11901 Samuel, Garden Grove, CA 92840-2546

Item ID Number	05565	☐ **Not Scanned**
Author		
Corporate Author		
Report/Article Title	Quantitative Assessment of Exposure to 2,4,5-T, Silvex and TCDD	
Journal/Book Title		
Year	1980	
Month/Day	September 12	
Color	☐	
Number of Images	0	
Descripton Notes	Alvin L. Young filed these documents together with others under the label, "Agent Orange Exposure Project."	

Appendix F to CAG report

Remarked as Exhibit 776

QUANTITATIVE ASSESSMENT OF EXPOSURE TO 2,4,5-T, SILVEX AND TCDD

September 12, 1980

QUANTITATIVE ASSESSMENT OF EXPOSURE TO 2,4,5-T, SILVEX AND TCDD

INTRODUCTION

As part of its risk-benefit balancing procedures, the Agency generally attempts to estimate potential human exposure to pesticides in quantitative terms. The ultimate objective of these assessments is to develop numerical estimates of the amount of exposure that certain segments of the population may experience as a result of pesticide use. These exposure data are combined with toxicity information to generate an overall risk assessment. The risk assessments are then used to predict potential health effects based on the toxicologic effects of the pesticide in question.

This document provides some quantitative estimates of exposure to 2,4,5-T, silvex, and TCDD for use in the cancellation hearings. These estimates are based as far as possible on observed residue levels in the environment. However, while these estimates are expressed as numerical values, they are in fact much less precise than their numerical nature would imply. This is because the available data are meager, because conditions (spray techniques, weather, etc.) are so variable, and because many assumptions have to be utilized in order to arrive at the estimates. This introduction describes some of the reservations which apply to the numerical estimates presented in this assessment, and comments on the limitations on the use and interpretations of this information.

General

Agency exposure assessments, including this analysis for 2,4,5-T, silvex, and TCDD, are based where possible on actual field data. In the present case, the data upon which this exposure assessment is based include data on chemical residues in soil, food and other environmental materials, on actual field exposure data for applicators, and on the data on transport and fate of these chemicals in the environment.

In addition, information on pesticide use practices and extent of use is necessary to arrive at reasonable estimates of exposure. This information includes the crops or sites which may be treated, the rates and methods of application, and information on the other activities during their subsequent application. This information is used to develop estimates of the number of people potentially exposed to the chemicals by oral, dermal and inhalation routes as a result of specific use practices.

The information available for use in this exposure assessment is variable as to its completeness, quality, and reliability. In general, the greatest confidence can be placed on the field exposure and residue data, even though it is incomplete in many ways. The information relating to use practices is somewhat less certain. Agency scientists started with information from the pesticide label to determine application rates and crops or sites likely to be treated. Estimates relating to the extent of sites or crops treated and other indicators of the probable extent of contamination are subject to many uncertainties. In particular, the numerical values for the populations at risk are highly uncertain. This is because information on population demographics, whether or not related to pesticide use, is not well developed.

The uncertainties described above are common, in varying degrees, to all exposure assessments, including these assessments for 2,4,5-T, silvex and TCDD. In sum, although Agency scientists have a high degree of confidence about much of the empirical data which form the basis for this analysis, they are far less confident about other information. The quantitative exposure estimates for the populations at risk are limited by these uncertainties.

Exposure Analysis

The starting point for exposure assessment for pesticides is descriptive information on pesticide release and distribution to the different environmental compartments such as air, water, soil, and animal and plant tissues during application. In addition, 2,4,5-T and silvex are known to move from sites of application to non-target areas under some conditions of application.

This qualitative information on potential sources of human exposure is supported by analytical chemical data showing that residues of these chemicals are present subsequent to application, both at application sites and at non-target sites. Such chemical residue information provides the initial numerical base for quantitative estimates of possible human exposure. For example, unlike many pesticides with relatively short half-lives and relatively rapid disappearance from the environment, 2,4,5-T and silvex may persist in the environment for several months after application; TCDD may remain for several months or years. Therefore, special concern is raised about 2,4,5-T, silvex and TCDD because they may remain in the environment in significant concentrations for several months or years after their application.

However, despite the availability of some useful information, there are gaps in our knowledge. For example, although large amounts of 2,4,5-T and silvex are used each year, comprehensive monitoring information on 2,4,5-T, silvex, and TCDD residues in the environment is, for the most part, unavailable.*/ This paucity of residue information limits the Agency's ability to make quantitative exposure estimates to only some routes of exposure and only for certain uses.

*/ The paucity of monitoring data on TCDD is due largely to the only recent development of analytical methodologies with sufficient sensitivity to measure the extremely low levels of TCDD which are of biological concern, to the limited number of facilities with these analytical capabilities, and to the high cost of analyzing samples at these levels. For 2,4,5-T and silvex, the problem of insufficient monitoring information appears to be largely due to a lack of comprehensive monitoring programs, or inappropriate sampling.

Even when some data are available for one kind of application, there may be uncertainty as to whether those data are applicable to other applications which may occur under different conditions. For example, residue data collected during springtime application in the Pacific Northwest may not properly describe the amount and distribution of chemicals under different environmental conditions at a different time of the year. Often, the only data available are data derived from laboratory studies, with little or no field data to verify that the laboratory data accurately describe the residue levels which might be present under field conditions.

Further, each of the several different human exposure pathways provides a different kind of exposure potential. Even when some empirical residue data on a given route of exposure are available, there are often uncertainties concerning the generalization of those data to other routes of exposure. These uncertainties are a particular concern when estimating exposure to chemicals such as TCDD which appear to pose risks at very low levels of exposure.

In attempting to generalize to "average" or "typical" use patterns, the Agency has encountered a wide variety of practices, which were very difficult to address. An example is the application rate to be used when rangeland vegetation is spot treated. Despite the fact that the USDA-EPA States Report (Ref. 2) notes a

2 lb/A maximal application rate on grazing lands, it was found that other rates have been used and are permitted by the label. Also, despite "typical" 5-15 year recommended intervals between herbicide spray applications, instances of successive annual treatments have been substantiated, and may, in fact, be more a common practice than the USDA Report assumes.

A very difficult aspect of quantitating risk is specifically identifying and quantitating populations at risk. The Agency has found, for example, that deer and elk from 2,4,5-T treated forested areas may contain TCDD residues in their fat at readily measured levels. Also, it is known that some people include deer and elk in their diets. But, the proportion of deer and elk taken by hunters annually that are actually contaminated, the level of contamination, and the numbers of people who consume given amounts of contaminated meat is not known.

To extrapolate from the available information to potential human exposure (and subsequently to risk assessments), assumptions based on the observed residue data, information about use practices, and "typical" consumption patterns are made. These assumptions may either over- or under-estimate actual risk. This can be confirmed only by the acquisition of additional data. Nevertheless, the Agency has developed some numerical values, however uncertain, to permit the quantitative estimation of risk for the cancellation proceedings.

The exposures which have been quantified in this document are as follows:**/

1) Occupational exposure to 2,4,5-T, silvex, and TCDD.

2) Dietary exposure of the general population and local populations to TCDD residues in beef and local populations to TCDD residues in dairy products resulting from the use of 2,4,5-T and silvex on rangeland and pasture.

3) Dietary exposure of local populations to TCDD residues in deer and elk resulting from the forestry use of 2,4,5-T and silvex.

4) Dietary exposure of the general population and local population to silvex residues in rice, apples, pears, prunes, and sugar (from sugarcane) resulting from the use of silvex on these food products.

5) Dietary exposure of the general population and local populations to 2,4,5-T and/or silvex residues in rice resulting from the use of 2,4,5-T and silvex on rice.

Finally, the available data relating to some uses of 2,4,5-T and silvex are inadequate even to begin assessing potential human exposure. For some situations, no monitoring information is known to the Agency, and in other situations the available data

**/ The Agency is still evaluating and generating monitoring data which were not utilized in these quantitative assessments. The Agency may utilize these data as they are developed.

are too incomplete or too uncertain to provide the basis for even a simple estimate of exposure. It is emphasized that the incompleteness of data and the consequent lack of an exposure analysis mean only that suitable data were not available, not that these pathways are biologically insignificant.

ESTIMATION OF OCCUPATIONAL EXPOSURE TO 2,4,5-T, SILVEX, AND TCDD

Introduction

This analysis provides a quantitative human exposure */ estimate for 2,4,5-T, silvex, and dioxin in terms of absorption by the body of these chemicals under normal agricultural working conditions.

Human exposure estimates are made on the basis of chemical analyses of dermal and inhaled concentrations of the chemical or chemicals, and if the information is available, on the basis of the amount of chemical(s) or their metabolites excreted by the body (e.g. in the urine). **/

In the case of the pesticides and contaminant under consideration, there are experimental data available on the occupational exposure to pesticide applicators and farmworkers applying 2,4,5-T under actual use conditions. These data consist of dermal, inhalation, and urinary concentrations of 2,4,5-T obtained from the field application of 2,4,5-T in forestry and rice***. Exposures to 2,4,5,-T from other uses and to silvex and TCDD for all uses were estimated by extrapolation and will be discussed below.

---

* The term "exposure", as used in this paper, refers to the amount of chemical absorbed by the body.

** During the past four years, since the initiation of the RPAR process, the Hazard Evaluation Division has estimated occupational exposures to many pesticides. In some cases data on dermal and inhalation exposure were available for these estimates. In other cases, these data had not been generated, necessitating extrapolations from information on other pesticides (with similar application techniques) for purposes of the exposure estimate.

*** Experimental data of the type required for this analysis were found only for 2,4,5-T. Consequently, exposure to silvex and TCDD was calculated on the basis of extrapolations from the 2,4,5-T data as explained in the text.

Duration of exposure to specified occupational groups and the number of individuals comprising these groups are critical elements in risk assessment. These parameters were estimated from use data from Reference 2 and are summarized in the Appendix (page 48, et seq.) Occupational exposure to 2,4,5-T, silvex, and TCDD are estimated for the following uses:

- forestry
- rice
- range and pasture
- rights-of-way

It should be noted that because of information gaps, it was necessary to make a number of assumptions and extrapolations in estimating applicator exposure to 2,4,5-T, silvex, and TCDD. As a result, our estimates are subject to a considerable degree of uncertainty.

Estimation of Occupational Exposure to 2,4,5-T

We are aware of three studies on the exposure of applicators to 2,4,5-T which provide experimental data to be used for exposure assessment. The most detailed of these studies is one conducted by Lavy on forest applicators (Ref. 14, 15). The data from this study has been analyzed using a pharmacokinetic model in a report by Ramsey et al. (Ref. 19). Lavy also conducted a somewhat abbreviated study of workers applying 2,4,5-T to rice and forests (Ref. 16). The third study yielding useful exposure information is one by Kolmodin-Hedman et al. (Ref. 13) in which two professional tractor crews consisting of two persons each were monitored for 2,4,5-T during and after two applications of 2,4,5-T to forests.

Two other studies reported in the literature */ provided confirmatory information on 2,4,5-T absorption by humans.

The information enabling us to estimate the absorption of 2,4,5-T by occupationally exposed individuals is contained in the field study conducted by Lavy on foresty applicators (Refs.14,15). The study was designed to measure 2,4,5-T exposure to pesticide workers applying this pesticide in the forest by three different methods:

- aerial (helicopter)
- ground application by tractor-driven mist blower
- ground application by backpack sprayers

Twenty-one individuals (including two females) participated in this study. The subjects were engaged in normal pesticide application activities (e.g. piloting a helicopter; driving a tractor and handling pesticide application equipment; mixing pesticides by dilution, etc.) A commercial product containing 2,4,5-T Esteron®, was applied at day "O" at a rate of 2 lbs a.e./A*

---

* Shafik et al. (Ref.24) report an average of 2.4 mg 2,4,5-T/1 of urine in 6 spray operators engaged in 2,4,5-T application. No spray history or total excretion is given, so it is impossible to calculate total exposure from this experiment. As a matter of fact, the purpose of the reported study was to develop analytical methodology rather than measure exposure.

Simpson et al. (Ref.25), in a very brief summary paper, reported urinary levels of 2,4,5-T in pesticide applicators handling this herbicide ranging from 0.160 mg/1 to 1.740 mg/1. These incomplete results make it impossible to calculate total body burden from 2,4,5-T exposure.

* a.e. = acid equivalent

for tractor-driven mist blower and helicopter applications and 1.6 lbs./A in the backpack study. Urinalyses for 2,4,5-T (acid) were performed daily for 7 days including 1 sample prior to exposure. On the 7th day, the herbicide application was repeated by the same individuals, and urine samples were analyzed as before. Dermal absorption was measured by the use of cellulose-backed gauze patches which were placed according to directions given by Wolfe, et al. (Ref.31).

Typical attire of individuals participating in the study was long trousers, shirt (long or short sleeves), cloth sneakers, and leather or field boots. Temperatures during the experiment ranged from a low of 18°C to a high of 26°C. Wind speeds on 5 days of application were recorded at 0 mph while the wind speed ranged from 0-5 mph on three other days. The experiments were carried out in South Central Arkansas near Hot Springs, Hampton, and New Monticello. The terrain there is less hilly than other areas where 2,4,5-T and silvex are used, such as that in western Washington and Oregon. It is conceivable that different terrain and weather conditions may change the exposure pattern of the occupationally exposed population. However, we know of no experimental work that has been carried out to investigate these variations. Complete experimental details may be found in the Project Completion Report (Ref.14) and in the published paper (Ref.15).

According to Ramsey et al. (ref.19), "the total amount of 2,4,5-T excreted in the urine following exposure represents a minimum estimate of the amount

...absorbed, since urinary excretion may not be complete at termination of the experiment. However, calculation of the absorbed dose of 2,4,5-T based on pharmacokinetic analysis... is not dependent on total excretion and can, therefore, provide a more realistic estimate of the absorbed dose." Ramsey et al. have chosen maximum estimated doses of 2,4,5-T obtained from three different kinetic equations (Ref.19, p. 20).

We have used Ramsey's adjusted data based on Lavy's study (Refs.14,15) in estimating occupational exposure. Results for forestry application of 2,4,5-T are tabulated in the last column of Table 1, giving the <u>average experimental dose</u> expressed as mg/kg body weight/hour. From Tables 2-A and 3-A it may be seen that some individual values varied widely. For example, the ranges for pilots were 0.005 - 0.024 mg/kg/hour and backpack applicators, 0.009 - 0.036 mg/kg/hour.

Lavy (Refs.14,15) provides experimental data only for forestry uses of 2,4,5-T. Therefore, exposure estimates for uses on rice, rangeland, pasture, and rights-of-way were calculated by comparing application rates, occupations, and application techniques with the corresponding figures in forestry use, assuming that exposure would be directly proportional to the application rate. It was further assumed that the difference in application rate was the only variable factor which would result in differences of applicator exposure for each type of occupational group. For example, the rate used for aerial application of 2,4,5-T in range and pasture is

1 lb/A (weighted average) and the corresponding rate in forest is 2.0 lbs/A (average). Thus, the exposure values for different occupational groups for range and pasture use is estimated by multiplying the experimental value (forestry use) by one-half.*

In order to convert unit exposure values to dose/person/hour, the figure in the last column of Table 1 may be multiplied by the estimated average body weight of a male worker, namely 70 kg. Table 1 also provides data on the estimated annual hours of exposure to each occupational group of workers and estimated number of workers in each occupational category. These numbers were derived from the total acreage** treated, found in Reference 2. The methodologies for arriving at these estimates are fully explained in the Appendix.

In the Lavy study (Refs.14,15), dermal and inhalation exposures by field personnel were measured. In addition, urinary 2,4,5-T and other urine

---

* Confirmation that absorption, as measured by urinary excretion, is directly proportional to dose applied has been recently shown by Franklin, et al. in a study involving the insecticide azinophosmethyl and orchard workers (soon to be published) (C.A., Franklin, R.A. Fenske, R. Greenhalgh, L. Mathieu, H.V. Denley, J.T., Leffingwell, and R.C. Spear, A Comparison of Direct and Indirect Methods of Estimating Dermal Exposure to Guthion in Orchard Workers. Accepted for publication in J. Toxicol. Env. Health).

** Reference 2 apparently does not separate 2,4,5-T and silvex treatment for range and pastures, although this is not explicitly stated. Since under recent usage pattern, silvex represents only 10% (Ref. 35) of the combined use of 2,4,5-T and silvex, we feel that our estimates of annual hours of exposure and number of workers in each exposed occupational group are indeed representative of 2,4,5-T treatment alone without correcting for the small percentage of silvex.

TABLE 1

Estimated Exposure of Pesticide Applicators and Farmworkers to 2,4,5-T

Use Pattern	Exposed Group	Application Rate[1] (lb/A)	Estimated No. Exposed Persons[1]	Estimated Exposure[1] (hrs/yr)	Average Exposure[2] (mg/kg/hr)
		FORESTRY			
1. Aerial	Pilots	2	73	200	0.015
	Mixer/Loaders	2	73-145	800	0.062
	Flaggers	2	—— [3]	800	0.003
	Supervisors	2	—— [3]	800	0.004
2. Ground Broadcast					
a. Tractor Mistblower	Mixer/Loader	2	90-180	480	0.020
	Tractor/operator/worker	2	90	240	0.013
	Supervisor	2	—— [3]	480	0.006
b. Backpack Sprayer	Applicators	1.6	300	800	0.021
	Mixer/Supervisor	1.6	—— [3]	800	0.005
		RANGE AND PASTURE			
1. Aerial	Pilots	1.0	130	75	0.008[4]
	Mixer/Loaders	1.0	130-260	100	0.031[4]
	Flaggers	1.0	800	25	0.002[4]
2. Ground Backpack	Applicators	0.6	20,000	80	0.008[4]
		RICE			
Aerial	Pilots	1.0	307	12	0.008[4]
	Mixer/Loader	1.0	307	48	0.030[4]
	Flaggers	1.0	6500-9500	0.6	0.002[4]
		RIGHTS-OF-WAY			
1. Aerial	Pilots	8.0	25	400	0.060[4]
	Mixer/Loaders	8.0	25-50	400	0.240[4]
2. Ground					
a. Selective	Applicators (hand) Basal	6.4	1380	1000	0.084[4]
b. Cut Stump	Applicators (hand)	4.0	60	500	0.053[4]
c. Mixed Brush	Applicators (hand)	6.0	270	660	0.079[4]
	Truck boom Applicators	0.8	178	660	0.005[4]
d. Railroad	Crew of Four	5.(avg)	114	264	0.066[4]
e. Electric Power	Applicators (hand)	6.(avg)	400	660	0.080[4]

1. See Table 1-A
2. Reference 19. Calculated dose levels; received by EPA on February 14, 1979; # 16P [30,000/26]; See also Table 2-A for raw data.
3. (——) indicates that the number of individuals cannot be estimated.
4. These values were extrapolated as explained in the text.

components were analyzed. By Lavy's calculations, very poor correlation existed between dermal exposure to 2,4,5-T, as measured by 2,4,5-T analyses of the body patches, and the amounts excreted in the urine.* One explanation for the lack of correlation might be the fact that the dermal exposure patches were not always placed in areas of highest potential exposure, e.g. the hands of mixer-loaders. Thus, the exposure derived from dermal patches might be expected to be too low, and, consequently, urinary excretion values would be more realistic.

In the second Lavy 2,4,5-T-exposure study (Ref.16), only dermal and no urinary analyses for 2,4,5-T were performed. However, only results from urinary excretion experiments were utilized by us for exposure estimates for the following reasons:

1. The pharmacokinetic behavior of 2,4,5-T has been described in mammals, including man.
2. Analysis of 2,4,5-T in the urine is a more direct measurement of 2,4,5-T absorption than the use of dermal patches.

Thus, in our exposure estimates for 2,4,5-T we have utilized exclusively urinary excretion data derived from Lavy's field study (Refs.14,15), transposed by pharmacokinetic calculations by Ramsey, et al. (Ref.19).

While we have relied heavily on Lavy's field studies and the pharmacokinetic derivations by Ramsey, et al., based on the same studies, it is

---

* Exposure through inhalation was much lower than that from dermal contact and, therefore, was not included by Lavy in the correlation test.

prudent to review these experimental studies and kinetic derivations in greater detail. During the cross examination testimony of Dr. Nisbet, several experimental deficiencies in the Lavy studies (Refs.14,15) were discussed and included apparently incomplete or variable urine collection and failure to correct urine volumes according to creatinine levels.

The Agency is presently engaged in an independent analysis of the pharmacokinetic treatment of Lavy's field data. After this review has been completed, the exposure estimates may have to be revised appropriately.

KOLMODIN-HEDMAN STUDY

Recently, another study from Sweden on the exposure of two tractor crews to 2,4,5-T has come to our attention (Ref.13). The study consisted of the surveillance of two work crews of 2 individuals each. They applied a mixture of phenoxy herbicides in a forest for one work week and 2-4 hrs/day spraying time using a Gullvik* Forest Tractor equipped with a fan sprayer. Blood and urine samples were analyzed before application of the herbicide, once or twice during the application period, and at 12, 24, and 36 hours after the last application. Urine samples were not taken at regular intervals during the study, making it less reliable for the estimation of total exposure than Lavy's study (Refs.14,15). Lavy showed that even a 6 day period is insufficient for complete elimination of 2,4,5-T from the body. Thus, it is quite certain that Kolmodin's results are on

---

* The make of the Swedish tractor is mentioned because the difference in exposure between Swedish and U.S. workers may be due to equipment differences.

the low side, since the last urine sample was taken only 1.5 days after the last application of 2,4,5-T. Nevertheless, we compared Kolmodin's results with Lavy's data. Table 2 recapitulates the urinalysis results originally reported by Kolmodin, et al. as well as the interpolated values on the days on which no urine sample was taken.

TABLE 2

URINARY EXCRETION OF 2,4,5-T (mg/L)†

DAY	PERSONS KK**	LJ**	JG**	LEO**
Monday	0.5***	0.5	3.1	1.3
Tuesday	1.0	0.4	11.4	4.9
Wednesday	1*	1*	9*	4*
Thursday	1*	1*	6.5	3.7
Friday	1.2	1.2	4.2; 3.0 (3.6 avg)	2.3; 3.3 (2.8 avg)
Saturday	0.9	0.9	2.7	4.3
Sunday (PM)	0.7; 0.4 (0.6 avg)	1.0; 0.7 (0.9 avg)	2.1; 2.2 (2.2 avg)	3.5; 2.5 (3.0 avg)
Total (mg/L)	6.2	5.9	38.5	24.0

† Reference 13.

* Interpolated; no experimental values

** KK was a mixer-worker and row leader in Crew I
LJ was a tractor driver in Crew I
JG was a tractor driver in Crew II
LEO was mixer-loader & row leader in Crew II

*** Analysis before first treatment were of the order of less than 0.05 ppm.

Exposure began on Monday and ended on Friday.

The exposure by Crew II in Kolmodin's study appears to be 3 to 6 times higher than that of Crew I. The reason for this may possibly be explained by the different working conditions during pesticide application by Crews I and II. Crew I changed work clothes each evening and their tractor had a partially protected seat. On the other hand, the mixer/worker of Crew II only changed his shirt in the middle of the week. Also, the tractor for Crew II had a completely open seat. In addition, the mixer/worker for Crew II, who also performed the job of row leader, could have received spray each time the tractor turned, as could the tractor driver, depending on the direction of the wind. Table 3 summarizes and compares the results of the exposure to 2,4,5-T of the two work crews in Kolmodin's study.

TABLE 3

EXPOSURE TO 2,4,5-T*

Crew No.	Person	Occupation	kg BW	Spray time (hrs/day)	Total mg excreted**	mg/kg-BW	mg/kg BW/hr***
I	KK	Mixer/worker	70	2-4 hours	9.30	0.13	0.01
	LJ	Tractor Driver	80	2-4 hours	8.85	0.11	0.01
II	LEO	Mixer/worker	75	2-4 hours	36.0	0.48	0.03
	JG	Tractor Driver	62	2-4 hours	57.75	0.93	0.06

Appropriate: 2-3 kg AI/ha (equivalent to about 2 lb/A) 330 g/liter 2,4-D and 170 g/liter 2,4,5-T. This calculates to about 0.66 lb./A 2,4,5-T

CREW I — Jeans, shirt; changed work clothes before evening meal. Tractor has partially protected seat. The sprayed areas were marked by KK.

CREW II — Jeans and shirt: LEO was the mixer and changed shirt once. JG was the tractor driver. LEO was "row leader." (A person who marks the row to direct tractor-driver). When the tractor turned, he could get spray liquid on his body. Tractor driver could also receive spray on his body, since tractor had a completely open seat.

* Reference 13.
** Based on 1.5 L urine/day; see Table 2 for tabulations.
*** Average 3x5 = 15 hrs/week spray time.

Table 4 is a comparison of the results from Tables 1 and 3

Table 4

Comparison of Lavy and Kolmodan-Hedman Studies

Occupation	Lavy Study (Refs.14,15) Av. Dose (mg/kg/hr)	Applic. Rate (lbs/A)	Kolmodin Study (Ref.13) Av. Dose (mg/kg/hr) Crew I	Crew II	Applic. Rate (lbs/A)
Mixer/Loader (ground)	0.020	2	0.01	0.03	0.66
Tractor Driver	0.013	2	0.01	0.06	0.66

By multiplying the exposure values obtained by Kolmodin by a factor of 3 (to adjust for the lower application rate in Kolmodin's study), the tractor driver of Crew II would appear to have a significantly higher exposure (by a factor of approximately 14) than the corresponding U.S. workers in the Lavy studies.

If the conditions of described by Kolmodin are typical of those encountered in the United States, it may be prudent to perform a quantitative risk assessment using the higher exposure figures.

EXPOSURE TO SILVEX AND TCDD

We could find no reports, either published or unpublished, on the exposure of workers in the field to silvex or TCDD. Therefore, in order to estimate occupational exposure to these chemicals, we have assumed the following:

1. Silvex exposure is the same as 2,4,5-T exposure, wherever and whenever the use pattern for silvex and 2,4,5-T are similar or identical. We believe that the chemical behavior of silvex and 2,4,5-T is sufficiently similar to justify this assumption.

2. We are not aware of any information regarding the rate of dermal absorption by man of TCDD relative to 2,4,5-T. In the absence of this information, we are assuming for the purpose of estimating exposure that TCDD and 2,4,5-T are absorbed at the same rate.*

3. TCDD exposure resulting from 2,4,5-T application may be estimated by applying concentration factors obtained by direct analysis of 2,4,5-T formulations. Lavy reported that TCDD was present in the Esteron® product used in his study (Refs. 14,15) at a level of 0.04 ppm (4×10^{-8}). Manufacturer's voluntary specifications of current 2,4,5-T production claim TCDD concentrations of 0.1 ppm or less.** Thus, TCDD exposure may be estimated by multiplying 2,4,5-T exposure for each applicator group by a factor ranging from 4×10^{-8} to 1×10^{-7}.***

4. Estimates for number of exposed individuals and annual hours of exposure due to silvex use can be made by using conversion factors based on ratios of 2,4,5-T treated acres to silvex treated acres for different uses as shown in Table 5; these ratios range from 1/10 to 1/1000.

---

* Another assumption is that the concentration of TCDD relative to 2,4,5-T does not change from the time it is formulated until it is deposited on the skin of the occupationally exposed personnel.

** There are some manufacturers who claim that their 2,4,5-T products contain 0.02 ppm or even less dioxin.

*** Since the concentrations of TCDD in 2,4,5-T and silvex are approximately the same, the same factors may be used in estimating exposure to TCDD resulting from silvex applications. The same number of persons exposed to 2,4,5-T or silvex are, therefore, assumed to be exposed to TCDD. Moreover, the annual hours of exposure of a person to 2,4,5-T and/or silvex are assumed to be the same as his annual hours of exposure to TCDD.

Table 5

Comparison of Relative Rates of Usage of 2,4,5-T and Silvex

Uses	2,4,5-T:Silvex Ratio
Rangeland/pasture[a]	10:1
Forestry (Ref.2)	100:1
Rice[b]	1000:1
Rights-of-way[b]	appx. 10:1

a. Reference 35.
b. Reference 17.

EXPOSURE ESTIMATE - INCREASED USE OF 2,4,5-T AND SILVEX

The exposure estimates summarized in Table 1 are based on recent pre-suspension use volume data for 2,4,5-T and silvex. For all registered uses, only a relatively low percentage of all potential acreage is actually treated with these two herbicides. If the acreage treated were to increase, the total number of exposure hours * would increase proportionately. It is extremely unlikely that one hundred percent of the acreage which could be treated annually with 2,4,5-T or silvex consistent with the labeling would in fact be treated. ** However, because the increase in annual exposure hours resulting from such maximum possible use provides an upper limit on the total number of annual exposure hours, we are estimating the increase in total number of exposure hoiurs which would result from such maximum possible use.

Of the approximately one billion acres of pasture and rangeland in the U.S., only 0.33% is treated with either 2,4,5-T or silvex. If all pasture and rangeland were treated annually,** the total annual exposure hours for

*/ Total number of exposure hours is defined as the product of total number of workers in a particular occupational group times the annual number of hours per worker for this use.

**/ In fact, only 26% of total rangeland and pasture land has undesirable plants susceptible to treatment by 2,4,5-T or silvex. (Ref. 17) each type of applicator would increase by a factor of 300 over our estimate of total number of annual exposure hours estimated to occur at the time of suspension.

Similar projections for increase in total number of exposure hours to either 2,4,5-T, silvex, or TCDD might be made if the extent of use of 2,4,5-T or silvex approached the maximum possible market for commercial forest land (factor = 500), rice land (factor of 10), or rights-of-way (factor = 200) (ref. 17).

SUMMARY OF OCCUPATIONAL EXPOSURE

Based on the Lavy study, which measured 2,4,5-T levels in the urine of applicators who applied 2,4,5-T, as well as on a pharmacokinetic analysis by Ramsey of these experimental data, we have estimated applicator exposure to 2,4,5-T, silvex and TCDD resulting from a number of uses of 2,4,5-T and silvex. These estimates are provided in Table 1.

Because of several factors, the exposure estimates made in this document are subject to considerable uncertainty. Some of the more important factors are:

1. It is possible that the degree of care to avoid exposure which was exercised by the applicators in the Lavy study may not be typical of that used in routine 2,4,5-T or silvex applications.

2. The applications in the Lavy study were conducted under essentially windless conditions and on relatively level terrain. At higher wind velocities or different terrain (rolling hills or mountains) exposure rates may be quite different

3. In estimating TCDD exposure, it was necessary to extrapolate from data on 2,4,5-T exposure. In so doing, it was assumed that TCDD was absorbed by the body with an efficiency equal to that of 2,4,5-T. In fact, TCDD may be absorbed at rates considerably different than those of 2,4,5-T.

4. The Lavy study may have had certain experimental deficiencies, including incomplete or variable urine collections.

The Swedish study (ref.13) indicated that under certain conditions, applicator exposure, at least with respect to tractor drivers, may be considerably higher than that estimated from data generated in the Lavy study. Correcting for differences in application rates, the exposure rate of one of the tractor-drivers in the Swedish study was about 14 times higher than the exposure rate measured in his American counterpart (0.18 vs. 0.013 mg/kg/hr). Thus, if U.S. field conditions were comparable to those encountered in the Swedish study, it might be prudent to estimate risk on the basis of higher levels of exposure than those found in the one U.S. study.