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**Author**

**Corporate Author**

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**Description Notes** Includes notes and calculations on various exposure scenarios. Items were filed in one folder labeled "Exposure Calculations"

ACGIH 8-hr TWA TLV for  
2,4-D or 2,4,5-T

$$10 \text{ mg/m}^3$$

If 2,4,5-T now has TCDD @  
0.1 mg/kg then the implied  
std is

$$\frac{10 \text{ mg } 2,4,5\text{-T}}{\text{m}^3} \times \frac{0.1 \text{ mg TCDD}}{\text{kg } 2,4,5\text{-T}} \times \frac{\text{kg}}{10^6 \text{ mg}}$$
$$= 1 \times 10^{-6} \frac{\text{mg TCDD}}{\text{m}^3} = \frac{1 \text{ mg TCDD}}{\text{m}^3}$$

$$\frac{1 \text{ mg TCDD}}{\text{m}^3} \times \frac{1.8 \text{ m}^3}{\text{hr}} \times \frac{8 \text{ hr}}{\text{day}} = \frac{14.4 \text{ mg}}{\text{day}}$$

$$\frac{14.4 \text{ mg}}{\text{day}} \times \frac{\text{man}}{70 \text{ kg}} = 0.21 \frac{\text{mg}}{\text{kg}}$$

2/

Respiration rate for Average Man  
at work

2  
• { 30 resp/min }  
  { 500 ml/resp. }

$$\therefore \frac{30 \text{ resp}}{\text{min}} \times \frac{500 \text{ ml}}{\text{resp}} \times \frac{\text{m}^3}{10^6 \text{ ml}} \times \frac{60 \text{ min}}{\text{hr}} \times \frac{8 \text{ hr}}{\text{day}}$$
$$= 7.2 \text{ m}^3/\text{day}$$

Assume average man is 72 Kg

No TCDD was detected in air samples (See Ch 2)

Taking worst case of minimum detectable concentration (MDC) of  $\leq 36 \text{ mg/m}^3$  and assuming levels of TCDD were just equal to this MDC

$$\frac{36 \text{ mg}}{\text{m}^3} \times \frac{7.2 \text{ m}^3}{8\text{-hr Day}} = \frac{259.2 \text{ mg TCDD}}{8\text{-hr Day}}$$

Assume man is 72 Kg

$$\frac{259.2 \text{ mg TCDD}}{8\text{-hr Day}} \times \frac{\text{Man}}{72 \text{ Kg Man}} = \frac{3.6 \text{ mg TCDD}}{\text{Kg} \cdot \text{Day}}$$

Use worst case of 2,4,5-T noted at NCBC along with worst case of TCDD in 2,4,5-T as 94 mg TCDD/Kg 2,4,5-T, also use mean TCDD in 2,4,5-T as 1 mg/Kg

Worst Case: 79.62 ug 2,4,5-T/m<sup>3</sup>  
@ NCBC

$$\frac{79.62 \text{ ug } 2,4,5\text{-T}}{\text{m}^3} \times \frac{94 \text{ mg TCDD}}{\text{Kg } 2,4,5\text{-T}} \times \frac{\text{Kg}}{10^9 \text{ ug}}$$

$$= 7.48 \times 10^{-6} \frac{\text{mg TCDD}}{\text{m}^3}$$

$$= 7.48 \frac{\text{mg TCDD}}{\text{m}^3}$$

Assuming unprotected worker  
respiring 30 x /min @ 500 ml/resp  
= 7.2 m<sup>3</sup>/day

∴ Total inhaled =

$$\frac{7.48 \text{ mg TCDD}}{\text{m}^3} \times \frac{7.2 \text{ m}^3}{\text{day}} \times \frac{\text{man}}{72 \text{ Kg}} = \frac{0.748 \text{ mg}}{\text{Kg} \cdot \text{Day}}$$

∴ This is < 1.0 mg / Kg · Day

Using: 4 mg TCDD / Kg 2,4,5-T

high Mean  $32.39 \frac{\mu\text{g } 2,4,5\text{-T}}{\text{m}^3}$

STD Dev 21.02

95% Mean + 2SD =  $\frac{74.549}{\text{m}^3}$

HD —  $32 \frac{\text{mg}}{\text{kg T}}$

Inhalation exposures Direct  
Exposure to spray (Using RPAR  
approach)

$$\textcircled{1} \quad \frac{0.067 \text{ mg/m}^3}{0.46 \text{ \# / A}} \times \frac{12 \text{ \# } 2,4,5\text{-T}}{\text{A}} = 1.748 \text{ mg/m}^3$$

$\textcircled{2}$  Respirable fraction "worst case"  
is  $\frac{1}{6}$  (see RPAR) - 60 $\mu$  size -

$$(1.748 \text{ mg/m}^3) \left( \frac{1}{6} \right) = 0.291 \text{ mg/m}^3$$

$\textcircled{3}$  At a respiration rate of  $1.8 \text{ m}^3/\text{hr}$   
and a duration of exposure of 2 hrs.

the total absorbed (assuming 100%  
absorption of all inhaled) would  
be

$$\frac{0.291 \text{ mg}}{\text{m}^3} \times \frac{1.8 \text{ m}^3}{\text{hr}} \times \frac{2 \text{ hr}}{\text{day}} = 1.0476 \text{ mg/day}$$

④ Assume 4 cases

1)	TCDD	mean	conc	Purple	max	94 mg/Kg
2)	"	"	"	"	mean	32 mg/Kg
3)	"	"	"	HO	Max	14 mg/Kg
4)	"	"	"	"	Mean	2 mg/Kg

then the TCDD exposures would be,

$$1) \frac{1.0476 \text{ mg 2,4,5-T}}{\text{day}} \times \frac{94 \text{ mg TCDD}}{\text{mg 2,4,5-T}} = \frac{98.47 \text{ mg}}{\text{day}}$$

$$2) \quad \quad \quad \times 32 \quad \quad \quad = 33.52 \quad \quad \quad "$$

$$3) \quad \quad \quad \times 14 \quad \quad \quad = 14.67 \quad \quad \quad "$$

$$4) \quad \quad \quad \times 2 \quad \quad \quad = 2.095 \quad \quad \quad "$$

⑤ Assuming a 70 Kg man the inhaled dose would be

$$2,4,5-T \quad 1.0476 \frac{\text{mg}}{\text{day}} \times \frac{1}{70 \text{ Kg}} = \frac{15 \mu\text{g 2,4,5-T}}{\text{Day Kg}}$$



⑥ TCDD

(ug/Kg Day)

0.012      0.0025      0.0007

100% penet.      79% penet      6% penet

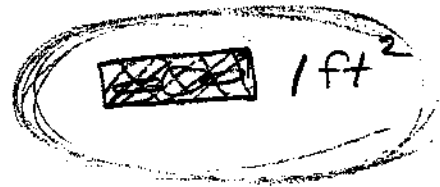
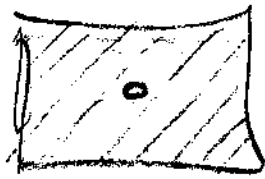
Dermal + Inhal      \_\_\_\_\_

Case	TCDD (mg/Kg Day)			
1	1.407	13.41	3.91	2.11
2	0.479	12.48	2.98	1.18
3	0.209	12.21	2.71	0.91
4	0.030	12.03	2.53	0.73

These calculations do not take into account the degradation that would occur in TCDD during application.

% dermal dose to Total

Case	Penetration	<u>100% P</u>	<u>79% P</u>	<u>6% P</u>
1	Purple 94	89	64	33
2	" 32	96	84	59
3	HO 14	98	92	77
4	" 2	99	99	96



2

$$\frac{3.556 \text{ mg M}}{0.46 \text{ \# M}} = 0.76 \text{ gal/Acre}$$

$$\frac{(3.556 \text{ mg M})(0.76 \text{ gal/A}^{\text{H}_2\text{O}})}{0.46 \text{ \# M}} \times \frac{4 \text{ \# T}}{10 \text{ gal/A}} = \text{RPAR}$$

2.35 mg T

$$\frac{3.556 \text{ mg M} (0.76 \text{ gal H}_2\text{O/A})}{0.46 \text{ \# M}} \times \frac{4 \text{ \# T}}{\text{gal H}_2\text{O}} = \text{RVN}$$

(23.5 mg T)

$$\frac{0.46 \text{ \# M}}{\text{A}} \times \frac{4549 \text{ \#}}{\text{A}} \times \frac{1000 \text{ mg}}{9} = 48,560 \text{ ft}^2/\text{A}$$

4.88  $\frac{\text{mg M}}{\text{ft}^2}$

i.e.,

A

Caplan et al. (167 in RPAR) working with aerially applied malathion in oil sprays applied at 0.46 pounds per 0.76 gallons water/acre, determined a dermal exposure to persons directly beneath the spray plane for bare skin (head, neck, shoulders, forearms, hands and thighs) of 3.556 mg/day <sup>malathion</sup>. Using these data, an equivalent dermal exposure for 2,4,5-T and TCDD, aerially applied at 12 pounds acid equivalent 2,4,5-T per 3 gallons of Herbicide Orange / acre can be determined

3

The following calculations will give the daily worst-case daily dermal exposure for 2,4,5-T and

TCDD:



D)

See Ch 1

5) Assuming canopy penetration rate is 21%, the dermal dose rates are

(b)

2,4,5-T  
TCDD

0.0279 mg/Kg  
0.0025  $\mu$ g/Kg

6) Assuming canopy penetration rate is 6%, the dermal dose rates are

(c)

2,4,5-T  
TCDD

0.0080 mg/Kg  
0.0007  $\mu$ g/Kg

e)

$$1.8 \text{ m}^3/\text{hr}$$

## Inhalation Exposure Aerial Application

$$\frac{0.067 \text{ mg}/\text{m}^3 \times 12}{.46 \#} = 1.748 \text{ mg}$$

$$1.748 \times \frac{1}{6} = 0.291 \text{ mg}/\text{m}^3$$

$$\text{Resp Rate} = 7.2 \text{ m}^3/\text{day} = 0.9 \text{ m}^3/\text{hr}$$

$$\frac{291 \text{ mg}}{\text{m}^3} \times \frac{0.9 \text{ m}^3}{\text{hr}} \times \frac{8 \text{ hr}}{\text{day}} = \frac{2.09 \text{ mg}}{\text{day}}$$

~~$$\frac{0.524 \text{ mg}}{2 \text{ m}} \times \frac{8 \text{ hr}}{8 \text{ hr}}$$~~

$$2,4,5\text{-T} = \frac{2.09 \text{ mg}}{\text{day}} \div 80 \text{ Kg} = \frac{0.029 \text{ mg}}{\text{Kg} \cdot \text{Day}}$$

Assuming  $94 \text{ mg TCDD} / \text{Kg } 2,4,5\text{-T} (\text{ug/g}) = (\text{mg/mg})$

$$\frac{0.029 \text{ mg } 2,4,5\text{-T}}{\text{Kg} \cdot \text{Day}} \times \frac{94 \text{ mg TCDD}}{\text{mg } 2,4,5\text{-T}} = \frac{2.814 \text{ mg}}{\text{Kg} \cdot \text{Day}}$$

F

But Canopy penetration ~ 21%

2,4,5-T exposure

$$(.029 \text{ mg})(.21) = 6.09 \mu\text{g/Kg Day}$$

TCDD exposure

$$\frac{2.814 \text{ mg}}{\text{Kg Day}} (.21) = \underline{\underline{0.59 \text{ mg/Kg Day}}}$$

Cumulative exposure =

	<u>2,4,5-T</u>	<u>TCDD</u>
Skin	= 27.9 $\mu\text{g/Kg}$	2.5 mg
+ Inhal	= 6.09 $\mu\text{g/Kg}$	0.59 mg/Kg
	<u>33.99 <math>\mu\text{g/Kg}</math></u>	<u>3.09 mg/Kg</u>

PEL

20 mg/Kg

30 mg/Kg



HP

Worst case

Herb. Purple  $\bar{c}$  TCDD = 47 mg/Kg

10% skin absorption

100% canopy penetration

70 Kg man

1/6 respirable fraction 60  $\mu$  size

1.8 m<sup>3</sup>/h respiration rate, 100% abs.

2-hr exposure

Dermal Exposure

From RPAR

$$- \frac{3,556 \text{ mg Malathion}}{0.46 \# \text{ Applied (Malathion)}} \times 12 \# 2,4,5-T$$

$$= 93 \text{ mg } 2,4,5-T$$

$$- 10\% \text{ skin absorption} = 9.3 \text{ mg } 2,4,5-T$$

- TCDD

$$9.3 \text{ mg } 2,4,5-T \times \frac{94 \text{ mg TCDD}}{\text{Kg } 2,4,5-T} \times \frac{\text{Kg}}{10^6 \text{ mg}}$$

$$= 0.87 \text{ } \mu\text{g TCDD}$$

HP

# Inhalation + Dermal Exposure

## 2,4,5-T

Inhal	1.05 mg
Dermal	9.3 mg
	<u>10.35 mg</u>

For 70 Kg man

$$\frac{10.35 \text{ mg T}}{70 \text{ Kg}} = \frac{0.148 \text{ mg T}}{\text{Kg}}$$

## TCDD

Inhal	0.098 ug
Dermal	0.87 ug
	<u>0.968</u>

For 70 Kg man

$$\frac{0.968 \text{ ug TCDD}}{70 \text{ Kg}} = \frac{0.014 \text{ ug TCDD}}{\text{Kg}}$$

HP

## Inhalation Exposure

From RPAR

$$\frac{0.067 \text{ mg/m}^3}{0.46\#} \times 12 = 1.75 \text{ mg/m}^3$$

Respirable fraction 'worst case'

$$(1.75 \text{ mg/m}^3) \left(\frac{1}{6}\right) = 0.29 \text{ mg/m}^3$$

@  $1.8 \text{ m}^3/\text{h}$

$$\frac{0.29 \text{ mg}}{\text{m}^3} \times \frac{1.8 \text{ m}^3}{\text{day}} \times 2 \text{ hr} = \frac{1.05 \text{ mg}}{\text{day}}$$

TCDD @  $94 \text{ mg TCDD/Kg 2,4,5-T}$

$$\frac{1.05 \text{ mg T}}{\text{day}} \times \frac{94 \text{ mg TCDD}}{\text{Kg T}} \times \frac{\text{Kg}}{10^6 \text{ mg}}$$

$$= 9.87 \times 10^{-5} \text{ mg TCDD}$$

$$9.87 \times 10^{-2} \text{ ug}$$

HP

Average Case for HP

TCDD = 32 mg TCDD / Kg T  
10% thin air  
100% canopy penet.

2,4,5-T Same

Dermal	9.3 mg
Inhal	1.05 mg
	<hr/>
	10.35 mg

For 70 Kg man  $\frac{0.148 \text{ mg T}}{\text{Kg}}$

TCDD

Dermal  $\frac{9.3 \text{ mg T}}{\text{Kg T}} \times \frac{32 \text{ mg TCDD}}{\text{Kg T}} \times \frac{\text{Kg}}{10^6 \text{ mg}}$   
  
= 0.29  $\mu\text{g TCDD}$

Inhal  $\frac{1.05 \text{ mg T}}{\text{Kg T}} \times \frac{32 \text{ mg TCDD}}{\text{Kg T}} \times \frac{\text{Kg}}{10^6 \text{ mg}}$   
  
=  $3.36 \times 10^{-5}$   
=  $3.36 \times 10^{-2} \mu\text{g}$

HP

Inhal + Dermal Ego:

2,4,5-T

$$\frac{10.35}{70} = \frac{0.148 \text{ mg T}}{\text{Kg}}$$

TCDD

Dermal 0.29  $\mu\text{g}$

Inhal 0.03  

---

0.32  $\mu\text{g}$

$$\frac{0.32}{70} =$$

$$\frac{0.004 \mu\text{g TCDD}}{\text{Kg}}$$

HD

Worst Case for HD

$$TCDD = 14 \text{ mg TCDD / Kg T}$$

2,4,5-T Same

$$\frac{0.148 \text{ mg T}}{\text{Kg}}$$

TCDD

$$\frac{0.148 \text{ mg T}}{\text{Kg}} \times \frac{14 \text{ mg TCDD}}{\text{Kg}}$$

$$\text{Dermal } 9.3 \text{ mg T} \times \frac{14 \text{ mg TCDD}}{\text{Kg}} \times \frac{\text{Kg}}{10^6 \text{ mg}}$$

$$= 0.13 \mu\text{g TCDD}$$

$$\text{Inhal } 1.05 \times \frac{14}{10^6} =$$

$$1.47 \times 10^{-5} \text{ mg}$$

$$1.47 \times 10^{-2} \mu\text{g}$$

MO

Inhal + Dermal

2.4.5-7

$$\frac{0.148 \text{ mg T}}{\text{Kg}}$$

TCDD

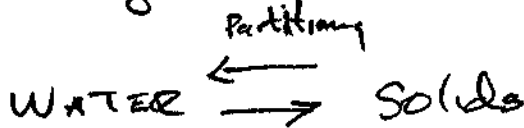
Dermal  
Inhal

$$\begin{array}{r} 0.13 \mu\text{g} \\ 0.01 \\ \hline 0.14 \mu\text{g TCDD} \\ \hline \text{Kg} \end{array}$$

\* Gas Chromatographic estimate

	<u>TCDD</u>	<u>DDT</u>
Vapor Pressure	$1 \times 10^{-7}$	$2 \times 10^{-7}$
Water Sol.	0.2 ppb	1.2 ppb
$K_{oc}$	( $\sim 200,000$ )	240,000
Octanol/water	$1.4 \times 10^6$	$1.6 \times 10^6$

Migration Tendency      Soil Movement

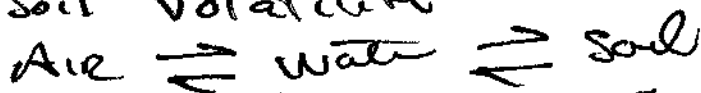


<u>Chemical</u>	<u><math>K_{oc}</math></u>
Dicamba	0
1,3-D	26
EDB <sup>-2,4,5-T</sup>	
Momuron	



1,3-D	18
<u>TCDD</u>	115
DDT	130

Soil Volatilities



$\text{TCDD} = 9 \times 10^{-5}$



Physical or Chemical

Persistent  
Chemical  
AND  
Dioxin (TCDD)

Factors Affecting Exposure to Herbicide Orange

1. WATER INSOLUBLE formulation (specific gravity = 1.28)
2. Concentrated Formulation (8.6 lb ai/gal)
3. LIQUID at Room Temperature, Oily consistency
4. VAPOR PRESSURE  $\sim 3.6 \times 10^{-4}$  mm Hg at droplet surface  $0.01263$  dynes/cm<sup>2</sup>
5. Noncorrosive to metal. Deleterious to paints, rubber and neoprene
6. Viscous (43 at 23°C)
7. Long Shelf life

freezing point = 8°C  
Flash point = 46°C

Pressure = dynes/cm<sup>2</sup>  $\leq P = \frac{2T}{r}$   
 where  $T = \text{dynes/cm}$   
 $r = \text{radius of droplet}$   
 Ave = 350 micrometers

These factors influence ① performance in application equipment ② interaction of the spray with the target ③ final fate in the environment.

Viscosity of aerosol 0.185 centipoise

Surface tension = -

Chloroform	=	27.14	dynes/cm
Water	=	73	dynes/cm
butanol	=	25	dynes/cm

Environment  
Wash/Bead

15 ppm formulation

Sunlight

TCDD on grass

1.83 ppb

Day 1 (10 AM)

↓  
0.5 ppb

6 HR (4 PM)

180 OCTYL  
after 24-hr/sunlight

0.41

Day 2 (10 AM)

0.26 (86% degraded in 2 days) (4 PM)

7.5 ppm TCDD in solvent

2,800 ppt

Day 0

~~82 ppt~~

Day 24

micro ecosystem

$T_{1/2} = 4$  days

LT Wilkinson

~~Roese~~

BS.  
- Chemistry

# Dissemination

PARTICLE SIZE

Size	Percent
less than 100 $\mu$	1.9
100 to 500 $\mu$	76.2
greater than 500	21.9

## Rate of Fall

1 min ( $\sim$  350  $\mu$  particle)  
(2.5 ft/sec)  
150 feet.

30 min 200  $\mu$  — 25% collected  
as vap or 250 ft downwind

Typically — multicanopy forest

of 1000 gallons disseminated — on 346 acres

940 deposited on canopy  
60 ~~at~~ " at ground level

94% intercepted

Actual ground level deposition

~~1.16~~

0.17 gal/A or 14 lbs 34.0/2,457  
per acre.

Aircraft Delivery

A/A 454-1 C-123

130 KIAS

150 ft alt. height

Droplet size 100  $\mu$  to 500  $\mu$

Swath 260 ft

1 cm = 10 mm = 1000  $\mu$   
#

~~P = 2T~~

$$\text{average drop} = \frac{350 \mu}{2} = 175 \mu$$

1 cm = 1000  $\mu$

$$\frac{0.01263 \text{ dynes/cm}^2}{\text{cm}^2} = \frac{2(T)}{0.0175 \text{ cm}}$$

$$\frac{(0.01263)(0.0175)}{2} = T$$

$$\frac{0.000221}{2} = T$$

$$.000111 = T$$
$$1.1 \times 10^{-4}$$

$$2^3 = 8$$

$$1 \text{ ft} = 30.48 \text{ cm}$$

$$\begin{aligned} \text{Average mass} &= 70 \text{ kg} \text{ wt.} \\ 6' &= 182.9 \text{ cm height} \end{aligned}$$

Body Surface area =

$$(W)^{0.425} \times (H)^{0.725} \times (0.07184)$$

$$(70)^{0.425} \times (183)^{0.725} \times (0.07184)$$

$$(6.08) \times 43.68 \times .07184$$

$$= 19.08 \text{ m}^2$$

1.5 - 2.0  $\text{m}^2$  for Fig 661

$30^{\circ}\text{C} = 86^{\circ}\text{F}$

Vapor Pressure at 20°C

NBE 2,4-D = ~~4.5 x 10<sup>-4</sup>~~  $1.2 \times 10^{-4}$

NBE 2,4,5-T =  $0.15 \times 10^{-4}$

ORANGE - ~~30°C~~ =  $3.6 \times 10^{-4}$  mm Hg.

at 30°C ( D =  $3.1 \times 10^{-4}$

T =  $0.45 \times 10^{-4}$

$3.55 \times 10^{-4}$

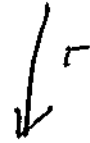
20°C =  $1 \times 10^{-7}$  TCDD

= Orange =

Days	T <sub>1/2</sub>
10	B
40	T
300	TCDD

T<sub>0</sub> = #01

T =



350 # particle size

2-3 ft sect

150 ft 1 min } }

Viscosity - all fluids possess a definite resistance to change of form. This property, a sort of internal friction is called viscosity; it is expressed in

dyne-seconds/cm<sup>2</sup>

~~usual~~ usual units = centipoise

	Chloroform	0.6
at 20°C	water	1
	Butanol	3
	Orange	40
	Light Machine oil	40

gas - 100°C

Chloroform	=	129 $\mu$ p
Butanol	=	140
Water	=	125

Vapor Pressure - at 20°C

Mercury	=	0.0012 (1.2 x 10 <sup>-3</sup> )
Water	=	17.54 mm
Diesel oil	=	22 mm
	=	3.6 x 10 <sup>-4</sup> mm

Pressure exerted when a liquid is in equilibrium with its own vapor

①

350  $\mu$

0.6  $\mu$ l

7  $\text{mm}^2$

70 Kg man

180 cm = ht

Area  $1.9 \text{ m}^2 = 1.9 \times 10^6 \text{ mm}^2$

$$\frac{0.6 \mu\text{l HD}}{7 \text{ mm}^2} \times \frac{1.9 \times 10^6 \text{ mm}^2}{\text{man}} =$$

$$= 1.63 \times 10^5 \mu\text{l HD on a nude man}$$

0.66 e HD

0.16

7.7 gms  $2,4,7$

0.08 e T  
+ 0.08 e D

Calculate TCDD using  $[ETCDD] = 2 \text{ mg/Kg}$

$$\frac{2 \text{ mg TCDD}}{\text{Kg HD}} \times \frac{10.7 \text{ gal}}{\text{gal}} \times \frac{\text{Kg}}{2.2 \text{ gal}} \times \frac{\text{gal}}{3.785 \text{ e}} \times$$

$$= \frac{2.57 \text{ mg TCDD}}{\text{e HD}}$$

Want Core - nude

$$0.16 \text{ e HD} \times \frac{2.57 \text{ mg}}{\text{e HD}} = 0.41 \text{ mg TCDD}$$



(2)

For 70 Kg man

- this represents dose of

$$\frac{0.41 \text{ mg TCDD}}{70 \text{ Kg}} \times =$$

$$5.87 \times 10^{-3} \frac{\text{mg}}{\text{Kg}} = 6.0 \frac{\mu\text{g}}{\text{Kg}}$$

Assume absorption @ 2%

$$\frac{1 \text{ mg}}{\text{Kg}}$$

$$\boxed{\frac{120 \text{ mg}}{\text{Kg} \cdot \text{Day}}}$$

which is 12.0 X PEL

(3)

Put clothing on him  
such that exposed skin  
is only 10% of Total  
∴ on skin is

$$0. \underline{41 \text{ mg TCDD}} \times 0.1$$

$$= 0.041 \text{ mg}$$

$$\frac{0.041}{70} = 5.87 \times 10^{-4} \text{ mg/kg}$$

$$\sim 0.64 \mu\text{g/kg}$$

assume 2% absorb

$$\frac{600 \text{ mg}}{\text{kg}} \times 0.02 = \frac{12 \text{ mg}}{\text{kg}}$$

mean deposition  $\rightarrow$   $\frac{3 \text{ gal H}_2\text{O}}{\text{acre}}$   
 $\frac{3.556 \text{ mg Mal}}{0.46 \# \cdot \text{Acre}}$   $\rightarrow$   $\frac{K \text{ mg 2,4,5-T}}{12 \# \cdot \text{Acre 2,4,5-T}}$

$$K = \frac{(3.6)(12)}{146} \rightarrow \frac{93 \text{ mg 2,4,5-T}}{\#}$$

Assume 10% obsor

Done would be  $9.3 \text{ mg 2,4,5-T}$

$$\frac{9.3}{70}$$

$$\frac{0.13 \text{ mg T}}{\text{Kg}}$$

Worst case

for TCDD is  $94 \frac{\text{mg TCDD}}{\text{Kg T}}$

$$\frac{0.13 \text{ mg T}}{\text{Kg Man}} \times \frac{94 \text{ mg TCDD}}{\text{Kg T}} \times \frac{\text{Kg}}{10^6 \text{ mg}}$$

$$= 1.25 \times 10^{-5} \text{ mg}$$

$$1.25 \times 10^{-2} \text{ ug}$$

$$= \frac{12.5 \text{ mg}}{\text{Kg} \cdot \text{Day}}$$

range of deposit

was  $\frac{1 \text{ gal HO}}{A} \rightarrow$

from Tischerly's data  
worst case (Ch  $\perp$ )

① 7-31

use 21% penetration

∴

Using RPAR Approach:

H<sub>2</sub>O applic rate

$$\frac{4 \#}{10 \text{ gal}}$$

10 gal

assume  $\frac{40 \# \text{ ac } 2,4,5T}{10 \text{ gal H}_2\text{O}}$

assume. 10% of

We applied  $\frac{12 \# T}{\text{acre}}$

# Calculations of TCDD exposures

Assumptions:

Concentration of TCDD in HD -

Mean of 2.0 mg/Kg

Concentration of TCDD in 2,4,5-T

Mean of 4.0 <sup>TCDD</sup> mg/Kg <sup>2,4,5-T</sup>

According to Ramsey, Lavy & Braun  
worker exposure to 2,4,5-T  
as MIXER in a 10 hour period  
is:

$$\frac{0.13 \text{ mg } 2,4,5\text{-T}}{(\text{Kg B.W.})(10 \text{ hours})}$$

$$\frac{0.13 \text{ mg T}}{\text{Kg BW } 10 \text{ hrs}} \times \frac{4 \text{ Ng TCDD}}{\text{mg T}} = \frac{.052 \text{ Ng TCDD}}{\text{Kg BW} \cdot \text{Hour}}$$

	Hours	TCDD Exposure (Ng/Kg)
Thalken	1056	54.9
Tremblay	1046	54.4
Young	6608	343.6

Assuming 10% of B.W. is fat  
 & 10% of Exposure dose is deposited

$$\frac{54.9 \text{ Ng TCDD}}{\text{Kg BW}} \times \frac{.1 \text{ BW}}{\text{BF}} \times \frac{\text{Deposited}}{.1 \text{ Exp}}$$

$$= 54.9 \text{ Ng TCDD / Kg B.F.}$$

i.e. ~55 ppt      Thalken  
           55 "        Tremblay  
           344 "        Young

95% Conf. Limits

$$\sigma = 0.046$$

$$n = 8$$

$$v = N - 1 = 7$$

95% Upper limit

$$z_c = 1.90$$

90 " "

$$z_c = 1.42$$

$$\bar{y} = z_c \sigma / (\sqrt{N-1})$$

$$95\% = \bar{y} + \frac{(1.9)(.046)}{\sqrt{7}}$$

$$\underline{\underline{2.645}}$$

$$\bar{y} + 0.033$$

$$0.073 + 0.033$$

$$\underline{\underline{= 0.106}}$$

$$90\% \bar{y} + \frac{1.42(.046)}{\sqrt{7}}$$

$$= \underline{\underline{2.6457}}$$

$$\bar{y} + 0.024$$

$$\underline{\underline{= .097}}$$



at a conc of 4 Ng TCDD / mg 2,4,5-T

$$\frac{0.2 \text{ mg } 2,4,5\text{-T}}{\text{Kg BW} \cdot \text{Hour}} \times \frac{4 \text{ Ng TCDD}}{\text{mg}} = \frac{0.8 \text{ Ng TCDD}}{\text{Kg BW} \cdot \text{hour}}$$

		(Ng TCDD / Kg BW)
ThalKen	1056 hrs	844
Tremblay	1046	837
Young	6608	5,286

Assuming 10% of B.W. is fat  
10% of exp. dose is  
 deposited

ThalKen	844	ppt
Tremblay	837	"
Young	5,286	"

Job <del>Mixer</del>	Max 2,4,5-T Dose (mg/kg)	
	<u>1<sup>st</sup></u>	<u>2<sup>nd</sup></u>
Backpack Mix	0.014	0.017
" Spray	<u>0.132</u>	0.085
<hr/>		
Tractor <sup>(mist)</sup> Mix.	0.086	0.053
" Oper.	0.041	0.054
<hr/>		
Helic (mist) Mix	0.092	0.081
Pilot	0.002	0.012
<hr/>		
Helic (Rain) Mix	0.086	<u>0.156</u>
Pilot	0.046	0.049

# Calculations of TCDD

x mg 2,4,5-T / Kg Body wt / 10 hr exposure

$$\frac{4 \text{ mg TCDD}}{\text{Kg 2,4,5-T}} = \frac{\mu\text{g}}{\text{g}} = \frac{\text{ng}}{\text{mg}}$$

using data from study on 2,4,5-T by Ransley, Lavy & Braun for MIXER of herbicides

$$0.13 \frac{\text{mg 2,4,5-T}}{\text{Kg BW} \cdot 10 \text{ hrs}} \times \frac{4 \text{ mg TCDD}}{\text{mg 2,4,5-T}}$$

$$0.52 \frac{\text{ng TCDD}}{\text{Kg BW} \cdot 10 \text{ hrs}}$$

Assume Thatkew 1056 hr

$$\therefore \text{Total dose} = 10.56 \times \frac{52 \text{ ng}}{\text{Kg BW}} = \frac{549 \text{ ng TCDD}}{\text{Kg BW}}$$

Assume 10% of BW = Body fat

Then, in body fat will have

$$5490 \text{ ng/kg} \approx 5.49 \text{ ng/kg B.F.}$$

For Yang 6,608

$$66.08 \times \frac{52 \text{ ng}}{\text{Kg BW}} = \frac{3436 \text{ ng/kg}}{3,000}$$

Assume 10% of BW = Body fat

$$\text{Then: } 34 \text{ ng/kg B.F.}$$

or 10% retention

$$\text{BF should contain } \underline{\underline{34 \text{ ppt}}}$$

# Dermal Exposure:

# Inhalation

	Total Skin mg 2,4,5-T/Kg	Exp Skin	mg 2,4,5-T/Kg
Spray / mix	0.2	0.03	0
Tractor // mix	11.7	1.624	0.000191
Microfilar / 3 mix	0.95	0.122	0
Roundup / 8 mix	0.40	0.042	0
		1.818	
Mean $\frac{\text{mg T}}{\text{kg BW}}$	3.31	0.45	0

Exposure time was 2-3 hours

∴ Based on Dermal exposure of  
 $\frac{0.5 \text{ mg } 2,4,5\text{-T}}{\text{Kg BW} \cdot 2.5 \text{ hours}}$  for exposed skin

$$\frac{0.2 \text{ mg } 2,4,5\text{-T}}{(\text{Kg} \cdot \text{BW}) (\text{hour})}$$

Pls see me  
about these  
materials.  
① P12

①

Assume that in walking thru an area just treated that a man would have his feet, & calves exposed to HD. (24% of total body skin surface) The level would be based on his reaching equilibrium w amt deposited / m<sup>2</sup>

$\frac{3}{.06}$   
 $.18$

$$1 \text{ Acre} = 4,047 \text{ m}^2$$

$$\text{Application rate} = 3 \text{ gal HD/Acre}$$

$$\text{Penetration to ground} = 10\% = 0.30 \text{ gal/acre}$$

~~0.48 gal / 3.785 l~~

$$2.4,5\text{-T} = 4 \#/\text{gal} = 1.2 \#/\text{acre}$$

$$\frac{0.55 \text{ Kg}}{\text{acre}} \times \frac{\text{acre}}{4,047 \text{ m}^2} = 1.35 \times 10^{-4} \frac{\text{Kg}}{\text{m}^2}$$

(2)

$$1.35 \times 10^{-1} \text{ g/m}^2 = 0.135 \text{ g/m}^2$$

Average man has  $1.9 \text{ m}^2$

Skin area affected =  $0.46 \text{ m}^2$   
24% of  $1.9 \text{ m}^2$

∴ The 2,4,5-T on skin would be

$$\frac{0.135 \text{ g T}}{\text{m}^2} \times 0.46 \text{ m}^2 = \frac{62 \text{ mg T}}{\text{man}}$$

Assume 10% absorption

$$(0.1)(62) = 6.2 \text{ mg T}$$

70 Kg man  
mg/Kg

0.18	TCDD	@	2 mg/Kg	ug/g	mg/mg	12.4 mg/man
0.89		@	10			62 "
1.77		@	20			124 "
8.3		@	94			582 "

With a mean droplet diameter of  $350\mu$  one can determine from Hurtt report that a total of  $0.6\mu\text{l}$  of  $\text{H}_2\text{O}$  would cause an area of approximately  $70\text{ mm}^2$ . For an average man of  $70\text{ Kg}$ , height of  $180\text{ cm}$  the total skin surface area would be  $1.9 \times 10^6\text{ mm}^2$  (<sup>Guyton</sup>~~DuBois~~)



A-1, L

$$\left( \frac{0.6 \text{ ul}}{7.0 \text{ mm}^2} \right) \left( \frac{1.9 \times 10^6 \text{ mm}^2 \text{ Skin}}{\text{whole man}} \right) \left( \frac{0.1 \text{ whole man's Skin}}{\text{affected skin}} \right)$$

$$= 1.63 \times 10^4 \text{ ul HD} = 16 \text{ ml HD}$$

$$\frac{16 \text{ ml HD}}{\text{man}} \times \frac{\text{gal}}{3,785 \text{ ml}} \times \frac{4 \# \text{ 2,4,5-T}}{\text{gal}} \times \frac{\text{Kg}}{2.2 \#} = 7.69 \times 10^{-3} \text{ Kg}$$

$$= \frac{7.69 \text{ g 2,4,5-T}}{\text{affected SKIN}}$$

Assuming 21% penetrates cover:

$$(7.69)(.21) = \frac{1.615 \text{ g 2,4,5-T}}{\text{affected SKIN}}$$

Assuming 10% absorbed

$$(1.615)(.1) = \frac{0.162 \text{ g 2,4,5-T}}{\text{man}}$$

Assuming 70 Kg Man

$$\left( \frac{0.162}{70} \right) = 0.00233 \text{ g} = 2.33 \text{ mg/Kg}$$

A-1, 2

$$\text{with TCDD} = \frac{94 \text{ mg TCDD}}{\text{Kg T}}$$

0.023g  
absorbed  $\frac{\text{mg}}{\text{man}}$

$$\frac{0.162 \text{g } 2,4,5\text{-T}}{\text{man}} \times \frac{94 \text{ mg TCDD}}{\text{Kg T}} \times \frac{\text{Kg}}{1000 \text{g}} \times \frac{\text{man}}{70 \text{Kg}}$$

$$= 2.18 \times 10^{-4} \text{ mg} = 2.18 \times 10^{-1} \mu\text{g}$$

$$= \frac{0.22 \mu\text{g}}{\text{Kg} \cdot \text{Day}}$$

$$\frac{220 \text{ ng}}{\text{Kg} \cdot \text{Day}}$$

0.008 l  $\frac{3.785 l}{gal}$

A-2

$$\begin{aligned} 1) \quad \frac{0.6 \text{ ul}}{7.0 \text{ mm}^2} \times \frac{1.9 \times 10^6 \text{ mm}^2}{\text{man}} &= 1.63 \times 10^5 \text{ ul HD} \\ &= 1.63 \times 10^2 \text{ ml HD} \\ &= 0.16 \text{ l HD} \end{aligned}$$

2) with a TCDD worst case of 47 mg TCDD/kg HD

$$\begin{aligned} \frac{47 \text{ mg TCDD}}{\text{kg HD}} \times \frac{10.7 \#}{\text{gal}} \times \frac{\text{kg}}{2.2 \#} \times \frac{\text{gal}}{3.785 \text{ l}} \\ = 60.39 \text{ mg TCDD/l HD} \end{aligned}$$

3) TCDD dermal exposure

$$\frac{60.39 \text{ mg TCDD}}{\text{l HD}} \times 0.16 \text{ l HD} = 9.66 \text{ mg}$$

4) 2,4,5-T dermal exposure:

$$0.016 \text{ l HD} \times .5 = 0.08 \text{ l 2,4,5-T}$$

$$0.008 \text{ l} = 2.11 \times 10^{-3} \text{ gal}$$

$$2.11 \times 10^{-3} \text{ gal} \times \frac{4 \# \text{ ae 2,4,5-T}}{\text{gal}} = 8.454 \# \text{ 2,4,5-T}$$

$$5) \quad 8.454 \times 10^{-3} \# 2,4,5-T \times \frac{Kg}{2.2\#}$$

$$= 3.84 \times 10^{-3} Kg = 3.84g \text{ 2,4,5-T}$$

$$0.016 \text{ l HD} \times \frac{gal}{3.785l} \times \frac{4\# 2,4,5-T}{gal} \times \frac{Kg}{2.2\#}$$

$$= 7.686 \times 10^{-3} \frac{Kg \text{ 2,4,5-T}}{man} = 7.68g \frac{2,4,5-T}{man}$$

Checking TCDD exposure

$$\frac{7.68g \text{ 2,4,5-T}}{man} \times \frac{94mg \text{ TCDD}}{Kg} \times \frac{Kg}{10^3g}$$

$$= 0.721 \frac{mg \text{ TCDD}}{man}$$

Assuming only 10% of body (head, shoulders, neck, forearms, hand & thighs) ~~are~~ is affected,

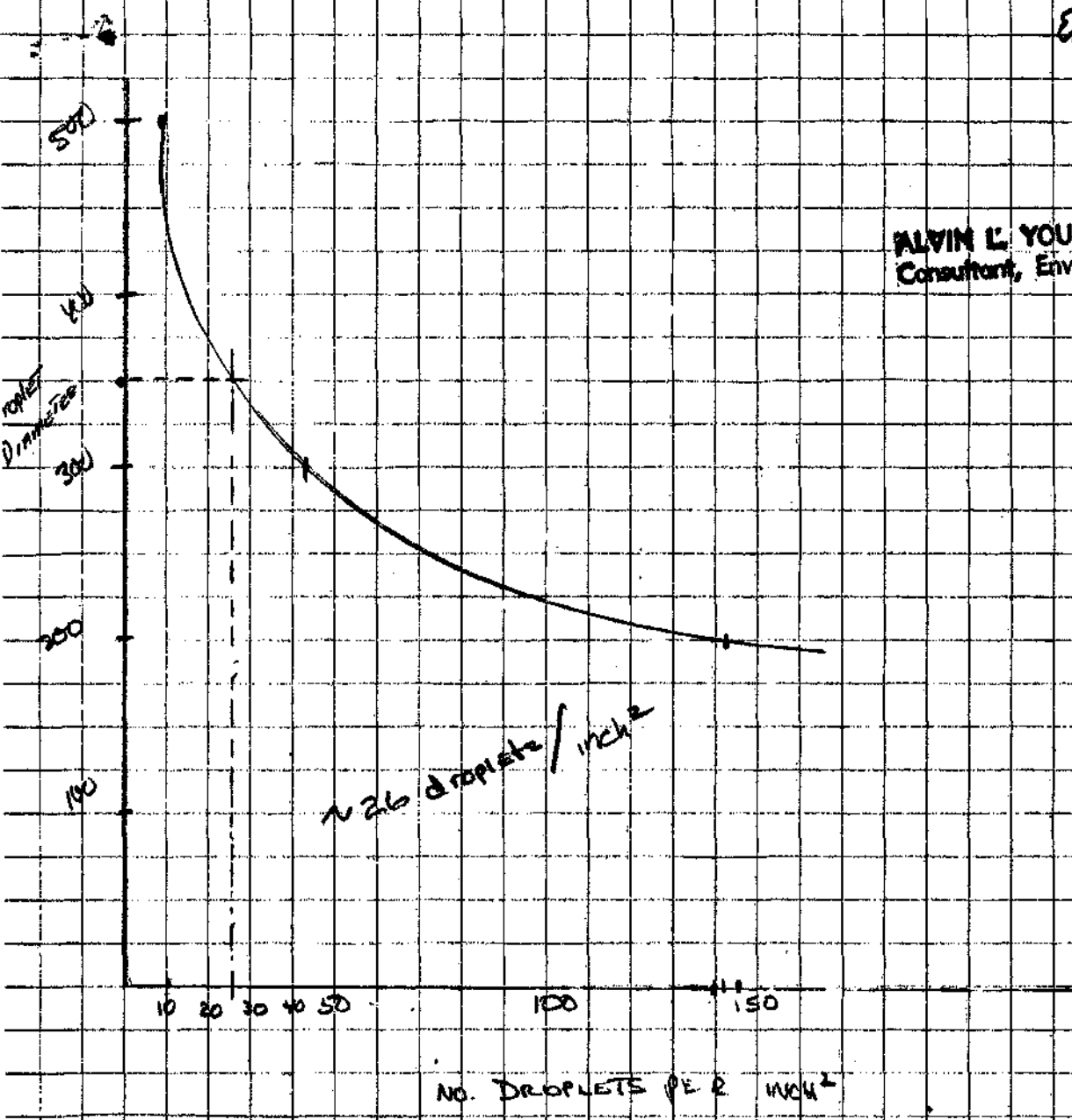
$$\frac{7.68g \text{ 2,4,5-T}}{man} (0.1) \text{ Skin}$$

EXPOSURE DATA

25 OCT 1979

25 OCT 1979

ALVIN L. YOUNG, Major, USAF  
Consultant, Environmental Sciences



**TABLE 1. Effect of Atomization on Coverage (a). Rate of Application — 1 gallon per acre.**

Droplet Diameter (microns)	No. spray droplets per square inch
10	1,148,000
20	143,000
50	9,224
100	1,164
200	142
300	43
500	9

(a) from Himel (1969) p. 920

sect control was the effect of low relative humidity. When the humidity dropped below 70%, insect control declined. In 1977, a comparatively humid year, excellent insect control was obtained with all of the standard insecticides. It was determined that rapid evaporation of the smaller, insecticidally effective droplets was a major factor in poor insect control.

Droplet size is of major importance in insect control. Very fine droplets (less than 50 microns or 1/500th inch in diameter) of short residual insecticides appear to be highly effective in controlling insects. These small droplets impinge on the setae and other parts of the insect's body. A larger droplet may strike the pest causing mortality; however, the smaller droplets increase the probability of hitting the target pest. According to Himel and Moore<sup>1</sup>, 93 percent of the mortality of tobacco budworm (*Heliothis virescens*), cabbage looper (*Trichoplusia ni*) and boll weevil (*Anthonomus grandis*) was caused by droplets less than 50 microns in diameter. Later, Himel<sup>2</sup> reported that if the optimum droplet size is around 20 microns, then our present spray efficiency is about 1% or less.

Of almost equal importance is the effect of droplet size on coverage and penetration of the canopy. Higher volumes of spray are generally recommended in an effort to obtain more complete coverage and better penetration of the plant canopy. It is true that increasing volume will increase numbers of droplets and, therefore, coverage. However, since coverage is primarily a function of numbers of

droplets, a more practical way to increase it is to break the spray up into small drops. Each time the average drop size is divided in half, the number of drops is increased approximately 8 times. These data are presented in Table 1. Thus, one gallon of spray per acre divided into 50 micron drops will produce the same coverage as 64 gallons applied in 200 micron drops.

A third major advantage of very fine droplet sprays is their ability to penetrate through very small openings in the bud tissues and beneath bracts enclosing squares and bolls where the bollworm and boll weevil live and feed. Additionally, fine droplets, because of their tendency to float on air currents, penetrate plant canopies more efficiently, are deposited on the undersides of the leaf, and deliver more insecticide to the lower portions of the plant. This gets the insecticide out of the sunlight and slows the rate of ultraviolet degradation. This in turn, extends the efficacy and increases the control of the bollworm and budworm moths that spend the day down in the canopy.

Since mites and whiteflies live almost exclusively on the undersides of the leaf, only fine droplet sprays can reach them.

Larger drops, due to their greater vertical velocity, tend to impinge on the upper surface of the leaves.

Despite the many important advantages of small particle sprays, there are a number of serious disadvantages. The most serious of these is the rapid rate of evaporation of the insecticide carriers. In practice, this is almost

universally water. Seymour and Byrd<sup>3</sup> projected that an 80 micron water droplet falling through air at 70% relative humidity will disappear in approximately 8.5 seconds. During that time, the 80 micron drop will fall less than 2 feet! A 50 micron drop will last only about 2 seconds. Figure 1 shows this relationship. Boise<sup>4</sup> reports that evaporation and liquid density are often overlooked as factors contributing to the drift of sprays. A spray mixture that is 95% water will evaporate readily, with a 100 micron diameter drop being reduced to a 40 micron drop in about 15 seconds when the air temperature is 80° F and relative humidity is 50%.

Even though the solvents and emulsifiers in the insecticidal formulations reduce the rate of evaporation somewhat, it is still extremely difficult to get an appreciable percentage of the applied insecticide into a cotton crop in an effective droplet size range as long as water is used as the principal carrier. Thus, evaporation can be reduced by using low-volatile spray carriers in lieu of water.

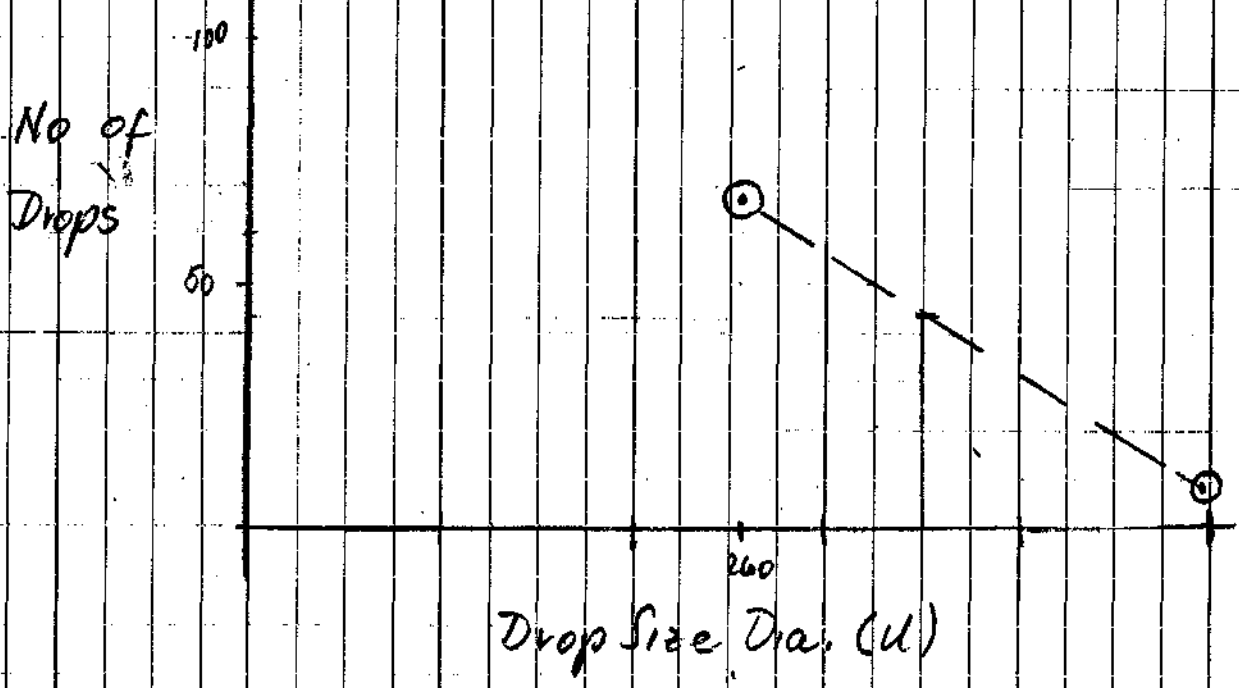
A large number of low volatile materials may be used as substitutes for water as insecticide carriers. Wright<sup>5</sup> suggested that when concerned with evaporation on a real hot, dry day, to add some propylene glycol or even ethylene glycol to the spray mixture. In the initial screening a number of criteria were used for selecting candidate carriers for inclusion in these studies:

1. relatively non-volatile
2. non-phytotoxic
3. compatible with insecticides
4. non-corrosive and non-damaging to aircraft components
5. non-flammable
6. relatively non-toxic
7. physical characteristics as close to water as possible or at least sprayable through systems in current use without major modifications
8. inexpensive (or their cost to be more than offset through reduction of insecticide required)
9. cleared for use on crops

Small plot studies on two month old cotton were conducted during 1978 on insecticidal formulations containing

Review Exec  
Summary  
Send to A

(1)



<u>No Drops</u>	<u>MPD</u>	<u>μL</u>
67	260	0.617
9.1	499	.594

Mean = 0.61 μL

Mean diameter (spread) = 2,000 μ dia for drop dia of 350 μ

∴ Upon impact a drop of 350 μ dia containing 0.61 μL for a total of 42 drops

each drop 2.0 mm diameter impact surface dia  
Area covered would be

42 drops (Area)

$$\text{Area} = \frac{\pi (2)^2}{4} = 3.14 \text{ mm}^2$$

3 gallons / Area  
3 x 3,785 ml

10,000 mls = 144,000



2

$$\frac{0.161 \text{ mL}}{42 \text{ drops}} = \frac{0.014 \text{ mL}}{\text{drop}}$$

each drop could cover  $3.14 \text{ mm}^2$

$$\frac{0.014 \text{ mL}}{3.14 \text{ mm}^2} = 0.0046 \frac{\text{mL}}{\text{mm}^2}$$

Assuming total affected skin surface is wetted, and total affected area is 25% of skin surface

1000 mm  
1000 mm

$$(1.9 \text{ m}^2)(.25) = 0.4750 \text{ m}^2$$

$$= 4.75 \times 10^5 \text{ mm}^2$$

$$4.75 \times 10^5 \text{ mm}^2 \times 0.0046 \frac{\text{mL}}{\text{mm}^2} = 2.185 \text{ mL HC}$$

$$2.2 \text{ mL HC} \times \frac{1 \text{ gal}}{3785 \text{ mL}} \times \frac{4\% \text{ T}}{1 \text{ gal}} \times \frac{1 \text{ kg}}{2.2 \text{ gal}}$$

$$= 0.0011 \text{ kg} = 1.1 \text{ g T}$$

@  $94 \text{ mg TCDD} / \text{kg T}$

$$1.1 \text{ g T} \times \frac{94 \text{ } \mu\text{g}}{1 \text{ g}} = 103 \text{ } \mu\text{g TCDD}$$

Assuming 10% absorption

$$2.4 \text{ g T} = 110 \text{ mg}$$

$$\text{TCDD} = 10.3 \text{ } \mu\text{g}$$

~~17 ppm~~  
TCDD @ highest value

3

Assuming a 70 Kg man

$$2,4,5-T \quad \frac{110 \text{ mg}}{70 \text{ Kg}} = 1.57 \text{ mg/Kg}$$

$$\text{TCDD} \quad \frac{10.3 \text{ } \mu\text{g}}{70 \text{ Kg}} = 147 \text{ mg/Kg}$$

TCDD @ 4 mg TCDD/Kg

$$\text{TCDD} : 1.19 \times \frac{4 \text{ } \mu\text{g}}{9} = 4.4 \text{ } \mu\text{g TCDD}$$

$$10\% \text{ absorpt.} : 0.44 \text{ } \mu\text{g TCDD}$$

$$70 \text{ Kg man} \quad \frac{0.44 \text{ } \mu\text{g}}{70} = 6.3 \text{ mg/Kg}$$

$$0.063 \text{ } \mu\text{g/Kg}$$

EPA - ~~NO EFFECT~~ - (0.03  $\mu\text{g/Kg}$ )  
 in Animals

MEAN FOR Orange  
367 mm

Hurt & Darnow

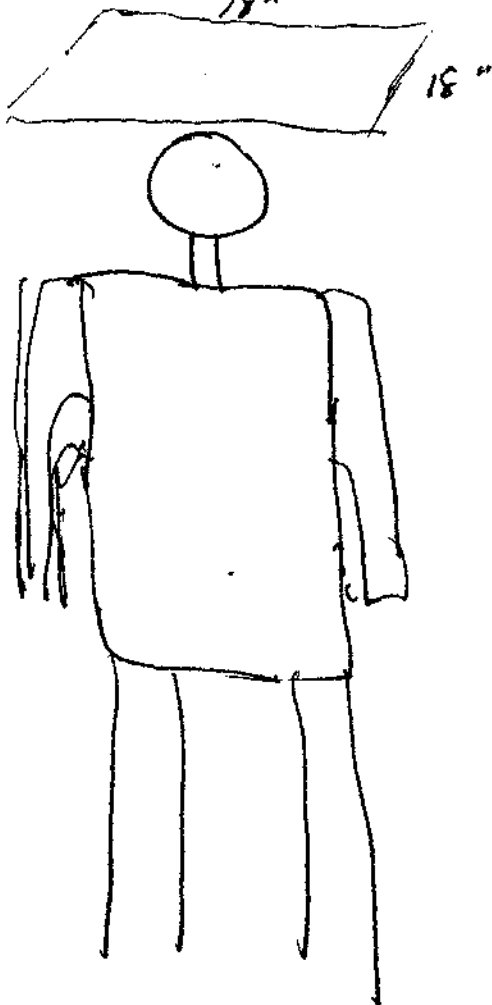
Case  
Orange  
formulation  
125 µg  
250 µg  
500 µg

Drop  
m.m.D  
→ 126  
260  
498

$$\frac{250}{260} = \frac{367}{x}$$

$$x = \frac{367(260)}{250}$$

# drops in<sup>2</sup> =  $\frac{400\text{m} - 500\text{m}}{18''} = 100 \text{ drops/in}^2$



1/4 454-4

1.5 SQ METER

= 2325 in<sup>2</sup>

232500 drops

381 µg Orange = 377 mm drop

88.582500 grams

88 grams if inhaled  
entire body

if  $\frac{191 \text{ mg}}{\text{kg}} \times 0.88 \text{ kg} = .17 \text{ mg TDD}$

if 70 kg man =  $\frac{.17 \text{ mg}}{70 \text{ kg}} = .0024 \text{ mg/kg}$

Textbook of  
**MEDICAL PHYSIOLOGY**

SECOND EDITION, *Illustrated*

**ARTHUR C. GUYTON, M.D.**

*Professor and Chairman of the  
Department of Physiology and Biophysics,  
University of Mississippi School of Medicine*

1961

**W. B. SAUNDERS COMPANY**

Philadelphia and London

is not the reason why the basal metabolic rates of different persons vary according to the surface area; instead, this relationship is only an empirical one.

Referring once again to Figure 660 it will be noted that the total number of Calories liberated by the patient per hour is divided by his total body surface area of 1.5 square meters. This means that his basal metabolic rate is 48.3 Calories per square meter per hour.

**Method for calculating the total surface area.** The surface area of the body varies approximately in proportion to weight<sup>0.67</sup>. However, more accurate measurements of the body surface area have shown that it can be determined more accurately by a complicated formula based on weight and height of the subject as follows:

Body surface area =

$$\text{Weight}^{0.425} \times \text{Height}^{0.725} \times 0.07184$$

Figure 661 presents a graph based on this formula. In the formula and in the figure, body surface area is expressed in *square meters*, weight in *kilograms*, and height in *centimeters*.

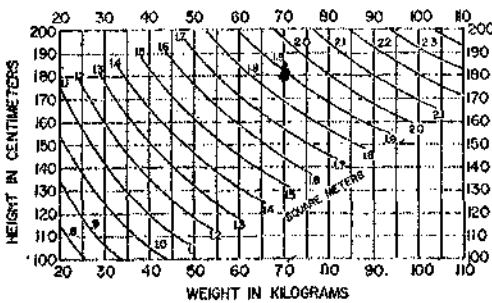


Figure 661. Relationship of height and weight to body surface area. (From DuBois: *Metabolism in Health and Disease*. Lea & Febiger.)

**Expression of Basal Metabolic Rate in Terms of Weight.** Measurement of the basal metabolic rates of many different species of animals has shown that the rates do not vary precisely in proportion to the body surface area. Instead, in animals ranging in size from the mouse to the horse, the basal metabolic rate has been found to be proportional to weight<sup>0.784</sup>. Because surface area is approximately proportional to weight<sup>0.67</sup>, it is obvious that correlating basal metabolic rates between animal species on the basis of surface areas would be in extreme error. This fact has considerable implication in human physiology and in clinical medicine, for some physiologists believe that even in comparing basal metabolic rates between human beings the factor weight<sup>0.784</sup> should be used instead of surface area. *If this is true, overweight subjects would have to have basal metabolic rates considerably above the mean as based on the sur-*

*face area method in order to be normal, and very thin subjects would have to have basal metabolic rates considerably less than the mean as based on the surface area method in order to be normal.*

**Expression of Basal Metabolic Rate in Percentage Above or Below Normal.** In Fig. 659 it will be noted that the basal metabolic rate varies tremendously with age; also, males in general have a basal metabolic rate approximately 8 per cent greater per square meter than that of females. Therefore, to compare the basal metabolic rate of any one subject with the normal basal metabolic rate, it is necessary to refer to a chart such as that in Figure 659, which gives the normal basal metabolic rate per square meter at each age and for each sex. Once reference has been made to such a chart, the basal metabolic rate is ordinarily expressed as a percentage above or below normal. For example, in Figure 659 the normal basal metabolic rate for a 20-year-old male is shown to be 38.5 Calories per square meter per hour. Therefore, if the particular patient represented in the calculations of Figure 660 is a 20-year-old male, he liberates 9.8 Calories per square meter per hour above the normal mean value. It is then determined that this is 25.5 per cent above normal. Therefore, the basal metabolic rate is expressed as plus 25.5. Similarly, basal metabolic rates below normal are expressed as minus values.

**Constancy of Basal Metabolic Rate in the Same Person.** Basal metabolic rates have been measured in many subjects at repeated intervals for as long as 20 or more years. As long as a subject remains healthy, almost invariably his basal metabolic rate as expressed in percentage of normal does not vary more than 5 to 10 per cent.

**Constancy of Basal Metabolic Rate from Person to Person.** When the basal metabolic rate is measured in a wide variety of different persons and comparisons are made within single age, weight, and sex groups, 85 per cent of normal persons have been found to have basal metabolic rates within 10 per cent of the mean. Thus, it is obvious that measurements of metabolic rates performed under basal conditions offer an excellent means for comparing the rates of metabolism from one person to another.

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# Hurt Report

# ORANGE

Drop diameter	No. of Drops	total $\mu$ l	leaf area contacted
260 $\mu$	64	0.6	8.6 $\text{mm}^2$
498 $\mu$	9	0.6	5.7
127 $\mu$	70	0.75	
260 $\mu$	67	0.62	
499 $\mu$	9	0.59	

Orange

Average Flow Rate  
227 GPM

Average Swath  
259

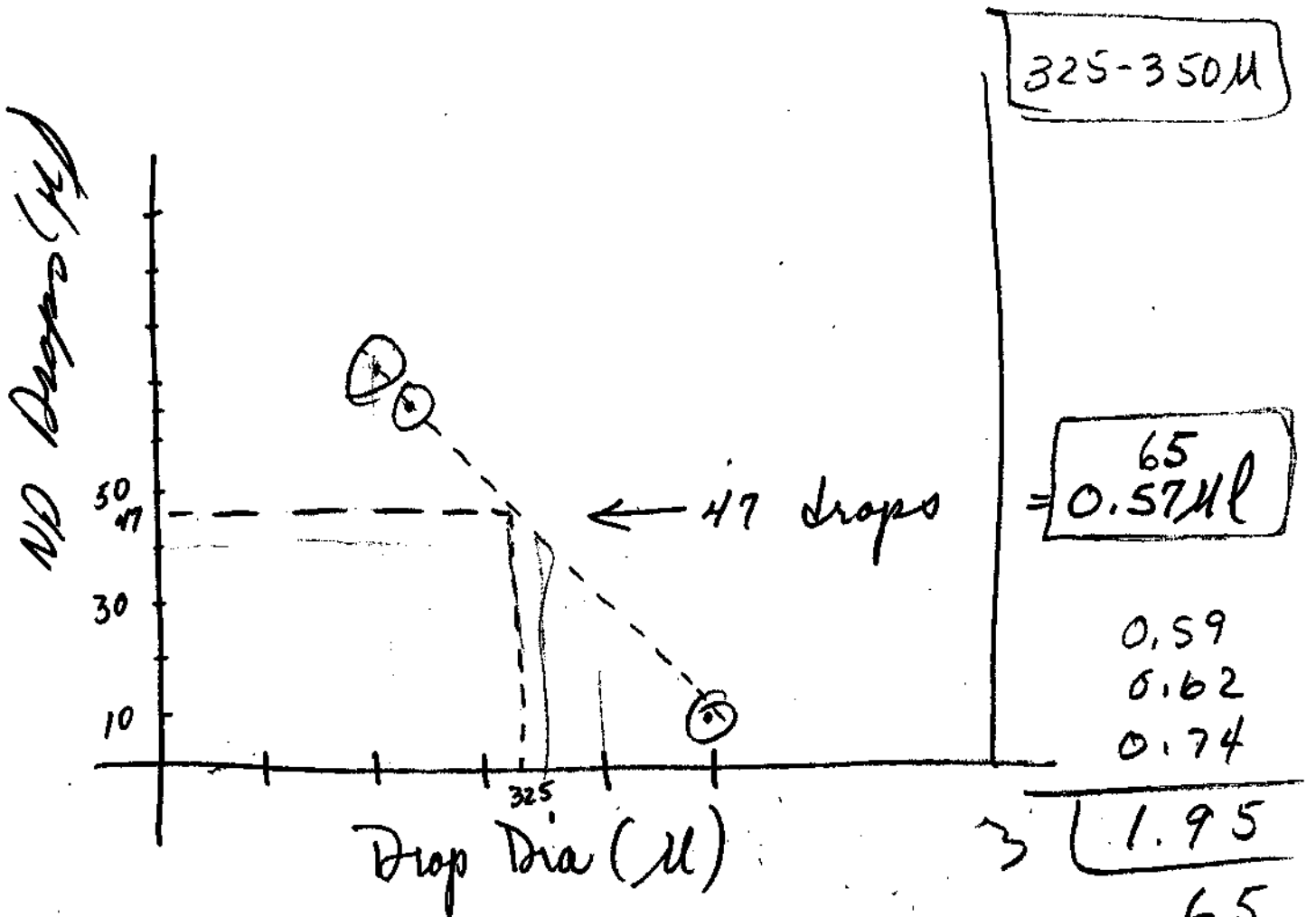
(1000 gal/acre)  
Average Area  
364

Aerial appl : RPAR —

Dermal —	$5 \times 10^{-6}$	ug/Kg	<u>71%</u>
Inhal —	$2 \times 10^{-6}$	ug/Kg	<u>29%</u>



1 drop (325  $\mu$  diameter) will cover 2000  $\mu$  dia surface and will consist of 0.012  $\mu$ l of H<sub>2</sub>O



Therefore:

$$\text{Area} = \frac{\pi D^2}{4} = \frac{\pi (2 \text{ mm})^2}{4} = \frac{18}{15} = 3.14 \text{ mm}^2$$

The body surface area affected is 31% of total area

$$(\cancel{1.9} \text{ m}^2)(.31) = 0.59 \text{ m}^2$$

$$= 5.9 \times 10^5 \text{ mm}^2$$

for each  $3.14 \text{ mm}^2$  we have  $0.012 \text{ mL}$  of  $\text{H}_2\text{O}$

$$\therefore \frac{5.9 \times 10^5 \text{ mm}^2}{3.14 \text{ mm}^2} \times 0.012 \text{ mL}$$

$$= 2,082 \text{ mL} = 2.1 \text{ mL}$$

Assuming 10% absorption

$$\text{Total} = 0.21 \text{ mL}$$

$$0.21 \text{ mL H}_2\text{O} \times \frac{\text{gal}}{3785 \text{ mL}} \times \frac{4\#}{\text{gal}} \times \frac{\text{Kg}}{2.2\#} \times$$

$$1 \times 10^{-1} \text{ g}$$

$$.1 \text{ g}$$

$$100 \text{ mg}$$

$$= 1.0 \times 10^{-4} \text{ Kg}$$

$$101 \text{ mg}$$

2.4, 5-T absorbed

$$\frac{101 \text{ mg}}{70 \text{ Kg}} = 1.43 \text{ mg/Kg } 245 \text{ T}$$

$$\frac{1.43 \text{ mg } 2,4,5\text{-T}}{\text{Kg man}} \times \frac{\text{X} \text{ ~~mg~~ mg}}{\text{Kg mg}} \quad \frac{49}{9}$$

TCDD	TCDD mg/Kg man absorbed
2	2.86
15	21.3
30	42.6
<u>90</u>	



$$100 \text{ cm} = 1 \text{ m}$$

$$1000 \text{ mm} = 1 \text{ m}$$

$$1,000,000 \text{ } \mu\text{m} = 1 \text{ m}$$

$$1,000,000 \text{ } \mu\text{m} = 1 \text{ m}$$

S.F.

Drop dia  
Card Spot dia

$$10^6 \mu = 1 \text{ m}$$

$$10^3 \mu = 1 \text{ cm}$$

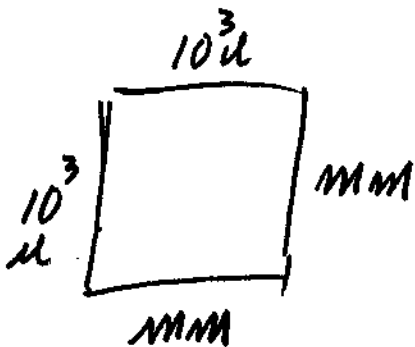
$$1 \mu =$$

$$\frac{\text{Card spot dia}}{\text{drop}} = \frac{\text{drop dia}}{\text{S.F.}} \times \frac{\# \text{ drops}}{\text{drop}}$$

$$= \frac{495 \mu}{1.79}$$

$$\text{Area} = \frac{\pi D^2}{4}$$

$$6.006 \times 9 \text{ Drops}$$



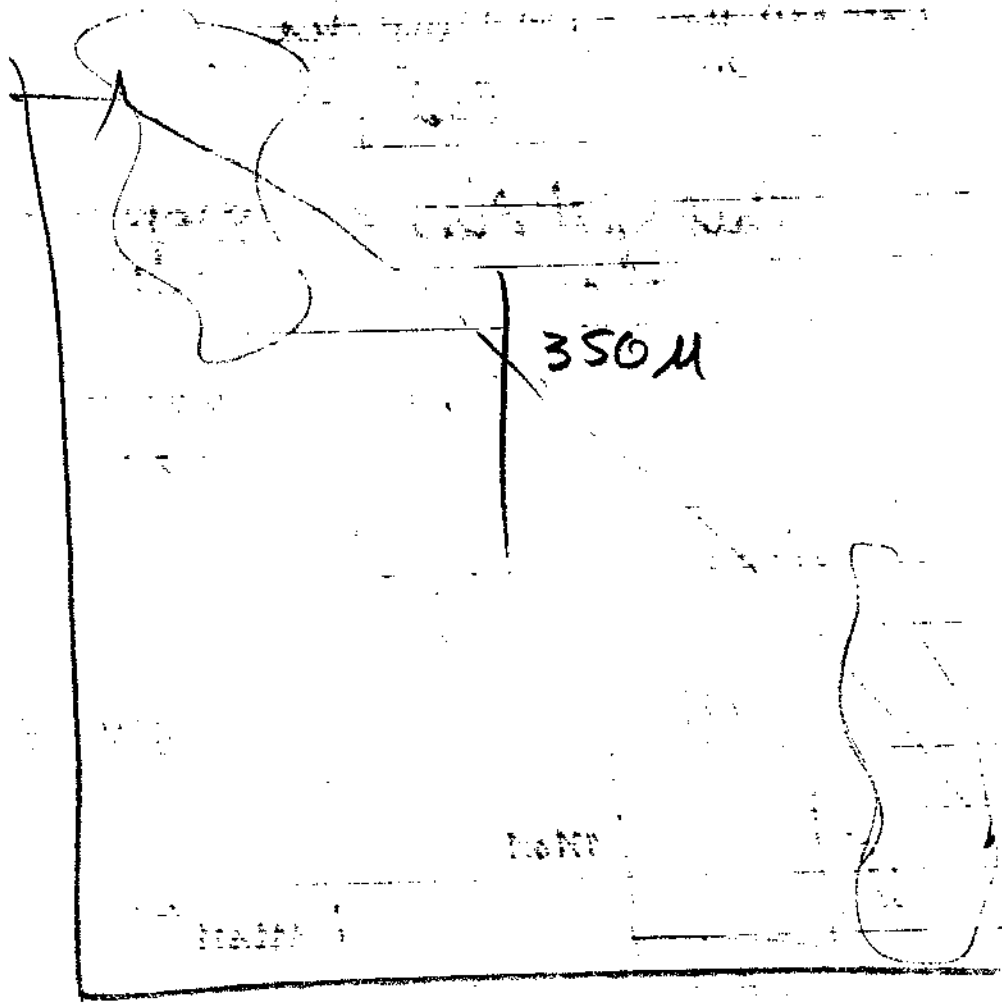
$$540,551 \mu\text{m}^2$$

$$1 \text{ mm}^2 = 10^6 \mu\text{m}^2$$

$$5.4 \times 10^5 \mu\text{m}^2$$

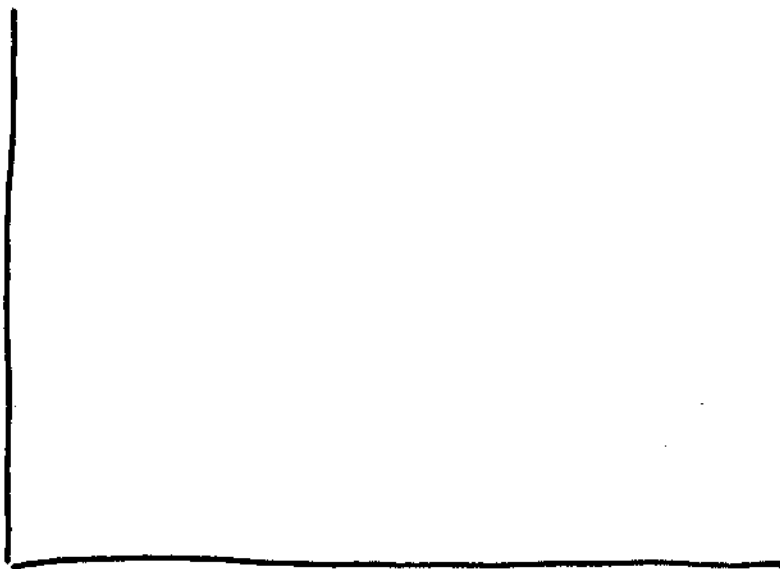
$$1,750 \mu - 2,100 \mu$$

Say 2,000  $\mu$  for each  
droplet of size 325  $\mu$



*[Faint, illegible handwritten notes at the bottom of the page]*

0.57 mL	125 $\mu$	564 drops
0.57 $\mu$ L	250 $\mu$	70 drops
"	500 $\mu$	8.7 "



with 47 drops

$$= \frac{\text{drops}}{0.57 \text{ mL}} \left( \frac{\pi}{4} \right) (2000 \mu)^2$$
$$(2 \times 10^{-3} \text{ mL})^2$$
$$\frac{47}{.57} \left( \frac{\pi}{4} \right) (= 2 \text{ mm})^2$$
$$= \frac{259 \text{ mm}^2}{\text{mL}}$$

$$\left( \frac{1 \text{ mL}}{259 \text{ mm}^2} \right) \left( \frac{1.9 \times 10^6 \text{ mm}^2}{\text{man}} \right)$$

$$7,336 \text{ mL}$$

$$= \frac{7.4 \text{ mL}}{\text{man}}$$

made  
100% cancer

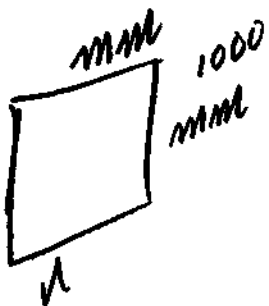
$$\left( \frac{7.4 \text{ mL}}{\text{man}} \right) \left( \frac{\text{gal}}{3785 \text{ mL}} \right) \left( \frac{4 \# 2.4,5\text{-T ae}}{\text{gal}} \right) \left( \frac{\text{Kg}}{2.2 \#} \right)$$

$$= \frac{0.004 \text{ Kg}}{\text{man}} = 4 \text{ g } 2.4,5\text{-T}$$

<u>Drop Dia (μ)</u>	<u>No Drops</u>	<u>Total μl</u>	<u>Area Contacted</u>
120	618	.572	16.68
126	584	.583	18.09
243	70.8	0.534	9.10
260	64.1	.590	8.59
495	9.0	.572	5.11

$$\text{Spread factor} = \frac{\text{Drop dia } \mu}{\text{Card spot dia } \mu}$$

$$\text{Card spot} = \frac{495}{1.790} = 276 \mu$$



$$\text{Area} = \frac{\pi D^2}{4} = 5.4055 \text{ mm}^2$$



*W. B.*

PERSONNEL

COMPARISON OF RANCH HAND, AND GROUND TROOP  
EXPOSURE TO AGENT ORANGE

RANCH HAND

Console Operator:

VAPOR: PACER HO data (Air Force Technical Report  
78-92, 1978) - within Dedrum Facility  
at Naval Construction Battalion Center, Gulfport  
MS, 90-95° F.

~~at~~ - Air Concentration

2,4-D = 135  $\mu\text{g}/\text{m}^3$

2,4,5-T = 80  $\mu\text{g}/\text{m}^3$

- Respiration rate for average man at work

$\frac{30 \text{ resp}}{\text{min}}$

Water/Air Ratio:

$$\text{Water/Air} = \frac{(\text{Water Sol.}) (8.206) (0.76) (273.15 + T^{\circ}\text{C})}{(\text{Vapor Press.}) (\text{Mol. wt.}) (10^2)}$$

$$\text{Water/Air} = \text{ppm} / \mu\text{g}/\text{cc}$$

$$\text{Water sol.} = \text{ppm}$$

$$\text{Vapor Press.} = \text{mm Hg}^{\circ}$$

LET TO DOD

Auto AOWG

500 names from Army Units  
200 names from Marine Units

Criteria - 4400 Names

no consider effort to exclude ~~rotated~~ Service

- Exclude OFFICERS
- Exclude MULTIPLE TOURS
- Exclude KIA

- Engineer battalions - CONSTRUCTION
- Air Cavalry <sup>MOBILE</sup> - Infantry

MARINES

Division 18,000  
INFANTRY BRIGADES  
3 Man.

Delete Charlie Company

Signal Brigade  
Medical Brigade

Engineer Command

Universe of VIETNAM Veterans

• Infantry - MOS

Platoon 34 + office  
↓  
4 SQUADS

Participant - Date individual rotates out of Vietnam.

Entry on death

Selection of Subjects for the pilot phase.  
Reference Abstracts

80%  
200/10

Population <sup>of interest</sup> description

↓  
all soldiers in qualified Battalions

NOT Survey of the population

e.g. → two groups of high exposure -  
RANCH HAND  
Chemical Corps

Criteria for inclusion & Exclusion

• Cover majority of persons & homogeneity

— Draftees with one tour of duty in Vietnam.

→ ONE yr tour in Vietnam

— Exclude Officers  
Statistical problem - need to over-sample  
stratification required

— Epi. study - compare health outcomes between two major groups.

— Exclude Multiple tours.

Officers may have more confounders

n = enlisted groups

- Must be in unit for 10 months
- Must track more carefully the unexposed personnel.

⊙ Wounded in Action  
 & Bases excess risk.

Characterization of Population

Mortality

Group Matching

- \* Age & SEX Similar
- Racial
- WIA
- Education
- Regional Sited
- MOS

Officers vs  
 enlisted

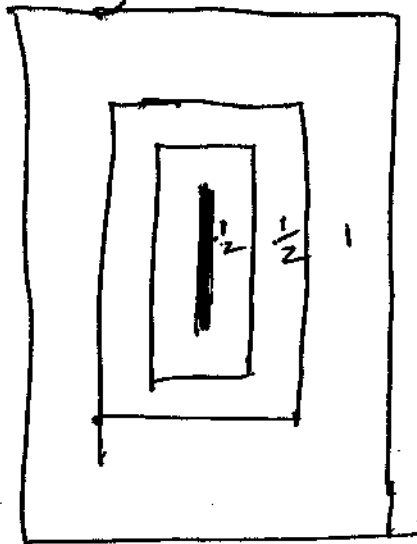
Rural/Urban

Army vs Marine

Branch of Service

# Exposure Subcommittee

• Carl Keller - Hearing test for VA Health Effects Comm



~~Jump~~

0-23 Hz

24-47

48-72

✓ Manuscript for Salzburg

✓ Ltr to Ayres

✓ Book for Pegram

o Ltr to AAOTF ✓

o Australian Response ✓

o Ltr on Dr Hood → Identified

o Slides for Salzburg

✓ ITM

✓ Jeff Ryan

✓ Ray Carroll "

✓ Ltr to Ed Gungless

SALZBURG -

Penrose - Twin Study

• Ltr. to DOD

copy to:

Houk

HHS.

~~Atwood~~

PETE Flynn.

• Start Cohort Selection

• Keenan/Hobbes

Ltr on 1,000 ?

Subjects of  
used to

our Pilot phase will not be  
Vietnam

Phase I

Recruitment

• Religious Oversight

Ltr - Sepp

Over  
Advisory Committee

Epidemics



## Model

Chemical, Target, Time after application,  
and distance from application site.

## Factors that influenced exposure to herbicides

- o Herbicide Formulation
  - Chemical / Physical Characteristics
  - Solubility
  - Vapor Pressure
- o Dissemination of Herbicides
  - Application Parameters
  - Target vegetation
- o Route of Exposure
  - Dermal
  - Inhalation
  - Ingestion
- o Environmental Fate
  - In air
  - on vegetation
  - in soil
  - in water

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## Dissemination Systems

1. Ranch HAND A/A45V-1 Internal Defoliant Dispenser
2. UH-1B/D Helicopter Spray System (AgriNAVIGATOR)
3. Buffalo Turbine
4. Power-Driven Decontamination Apparatus (PDDA)
5. Back-Pack Sprayers (2.5 gallon)
6. "Jerry-rigged" or Field Expedient Devices

# ASSIGNMENT OF WEIGHTS

		<u>Score wt</u>
o Toxicity of Herbicide		
Orange	6000 mg/kg	5
White	2600 mg/kg	2
Blue	3100 mg/kg	1
o Location of Mission		
Defoliation		
Jungle (heavy canopy)	10% penetration	1
Mangrove (light canopy)	30% "	3
Crop / Above	100% "	10
Perimeter	40% "	7

## Time / Distance MATRIX

<u>TIME</u>	<u>DISTANCE (km)</u>
<u>DAYS</u>	

Sat 28, 29 - RTP

RH advisory comm.

SUBCOMMITTEE

Resolve

- 3<sup>rd</sup> Cohort Issue - Study design
- Individual criteria to determine eligibility for study
- Time & distance parameters
- Weighting scheme for exposure index

• Rifleman

→ dose response vs threshold

• #

Review

Building

60 minutes freedom of information act

Window

Time

- Prepare a map
- Define area & select area for
- Obtain appropriate search
- Identify battalions
- Determine availability of records
- record unit daily ~~positions~~ coordinates (activity)
- Develop "In-service" HERBS TAPE

- Index of weighting

days	Kon drop			
	<0.5	1	1.5	2
1	8	2	1	1
2	4	1		
3	2	-	-	
4	1	-	-	

Day	<0.5	1	1.5	2.0
1	70	15	10	5
2	35	8	5	3
3	18	4	3	1

## Weighted System

Fate of TCDD

Location of Mission

Jungle

Mangrove

Crop

Other

Type of Mission Included

RANCH HAND

Perimeter

Above

Time after Exposure

Days

• within 1

• " 2

• " 3

Distance from Exposure Type  
(Application Site)

• within 0.5 km

• " 1.0 "

• " 1.5 "

• " 2.0 "

Exposure Cohort

See Stevenson

Combat Orange	$\bar{c} \bar{o}$
Non Combat Orange	$c \bar{o}$
Non Combat Non Orange	$c o$

EXPOSURE } GRADIENT } Model of Disease

1. Threshold

2. INDEX

Calculation (Biological Assumptions)

Validation (Social/Political)

20 Hits of Orange

1-4 Hits Low  
8-12 Intermediate  
16-20 High

Off Roads  
Orange data  
Location

Weighting Scheme: Perimeter Day and distance

Example: "Non-HTT"

Distance vs Time