Shaughnessy No: 057501

Date Out of EAB: 12/3/87

To: Donna Kostka
Product Manager #80
Registration Division (TS-767C)

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

Michael P. Firestone

Attached, please find the EAB review of:

Reg./File # : 207199

Chemical Name : Parathion

Type Product : Insecticide

Product Name :

Company Name : Cheminova

Purpose : Exposure assessment/PD2/3 Science Chapter

Date Received : 11/3/87 Action Code: 870

Date Completed: 11/20/87 EAB #(s): 80090

Monitoring study requested: X Total Reviewing Time: 12 days

Monitoring study voluntarily: ____

Deferrals to:

____ Ecological Effects Branch

____ Residue Chemistry Branch

____ Toxicology Branch

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

NOV 23 1987

OFFICE OF
PESTICIDES AND TOXIC SUBSTANCES

MEMORANDUM

SUBJECT: Parathion Poisoning Statistics Summary

TO: Donna Kostha
Special review Branch
Registration Division (TS-767C)

Attached please find the preliminary parathion poisoning summary which you requested.

Jerome Blondell

Jerome Blondell, Health Statistacian
Exposure Assessment Branch (TS-769C)
Hazard Evaluation Division

Attachment

Parathion Poisoning Statistics Summary

NOV 23 1987

Prepared by: Jerome Blondell

Acute hazards to parathion can be measured by counting or estimating the number of deaths, hospitalizations, emergency room visits, and visits to physicians outside of the hospitals.

Mortality

During four years (1961, 1969, 1973, 1974), when all accidental deaths due to pesticides in the U.S. were counted, parathion was found to be the second most frequent cause of death (arsenical pesticides were first). On average, parathion caused 7 deaths per year during the 4 years surveyed or 8% of the total (1). Three parathion deaths have been reported to EPA since December, 1984.

In California, accidental deaths due to pesticides were counted each year from 1965 through 1977 and again in 1982 through 1986. During this 18 year period, parathion was responsible for 6 deaths or 7% of the total of 88 accidental pesticide-related deaths (2). All 6 parathion deaths occurred between the years 1965 and 1973.

Hospitalizations and Emergency Room Visits

Based on a 12% sample of the nation's hospitals, parathion was estimated to have caused an average of 150 hospitalizations each year during the time period 1974 through 1976(3). This amount represented 5% of all hospitalizations and was only exceeded by warfarin and arsenical pesticides. A 1 to 2% sample of the nation's emergency rooms has been sampled every year since 1979, however the sample is biased toward urban areas and is too small to provide realiable estimates for parathion.

Visits to Physicians

Visits to physicians for pesticide exposure has never been measured nationwide. Data are available in California where physician reporting of all occupational pesticide injuries is enforced. However, California data includes hospitalizations and emergency room visits. During the time period 1982 through 1986, California physicians treated an average of 21.6 parathion poisonings each year (2). Parathion was the third largest cause of systemic poisoning in California during the 1981 to 1985 time period, accounting for 4 percent of the total. Mevinphos and diazinon exceed parathion as a cause of systemic poisoning, however only mevinphos and parathion are regulated with long reentry intervals, closed system requirements and protective clothing requirements.

Circumstances of Parathion Poisoning in California

Parathion was the second most important cause of poisoning (methyl bromide was first) in terms of days hospitalized during the time period 1981 through 1985. Earlier data (1976-78) had indicated mixer/loaders and workers reentering fields are the most likely job categories to be poisoned by parathion, accounting for almost half of the cases. The introduction of longer reentry intervals and closed system requirements have greatly reduced the number of these poisonings, so that in the 1979-81 time period only 30 percent as many poisonings occurred for these job categories. During this time period, applicators were the most likely group to be poisoned, accounting for over a third of the parathion cases.

An analysis of 100 parathion poisonings during the 1975 to 1981 time period revealed that over half of the cases occurred even though the worker apparently adhered to the label directions. In 21% of the cases the worker had not followed label restrictions and in 27% of the cases adherence could not be determined. California restrictions on parathion use are greater than those imposed in other states.

Further analysis of cases occurring between 1975 and 1981 revealed that 63 cases could be categorized by the circumstance associated with the cause of the incident. Twenty-two cases occurred when workers reentered fields prior to the expiration of the required reentry interval. Seventeen of these 22 cases resulted from a single incident. Twelve workers were poisoned by spray drift from a nearby field. Ten workers became exposed as a result of equipment maintenance activity and another 10 were exposed when they accidently spilled the parathion on themselves. Six were cases that accidently sprayed themselves when applying the chemical and three cases occurred as a result of equipment failure.

1. Hayes, W.J. and Vaughn, W.K. Mortality from pesticides in the United States in 1973 and 1974. Toxicology and Applied Pharmacology 42:235-252. 1977.

2. From Various Reports issued by the California Department of Food and Agriculture, Sacramento, California. Included are reports number HS-322, HS-544, HS-545, HS-985, HS-1098, HS-1186, HS-1188, HS-1304, HS-1305, HS-1370, and HS-1371.

3. Keefe, T.J., Savage E.P., Munn S., Wheeler, H.W. Evaluation of Epidemiologic Factors From Two National Studies of Pesticide Poisonings, U.S.A. EPA Report.

Illness Due to Parathion Exposure Reported by Type of Illness and Job Category for 1976 through 1986 in California.

prepared by Jerome Blondell, November 10, 1987

Systemic Illness	1976-78	1979-81	1982-84	1985-86	Total
Ground Applicator	19	18	23	8	68
Aerial Applicator	2	0	0	0	2
Mixer/Loader*	23	9	7	5	44
Field Worker	28	6	24	7	65
Coincidental (drift)	5	3	7	3	18
Warehouse/Transportation	12	3	4	0	19
Manufacturing/Formulation	4	0	1	0	5
All Other	26	14	6	13	59
SUBTOTAL	119	53	72	36	280
Skin or Eye Injuries					
Ground Applicator	3	2	4	1	10
Mixer/Loader	2	0	2	1	5
Warehouse/Transportation	1	1	0	0	2
Manufacturing/Formulation	2	0	0	0	2
All Other	1	2	2	1	6
SUBTOTAL	9	5	8	3	25
TOTAL PARATHION ILLNESS AND INJURIES	128	58	80	39	305

* Requirement that parathion be mixed and loaded in a closed system was initiated in 1977 and fully implemented in 1978.

Worker Illness Due to Parathion in California 1974 to 1986

Physicians must report all worker-related injuries due to pesticides under California law. The following counts were recorded:

Year	Parathion Illness	Total Occupational Pesticide Illness	Percent of Total for That Year
1974	64	1157	6
1975	55	1343	4
1976	38	1452	3
1977	67	1518	4
1978	24	1194	2
1979	22	1019	2
1980	25	1402	2
1981	14	1093	1
1982	36	1334	3
1983	25	1270	2
1984	20	1156	2
1985	17	1516	1
1986	22	1065	2

Prepared by Jerome Blondell
November 10, 1987

OCCUPATIONAL ILLNESS AND INJURIES DUE TO EXPOSURE TO PARATHION AS REPORTED BY PHYSICIANS IN CALIFORNIA

Prepared by Jerome Blondell

Code	Adherence to Label	1975*	1978**	1979	1980	1981	Total
✓	Followed Instruction	8	7	16	12	9	52
X	Did Not Follow Instructions	5	7	1	6	2	21
U	Unknown	8	7	5	4	3	27
	TOTAL	21	21	22	22	14	100

* One incident involving 17 workers that reentered a field early was excluded.

** One case in 1978 was excluded, not ruled a parathion related illness by the attending physician.

This table is based on a description of all cases that occurred in 1978, 1979, 1980 and 1981. It also includes 38 cases that were described in 1975 out of the total of 68 which occurred. In many cases subjective judgement was used when deciding which category best described the adherence to the label.

OCCUPATIONAL ILLNESS AND INJURIES DUE TO EXPOSURE PARATHION AS REPORTED BY PHYSICIANS IN CALIFORNIA

Code	Circumstance	1975	1978	1979	1980	1981	TOTAL
FR	Fieldworker Reentry	18*	2	3	2	0	25
SD	Spray Drift	2	6	2	1	1	12
EM	Equipment Maintanence	2	3	1	3	1	10
AS	Accidental Spill	3	1	3	2	1	10
SS	Sprayed Self Accidently	0	0	1	3	2	6
EF	Equipment Failure	0	1	1	1	0	3
	SUBTOTAL						63
U	Other and unknown	13	8	11	10	9	51
	TOTAL	38	21**	22	22	14	117

* Includes one incident involving 17 workers

** One case not considered an organophosphate poisoning by the attending physician which did not display any symptoms was excluded.

This table is based on a description of all cases that occurred in 1978, 1979, 1980 and 1981. It also includes 38 cases that were described in 1975 out of the total of 68 which occurred. In many casses subjective judgement was used when deciding which category best described the circumstance associated with a particular case.

1.0 INTRODUCTION

The Exposure Assessment Branch (EAB) has undertaken an evaluation of the potential hazards to humans from nondietary exposure to ethyl parathion (parathion). The Agency issued the "Guidance for the Preregistration of Pesticide Products Containing Parathion as the Active Ingredient" on December 15, 1986. The Agency announced in that document its intent to initiate a Special Review of parathion because of acute human toxicity and acute avian toxicity concerns.

2.0 PARATHION PESTICIDE POISONING INCIDENCE

In the 1986 reregistration document, the Agency stated that parathion had a long history of poisonings. The Pesticide Incidence Monitoring System (PIMS) and occupational pesticide poisoning data from the California Department of Food and Agriculture (CDFA) were previously evaluated. Because PIMS was discontinued in 1980, no reevaluation of the data has been conducted for the Parathion Position Document 2/3. CDFA poisoning data, evaluated in the reregistration document, covered the period of 1976 to 1981. Since the issuance of the reregistration document, EAB has evaluated more recent poisoning data supplied by CDFA for the period 1982 to 1986. Attachment 1 contains a detailed evaluation of the CDFA poisoning incidence data. A summary of the data indicates that ground applicators, mixer/loaders, and field workers make up the majority of job categories reporting systemic parathion poisonings (63 percent, 177 of 280 poisonings). The incidence of ground applicator poisonings has remained relatively stable from 1976 to 1986, although the period 1985-86 did show a decrease. Over half of the mixer/loader poisonings occurred in the 1976-78 reporting period. This is prior to full implementation in 1978 of the requirement in California that liquid formulation pesticides in Toxicity Category I be mixed and loaded by a closed loading system. The poisoning incidents for field workers appear cyclical in nature. Since 1979, aerial applicator poisonings have been reported as not occurring. Coincidental exposure from drift has occurred at a rate of three to seven per three-year reporting period and accounts for six percent (19 of 280) of parathion reporting incidents. A table of parathion poisoning incidence in California is presented as follows:

SYSTEMIC ILLNESSES DUE TO PARATHION EXPOSURE REPORTED BY JOB CATEGORY IN CALIFORNIA 1976 THROUGH 1986

Job Category	1976-78	1979-81	1982-84	1985-86	Total
Ground Applicator	19	18	23	8	68
Aerial Applicator	2	0	0	0	2
Mixer/Loader	23	9	7	5	44
Field Worker	28	6	24	7	65
Coincidental (drift)	5	3	7	3	18
Warehouse/Transportation	12	3	4	0	19
Manufacturing/Formulation	4	0	1	0	5
All Other	26	14	6	13	59
Subtotal	119	53	72	36	280

Based on the distribution and trends in poisoning incidence reported by CDFA, EAB has concentrated its evaluation of nondietary exposure to mixer/loaders, applicators, and field workers.

3.0 NONDIETARY EXPOSURE TO MIXER/LOADERS AND APPLICATORS

The hazard that any pesticide presents to an individual is dependent on both the toxicity of the pesticide and the body burden of that pesticide to the handler. Body burden can be estimated by measuring the dermal and inhalation exposure to the pesticide during a given job function and adjusting the exposure by the absorption of the pesticide across the skin and lungs. This exposure is measured by passive dosimetry techniques. A second method of measuring body burden is to measure the quantity of the pesticide or its metabolite(s) excreted, usually in the urine. If the pharmacokinetics of the pesticide is understood, the quantity of pesticide measured in the urine can be utilized to calculate the quantity of pesticide in the body. This technique is commonly called biological monitoring. On January 28, 1986, the Agency issued a Data Call-In Notice (DCI) requiring the registrants of parathion to submit both passive dosimetry and biological monitoring data for parathion.

EAB has evaluated available exposure studies for parathion in order to understand where the exposure is occurring, which job functions present the greatest risk, and what exposure reduction actions present the greatest potential for reducing risk to handlers of parathion. EAB has not attempted to quantify daily exposure to parathion on a crop basis. Daily exposures are normally calculated to permit the estimation of Margins of Safety (MOS) for toxicity endpoints, such as developmental toxicity. The human concern with parathion centers on the acute toxicity resulting from the ability of parathion to inhibit cholinesterase activity. The previously discussed poisoning incidence data are evidence that in particular situations, a MOS does not exist since the user suffered from significant cholinesterase inhibition. The occurrence of systemic poisonings from parathion obviates the need to calculate a MOS and pushes the thrust of exposure assessment toward identifying job functions and formulations with the greatest risk potential and identifying practical exposure reduction methods.

Four exposure studies were evaluated by EAB to estimate the potential dermal exposure to parathion during mixing/loading and application. Inhalation exposure was not specifically addressed because previous studies (Durham, 1961; Wolfe, et al, 1966; Durham, et al, 1972; Feldman and Maibach, 1973; Maddy, et al, 1982; and exposure studies submitted to the Agency to support the registration of specific pesticides) have shown that dermal exposure is of much greater concern than inhalation exposure for pesticides like parathion with low vapor pressures. Inhalation exposure generally accounts for less than one percent of the total exposure. Proper use of a respirator would be expected to virtually eliminate potential parathion exposure by the respiratory route.

3.1 CDFA MIXER/LOADER, AIRBLAST APPLICATOR EXPOSURE STUDY-TULARE COUNTY

Maddy, et al. ("A Study of Potential Occupational Exposure of a Ground Applicator During Mixing, Loading, and Application of Parathion in Tulare County in June 1981," CDFA, Worker Health and Safety Unit, July 1, 1982, Study Number HS-888) monitored the potential dermal and inhalation exposure to an experienced worker mixing, loading, and applying Parathion 25W Wettable by airblast to a lemon orchard. The worker wore clean, long-sleeved and long-legged coveralls, heavy rubber boots, a waterproof hat, and half-faced respirator with organic vapo-cartridges. The ten-pound bags of parathion wettable powder were opened with a knife and handpoured into a nurse tank. The mixed spray was pumped into a FMC 757 Speed Sprayer. The parathion was applied at 125 gallons finished spray/acre, at an application rate of 2.5 lb ai/acre. The speed sprayer was pulled by a cab-less tractor at a forward speed of 2.25 mph. The worker handled 10 lb ai/day and was monitored for three days.

Dermal exposure was measured by patches consisting of an outer layer of 65/35 percent polyester/cotton material to represent coveralls and an inner layer of 100 percent cotton gauze to represent skin. The patches were backed by aluminum foil. Patches were placed on the back of the neck, upper chest, lower back, each upper arm, and each thigh. Hand exposure was measured by hand rinses at the end of the work day. The patches were left on the worker all day to minimize inconvenience to the worker.

Potential inhalation exposure was measured by a portable air pump with an air sampler attached near the worker's breathing zone. A flow rate of 0.25 l/min was maintained, and the air sampler contained Amberlite XAD-4 resin. The presence of parathion inside the body was monitored by taking urine samples prior to application and following each day's application. The urine was analyzed for para-nitrophenol (PNP) which is a metabolite of parathion. Because grab samples rather than total urine excreted were collected, it was not possible to quantify the internal dosage of parathion. Blood was also collected to monitor for plasma and red blood cell (RBC) cholinesterase levels.

Based on the amount of parathion reported on the patches by Maddy, et al, EAB has estimated the potential dermal exposure to be 12 mg/lb ai on June 8, 1981, 28 mg/lb ai on June 9, 1981, and 93 mg/lb ai on June 11, 1981. Potential dermal exposure is defined as the dermal exposure to the exposed skin and clothing and was calculated from residue levels on both the inner and outer layers of the patches. The dermal exposure, defined as the exposure to the uncovered skin and skin covered by protective clothing was estimated to be 0.75 mg/lb ai on June 8, 1981, 1.3 mg/lb ai on June 9, 1981, and 4.1 mg/lb ai on June 11, 1981. The exposure to skin covered by protective clothing was estimated from residues of parathion on the inside layer of gauze that was covered by the outer coverall layer.

The concentration of PNP in the urine rose from 40 ppb prior to the first parathion application to 240 ppb after the first parathion application. PNP levels peaked at 610 ppb prior to the third application. Only slight decreases in plasma and RBC cholinesterase activity were detected. Potential inhalation exposure was 0.026, 0.052, and 0.045 mg/lb ai on June 8, 9, and 11, 1981, respectively.

3.2 CDFA AIRBLAST APPLICATOR EXPOSURE STUDY-RIVERSIDE COUNTY

Maddy, et al, ("Potential Exposure of Applicators to Parathion When Treating Citrus in Riverside County," CDFA, Worker Health and Safety Unit, March 19, 1984, Study Number HS-1059) monitored dermal and inhalation exposure and internal dosage to two airblast applicators spraying citrus with parathion by airblast equipment. Exposure during mixing/loading was not monitored. The two applicators were experienced in pesticide application and used a custom-built vehicle. The vehicle consisted of a truck chassis narrow enough to fit between the narrow rows of citrus trees. On the chassis were a spray tank and a vertically mounted boom 15 feet behind the driver. The open cab consisted of a metal roof and shower curtains on the sides. Parathion was applied at 5 lbs ai/acre at a spray volume of 1200 to 1800 gallons of spray/acre. A 25W wettable powder formulation was used. The Assistant Director of the Division of Pest Management, CDFA, has interpreted EPA regulations to permit alternate means of protecting the worker if the alternate means mitigate exposure equally or superior to EPA label requirements. CDFA recognizes that the use of label required waterproof clothing may be difficult to comply with during the summer, due to heat stress; therefore, exposure was monitored for the applicators using a semi-enclosed application vehicle rather than the label required protective clothing.

Each applicator wore clean, long-sleeved cotton t-shirts, cotton leggings, and polyester/cotton coveralls. The t-shirts, leggings, and coveralls were analyzed for parathion residues. The applicators also wore leather gloves. Hand exposure was monitored by hand rinses. Inhalation exposure was measured by an air sampler containing XAD-4 resin and glass fiber filters through which air was drawn through at a rate of 2 l/min.

Internal dosage of parathion was measured by collecting total urine output from application until 24 hours post-sampling. Pre-application urine samples were also collected. The time of collection and urine volumes were recorded. The urine was analyzed for PNP. The actual amount of parathion absorbed is calculated by multiplying PNP by 2.09. (Elliot, J.W., et al., A Sensitive Procedure for Urinary p-Nitrophenol Determination as a Measure of Exposure to Parathion, Agric. Food Chem., 8(2):111-113, 1960)

Inconsistencies in labeling prevented the use of the urine data for the first applicator. The second applicator excreted 7,194 ug of PNP over a 55.25 hour monitoring period. This is equivalent to an internal dosage of 15,035 ug of parathion. Applicator #2 applied parathion for eight hours a day for two days. Since he sprayed 1.5 acres/hr at five lbs ai/acre, the applicator sprayed approximately 120 lbs ai (1.5 acres/hr x 8 hrs/day x 2 days x 5 lbs ai/acre = 120 lbs/ai). The internal dosage of parathion is estimated by EAB to be 125 ug/lb ai.

The total dermal exposure can be represented by the quantity of parathion recovered from the coveralls and the hand rinses. The total potential dermal exposures for the three replicates were 2.1 mg/lb ai, 1.1 mg/lb ai, and 11 mg/lb ai assuming each individual handled 60 lbs ai daily. The dermal exposure to the skin can be represented by the parathion residues recovered from the cotton t-shirts and leggings worn under the coveralls and the hand rinses. The dermal exposures for the three replicates were 0.10 mg/lb ai, 0.048 mg/lb ai, and 0.32 mg/lb ai. Facial exposure was not incorporated into the exposure estimates because of the methodology involved. The breathing zone parathion concentrations were calculated on an eight-hour TWA to be 12.4 ug/m^3, 14.8 ug/m^3, and 53.1 ug/m3.

3.3 UC-RIVERSIDE OSCILLATING BOOM AND AIRBLAST EXPOSURE STUDY

Carmen, G.E. et al, ("Pesticide Applicator Exposure to Insecticides During Treatment of Citrus Trees with Oscillating Boom and Airblast Units," Department of Entomology, University of California at Riverside, and Arch. Environ. Contam. Toxicol., 11:651-9, 1982) measured the dermal and inhalation exposure to applicators applying parathion or dimethoate to citrus trees by oscillating booms and airblast equipment. Urine samples were collected and analyzed for dialkylphosphate and thiophosphate levels. EAB has not calculated internal dosage based on dialkylphosphate and thiophosphate levels since the Toxicology Branch believes these metabolites are not specific for parathion but are also metabolites of other organophosphates as well.

Dermal exposure was monitored by gauze sponges attached to the upper chest, nape of the neck, top of each shoulder, upper arms, forearms, and thighs. The patches were placed outside the outer clothing and, therefore, predict potential exposure to a person not protected by clothing. Hand exposure was not monitored, so the results of the individual replicates are useful in comparing to other replicates within the study. Because many different vehicle cab types were studied, the Carmen study provides insight into the efficiency of different cab types in reducing exposure. Inhalation exposure was monitored by placing impingers containing ethylene glycol on the subject's chest. Airflow through the impingers was at a rate of 2.7 l/min.

Eight replicates were performed in which parathion was applied to lemon and orange trees by oscillating boom. The applicator was either in an open cab tractor, or a closed cab tractor with open windows, a closed cab tractor with closed windows and unfiltered air, or a closed cab tractor with closed windows and filtered air. There were two replications for each cab type to yield the eight total replications. The density of citrus trees was 115 trees/acre. An emulsifiable concentrate was applied at 6.8 to 7.6 lb ai/acre in a volume of 1800-2000 gallons spray/acre at 500 psi and 66 oscillations/min. The spraying was single-sided, and the forward direction of the spray equipment was 1.4 mph. Each replicate involved the spraying of 2500 gallons of finished spray which contained 9.5 lb of parathion.

The parathion deposition on the patches was presented by Carmen in ug/cm^2/hr. By adjusting for body surface area and incorporating the application times, EAB was able to calculate potential dermal exposure, excluding the hands. Mean air concentrations were provided by Carmen. The potential dermal exposures and mean air concentrations are provided as follows:

POTENTIAL DERMAL EXPOSURE (EXCLUDING HANDS) AND MEAN AIR CONCENTRATIONS OF PARATHION DURING OSCILLATING BOOM APPLICATION TO CITRUS TREES

Vehicle Description	Potential Dermal Exposure mg/hr	Potential Dermal Exposure mg/lb ai	Mean Air Concentration (ug/m^3)
Open Tractor	63	6.3	68
	25	3.9	60
Cab, Open Windows	18	2.5	93
	13	1.6	71
Cab, Closed Windows	0.29	0.038	12
	0.38	0.059	11
Cab, Closed Windows, Filtered Air	0.21	0.024	6
	0.13	0.019	4

A total of 23 replicates were conducted in which emulsifiable or wettable powder formulations of parathion were applied by airblast to lemon and orange trees. An FMC 757 Speed Sprayer was used and, as with the oscillating boom, a variety of cab types were used. The use conditions, potential dermal exposures (excluding hands), and mean air concentrations of parathion are provided in Table 1.

Table 1.

POTENTIAL DERMAL EXPOSURE (EXCLUDING HANDS) AND MEAN AIR CONCENTRATIONS OF PARATHION DURING AIRBLAST APPLICATION TO CITRUS TREES

Replicate	Delivery	Vehicle Descr.	Lbs ai	Potential Dermal Exposure mg/hr	Potential Dermal Exposure mg/lb ai	Mean Air Conc. (ug/m^3)
9	One-side	Open Tractor	9.5	3.0	0.48	12
10	One-side	Cab, Open Windows	9.5	3.7	0.53	45
11	One-side	Cab, Closed Windows	9.5	0.12	0.025	4
15	One-side	Open Tractor	9.5	18.6	2.3	43
16	One-side	Open Tractor	9.5	4.5	0.62	19
17	One-side	Open Tractor	9.5	36.4	4.9	40
18	One-side	Open Tractor	9.5	68.3	9.1	43
19	One-side	Truck, Open Windows	9.5	23.7	3.1	28
20	One-side	Truck, Open Driver Window	9.5	6.6	0.98	6
21	One-side	Truck, Open Pass. Window	9.5	1.4	0.19	8
22	One-side	Truck, Closed Windows	9.5	0.14	0.018	7
27	One-side	Cab, Open Pass. Window w/ grid	4.75	0.15	0.038	5
28	Two-side	Cab, Open Pass. Window w/ grid	4.75	0.28	0.074	5
29	Two-side	Open Tractor	9.5	37.0	4.1	53
30	Two-side	Tractor, Open Canopy	9.5	21.0	2.3	53
31	Two-side	Cab, Open Windows	9.5	8.4	1.1	3
32	Two-side	Cab, Open Driver Window	9.5	16.0	1.9	53
33	Two-side	Cab, Open Pass. Window	9.5	0.71	0.083	13
34	Two-side	Cab, Closed Windows	9.5	0.02	0.003	4
35	Two-side	Cab, Open Pass. Window w/ grid	4.75	0.02	0.004	5
36	Two-side	As Above	0.95	0.073	0.045	9
37	Two-side	As Above	9.4	0.38	0.037	28
38	Two-side	As Above	9.5	0.61	0.035	36

3.4 CHEMINOVA ETHYL PARATHION MIXER/LOADER APPLICATION STUDY

Cheminova submitted a mixer/loader, applicator exposure study on November 2, 1987, in which parathion was applied by ground boom to cotton and sorghum, aerially to sorghum and cotton, and by airblast to apples, pears, and olives. The study was conducted by Pan-Agricultural Labs, Inc., and involved nine application sites in five states. Dermal exposure was monitored by 12-ply gauze patches attached outside the workers' clothing on the forearms, shins, thighs, shoulders, upper back, and upper chest. Hand exposure was monitored by hand rinses. The dermal exposure was measured on eight mixer/loaders for a combined total of 23 replicates. The mixer/loaders handled either a wettable powder or emulsifiable concentrate formulation and used either open pour or closed mixing/loading techniques. Attachment 2 provides details of the individual replications. Dermal exposure was also monitored for four pilots for a combined total of 11 replications. (See Attachment ~~3~~ 2 for details.)

Internal dosage was monitored by collecting 48-hour urine voids and analyzing the urine for PNP. Urine was collected from the eight mixer/loaders, four pilots, four ground boom applicators, and three airblast applicators. The mixer/loaders and ground applicators wore rubber boots, waterproof sleeveless coveralls, waterproof coats, chemical-resistant gloves, waterproof hats with neck shields, face goggles, and NIOSH-approved respirators. Shirts and pants were worn under the protective gear. The pilots did not wear the chemical-resistant clothing. They wore a shirt, coveralls or flight suit, long pants or shorts, tennis shoes, and flight helmets.

The potential dermal exposure to the mixer/loader handling the emulsifiable concentrate formulation of parathion by open pour averaged 64 ug/lb ai with the exclusion of the aerial mixer/loader from Welch, Texas. This individual had parathion rinseate accidentally run down his arm. The rinseate went over the protective glove and down the right sleeve of the waterproof jacket. The mean potential dermal exposure to this individual was 911 ug/lb ai. When a closed loading system was used, the mean potential dermal exposure was 5.8 ug/lb ai. All mixer/loaders handling the wettable powder used open pour loading of parathion. The mean potential dermal exposure of these mixer/loaders was 5,300 ug/lb ai.

An evaluation of the internal dosage provides an estimation of the parathion exposure occurring under the extensive protective gear worn by the mixer/loaders. The internal dosage for the four mixer/loaders handling the emulsifiable concentrate by open pour was 2.4 ug/lb ai. The four data points included two mixer/loaders with nondetectable levels of PNP and the mixer/loader from Welch who spilled parathion. The internal dosage of the individual with the spill was 1.2 ug/lb ai which indicates that thorough scrubbing of the individual's arm immediately after the spill occurred was effective in limiting the internal dosage. The internal dosage of the mixer/loader using the closed loading system was below the detection limit. For the three mixer/loaders handling the wettable powder formulation, two had nondetectable levels of PNP in their urine and the third individual had an internal parathion dosage of 3.0 ug/lb ai. The low dosages of parathion compared to the high potential exposures for the mixer/loaders handling the wettable powder suggests that the protective equipment in combination with possibly low dermal absorption of the wettable powder greatly reduced the amount of parathion, potentially available for absorption, from actually being absorbed into the body.

The potential dermal exposure for the three pilots using aircraft with enclosed cockpits averaged 1.7 ug/lb ai. The fourth pilot used an open cockpit biplane and received a potential dermal exposure of 26 ug/lb ai. The internal dosage for two of the pilots applying parathion from enclosed cockpits was below detectable levels, while for the third pilot, the internal dosage was 1.4 ug/lb ai. The internal dosage for the pilot flying the open cockpit biplane was 1.7 ug/lb ai; however, the reliability of this dosage estimate is suspect since the pilot had applied parathion just prior to participating in the study. The pilot had initially denied doing such until pressed on the issue after the preapplication urine sample showed appreciable levels of PNP.

Internal dosages of parathion were measured for the ground applicators. Details are provided in Attachment 4. Four applicators applied parathion by ground boom equipment. The internal dosages to three of the ground boom applicators were below detection limits. The fourth ground boom applicator had an internal dosage of 1.6 ug/lb ai. This individual, unlike the other three, had to perform maintenance on clogged spray nozzles during the application. Three applicators applied parathion to orchard crops by airblast spraying. They used either open cabs or closed cabs with open windows. The internal dosage of parathion to the airblast applicators averaged 6.8 ug/lb ai.

3.5 SUMMARY OF EXPOSURE DATA

EAB, as previously discussed, evaluated four studies in which the exposure to parathion was monitored. The four studies monitored exposure during the mixing/loading and application processes and involved various types of equipment, formulations, work practices, environmental conditions, and protective gear. These variables are important because they reflect the wide range of variables that occur during everyday use of parathion.

Mixer/loaders using open and closed loading systems for the emulsifiable concentrate and using the wettable powder formulation were studied. The exposures to mixer/loaders handling the emulsifiable concentrate are summarized as follows:

Open Pour;	Total Potential Exposure: Range = 17-129 ug/lb ai	Mean = 64 ug/lb ai Spill = 911 ug/lb ai
Closed Loading;	Total Potential Exposure:	5.8 ug/lb ai
Open Pour;	Internal Dosage: Range = nondetectable-8.5 ug/lb ai	Mean = 2.4 ug/lb ai
Closed Loading;	Internal Dosage:	Not detectable

The exposures to the mixer/loaders handling the wettable powder are as follows:

Total Potential Exposure:	Mean = 5,300 ug/lb ai Range = 370-13,200 ug/lb ai
Internal Dosage:	Mean = 1.0 ug/lb ai Range = nondetectable-3.0 ug/lb ai

These data indicate that the WP produces a higher potential exposure than the open pour loading of the EC. The use of a closed loading system reduced the potential exposure to mixer/loader approximately one order of magnitude. The reduction of potential dermal exposure by a closed loading system as compared to open pouring is consistent with reductions previously estimated from non-parathion data evaluated by EAB. A review of the internal dosages indicates that the EC open pour, EC closed loading system, and WP dosages were similar. The similarity of the dosages as compared to the differences with potential dermal exposure suggests that the protective clothing used or the closed loading system were both effective in reducing parathion body burdens.

A review of pilot exposure indicated that potential dermal exposure to pilots in enclosed cockpits was 1.7 ug/lb ai (range 1.4-2.2 ug/lb ai). The potential dermal exposure to the pilot in an open cockpit was 26 ug/lb ai or about one order of magnitude greater than the pilots in the enclosed cockpit. The internal dosages for all pilots averaged 0.78 ug/lb ai (range: non-detectable to 1.7 ug/lb ai).

The ground boom applicators all had low internal dosages of parathion, regardless of the tractor type. Three applicators had nondetectable levels of PNP and the fourth applicator, who had to repair a clogged nozzle, had a dosage of 1.6 ug/lb ai. It should be noted that the four applicators wore clean waterproof protective clothing which appears to provide an efficient barrier to parathion when properly used.

The airblast applicators generally received the greatest potential dermal exposure and internal dosages of the job functions evaluated. No differences were noted between the oscillating boom and airblast methods of spraying trees. The use of a truck instead of a tractor did not appear to affect exposure. The use of an enclosed cab appeared to have a significant effect on reducing potential dermal exposure.

The potential dermal exposure to airblast sprayers are summarized as follows:

Open tractor: Mean = 3,800 ug/lb ai
Range = 480-9,100 ug/lb ai, 9 replicates

Open cab, canopy, shower curtain:
Mean = 4,700 ug/lb ai
Range = 1,100-11,000 ug/lb ai, 3 replicates

Cab, open windows: Mean = 1,400 ug/lb ai
Range = 530-2,500 ug/lb ai, 4 replicates

Truck, open windows: 3,100 ug/lb ai, 1 replicate

Cab, open driver window: 1,900 ug/lb ai, 1 replicate

Truck, open driver window: 980 ug/lb ai, 1 replicate

Cab, open passenger window: Mean = 45 ug/lb ai,
Range = 4-83 ug/lb ai, 7 replicates

Truck, open passenger window: 190 ug/lb ai, 1 replicate

Cab, closed windows: Mean = 28 ug/lb ai,
Range = 3-59 ug/lb ai, 6 replicates

Truck, closed windows: 18 ug/lb ai, 1 replicate

Although the potential dermal exposure to the driver of vehicles with the passenger window open is similar to that of drivers with closed windows, this is deceptive. Pads placed on the passenger side show that significant contamination to the right side of the cab is occurring. The above data also indicate that opening the windows on an enclosed cab negate the potential protective value of the enclosed cab.

The internal dosage of the airblast applicator using an open cab with shower curtains and not wearing waterproof protective clothing was relatively high at 125 ug/lb ai. The internal dosage of three airblast applicators wearing waterproof protective clothing in open cabs or an enclosed cab with open windows was much less than the unprotected airblast applicator. The mean internal dosage of these three airblast applicators was 6.8 ug/lb ai (range: 5.3-8.3 ug/lb ai).

It is interesting to note that the pilots and ground boom applicators tended to have nondetectable levels of parathion in the body while the airblast applicators in open cabs wearing waterproof protective clothing are receiving relatively higher dosages of parathion. This may be a result of parathion spray running down inside the protective clothing from the drenching nature of airblast application.

4.0 STRATEGIES FOR REDUCING WORKER EXPOSURE TO PARATHION

As clearly illustrated by the poisoning incidents involving parathion, this insecticide is very capable of producing serious systemic illness with sufficient exposure. The 1987 Farm Chemicals Handbook lists the dermal LD_{50} (rat) for parathion as 55 mg/kg, which is in Toxicity Category I. A chemical with the toxicity demonstrated by parathion requires controls to reduce the potential exposure to the handler and, therefore, reduce the risk.

Traditionally, health and safety experts have ranked controls according to their reliability and efficiency in removing or controlling a hazard. This hierarchical approach involves first attempting to control the hazard as close to the source as possible and then moving as a secondary option toward protecting people on an individual basis. The Office of Technology Assessment (OTA) of the U.S. Congress issued a report in April 1985 entitled "Preventing Illness and Injury in the Workplace" (OTA-H-256). The report reviewed the hierarchy of controls for reducing worker hazard and stated the views of health professionals as follows:

> The hierarchy of controls is widely supported in the professional community. Every current industrial hygiene textbook endorses the idea of such a hierarchy and lists engineering controls as the first priority and personal protective equipment as a last resort. It is often expressed in the context of controlling exposures to airborne contaminants - fumes, dusts, and vapors - that may enter the work's respiratory system. Elimination of the contaminants by substitution of materials, enclosure of operations that generate fumes and vapors, dust suppression methods, or dilution of the contaminants by ventilation are all preferred over reliance on

respirators. Leaders in this field and industrial hygiene texts all agree on this point.

The hierarchical approach described by OTA can be readily transferred from its intended industrial setting to an agricultural setting. Elimination of the contaminants by substitution is analogous to cancellation of the pesticide's registration and subsequent replacement by alternative pesticides. The enclosure of operations generating fumes, etc., or dilution of the contaminants are engineering controls. The agricultural equivalent would consist of enclosure of the pesticide during mixing/loading operations, i.e., closed loading systems for liquids or water-soluble packages for wettable powders; enclosure of the applicators in enclosed vehicles; or improvement in application methods that would increase target efficiency and, therefore, reduce or dilute the amount of off-target pesticide available for worker exposure and drift. Finally, the reliance on respirators in an industrial setting can be expanded to include the reliance on respirators and protective clothing in the agricultural setting.

Traditionally, the regulation of occupational safety hazards from pesticides to humans has involved implementing protective clothing requirement as a first option, rather than the last option. If protective clothing is determined to provide inadequate safety, then cancellation or reduction in application rates for the use of concern is required. Parathion has followed the pattern of first implementing protective clothing requirements.

Shortly after the creation of EPA in December 1970, the predecessor of the Office of Pesticide Programs evaluated the hazards resulting from the use of parathion. During the 1960s, the use of chlorinated hydrocarbon insecticides, such as DDT, was decreasing and these insecticides were being replaced by the organophosphates. Some of the organophosphates, such as parathion, were extremely toxic and the U.S. Department of Agriculture became concerned about parathion poisonings and deaths. The regulatory responsibility for parathion was transferred to EPA from USDA and on April 5, 1971, EPA took its first regulatory action concerning parathion. In 1971, EPA was still operating under the 1947 Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) which limited the Agency's jurisdiction with respect to safety to the labeling of parathion products. To reduce the incidence of poisonings from parathion use, the April 5, 1971, notice (PR Notice 71-2) required the use of "(1) waterproof pants, coat, hat, rubber boots or rubber overshoes, (2) safety goggles, (3) mask or respirator approved by the U.S. Bureau of Mines for parathion protection, (4) heavy duty, natural rubber gloves." In preparing the 1986 reregistration document, the Agency became aware of the shortcomings of the protective clothing requirements. In response, the reregistration document labeling requirements permitted the use of engineering controls as an alternative to the waterproof protective clothing.

5.0 EVALUATION OF PROTECTIVE CLOTHING

As demonstrated by the parathion exposure data, properly used protective clothing can be efficient in reducing the exposure received by the pesticide handler. In addition, protective clothing is relatively inexpensive and, therefore, more accessible to pesticide users. There are several major disadvantages of extensive protective clothing requirements that concern EAB, especially in respect to the waterproof, chemical-resistant protective clothing, such as raincoats and Tyvek suits.

A review of protective clothing use surveys indicates that compliance with extensive label required protective clothing is not high. A.C. Waldron ("Minimizing Pesticide Exposure Risk for the Mixer-Loader, Applicator, and Field Worker," Dermal Exposure Related to Pesticide Use, American Chemical Society Symposium Series 273, 1985, pp. 413-425) surveyed Ohio farmers and estimated that 38 percent of farmers applying highly toxic pesticides used gloves. This contrasts to 81 percent of the mixer/loaders. Waldron also specifically looked at parathion users. The use of gloves, long-sleeved shirts, and hats was high at 83, 74, and 87 percent respectively, for both mixer/loaders and applicators. Minimal compliance was found for the label required spray suit, rubber boots, eye protection, and respirator. The percentage of farmers using this equipment was as follows:

Protective Gear	Mixer/Loader	Applicator
Spray Suit	30%	39%
Rubber Boots	26%	26%
Eye/Face Shield	35%	22%
Respirator	35%	35%

V.B. Keeble, et al ("Clothing and Personal Equipment Used by Fruit Growers and Workers When Handling Pesticides," ASTM, in press) surveyed apple growers in Virginia who used parathion. A total of 51 percent of the growers used protective gloves. The compliance with the other label required protective equipment was even less with 19 percent using waterproof pants, 35 percent using waterproof coats or waterproof coats with hoods, 23 percent using waterproof boots, 21 percent using goggles, and 45 percent using respirators. The poor compliance did not result from ignorance of parathion's toxic potential since 93 percent of the growers recognized that parathion is a very hazardous pesticide. Keeble stated that the poor compliance may have resulted from growers employing other unstated safety practices which they believed obviated the need for protective gear or that they may have chosen comfort over protection. Heat discomfort may be a critical factor. Respirators and gloves were used by nearly half the growers, while waterproof pants and coats were worn by 19 to 35 percent of the growers. Respirators and gloves are less restrictive than the coat and pants in blocking dissipation of body heat.

Heat stress from the use of waterproof protection suits is a major concern with an insecticide like parathion which is used predominantly in the summer months. Arthur D. Little, Inc. (Manual for Selecting Protective Clothing for Agricultural Pesticide Operations, EPA Project No 68-03-3293, Work Assignment 0-09, 1986) evaluated the heat stress issue for the Agency and has developed a heat stress model. The model relates to a hypothetical 1.7m, 70 kg, 25-year-old male applicator doing light work, such as driving a tractor, in a 20°C and 50 percent relative humidity environment. Based on the model, a nude individual would obtain an equilibrium rectal temperature of 37.7°C. An individual in a long-sleeved shirt and long pants would achieve an equilibrium rectal temperature of 38.0°C. The use of a Tyvek coverall over a shirt and pants was predicted to produce an equilibrium rectal temperature of 38.3°C.

The EPA Standard Operating Safety Guides (Office of Emergency and Remedial Response, Hazardous Response Support Division, Edison, New Jersey, November 1984) states that internal body temperature in excess of 38.3°C is a sign of heat stress in which excessive fatigue, physical exhaustion, and dizziness can occur. Such symptoms reduce the alertness of the applicator and are a definite hazard during pesticide applications. The California Department of Food and Agriculture has recognized the threat of heat stress from chemical-resistant or waterproof protective suits. The 1986 amendments to Title 3 of the Administrative Code, State of California, prohibits the use of this type of protective clothing at ambient temperatures in excess of 85°F (80°F in sunlight) unless a cooling source is provided.

Protective clothing has the potential to greatly reduce exposure when properly used. Proper use is extremely important and less than proper use will reduce the efficiency of the protective gear. Maddy, et al. ("Risk Assessment of Excess Pesticide Exposure to Workers in California," Dermal Exposure Related to Pesticide Use, American Chemical Society Symposium Series 273, 1985, pp. 445-465) found that workers wearing waterproof gloves experienced hand exposure that accounted for 40.9 percent of the total dermal exposure. Maddy concluded that the relative ineffectiveness of gloves may have resulted from contamination of the inside of the glove, removal of gloves during mechanical adjustments to equipment, and the handling of the contaminated outside of the gloves while taking them on and off.

Nigg, et al. ("Dicofol Exposure to Florida Citrus Applicators:

Effects of Protective Clothing," Arch. Environ. Contam. Toxicol. 15:121-134, 1986) studied the protective value of protective clothing under actual use conditions over a six-week period. Nigg determined that an ungloved airblast applicator wearing a cotton coverall reduced the total dermal exposure 38 percent by wearing a Tyvek suit, 27 percent by wearing protective gloves, and 65 percent by wearing both. Mixer/loaders reduced total dermal exposure 40 percent by wearing the Tyvek suit, but increased total dermal exposure 9 percent by wearing protective gloves. Nigg believes that the increase in exposure from the use of protective gloves resulted from the intermittent removal of the gloves by mixer/loaders. The workers also refused to wear the Tyvek suits after July 18 because of heat discomfort.

The advantages of chemical-resistant protective clothing are the relatively inexpensive cost and the efficient reduction in potential exposure with proper use. The disadvantages are lack of use from discomfort and inconvenience, heat stress in hot weather, and failure of the equipment to provide maximum protection from poorly fitting equipment or improperly used equipment.

6.0 EVALUATION OF ENGINEERING CONTROLS

The use of engineering controls as a means of reducing worker exposure during the handling of pesticides has not been commonly employed as a regulatory requirement. In its broad sense, the term "engineering control" is defined as any mechanical method that provides a barrier between the pesticide handler and the pesticide. This definition is intended to encompass as examples closed loading devices, water-soluble packing for wettable powder formulations, enclosed tractor cabs, boom shielding, or adjustments to the spray nozzle and delivery systems that will increase target efficiency and reduce spray drift.

California has the most extensive engineering control requirements in the United States at this time. Shortly after the development of pesticide worker safety regulations in 1972 (Chapter 794), an investigation of pesticide illnesses was conducted. The investigation noted that handlers of the more toxic undiluted pesticides were having the greater number of serious illnesses. The state concluded that the open pouring of the more toxic liquid pesticides should be eliminated. Increased use of protective clothing and equipment was rejected for four reasons:

1. General industrial hygiene practice prefers that engineering measures be taken to increase the safety of workers before resorting to body protection.

2. There is an inherent difficulty in wearing increased amount of protective clothing due to the warm

temperatures that are prevalent in large portions of California during the time of highest pesticide use.

3. The possible attitude of "It can't happen to me. Protective clothing is a needless bother."

4. The remoteness of many worksites and the continual pressure for rapid completion of the treatment contributes to carelessness in the use of protective equipment.

Therefore, commercial pest control operators were required to use closed loading systems beginning on April 1, 1977. The same requirement for growers and others began on July 1, 1977.

CDFA found that initial reaction to the closed system requirement was swift and negative. This resulted from lack of availability of equipment due to the inability of industry to produce sufficient quantities of the equipment to meet demand. Container conformity also presented a problem. A given system was not compatible with all pesticide containers. The conformity problem was evident in the Cheminova parathion exposure study. The use of "barrel suckers" in which probes are punched into metal pesticide containers is a common loading system. Currently, a shift from metal containers, which present splashing problems during open pouring, to two and a half gallon wide mouth plastic containers, which pour much more easily, appears to be occurring. The plastic jugs shatter or crack if stabbed with a probe and users don't like hand coupling a hose to the plastic container opening. This resulted in the Helm, California, mixer/loader violating the California closed system requirement. The lack of container conformity can seriously hinder the effectiveness of a closed loading system requirement.

As a result of the initial negative response, California instituted incentives for the use of closed systems. The state's medical supervision requirements were relaxed for individuals using closed systems exclusively. The changes were based on field findings of the benefits of using closed systems. A second incentive was to reduce the Federal and state required protective clothing when using closed loading systems. On May 10, 1982, EPA attacked this incentive when it issued FIFRA Compliance Program Policy No. 12.2, Closed Application System. This program promised enforcement action for violation of Federal label protective clothing requirements. This position was partially rescinded on December 15, 1983, based on California requiring that protective equipment be available on site, training of operators, and conducting inspections of the equipment. The concept of permitting less stringent protective clothing was adopted in the Agency's 1986 reregistration standard for users of closed loading systems and enclosed vehicles.

The effectiveness of the California closed loading requirement for Toxicity I liquid pesticides in reducing mixer/loader illnesses is evidenced in the incidence of illnesses reported below:

PESTICIDE MIXER/LOADER ILLNESSES IN CALIFORNIA

Year	Toxicity Category I	Other	Total
1985	16	62	78
1984	17	68	85
1983	22	74	96
1982	31	96	127
1981	52	69	121
1980	50	66	116
1979	73	59	132
1978	89	53	142
1977	85	60	145
1976	75	47	122

CDFA has concluded that the closed loading system requirement has succeeded in reducing or eliminating handpouring of certain pesticides, but has been less successful in ensuring the use of a system meeting certain state criteria (Rutz, R., Closed System Acceptance and Use in California, CDFA, Worker Health and Safety Branch, Report No HS-1393, August 14, 1987).

The use of enclosed cabs has been shown to significantly reduce the exposure to the applicators by placing a physical barrier between them and the pesticide spray. The Carmen study discussed in Section 3.3 investigated the reduction in exposure from the use of enclosed vehicles during airblast or oscillating boom applications. The potential dermal exposure was decreased from 3,800 ug/lb ai when an open cab was used to 28 ug/lb ai for an enclosed tractor cab and 18 ug/lb ai for a truck with closed windows. The decrease in actual dermal exposure would be expected to be less since clothing would already provide a partial barrier to the amount of pesticide reaching the skin.

Wojeck, G.A., et al. ("Worker Exposure to Paraquat and Diquat," Arch Environ. Contam. Toxicol., 12:65-70, 1983) measured the dermal and inhalation exposure to ground boom applicators. The applicators in open tractor cabs received a dermal exposure of 169 mg/hr compared to an exposure of 27 mg/hr for applicators in an enclosed, air-conditioned tractor cab. The enclosed cab produced six-fold reduction in dermal exposure as all other application parameters were essentially the same. Inhalation exposure was similarly reduced from 0.07 mg/hr with the open tractor to 0.01 mg/hr with the enclosed cab.

Other engineering controls may also provide reduction in exposure, as evidenced by Wojeck. Applicators on high-clearance tractors without cabs had dermal and inhalation exposures of 18 mg/hr and 0.02 mg/hr, respectively. Paraquat applied from open tractors in which the spray booms were shielded produced mean dermal exposures of 29 mg/hr and 12 mg/hr at two application sites. The inhalation exposures were 0.01 mg/hr and nondetectable.

Engineering controls applicable for agriculture suffer some disadvantages, in addition to the advantages. California's experience with closed loading systems illustrates some of the problems. Problems likely to limit the implementation of application engineering controls would include the expense of some large enclosed cab tractors, size compatibility of the equipment with the crop it is used with, and availability of required equipment if it becomes required for use. Also, the need to have some form of protective clothing available during application would still exist. The protective clothing would be necessary during repair of the spray equipment as an example.

7.0 CONCLUSIONS

A review of parathion poisoning incidents, exposure data, and protective clothing surveys has led EAB to conclude the following:

1. Parathion is a highly toxic pesticide that can and does produce serious systemic poisonings.

2. With proper use and protection, parathion can be safely handled by mixer/loaders and applicators.

3. Improper use and accidental exposure can produce serious illness.

4. Chemical-resistant protective clothing provides adequate safety to mixer/loaders handling the emulsifiable and wettable powder formulations and to ground boom applicators when clean, properly used protective gear is used.

5. The required chemical-resistant protective clothing does not completely protect airblast type applicators. This application method can drench the outside of the worker and allow parathion to leak in under the protective gear.

6. Engineering controls can reduce exposure and poisoning incidents.

7. The current label requirement for chemical-resistant protective clothing is commonly ignored.

8.0 PROPOSED REGULATORY OPTIONS

The Exposure Assessment Branch does not believe that reliance solely on chemical-resistant clothing provides an acceptable means for limiting the poisonings that occur from parathion use. For reasons previously discussed, this requirement is often ignored and in the case of airblast application, may not be adequate.

In order to limit exposure to workers, EAB recommends that the use of closed loading systems for liquid formulations, water-soluble packaging for wettable powders, and the use of enclosed vehicle cabs or other possible application engineering controls be required for parathion. During the period between issuance of a Position Document (PD) 2/3 and the PD 4, discussion with parathion user groups should be conducted to determine which specific engineering controls are most realistic for a given crop's cultural practices. Should such engineering controls not be currently practical, a transition period may be required during which the option of using chemical-resistant protective clothing or engineering controls would be acceptable. The label language presented in the 1986 reregistration document provides a framework for the requirement during such a transition period.

Ultimately, parathion use should only be permitted when engineering controls are in place. This would require that liquid formulations be mixed and loaded by closed loading systems. Wettable powder formulations would be packaged only in water-soluble bags. Airblast application would occur only from enclosed cab vehicles. Ground boom application appears to offer greater latitude in that in addition to enclosed vehicles; shielded booms, high-clearance tractors, or directed low pressure coarse spraying may provide adequate protection. Any final requirement for the use of engineering controls would still require the use of protective gloves and possibly other equipment (e.g., a face shield or chemical-resistant apron worn while closed loading systems are pressurized or during equipment repair). Again, it must be emphasized that the success of the above regulatory option will require input from user groups and university and equipment company agricultural engineers to permit EPA to institute feasible engineering control regulations.

Curt Lunchick
Curt Lunchick
Special Review Section
Exposure Assessment Branch
Hazard Evaluation Division (TS-769C)

ATTACHMENT 2 - MIXER/LOADER DATA

Missouri Aerial Mixer/Loader — Dave Hendrick

Repl. 1	383 ug
2	9168 ug
3	9770 ug
Total	19321 ug
Lb ai	150
Exposure	129 ug/lb ai
Internal Exposure	8.5 ug/lb ai

Mixing/loading used open and closed systems. 8EC was pumped through 3-foot hose into empty 2.5 gallon plastic containers. Contents emptied into mixing drum 1.5' diam. by 2 1/2' H. Water added by hose to drum. Contents of drum pumped into spray tank via hose.

Missouri Ground M/L — Jeff Brown

Repl. 1	2152 ug
2	1086 ug
3	204 ug
Total	3443 ug
Lb ai	75
Exposure	46 ug/lb ai
Internal Dosage	Not detectable

Mixing/loading by open and closed systems. 8EC in 55-gallon drum was pumped through 3' hose into empty 2 1/2 gallon containers. Container emptied into spray tank.

Alton, New York, Ground M/L — Jim Luke

Repl. 1	16,349 ug
2	23,387 ug
3	27,652 ug
Total	67,388 ug
Lb ai	30
Exposure	2,246 ug/lb ai
Internal Dosage	3.0 ug/lb ai

Mixing/loading by open pour 25 WP in 4-lb bags
Bags opened and poured into tank.

Bags ripped down 1 side and rinsed 2-3 times under water to fill tank.

Toppenish, Washington, Ground M/L — Jack Polumsky

Repl. 1	447 ug
2	978 ug
3	5237 ug
	6662 ug
Lb ai	18
Exposure	370 ug/lb ai
Internal Dosage	Not detectable

Mixing/loading open pour. 25 WP in 4-lb bags. Bags opened and poured into tanks. Bags rinsed 3x with water used to fill tanks.

MIXER/LOADER DATA (CONT.)

Fresno, California, Ground M/L — Ray Saldana

Mixing/loading open pour 25 WP
Bag opened and 1/2 bag emptied into tank.
Bags not rinsed.

Repl.	1	1709 ug
	2	34064 ug
	3	13632 ug
Total		49405 ug
Lb ai		3.75
Exposure		13175 ug/lb ai
Internal Dosage		Not detectable

Kerman, California, Aerial M/L — Pete Ramirez

Closed system M/L
8EC
Probe punched into steel can. Concentrate forced into mix tank. Cans rinsed 3x with rinseate forced into mix tank. Probe removed from can.

Repl.	1	528 ug
	2	704 ug
	3	272 ug
Total		1504 ug
Lb ai		260
Exposure		5.8 ug/lb ai
Internal Dosage		Not detectable

Helm, California, Ground M/L — Jose Flores

Open pour M/L
5-gallon steel drum poured into smaller plastic jug. The jug was emptied into spray tank

Repl.	1	170 ug
	2	230 ug
	3	210 ug
Total		610 ug
Lb ai		36
Exposure		17 ug/lb ai
Internal Dosage		Not detectable

MIXER/LOADER DATA (CONT)

Welch, Texas, Ground M/L

Ron Hobbs
Mixing/loading by open/closed pour

Repl. 1	382,224 ug	Spill	8EC in 5-gallon drums. Air vent punched into can and can poured into 55-gallon mix drum emptied by pump.
2	14,047 ug		
3	4,617 ug		
Total	400,889 ug		
Lb ai	440		
Exposure	911 ug/lb ai		
Internal Dosage	1.2 ug/lb ai		

ATTACHMENT 3 - PILOT DATA

Lars Ness   Clarence, Missouri   3 Replicates

Piper Pawnee spray aircraft used with 120-gallon tank. 21 nozzles/wing boom. #40 nozzles used. 40' spray swath. Application volume 2 gpa at 100 mph to grain sorghum

Dermal Exposure   1.4 ug/lb ai
Internal Dosage   Not detectable.

Dennis Hanson   Kerman, California   3 Replicates

Ayers Turbothrust aircraft. Largest and best spray plane in agriculture. Sealed cockpit with recirculation of cockpit air through filters during application. 72 spray nozzles on wing booms. 52' spray swath. Application volume 10 gpa at 115 mph at 50 psi to cotton.

Dermal Exposure   2.2 ug/lb ai
Internal Dosage   Not detectable

Glenn Miller   Kerman, California   3 Replicates

Same equipment and crop as Dennis Hanson

Dermal Exposure   1.6 ug/lb ai
Internal Dosage   1.4 ug/lb ai

Carl Tidwell   Welch, Texas   2 Replicates

Gruman Ag-Cat Open cockpit biplane with 285-gallon spray tank. Spray boom had 18 nozzles made up of A5 hollow core nozzles and #46 swirl plates. 60' spray swath. Application volume 1 gpa at 25 psi at 110 mph to grain sorghum

Dermal Exposure   26 ug/lb ai
Internal Dosage   worked with parathion just prior to study
pre-sample 34 ug
48-hr post samples 761 ug parathion
1.7 ug/lb ai

ATTACHMENT 4 - GROUND APPLICATOR DATA

Mark Sickel		Clarence, Missouri

525-gallon wheel-mounted sprayer pulled by International Harvester tractor with open canopy covered seat. Two booms with 8003E flat form nozzles at 35 psi delivered 20 gallons/acre. Ground speed 3 mph. 24' spray swath to 6" wheat stubble

Internal Dosage	Not detectable

Jeff Brown		Clarence, Missouri

Same equipment

Internal Dosage	Not detectable

Allen Kotuis		Alton, New York

FMC 587 Speedsprayer with 500-gallon tank. Equipped with 10 solid core nozzles per side. Delivered 100 gpa at 200 psi. Tractor speed 3 mph. Applied to Spy, Rome, and Greening apples 18' in height. 30' row spacing. Trees 25-50 years old. Speedsprayer pulled by John Deere 2440 cabbed tractor in which the door and rear windows were open.

Internal Dosage	8.3 ug/lb ai

Paul Rush		Toppenish, Washington

Orchardmaster with 400-gallon sprayer and 29-inch fan and 6 D-4 nozzles with #25 swirl plates per side. Delivered 100 gpa at 150 psi. Forward speed 1.5 mph. Trees - 10'-15' Bartlett and D'Anju pears of various row spacings. Orchardmaster pulled by John Deere 2040 open cab tractor.

Internal Dosage	6.8 ug/lb ai

Elipido Flores		Fresno, California

Air-O-Fan 500-gallon sprayer with 42" fan. 27 nozzles of various types per side. Delivered 1500 gpa at 120 psi. Forward speed 0.25 mph. Spray reaches 40' in height. Applied to 70-year-old olives 25' high and 42' center spacings. Tractor was a John Deere 2040 open cab tractor.

Internal Dosage	5.3 ug/lb ai

GROUND APPLICATOR DATA (CONT.)

Willy Redman Helm, California

A John Deere 6000 High Clearance Spray rig was used to treat cotton. The tractor had a closed, air-conditioned cab that circulated unfiltered air. The booms consisted of 54 nozzles of a #33 swirlplate and D-3 hollow cone tip. Cotton sprayed at 26 gpa at 25 psi. Forward speed 5.5 mph. 320-gallon spray tank.

Internal Dosage 1.6 ug/lb ai
Willy Redman performed maintenance of clogged nozzles during application.

Edwin Hensen La Mesa, Texas

John Deere Hi Cycle sprayer used. Same unit as in Helm, California. Used 20 flat fan 8004E nozzles. Sorghum was sprayed at 4 gpa at 25 psi. Forward speed 10 mph.

Internal Dosage Not detectable

ISSUE: ACUTE POISONING OF MIXER/LOADERS, APPLICATORS, FIELDWORKERS AND THE PUBLIC TO ETHYL PARATHION

This paper deals with poisonings occuring from the use of ethyl parathion. It discusses new information received one day prior to the 9 January 1986 policy group meeting and other information received after the policy group meeting. Although it is specific to ethyl parathion, similar situations exist for the use of mevinphos (Phosdrin). The majority of the data is reported from California which has tighter parathion regulations than other states. Therefore the California data represent a best case situation.

California is the only state that has compulsary reporting for pesticide injuries. An analysis of the poisoning reports has lead CDFA to conclude that "ethyl parathion and mevinphos in particular are responsible for most of the serious poisonings." CDFA further concluded that ethyl parathion causes human illnesses in numbers of persons exposed as users and field workers in proportions far out of line to its usage as compared to other pesticides.

Systemic poisonings from parathion in California are reported below for the period 1976 to 1981.

Job Catagory	1976-1978	1979-1981	Total
Ground Applicator	19	18	37
Pilot	2	0	2
Mixer/Loader	23	9	32
Field Worker	28	6	34
Total Reported	119	53	172

A drop in poisonings has occurred in the second reporting period for mixer/loaders and field workers. This drop corresponds to California increasing reentry intervals, requiring a closed loading system for liquid formulations, and requiring a reformulation of the powder formulations to reduce dustiness. Ground applicator poisonings remained steady. Hearings are scheduled in February 1986 on CDFA's proposed requirement for closed cabs for ground applications.

Based on California's experience, the issue of reformulating the powders nationwide appears realistic. The registrants in California were given 30 days to reformulate the powder formulations or face state cancellation. California formulation plants complied by increasing the mineral oil content of the powders. This has given the powder formulations the consistency of brown sugar and reduced the dustiness.

Based on the California data the label amendments proposed at the 9 January 1986 policy group meeting would be expected to reduce the incidences of parathion poisonings nationally. However, a baseline of poisonings would still be expected to occur despite the label changes. As is evident from the attached examples of poisoning reports, the illness can be quite severe and require hospitalization. Continued poisonings are to be expected regardless of label amendments to increase worker protection for the following reasons:

1) Failure to follow label requirements.
2) Equipment failure such as hose rupture on closed loading systems.
3) Improper use of protective clothing worn due to lack of education on proper use or due to heat stress and inconvenience.
4) Expected exposure due to unavoidable contact with spray drift.
5) Unpredictability of the fate of parathion after application. Keith Maddy stated that some soils in California so effectively convert parathion to paraoxon that field workers are poisoned within 2 hours from dust contact with the ankles.

I believe that sufficent evidence exists, based on California data, that one can conclude that parathion presents a clear risk of serious illness to workers based on its acute toxicity. The individual incidence reports indicate that individuals in the general public are being poisoned by parathion drift. Further, the toxicity is so great that a certain undefined incidence of serious poisonings will continue despite any improvements in the label language.

More expensive and much less toxic alternative insecticides are available. In Florida, Coca-Cola and the Farm Workers Union contract stipulates that Coke will not use parathion on the citrus crops.

The policy question facing OPP therefore is: What is an acceptable level, if one exists, of serious poisonings from parathion use that will justified by the benefits of parathion use?

OPTIONS:

1) Based on the fact that parathion use will continue to produce some level of serious poisonings in humans regardless of label amendments and that less toxic alternatives exist; all registrations of parathion should be cancelled immediately.

2) Based on the acute injury trigger to humans as stated in the Special Review Procedures, the Agency should initiate a Special Review of ethyl parathion (and concurrently mevinphos).

3) Proceed with the label amendments presented to policy group on 9 January 1986.

Curt Lunchick
Curt Lunchick
EAB/HED
16 January 1986

INCIDENCE REPORTS OF PARATHION POISONINGS

Feb. 1975/Florida	Individual treated for parathion poisoning after exposure in his office. Adjoining corn and sugar cane fields treated previous day with parathion. Man had tightness of the chest, nausea, headache, and dilated pupils. Administered atropine.
July 1975/Idaho	Mixer/loader worked with parathion, demeton, and trichlorofon. Encountered splash back while loading. Awoke on 4 July with nausea, vomiting, and ataxia. Hospitalized for 5 days.
July 1975/Florida	Mixer/loader admitted to hospital after he began sweating and lost consciousness. Had been applying parathion to peaches for 2 weeks. Had one spill on legs 1 week prior to which he immediately washed and changed clothes.
Aug. 1975/Georgia	Pilot inhaled spray fumes during application. Hospitalized in the afternoon and died that night. No plane crash involved.
July 1978/Michigan	Mexican farm worker helped load parathion and Phosdrin into spray helicopter. Hospitalized with bradycardia and breathing difficulties. Treated with atropine.
July 1978/Washington	Mixer/loader working with parathion and Phosdrin had hose rupture. Admitted to hospital with nausea, vertigo, and blurred vision. Ach-ase level was 481 compared to normal levels of 1900 to 3800. Hospitalized for 2 days.
Sep. 1979/Florida	Bulldozer operator was misted with ethyl parathion and methyl parathion spray from aerial application to adjacent soybean field. Developed shortness of breath, sweating, increased fluid consumption, headache, diarrhea, weakness, failure to obtain erection and ejaculate, muscle twitching, and unconsciousness.
California	Ground applicator developed parathion poisoning after spraying with parathion for 4 hours. The employee used all required safety equipment and avoided drift. He had worked with parathion for 41 hours during the preceeding 30 days.
California	A mixer/loader handling parathion experienced nausea and vomiting and required 3 days of hospitalization.

California	A ground applicator developed a headache and became nauseous after spraying parathion. He used all safety equipment required but was poisoned in spite of this.
California	A worker, wearing all required protective equipment, developed poisoning symptoms 4 hours after helping to fill a spray tank with parathion. He was hospitalized for 7 days with parathion poisoning.

EXCERPTS FROM CALIFORNIA REPORTS ON OCCUPATIONAL ILLNESS DUE TO PARATHION

1981

"In 1981, California physicians reported 14 cases of illness or injury resulting from occupational exposure to parathion." "Equipment failure were at least partially responsible for five of the illnesses. Three additional illnesses were attributed to the lack of proper protective clothing and equipment furnished to the workers. Detailed investigations were unsuccessful in determining the exposure circumstances in six of the cases."

1980

"In 1980, California reported 22 cases of illness or injury resulting from occupational exposures to parathion." "Human error, either on the part of the exposed person or a related second party can be cited as at least a partial cause of exposure in 10 of the 22 cases reported in 1980. Errors included failures in communication of proper safety procedures; lack of use of proper protective clothing and equipment; and failure to follow proper procedures for mixing and loading, applying, or cleaning and maintainance of application equipment."

1979

"During the year 1979, there were 22 cases of occupational exposure to parathion reported by California physicians". "Some incidents involved accidents and/or carelessness, but a number of poisonings occurred even though all recommended safety measures were reported as being complied with". "A number of the workers could not explain the exact circumstances of their exposure".

1978

"There were 22 cases of occupational exposure to the agricultural pesticide ethyl parathion reported by California physicians in 1978". "The greatest single cause of exposure to parathion was lacck of care in the handling of spray equipment and in actual application. Eight cases apparently involved employee negligence, such as failure to use safety equipment provided by the employer, carelessness, and poor personal hygiene. One worker became ill even though he reportedly used all of the safety equipment specified on the label. Other exposures were due to a spill during a plane crash caused by a malfunctioning on take-off, a misunderstanding regarding the application date in a wildlife area by a mosquito abatement district worker, and a worker improperly cleaning the inside of a parathion mix tank. Also, there were 3 drift exposure incidents".

1975

"There were 68 cases of human exposure reported for ethyl parathion in 1975 that involved employed persons". "In the only incident that involved multiple exposure, 17 field workers slept at night in a grove that had been previously treated with ethyl parathion and was posted with warning signs to stay out for 21 days... One field was reentered 1 day early, the other was reentered 5 days too early". "This particular incident involved six different violations of California's pesticide regulations".

OCCUPATIONAL ILLNESS AND INJURIES DUE TO EXPOSURE PARATHION AS REPORTED BY PHYSICIANS IN CALIFORNIA

Circumstance	1975	1978	1979	1980	1981	TOTAL
Early Reentry of Fieldworker	18*	1	1	2	0	22*
Spray Drift	2	6	2	1	1	12
Equipment Maintanence	2	3	1	3	1	10
Accidental Spill	3	1	3	2	1	10
Accidently Sprayed Self	0	0	1	3	2	6
Equipment Failure	0	1	1	1	0	3
SUBTOTAL						63
OTHER AND UNKNOWN	13	10	13	10	9	55
TOTAL	38	22	22	22	14	118

* Includes one incident involving 17 workers

This table is based on a description of all cases that occurred in 1978, 1979, 1980 and 1981. It also includes 38 cases that were described in 1975 out of the total of 68 which occurred. In many casses subjective judgement was used when deciding which category best described the circumstance associated with a particular case.

Illness Due to Parathion Exposure Reported by Type of Illness and Job Category for 1976 through 1978 and 1979 through 1981 in California.

Systemic Illness	1976-1978	1979-1981	Total 1976-1981
Ground Applicator	19	18	37
Aerial Applicator	2	0	2
Mixer/Loader	23	9	32
Field Worker	28	6	34
Drift	5	3	8
Warehouse/Transportation	12	3	15
Manufacturing/Formulation	4	0	4
All Other	26	14	40
TOTAL	119	53	172
Skin or Eye Injuries			
Ground Applicator	3	2	5
Mixer/Loader	2	0	2
Warehouse/Transportation	1	1	2
Manufacturing/Formulation	2	0	2
All Other	1	2	3
TOTAL	9	5	14
TOTAL PARATHION ILLNESS AND INJURIES	128	58	186

25 LEADING CAUSES OF OCCUPATIONAL ILLNESSES AND INJURIES DUE TO PESTICIDES

REPORTED BY PHYSICIANS IN CALIFORNIA 1980-1984 (mixes excluded)

Prepared by Jerome Blondell

RANK	PESTICIDE	1980	1981	1982	1983	1984	TOTAL	% of all CASES
1	Sulfur	131	126	141	47	34	479	7.6
2	Propargite	116	86	55	61	100	418	6.7
3	Glyphosphate	38	36	52	56	41	223	3.6
4	Diazinon	40	44	35	41	39	199	3.2
5	Mevinphos	49	62	23	16	35	185	3.0
6	Malathion	41	51	18	23	36	169	2.7
7	Methomyl	28	30	18	22	26	124	2.0
8	Chlorpyrifos	28	21	11	26	34	120	1.9
9	Parathion	25	14	35	25	20	119	1.9
10	Dinitrophenol	40	28	24	16	8	116	1.8
11	Methyl Bromide	25	28	22	21	17	113	1.8
12	Creosote	36	14	19	6	17	92	1.5
13	Paraquat	18	12	19	14	13	76	1.2
14	Pyrethrins	13	6	16	23	11	69	1.1
15	Dimethoate	14	6	7	17	16	60	1.0
16	Carbaryl	18	5	12	10	13	58	0.9
17	Weed Oil	23	10	11	5	8	57	0.9
18	Chlordane	11	13	8	18	5	55	0.9
19	Bendiocarb	17	18	11	7	1	54	0.9
20	Guthion	32	5	5	5	7	54	0.9
21	Captan	4	5	10	17	17	53	0.8
22	Baygon (propoxur)	6	7	18	14	7	52	0.8
23	PCP	12	11	17	6	4	50	0.8
24	Aldicarb	15	10	11	6	7	49	0.8
25	Chlorine	1	4	14	15	14	48	0.8

PARATHION SUMMARY STATISTICS

Category	Time Period	PER YEAR Average Number	PER YEAR Average Percent	Rank
Deaths (count)	4 Years during 60's and 70's	7	8	2*
Hospitalized Poisonings (estimate)	1974-76	150	5	3**
Calif. Physician Treated Occupational Cases (count)	1980-84	24	2	9***

* Arsenicals as a group were the number one cause of deaths.

** Sodium arsenite and warfarin outranked parathion as a cause of hospitalized pesticide poisonings, though in the 1971-73 period parathion ranked number one.

*** California has regulated parathion more severly than other states with longer reentry intervals. The top three pesticide problems in California are all skin irritants: sulfur, propargite, and glyphosphate. Other pesticides which cause more illness than parathion include diazinon, mevinphos, malathion, methomyl, and chlorpyrifos.

Prepared by Jerome Blondell

10 LEADING CAUSES OF SYSTEMIC POISONING DUE TO PESTICIDES REPORTED BY PHYSICIANS IN CALIFORNIA 1980-1984 (mixes excluded)

Prepared by Jerome Blondell

RANK	PESTICIDE	1980	1981	1982	1983	1984	TOTAL	% of all cases
1	Mevinphos*	49	62	20	15	33	179	6.5
2	Diazinon	22	33	30	31	30	146	5.3
3	Malathion	24	34	11	15	25	109	4.0
4	Parathion*	23	12	32	22	18	107	3.9
5	Methomyl**	23	27	16	14	14	94	3.4
6	Chlorpyrifos	21	13	7	19	21	81	2.9
7	Methyl Bromide	16	13	11	7	11	58	2.1
8	Dinitrophenol	20	13	6	9	4	52	1.9
9	Guthion*	31	4	5	4	3	47	1.7
10	Dimethoate	11	6	6	11	11	45	1.6

* highly toxic organophosphate, oral LD_{50} (rat) less than 50mg/Kg.
** highly toxic carbamate, oral LD_{50} (rat) less than 50mg/Kg.

Mevinphos and Parathion are approximately twice as toxic as Methomyl and Guthion (based on LD_{50})
The top 10 pesticides account for one-third of all systemic ~~illnes~~ poisonings in California.