.1.1 are instituted where applicable; and
(b) products are used in accordance with label instructions.

. ***Ear tags***

Diazinon slow release ear tags are used for the control of buffalo fly in cattle. They provide an extended period of protection from fly strike (approximately 4 months). Herd treatment is anticipated to maximise buffalo fly control. Re-treatment will be required only once during the fly season.

No measured data were available and a suitable model was not identified to estimate worker exposure during application of ear tags. Potential exposure during application of ear tags could not be adequately quantified.

Considering the: (i) duration of the fly season;
(ii) extended protection afforded by the product;
(iii) frequency of re-application;
(iv) slow-release nature of the product;
(v) requirement to wear gloves when handling tags;
(vi) specialised application equipment; and
(vii) short contact time during application,

it is concluded that the risk to workers during application of ear tags is likely to be acceptable, under the following conditions:

(a) that exposure mitigation methods specified in Section 7.1.1 are instituted where applicable; and
(b) products are used in accordance with label instructions.

. ***Backline treatment of cattle***

Backline treatment with diazinon products is an alternative to the use of backrubbers or ear tags to control flystrike. It is anticipated that backline treatment will be carried out using a variety of hand-held application equipment. Normal animal husbandry practice is to treat the whole herd to maximise fly control.

No measured exposure data were available to assess exposure and risk during this use pattern. Predictive modelling was used to obtain a rough estimate of exposure during open mixing/loading only. The use pattern parameters used in the exposure assessment are considered representative of larger Australian cattle farms and dairy operations.

The risk was unacceptable when open pouring from containers of non-specific design and acceptable when handling wide neck containers. As indicated in Section 5.1, these MOE may overestimate risk. Predictive modelling could not be used to estimate exposure during hand-held backline application of diazinon products. A conservative theoretical calculation without an in-built safety factor indicated that skin contamination with a moderate volume of spray solution was required to equate to the repeat-dose NOEL.

Noting :

(i) that backline treatment of cattle is likely to result in infrequent and seasonal worker exposure;
(ii) that the work rate used to estimate exposure was representative of larger herds rather than small 'hobby farmers';
(iii) MOE calculated for mixer/loaders may overestimate risk;
(iv) the dilution of active constituent in the spray solution; and
(v) the extensive protective equipment prescribed on product labels,

it is concluded that the risk to workers during backline treatment of cattle is likely to be acceptable, under the following conditions:

(a) that exposure mitigation methods specified in Section 7.1.1 are instituted where applicable; and
(b) products are used in accordance with label instructions.

It is noted that label safety directions permit a choice of either protective waterproof clothing (or overalls and apron) or cotton overalls buttoned to the neck and wrist when using the prepared spray. Backline spraying may result in the generation of spray mist. Considering the proximity of the worker to the application equipment, maximum protection of torso and limbs is advisable. Therefore, it is preferable that workers involved in backline spraying wear waterproof clothing over normal work clothing.

- ***Manual and automatic spraying of cattle (and other animals)***

Diazinon products are used as a high volume spray for lice control in cattle, pigs, goats and horses. As indicated in Section 4.2, high volume hand spraying of cattle was assessed as a worst case exposure scenario. Low volume automatic spraying is conducted in cattle only.

No measured exposure data were available to determine worker exposure during manual and automatic spraying. Predictive modeling was used as a rough estimate of mixer/loader exposure and operator exposure during hand-held spray application. The model was not suitable to estimate operator exposure during automatic spraying. The parameters used in the exposure assessment are representative of larger farms and dairy operations in Australia. Most smaller 'hobby farmers' are expected to treat fewer head of cattle.

Exposure estimates obtained from modelling indicated unacceptable risk to mixer/loaders open pouring from containers of non-specific design. The risk was acceptable when handling wide neck containers. As indicated in Section 5.1, these MOE may overestimate risk.

Predictive modelling indicated a concern for workers involved in hand-spraying of cattle. The risk was determined to be unacceptable with and without water-proof clothing over cotton overalls.

Noting: (i) the potential for high operator exposure during manual and automatic spraying of cattle;
(ii) the large number of animals treated at any one time; and
(iii) the lack of measured exposure data,

it is concluded that the risk to workers involved in the hand spraying and automatic spraying of cattle cannot be adequately quantified. Additional worker exposure data are required. Refer to Section 7.3 for data requirements.

Whilst continued use is supported pending data generation, exposure mitigation methods specified in Section 7.1.1 should be instituted, where applicable, during any agreed interim data collection phase.

It is noted that label safety directions permit a choice of either protective water-proof clothing (or overalls and apron) or cotton overalls buttoned to the neck and wrist when using the prepared spray. During the interim data collection period, it is preferable that workers involved in hand spraying and automatic spraying of cattle (and other animals), wear water proof clothing over normal work clothing.

. ***Wound dressing***

Diazinon is used in liquid and powder forms, for wound dressing in cattle and other animals. Both formulations are used undiluted. Individual animal treatment rather than herd treatment is anticipated.

No measured worker exposure data were available for this use pattern. Product labels do not restrict its use either through a re-treatment interval or maximum number of applications. As indicated in Section 5.1, worker exposure and risk is not of occupational health and safety concern under the following conditions:

(a) that exposure mitigation methods specified in Section 7.1.1 are instituted where applicable; and
(b) products are used in accordance with label instructions.

. ***Treatment of animal housing***

The extent of use of diazinon for fly control in kennels and animal housing is unknown. No measured exposure data were available. Predictive modelling was used as a first tier approach, to obtain a rough estimate of potential worker exposure. Representative default values were used where definitive use pattern information was lacking.

The risk to mixer/loaders as determined by predictive modelling was unacceptable when handling containers of non-specific design. The risk was determined to be acceptable when open pouring from wide neck containers.

Applicator risk was estimated for high and low level hand spraying, with and without water-proof clothing, respectively, ie. water-proof clothing over cotton overalls was only modelled for the scenario known to result in higher operator exposure. The risk was unacceptable for both levels of spraying.

Although the MOE calculated using a repeat-dose NOEL may overestimate the risk to mixer/loaders and applicators (see Section 5.1), it is noted that the MOE were very low for applicators in particular.

Noting that : (i) exposure estimates obtained from predictive modelling indicated a concern;
(ii) hand-spraying, particularly overhead spraying, can result in significant operator exposure;
(iii) spraying may be conducted indoors where ventilation may be inadequate;
(iv) Measured exposure data were lacking and;
(v) Australian use pattern information was inadequate,

it is concluded that the risk to workers involved in the hand spraying of animal housing cannot be adequately quantified. Additional worker exposure data are required. Refer to Section 7.3 for data requirements.

Whilst continued use is supported pending data generation, exposure mitigation methods specified in Section 7.1.1 should be instituted, where applicable, during any agreed interim data collection phase.

It is noted that product labels permit a choice of either protective water-proof clothing (or overalls and apron) or cotton overalls buttoned to the neck and wrist when using the prepared spray. During the interim data collection period, it is preferable that workers involved in hand spraying of animal housing wear water proof clothing over normal work clothing.

Sheep treatment

. ***Plunge and shower dipping***

Diazinon is commonly used for sheep treatment in plunge and shower dips in Australia. Flock treatment is common, requiring workers to handle large volumes of product and dilute dip solution per day. Some worker exposure data were available for shower dipping only. This exposure data did not separate exposure during mixing/loading from dipping activities. Due to the lack of information on critical parameters and change in equipment design midway through the trial (refer to Section 5.1 for details), these results are used with caution.

Predictive modelling was used to obtain a frame of reference for worker exposure during mixing/loading only. The use pattern parameters used to estimate potential exposure are considered representative of sheep farms in Australia. Potential worker exposure during actual plunge and shower dipping could not be quantified. It is acknowledged that these are potentially high exposure scenarios.

Noting that : (i) some measured worker exposure data were available for shower dipping;
(ii) the use of diazinon in plunge and shower dipping of sheep is expected to be infrequent or at most only over a few consecutive days;
(iii) the dip solution contains a low concentration of the chemical; and
(iv) existing studies identify possible engineering controls to minimise worker exposure,
it is concluded that the risk to workers involved in plunge and shower dipping of sheep will be acceptable under the following conditions:

(c) that exposure mitigation methods specified in Section 7.1.1 are instituted where applicable; and
(d) the products are used in accordance with label instructions.

It is noted that label safety directions permit a choice of either water-proof clothing or cotton overalls buttoned to the neck and wrist (or equivalent clothing) and PVC or rubber apron, when using the prepared dip solution. Considering that this is potentially a high exposure scenario, it is prudent to provide maximum protection to the worker's torso and limbs. Therefore, it is preferable that workers involved in plunge and shower dipping of sheep wear water-proof clothing over normal work clothing, instead of a PVC or rubber apron over cotton overalls.

It is established that the sump sludge contains a high concentration of diazinon. Therefore, it is preferable that workers cleaning out this sludge wear the PPE recommended on the product label, namely waterproof clothing, elbow-length PVC gloves and water resistant footwear.

Hand jetting

Hand jetting is the preferred method for the control and treatment of blowfly strike in Australia. Large numbers of sheep can be treated by hand jetting per day, requiring workers to handle large quantities of jetting fluid. The use pattern parameters used in the exposure assessment are considered representative of the Australian use of diazinon products by jetting.

No measured worker exposure data were available. As a first tier risk assessment predictive modelling was used in order to estimate worker exposure during mixing/loading and hand jetting of sheep. It is possible that the MOE obtained using exposure estimates from POEM may overestimate the risk to workers. However, it is noted that the MOE were very low particularly for hand jetters, even when wearing water-proof clothing.

Noting the : (i) large number of animals treated and large volumes of jetting fluid handled per day;
(ii) potential for high operator exposure during hand jetting; and
(iii) lack of measured exposure data,
it is concluded that the risk to workers involved in hand jetting of sheep could not be adequately quantified. Considering that hand jetting comprises a significant proportion of diazinon use, additional worker exposure data are required. Refer to Section 7.3 for data requirements.

Continued use of diazinon products for hand jetting is supported pending data generation. Exposure mitigation methods specified in Section 7.1.1 should be instituted, where applicable, during any agreed interim data collection period.

It is noted that label safety directions permit a choice of either water-proof clothing or cotton overalls buttoned to the neck and wrist (or equivalent clothing) and PVC or rubber apron, when using the jetting solution. During the interim data collection period, it is preferable that workers involved in hand jetting operations wear water-proof clothing over normal work clothing, instead of a PVC or rubber apron over cotton overalls.

Automatic jetting

Automatic jetting is generally used off-shears for lice and ked control. When compared with hand jetting, automatic jetting is:

(i) a less labour intensive yet relatively ineffective method of applying jetting chemicals;
(ii) a method by which larger numbers of animals can be treated;
(iii) a non targeted application requiring a higher concentration of chemical in the jetting fluid;
(iv) an application method requiring workers to handle larger volumes of product [due to (ii) and (iii)];
(v) known to generate significant quantities of spray mist; and
(vi) mechanical in operation, therefore workers are not required to stand in close proximity to spray equipment or animals as they are jetted.

No measured worker exposure data were available for automatic jetting. POEM was used to obtain a frame of reference for potential mixer/loader exposure only. The risk to workers during mixing/loading activities was unacceptable, irrespective of container design or average/maximum flock sizes. As indicated in Section 5.1, these MOE may overestimate the risk to mixer/loaders.

Predictive modelling could not be used to estimate potential exposure during jetting race operation. As indicated above, work practices have some mitigating effect on potential exposure, however, exposure to spray mist can be significant. It is noted that the product labels recommend similar PPE for hand and automatic jetting.

Therefore, overall, it is concluded that the risk to workers during automatic jetting of sheep will be acceptable under the following conditions:

(a) that exposure mitigation methods specified in Section 7.1.1 are instituted where applicable; and
(b) the products are used in accordance with label instructions.

It is noted that label safety directions permit a choice of either water-proof clothing or cotton overalls buttoned to the neck and wrist (or equivalent clothing) and PVC or rubber apron, when using the jetting solution. In order to minimise contamination of torso and limbs from spray mist, it is preferable that workers involved in automatic jetting operations wear water-proof clothing over normal work clothing, instead of a PVC or rubber apron over cotton overalls.

Backline treatment

Diazinon products are used for long wool and off-shears backline treatment. Large numbers of sheep can be treated, however, the volume of product/spray applied per animal is small. Maximum application rates (worst case scenario) were used to estimate worker exposure during long wool treatment. The use pattern parameters used in the exposure assessment for off shears treatment are considered representative of industry work practices.

The following differences are noted between long wool and off shears treatment:

(i) long wool treatment is conducted using undiluted product (9.6% diazinon), whereas off shears treatment utilises a dilute solution (0.15% diazinon);
(ii) mixing of product and water is only required for off-shears treatment;
(iii) actual application time per sheep is shorter for off-shears treatment;
(iv) potential worker exposure during application is higher during long wool treatment due to the high concentration of diazinon applied and presence of wool.

Predictive modelling was used as a first tier approach to estimate the exposure and risk to mixer/loaders in the absence of measured exposure data. The MOE obtained for these workers indicated acceptable risk in most cases. These MOE may overestimate risk considering that backline treatment is generally conducted once per year. Applicator exposure could not be determined using POEM. Theoretical calculations used as rough estimates of worker exposure indicated that worker exposure, particularly during long wool treatment, was of OHS concern.

Noting the:
(i) differences in long wool and off shears applications (refer above);
(ii) small quantity of product that equates to the NOEL for long wool treatment;
(iii) the large number of animals that may be treated per day;
(iv) the proximity of the worker to the animal during application; and
(v) the lack of exposure data for backline treatments,

it is concluded that the risk to workers involved in **long wool backline treatment** of sheep could not be adequately quantified.

Continued use of diazinon products for long wool backline treatment is supported pending data generation. Exposure mitigation methods specified in Section 7.1.1 should be instituted, where applicable, during any agreed interim data collection period.

Noting the:

(i) differences between long wool and off-shears treatment;
(ii) theoretical estimation of dose equivalent to the NOEL for off-shears treatment;
(iii) MOE obtained for mixing/loading activities for off-shears treatment; and
(iv) PPE recommended on the product label,

it is concluded that the risk to workers involved in **off-shears backline treatment** of sheep will be acceptable under the following conditions:

(b) that exposure mitigation methods specified in Section 7.1.1 are instituted where applicable; and
(b) the products are used in accordance with label instructions.

Wound dressing

Diazinon may be used as a dilute liquid or dry powder formulation for wound dressing of sheep. Although in some instances flock treatment may be undertaken, such activity is expected to be intermittent or regular over short periods of time.

No measured worker exposure data were available. Worker exposure and risk could not be quantified. However, as indicated in Section 5.1 (risk assessment) the risk to workers during wound dressing of sheep is not expected to be of OHS concern under the following conditions:

(c) that exposure mitigation methods specified in Section 7.1.1 are instituted where applicable; and
(b) the products are used in accordance with label instructions.

7.1.1 Exposure mitigation methods

Where model data were used to estimate worker exposure, the risk to mixer/loaders during open-pour operations was determined to be unacceptable. However, the data highlighted that exposure (and risk) to mixer/loaders open-pouring from wide neck containers was significantly less than mixer/loaders handling containers of non-specific design. It is established that mixing/loading using closed systems results in less worker exposure, with dry coupling systems expected to provide almost total protection.

When assessing exposure to diazinon during ground application, the risk to applicators in closed cabs was unacceptable. The benefit of additional exposure mitigation methods such as pesticide filters could not be quantified. Worker exposure during hand-held spraying was demonstrated to be unacceptable using predictive modelling.

In addition, the potential for exposure to toxic degradation products of diazinon formed during storage, is of occupational health and safety concern.

Therefore, it is recommended that potential exposure of all workers be minimised, where possible.

Hazardous substances legislation

Diazinon and products currently registered in Australia are determined to be hazardous substances (refer to Section 6.1). In accordance with Commonwealth/State/Territory Hazardous Substances legislation, the following control measures must be instituted, where applicable (NOHSC, 1994a).

1. **Induction and training** - Appropriate induction and on-going training of all workers with the potential for exposure to diazinon products, in relation to those substances in the workplace and commensurate with the risk identified by the workplace assessment process.

It is recommended that appropriate training courses (eg. Farm Chemical User Course or recognised equivalent) be identified for all workers involved in the use of diazinon products.

2. Workplace assessment - A suitable and sufficient assessment of the risks to health created by work involving potential exposure to diazinon.

3. Control - As far as practicable, the prevention or adequate control of exposure of workers to hazardous substances should be secured by measures other than the provision of PPE. Control measures should be implemented in accordance with the hierarchy of controls.

It is preferable that the following engineering controls be adopted where possible:

(a) mixer/loaders;
- (i) containers designed to minimise spillage, eg wide-neck or no-glug containers;
- (ii) closed mixing/loading (mechanical transfer) systems, eg. closed filling/loading systems or dry coupling.

(b) applicators;
- (i) use of closed cab tractors – inclusion of air-conditioning and pesticide filters will provide added protection as well as worker comfort.
- (ii) Engineering controls identified through studies conducted by the NSW Department of Agriculture such as:

  * raising the side of the dip surround;
  * re-location of control valves and pump for remote operation;
  * good equipment maintenance to reduce the need for running repairs during dip operation;

* abandoning the bottom spray altogether and using high efficiency spray nozzles on top boom for a longer period of time;
* use of larger solid stream spray nozzles operating at lower pressure;
* Enclosing the exit gate.

(iii) Ensuring adequate worker protection when cleaning the sump ie. adequate PPE and safe work practices.

(c) flaggers in aerial operations;

(i) use of closed cab vehicles.

It is recommended that industry-based standard operating procedures (including safe work practices) be developed, where appropriate.

The use of PPE for exposure mitigation should be limited to situations where other control measures are not practical or where PPE is used in conjunction with other measures to increase protection. Where PPE is used, it should be selected and used in accordance with the relevant Australian Standards. Protective equipment should be properly selected for the individual and task, be readily available, clean and functional, correctly used and maintained.

4. Health surveillance – OPs including diazinon are listed on the Schedule for Health Surveillance. Therefore, workers should have access to health surveillance facilities in accordance with the NOHSC Control of Workplace Hazardous Substances (NOHSC, 1995).

5. Record keeping – Records should be maintained in accordance with the NOHSC Control of Workplace Hazardous Substances (NOHSC, 1994a).

The above exposure mitigation methods or OHS control measures are integral to the safe use of diazinon. Compliance with labeling instructions alone may not provide sufficient risk mitigation. These additional recommendations are made under the NOHSC Model Regulations for Control of Workplace Hazardous Substances under which all pesticide manufacturers and users should operate. These recommendations are intended to be taken up and enforced by relevant agencies in all States and Territories. Product registrants, users and OHS agencies are expected to be aware of these additional risk mitigation measures.

7.2 Labelling requirements

The following REPs must be included on agricultural product labels:

<u>*Mushrooms*</u>

Do not re-handle treated mushrooms within 14 days of spraying. If entry to treated areas is required for watering of beds, or monitoring of carbon dioxide, workers must avoid contact with treated casing".

<u>*Onions*</u>

"**Do not re-enter treated areas within 48 hours of spraying**".

Bananas

"Do not re-enter treated areas for purposes of crop monitoring, or other related activities, such as irrigation and scouting of immature/low foliage plants within 48 hours of spraying".

Pineapples:

"**Do not re-enter treated areas within 14 days of spraying**".

Nursery plants and ornamentals:

"**Do not re-enter treated areas, or handle treated pots within 48 hours of spraying**".

"**Pots should be irrigated thoroughly at least 3-4 times within the 48 hour period**."

"**If spraying has been conducted indoors, it is recommended that the enclosed areas are adequately ventilated before workers are allowed to enter."**

It is also recommended that labels be updated to reflect use of diazinon as a pot drench only.

Pest control operators:

"Do not re-enter until completely dry and adequately ventilated".

Skins and hides:

"Workers are advised to wear gloves when handling skins and hides"

Safety Directions

The safety directions must be consistent with the appropriate entries for diazinon, in the Handbook for First Aid Instructions and Safety Directions (TGA, 1999).

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NOHSC

OCCUPATIONAL HEALTH AND SAFETY ASSESSMENT

ATTACHMENTS

ACTIVE INGREDIENT: Diazinon

ATTACHMENTS:

(1) Agricultural – Estimates 1a – 28a

(2) Cattle – Estimates 1c – 10c

(3) Sheep – Estimates 1s – 24s

(4) Worker Exposure Study

ATTACHMENT (1): Agricultural – Estimates 1a – 28a

ATTACHMENT (2): Cattle – Estimates 1c – 10c

ATTACHMENT (3): Sheep – Estimates 1s – 24s

ATTACHMENT (4) Worker Exposure Study

The following study was submited by a registrant in response to the data call-in by the NRA.

Maizlish N, Schenker M, Weisskopf C, Seiber J, Samuels S (1987) A Behavioural Evaluation of Pest Control Workers with Short-term, Low-level Exposure to the Organophosphate Diazinon. American Journal of Industrial Medicine, 12:153-172.

The study, discussed in Section 2.4 investigated the neurobehavioural function of pest control workers following short-term exposure to low levels of diazinon. The study authors concluded that there was no evidence that short-term low level diazinon in a controlled pest control program using PPE caused any behavioural effects.

Discussion

The study is not considered suitable to assess the agricultural use of diazinon as the formulation, work practices, and application method are not cmparable with Australian conditions. Therefore the study results are not considered in the OHS risk assessment.