

# The Arizona Border Study

*An Extension of the  
Arizona National Human Exposure Assessment Survey (NHEXAS) Study  
Sponsored by the Environmental Health Workgroup of the Border XXI Program*

## Quality Systems and Implementation Plan for Human Exposure Assessment

The University of Arizona  
Tucson, Arizona 85721

Cooperative Agreement CR 824719

**Standard Operating Procedure**

**SOP-IIT-A-11.0**

**Title:** Dermal Exposure Calculation

**Source:** The University of Arizona

U.S. Environmental Protection Agency  
Office of Research and Development  
Human Exposure & Atmospheric Sciences Division  
Exposure & Dose Research Branch

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## STANDARD OPERATING PROCEDURE FOR DERMAL EXPOSURE CALCULATION

This Standard Operating Procedure (SOP) uses data that have been properly coded and certified with appropriate QA/QC procedures by the University of Arizona NHEXAS team.

### Objective

Calculate the dermal exposure to chlorpyrifos and diazinon.

### Exposure Calculation

The equation<sup>1</sup> used to calculate the dermal exposure for each subject is as follows:

$$E = \left[ \sum_{s=1}^S C_{Ds} \times A_{ps} \times T_{ps} \times (1 - DO_{ps}) \right] + \left[ \sum_{s=1}^S C_{Ss} \times (S_{ps} \times SA_{ps} - SO_{ps}) \times M \right] \quad (8-1)$$

where E is the total dermal exposure to pesticide (chlorpyrifos or diazinon), µg/day.

s is surfaces contacted per day.

$C_{Ds}$  is concentration of dislodgeable surface residue, µg/m<sup>2</sup>.

$A_{ps}$  is surface area contacted by subject p, m<sup>2</sup>/day.

$T_{ps}$  is transfer from surface by subject p, proportion.

$DO_{ps}$  is dislodgeable residue transferred to oral route by subject p via hands, food, and objects, proportion.

$C_{Ss}$  is concentration of pesticides in soil, µg/g.

$S_{ps}$  is soil covering on skin from surface s for subject p, g/m<sup>2</sup>.

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<sup>1</sup> Modified from "Research Solicitation : Human Exposure Assessment", Office of Research & Development, 1993. The variable  $AF_D$ , dermal absorption fraction, in the source equation is not included in this equation.

$SA_{ps}$  is surface area of skin exposed to surface  $s$  for subject  $p$ ,  $m^2$ .

$SO_{ps}$  is soil or dust from surface  $s$  transferred to oral route by subject  $p$ , g/day.

$M$  is matrix effect of soil, proportion.

### **Assumptions and Values of Variable Used in the Calculation**

Equation 8-1 being used to calculate the dermal exposure is modified from the source equation. Only variables regarding exposure, not dose, are retained. So the variable  $AF_D$ , dermal absorption fraction for the chemical, is not included in this equation. Assumptions made and/or values used for the rest of the variables are discussed below:

#### **Surface contacted, $s$**

There are 2 types of dislodgeable surface area in NHEXAS study. One is the floor surface area, and the other is the window sill surface. The later is assumed to be a representative of all surfaces such as furniture other than the floor in the house, and is called "non-floor surface".

As a result, there are totally 3 surfaces considered in this equation: Surface 1 is the measured concentration of residue on non-floor surface (sill), surface 2 is the measured concentration of residue on floor surface, and surface 3 is measured concentration of yard soil.

#### **Surface area contacted, $A_{ps}$**

For a 6-9 month old child, it is estimated<sup>2</sup> that he/she plays in an area of 18.6  $m^2$ , and comes into contact with 25% of that surface. Therefore, the surface area contacted is 4.65  $m^2$ . These 2 age groups, however, are not present in our dermal exposure calculation.

The floor surface area contacted by adults and children is assumed to be 10% and 50% of the total floor surface area in the house, respectively. The non-floor surface area is assumed to be proportional to the floor surface area, so it is assume as 30% of the total floor surface area in the house. The non-floor surface area contacted by each subject is then assumed to be equal to 50% and 70% of the non-floor surface area for adults and children, respectively. Therefore, the surface area contacted by adults and children are 15% and 21% of the total floor surface area, respectively.

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<sup>2</sup> "Insecticide absorption from indoor surfaces: Hazard assessment and regulatory requirements", Berteau Pe, et. al., ACS Symposium Series 382, Washington DC: Amer. Chem. Society, 1989.

**Transfer from surface,  $T_{ps}$**

The transfer from the two dislodgeable surfaces is estimated by the ratio of the measured concentration from dermal wipe (hands wipe) to the concentration of residue on the dislodgeable floor and soil surface.

### Dislodgeable residue transferred to oral route, $DO_{ps}$

The dislodgeable residue transferred to oral route is calculated by<sup>3</sup>:

$$DO_{ps} = SA_{ph} / SA_{ps} \quad (8-2)$$

where

$SA_{ph}$  is surface area of skin on the hands that is used to transfer material to mouth or food,  $m^2$ . This is assumed to be 25% of the hands area<sup>4</sup>.

$SA_{ps}$  is the surface area of skin exposed to surface s,  $m^2$ .

### Soil covering on skin, $S_{ps}$

The values used for soil covering on skin are 8 and  $11.1g/m^2$  for children and adults, respectively<sup>5</sup>.

### Surface area of skin exposed to surface, $SA_{ps}$

The total surface area of the skin is calculated from the following equation<sup>6</sup>:

$$SA = 0.0239 H^{0.417} W^{0.517} \quad (8-3)$$

where H is height of subject, cm.; and W is body weight of subject, kg.

The surface area of skin exposed to surface for a subject is assumed to be the area of hands, feet, legs and arms of the body for children; and hands and feet for adults. The percentage of total body surface area by part<sup>7</sup> is used to get the surface area of skin exposed for children and adults, respectively. For adults, the percentage of total body surface by part used is as follows :

Gender	Hands	Feet
Male	5.2	7.0
Female	5.1	6.5

Children are categorized into 7 age groups, and are not distinguished by gender. The percentage of total body surface area by part of each age group for children is as follows:

<sup>3</sup> "Research Solicitation : Human Exposure Assessment", Office of Research & Development, 1993.

<sup>4</sup> "Research Solicitation : Human Exposure Assessment", Office of Research & Development, 1993.

<sup>5</sup> Exposure Factor Handbook, 1997.

<sup>6</sup> Exposure Factor Handbook, 1997.

<sup>7</sup> Exposure Factor Handbook, 1997, Table 6-6 and 6-8.

Age	Hands	Feet	Legs	Arms
<1	5.30	6.54	20.60	13.70
1-2	5.43	6.63	23.30	12.83
3-5	5.89	7.25	27.30	14.20
6-8	4.71	6.90	27.10	13.10
9-11	5.30	7.58	28.70	12.30
12-14	5.25	7.53	31.25	12.90
15-17	5.41	7.11	32.20	15.30

### Soil transferred to oral route, $SO_{ps}$

The information on the soil from surface transferred to oral route is not available from literature papers, so it is assumed to be zero.

### Matrix effect of soil, $M$

The matrix effect of soil is assumed<sup>8</sup> to be 0.15.

### Variable List

Variable	Description
$HHID$	household I.D.
$C_{Ds1}$	measured concentration of dislodgeable surface residue on the sill surface, $\mu\text{g}/\text{m}^2$ .
$C_{Ds2}$	measured concentration of dislodgeable surface residue on the floor surface, $\mu\text{g}/\text{m}^2$ .
$A_{Ps1}$	area of sill surface contacted per day, $\text{m}^2/\text{day}$ .
$A_{Ps2}$	area of floor surface contacted per day, $\text{m}^2/\text{day}$ .
$DWP$	measured concentration of pesticide residue on the hands, $\mu\text{g}/\text{m}^2$ .
$T_{Ps1}$	transfer from sill surface (proportion).
$T_{Ps2}$	transfer from floor surface (proportion).
$DO_{ps}$	dislodgeable residue transferred to oral route via hands, food, and objects (proportion).
$ED_{s1}$	dermal exposure to pesticide (chlorpyrifos or diazinon) via sill surface, $\mu\text{g}/\text{day}$ .
$ED_{s2}$	dermal exposure to pesticide (chlorpyrifos or diazinon) via floor surface, $\mu\text{g}/\text{day}$ .
$ED$	dermal exposure to pesticide (chlorpyrifos or diazinon) via both

<sup>8</sup> "Research Solicitation : Human Exposure Assessment", Office of Research & Development, 1993.

Variable	Description
	dislodgeable surfaces (sill and floor), $\mu\text{g/day}$ .
$C_{ss}$	measured concentration of pesticide (chlorpyrifos or diazinon) in soil, $\mu\text{g/g}$ .
$S_{ps}$	soil covering on skin, $\text{g/m}^2$ .
$SA_{ps}$	surface area of skin exposed to the soil surface, $\text{m}^2$ .
$SA_{ph}$	surface area of skin on the hands that is used to transfer material to mouth or food, $\text{m}^2$ .
$SO_{ps}$	soil transferred to oral route, $\text{g/day}$ .
$M$	matrix effect of soil (proportion).
$ES$	dermal exposure to pesticide (chlorpyrifos or diazinon) via soil surface, $\mu\text{g/day}$ .
$DE$	total dermal exposure to pesticide (chlorpyrifos or diazinon), $\mu\text{g/day}$ .
$HT$	height of respondents, cm.
$BW$	body weight of respondents, kg.
$SA$	calculated total surface area of skin of respondent, $\text{m}^2$ .

### Procedure

The concentration data in each media will be censored with the approaches explained in SOP # 4. Generally, 3 sets of data resulted from the censored data treatment will be used in the exposure estimation:

- 1) Data set with all below detection limit values substituted by zero.
- 2) Data set with all below detection limit values substituted by the detection limit.
- 3) Data set with all below detection limit values substituted by values selected using the Robust Method.

The procedure explained next is for estimating unweighted exposure for the data sets. Weighted exposure estimates can be obtained by using the SUDAAN program. The unweighted exposure estimates, with corresponding sampling weights, will be used as the program's inputs. The sampling weights used will be calculated and adjusted according to the processes explained in details in SOP # 9 and 10.

The procedure for the unweighted exposure estimation in this SOP is the following:

1. In Excel, create a file with variables:  $HHID$ ,  $HT$ ,  $BW$ ,  $SA$ , and  $SA_{ps}$ . The first 3 variables will be obtained from the Baseline Questionnaire. Use equation 8-3 to calculate the values of  $SA$ . Then calculate  $SA_{ps}$  and  $SA_{ph}$  (see the discussion in this SOP). Save this file as **BODY SURFACE AREA**.

2. The following steps use the data sets which are censored<sup>9</sup> with Approach 1-Substitution with zero values. In SPSS, use *HHID* as a key variable and merge the following files:

- FDP BDL = ZERO (containing households with pesticide concentration in floor dust)
- SWP BDL = ZERO (containing households with pesticide concentration in sill wipe)
- YSP BDL = ZERO (containing households with pesticide concentration in yard soil)
- DWP BDL = ZERO (containing households with pesticide concentration in hand wipe)
- BODY SURFACE AREA

Select only the households which are present in all files and delete others. Then separate the merged file into 2 files, one for each pesticide. Save the files that contain chlorpyrifos and diazinon as DERMAL EXPO CHLORPYRIFOS BDL = ZERO and DERMAL EXPO DIAZINON BDL = ZERO, respectively.

1. In Excel, open DERMAL EXPO CHLORPYRIFOS BDL = ZERO, delete variables not related to the exposure calculation, then arrange the file so that it has the following variables:  $C_{Ds1}$ ,  $C_{Ds2}$ ,  $DWP$ ,  $SA_{P1}$ ,  $SA_{P2}$ ,  $CSs$ ,  $SPs$ ,  $SO_{Ps}$ , and  $M$ . The values for the last 3 variables will be obtained from literatures (see discussion in this SOP). Then create the following variables:
  - $A_{Ps1}$  and  $A_{Ps2}$ , calculated according to the discussion in the first section of this SOP.
  - $T_{Ps1}$  and  $T_{Ps2}$ , calculated according to the discussion in the first section of this SOP.
  - $DO_{Ps}$ , calculated by using equation 8-2.
  - $ED_{s1}$ , calculated from  $C_{Ds1} \times A_{Ps1} \times T_{Ps1} \times (1 - DO_{Ps})$ .
  - $ED_{s2}$ , calculated from  $C_{Ds2} \times A_{Ps2} \times T_{Ps2} \times (1 - DO_{Ps})$ .
  - $ED$ , calculated from  $ED_{s1} + ED_{s2}$ .
  - $ES$ , calculated from  $CSs \times ((SPs \times SA_{Ps}) - SO_{Ps}) \times M$ .
  - $DE$ , calculated from  $ED + ES$ .
2. Repeat step 3 for DERMAL EXPO DIAZINON BDL = ZERO.
3. Repeat step 2, 3, and 4 above using the data sets which are censored with Approach 2-Substitution with the detection limit.
4. Repeat step 2, 3, and 4 above using the data sets which are censored with Approach 3-Robust Method.

### Spreadsheet Format

In DERMAL EXPO CHLORPYRIFOS BDL = ZERO or DERMAL EXPO DIAZINON BDL = ZERO (also for similar files which use the data sets censored by Approach 2 and 3):

Column	Variable
1	<i>HHID</i>
2	$C_{Ds1}$

<sup>9</sup> See details in SOP#4



Column	Variable
3	$C_{Ds2}$
4	$A_{Ps1}$
5	$A_{Ps2}$
6	$DWP$
7	$T_{Ps1}$
8	$T_{Ps2}$
9	$SA_{Ps}$
10	$SA_{PH}$
11	$DO_{Ps}$ , calculated from $SA_{PH} / SA_{Ps}$
12	$ED_{s1}$ , calculated from $C_{Ds1} \times A_{Ps1} \times T_{Ps1} \times (1 - DO_{Ps})$
13	$ED_{s2}$ , calculated from $C_{Ds2} \times A_{Ps2} \times T_{Ps2} \times (1 - DO_{Ps})$
14	$ED$ , calculated from $ED_{s1} + ED_{s2}$
15	$C_{Ss}$
16	$S_{Ps}$
17	$SO_{Ps}$
18	$M$
19	$ES$ , calculated from $C_{Ss} \times ((S_{Ps} \times SA_{Ps}) - SO_{Ps}) \times M$
20	$DE$ , calculated from $ED + ES$