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SUBJECT: EVALUATION OF ONE MIXER/LOADER EXPOSURE ASSESSMENT STUDY (AHE30) PERFORMED BY THE AGRICULTURAL HANDLERS EXPOSURE TASK FORCE FOR THE SCENARIO OF OPEN POUR MIXING/LOADING A LIQUID FORMULATION

The purpose of this memo is to evaluate the quality of one exposure monitoring study performed by the Agricultural Handlers Exposure Task Force (AHETF) in two mixer/loaders who were open pour mixing/loading a liquid formulation and to decide whether the collected data are reliable for use by the Department of Pesticide Regulation (DPR) in agricultural pesticide handlers' exposure estimates to replace the current Pesticide Handlers Exposure Database (PHED) (Beauvais, *et al*., 2007). The review of the study in this memo is in observance of DPR's requirement of Reviewing Data for Use in Exposure Assessments (Frank, 2006). AHETF is a task force consisting of several major pesticide manufacturers and was created to develop new exposure data for use in assessing exposure levels in agricultural pesticide handlers. Pesticide handlers include mixer/loader (M/L), applicator, and mixer/loader/applicator (M/L/A). The study which is under review in this memo, titled Determination of Dermal and Inhalation Exposure to Workers in Oregon During Banded Applications to Crops Using Open Cab Groundboom Equipment and During Open Pour Mixing/Loading a Liquid Pesticide Product (Bruce, 2007), is one of the studies conducted by the AHETF for the handlers' exposure assessment where high quality generic data were lacking. In fact, it is one of the studies included in the current U.S. EPA's agricultural pesticide handlers' generic exposure table (U.S. EPA, 2015). This study was intended to meet the U.S. EPA requirements as defined in "Occupational and Residential Exposure Test Guidelines" in accordance with U.S. EPA FIFRA Good Laboratory Practice (GLP) Standards, 40 CFR 160 (Bruce, 2007). Princep® 4L Herbicide, which was manufactured by Syngenta Crop Protection, Inc. and contained simazine as the active ingredient (a.i.), was used as the studied chemical during normal working activities for weed control in blackberries, blueberries, apple trees, or pear trees. After reviewing the submitted

study report and verifying the raw and calculated data for the portion covering the two M/Ls (the section for the applicator study will be reviewed in a separate DPR memo), it is deemed that the conduct of the study was well documented with justifiable evidence of good quality assurance. The study results showed the dermal exposures for the two M/Ls were 203 and 4,882 µg. The unit dermal exposure was 2.81 and 22.31 µg/ai lb handled (not calculated in the study report). Corresponding adjusted air concentrations in their breathing zone were 3.64×10^{-4} and 2.65×10^{-3} µg/L. These air concentrations will be used for the estimate of potential inhalation exposure. The unit inhalation exposure is calculated as 0.0278 and 0.1191 µg/a.i. lb handled, respectively. The conclusion is that the dermal exposure and the measured air concentrations in the breathing zone in the two M/Ls are reliable for use by DPR in exposure assessment for agricultural pesticide handlers and no data quality concerns were found.

Description of the Study

There were two objectives of the study: the first was to determine the dermal and potential inhalation exposure of pesticide applicators who were performing banded applications to trellis and orchard crops using open cab groundboom equipment. The second was to estimate the dermal and potential inhalation exposure of two M/Ls during mixing and loading a liquid pesticide product in the scenario of open pouring of liquid formulation. But only the section related to the second objective is reviewed in this memo while the first one will be evaluated separately.

The field study was carried out from October 19 to 20, 2005. A total of two M/L replicates were observed at two different locations in Oregon. The field research on study Day 1 was conducted in Hillsboro in Washington County where blueberry and blackberry fields were treated. One M/L (M1) was monitored for exposure for one day. Field fortification samples were concurrently prepared and collected. The field study on Day 2 was conducted in Hood River in Hood River County where apple and pear orchards were treated. Another M/L (M2) was monitored for one day with field fortification samples were also prepared and collected. Both workers performed the tasks without any change of their normal practices. The two participants were trained workers with 20 and 27 years of experience as handlers, respectively.

Princep® 4L Herbicide is the product manufactured by Syngenta Crop Protection, Inc. and was used as the studied formulation. Simazine is the a.i. of this commercial formulation in a 2.5-gallon plastic container. One lot of product with the lot number of GBL3J16KB2 was used in this study (Bruce, 2007). The content (percentage of a.i.) had been confirmed by the GLP determination of purity by the product manufacturer, Syngenta Crop Protection, Inc. Simazine has a low vapor pressure of 2.2×10^{-8} mmHg at 25°C (Gunasekara, 2004). Therefore it is not a very volatile compound.

There are total of two replicates in this study with one worker monitored each day. Two experienced male M/Ls open poured the liquid formulation of Princep® 4L Herbicide directly

into spray tanks and then diluted with water. Both workers started their work by unscrewing the cap of the product container and removing a liner before pouring product directly into spray tanks or a measuring bucket. Whenever a portion of the formulation from one container was needed, a plastic pitcher or bucket with pre-measured volume marks were used to measure the volume needed. The pitcher, bucket, and empty formulation container were washed and the wash solution was added to the spray tank as well. The water tank mixture was then applied with groundboom in row applications for weed control in blackberries, blueberries, apple trees, or pear trees.

During the monitoring study, both workers wore their own outer work clothing as their personal protective equipment (PPE) required by the product label, i.e., long-sleeved shirt, long pants, socks and shoes and chemical-resistant nitrile gloves. Each worker confirmed that his work garments had been washed before the start of the exposure study. The outer clothing was inspected by the field investigator and was deemed as Worker Protection Standard compliant. Besides the outer clothing, the two M/L also wore baseball hats and the second worker wore eyeglasses. Dermal exposure was measured with the skin surrogate of 100% cotton inner whole body dosimeters (WBD) worn beneath one layer of outer work clothing. Hand washes and face/neck wipes were used to measure the dermal exposure in the hands and face/neck area. A 500 ml aliquot of 0.01% v/v Aerosol® OT (AOT) solution was used for the hand washes. Face/neck wipes were prepared with 100% cotton gauze with addition of 4 mL of 0.01% (v/v) AOT solution. The moistened gauze was used to wipe the workers' face and neck area.

The weather condition data including wind speed and direction, precipitation, ambient temperature, and relative humidity were recorded by the on-site weather station. There were no unexpected conditions that would impact or interfere to the two-day exposure monitoring study.

Data Collected in the Study

The exposure monitoring for the two M/Ls included dermal and inhalation exposure during mixing and loading of Princep® 4L Herbicide. Dermal exposure was measured using 100% cotton inner WBD worn beneath one layer of outer work clothing, plus hand washes and face/neck wipes. At the end of each work day, the WBD was collected and cut into upper and lower arms, upper and lower legs, and front and rear torso sections to measure simazine residue in each section of WBD. Hand washes were collected during work breaks and at the end of day, and face/neck wipes at the end of day were also collected. Both hand washes and face/neck wipes were analyzed for simazine residue by the designated analytical lab. The field fortification samples were prepared on the same day in the field with three spiked levels for each matrix using standard solutions. These spiked samples were processed as the same way as the study samples and analyzed for simazine residue level concurrently with the collected dosimeters.

Airborne simazine in the worker's breathing zone was measured for estimating potential inhalation exposure utilizing a personal air sampling pump and an OSHA Versatile Sampler

(OVS) tube with a glass fiber filter and Chromosorb® 102 sorbent (Bruce, 2007). At the beginning of the monitoring study, the air sampling pump was adjusted to 2.0 liter per minute (LPM) as the airflow rate. At the end of air sample collection when the worker finished his daily work, airflow rate was measured again to see if there was any deviation from 2.0 LPM. The measurement showed such deviation was not significant. The pump starting and stopping time plus starting and ending flow rates were all recorded. The air sampling tubes from the workers and the field fortification tubes fortified with three spike levels were sent to the analytical lab to measure the simazine residue.

The mixing/loading information was recorded on site. The information included tank capacity, number of loads mixed, total daily a.i. handled, and exposure monitoring time. Workers' personal information including age, gender, height, body weight, and years of work experience were also recorded. Weather information including wind speed and direction, rainfall, temperature, and relative humidity during the study was collected from a weather station set up at each site.

Analytical Method

The analytical work of this study was performed by Morse Laboratories, Inc., Sacramento, CA. Field workers' samples and field fortifications were collected, frozen, and shipped to the analytical laboratory and stored frozen until analysis. Analytical methods for each sample matrix were developed and validated before the analytical phase of the study. The methods usually started with an initial organic solvent extraction of the sampling matrix: acetone for cotton WBD and face/neck wipes, dichloromethane for hand washes, and acetonitrile for air sampling tubes (Bruce, 2007). Then a portion of the extracting solution was concentrated, re-suspended, and injected into a gas chromatograph of Hewlett-Packard (HP) gas chromatograph Model 6890 equipped with a HP 5973 mass selective detector (MSD) (Bruce, 2007). For each matrix, a limit of quantification (LOQ) was determined based on the lowest level of fortification with acceptable recovery rates of simazine residue. The limit of detection (LOD) for each sampling matrix was arbitrarily set as equal as 0.3 times of the LOQ (Bruce, 2007). The established LOQ and LOD values are presented in Table 1 below. None of the sample matrix residues was below the LOQ.

Table 1. The LOQs and LODs for the studied matrix in the M/L exposure study

Matrix	LOQ (µg/sample)	LOD (µg/sample)	Total number of worker samples	% of samples <LOQ
Whole Body Dosimeters	1.0	0.3	12	0
Hand Washes	1.0	0.3	2	0
Face/Neck Wipes	1.0	0.3	5	0
OVS Tubes	0.01	0.003	2	0

Quality Assurance

For quality assurance of the study, field fortification samples were prepared at three levels in triplicate for each matrix in both monitoring days, as indicated in Table 2. The purpose of the field fortification samples was to show the stability of the studied chemical in all matrices under the study conditions during the period of exposure monitoring, sample transportation, and storage. The dermal sample matrices (WBD, hand wash, and face/neck wipes) were fortified in the field with standards prepared from the formulated product diluted with water at the analytical lab. Fortification standards were shipped under ambient conditions to the field and stored under ambient environment until they were used. Air sampling tubes were spiked with analytical grade simazine dissolved in acetone in the analytical lab at three levels (Table 2) and were shipped and stored frozen until use.

The spiked air sampling tubes (OVS tubes) and WBD sections were left in the study environment conditions at the same length of time for each monitoring period (7 hours on Day 1 and 10 hours on Day 2). During this period of time, fortified WBD sections representing each part of the body surface were covered with a layer of shirt material. Lab-fortified OVS tubes were connected to air sampling pumps with the designated flow rate of 2 LPM. Hand wash and face/neck wipe fortification samples were frozen right after fortification. The same processing procedure was used for the study matrices which were also frozen right after sample collection. In short, these fortification samples were treated as exactly the same manner as those study samples.

For WDB and OVS tubes, two samples were also spiked at the highest fortification level, immediately frozen, and taken into the field as travel spikes. However, these samples were not analyzed due to the fact that the field fortification recoveries were acceptable. In addition to fortified samples, two blank controls for each matrix were included on each day.

Field fortification recoveries were within acceptable levels (Table 2). The mean recoveries for both days for WBDs ranged from 102% (high spike level) to 111% (low spike level). Hand washes mean recoveries for two days ranged from 75.8% (intermediate spike level) to 98.0% (low spike level). About half of the hand washes had residues that needed to be adjusted with the intermediate spike level recovery of 75.8%. Face/neck wipes mean recoveries for the two study days ranged from 68.7% (high spike level) to 84.0% (low spike level). The recoveries for the high spike level were found low on Day 2. However there was no face/neck wipe samples from workers had residues in the range that needed to be adjusted by the high level recovery, 68.7%. The mean recoveries for the OVS tubes ranged from 95.5% (high spike level) to 111% (low spike level).

Table 2. The field fortification levels and their recoveries in the study matrix

Matrix	Fortification Levels (µg/sample)			Overall recovery at each level (%)		
	low	medium	high	low	medium	high
Whole Body Dosimeters	5.0	100	5,000	111±6.0	103±8.7	102±5.6
Hand Washes	5.0	100	5,000	98.0±7.7	75.8±3.8	84.6±14.7
Face/Neck Wipes	5.0	100	5,000	84.0±7.7	82.8±11.3	68.7±22.7
OVS Tubes	0.05	1.0	50	111±10.9	102±7.0	95.5±5.7

These recovery rates were used to determine the corresponding adjustment factors for simazine residues in all study samples. Ranges for the recovery adjustment factors were defined by dividing the full range of spiked levels with the midpoint between adjacent fortification levels. For three spiked levels, there would be three ranges: the lowest level to the midpoint of the lowest and medium levels, the midpoint of the lowest and medium levels to the midpoint of medium and the highest levels, and the midpoint of medium and the highest levels to the highest level. If the measured value fell in any of these ranges, the recovery adjustment factor would be applied with recoveries for the low, medium, and high spike samples. Using the example provided by Bruce (2007), for hand washes a mean recovery of 98.0% was found for the 5 µg level and a mean of 75.8% was determined for the adjacent level of 100 µg. The midpoint between these levels (5 and 100 µg) was 52.5 µg. Therefore, a recovery adjustment factor of 0.980 was applied to all residues for the matrix with measured residue ≤ 52.5 µg and an adjustment factor of 0.758 was applied to all residues > 52.5 µg. This same strategy was followed for all adjacent fortification levels for each matrix. The measured residue level was adjusted for field fortification recovery by dividing the reported residue with the appropriate adjustment factor based on the corresponding matrix type, field fortification recoveries, and magnitude of the residue, as shown in the following algorithm:

Adjusted residue level (µg) = reported matrix residue (µg) ÷ matrix-specific and spike level-specific field recovery adjustment factor

All reported residue values ≥ LOQ were adjusted with the above formula to represent 100% recovery. Residue values < LOD would not be adjusted for recovery, but simply assigned a value of half LOD. Residue values between LOD and LOQ would be assigned with a value of half LOQ, and not adjusted for any recovery. Since no M/L samples were lower than LOQ, such value assignments were not implemented. Adjustment factors for each matrix are summarized in Table 3.

Table 3. The field recovery adjustment factors for all matrices

Matrix	Range of Matrix Residue for Recovery Adjustment (µg)	Field Recovery Adjustment Factor
Whole Body Dosimeters	≤ 52.5	1.11
	> 52.5 to ≤ 2550	1.03
	> 2550	1.02
Hand Washes	≤ 52.5	0.980
	> 52.5 to ≤ 2550	0.758
	> 2550	0.846
Face/Neck Wipes	≤ 52.5	0.840
	> 52.5 to ≤ 1300	0.828
	> 1300	0.687
OVS Tubes	≤ 1.025	1.11
	> 1.025 to ≤ 25.5	1.02
	> 25.5	0.955

Results

The workers' physical and work load information was recorded for the two M/Ls. The exposure monitoring periods were 330 and 590 minutes with actual mixing/loading times of 36 and 101 minutes to prepare 11 and 19 loads for a total of 72.2 and 218.8 pounds of active ingredient, respectively for M1 and M2. M1 mix/loaded a total of 11 loads into two spray groundbooms; five loads were for a sprayer having a 50-gallon tank and six loads were for a sprayer with a 100-gallon tank. Due to the need in each load for a portion of a jug, M1measured the needed amount by pouring into a plastic bucket that was marked with volume levels. M2 mix/loaded a total of 19 loads into three sprayers, each with a 100-gallon tank. Most loads needed a portion of one product container in addition to a full or partial container. The worker measured the amount needed by pouring into a pre-labeled 1-gallon plastic container. The workload and workers' descriptive information are summarized in Table 4.

Table 4. Mixing/Loading information for the two monitored Mixer/Loaders

Workers' information	Mixer/loader	
	M1 (Day 1, Hillsboro)	M2 (Day 2, Hood River)
Gender	Male	Male
Age	43	54
Body weight (kg)	102.6	74.6
Height (cm)	177	177
Years of work experience (yr)	20	27
Work load & monitoring time		
Spray tank capacity (gal)	50 and 100	100, 100, and 100
Loads mixed	11	19
a.i. mixed (lb)	72.2	218.8
Spray volume mixed (gal)	825	1,775
Mixing time (min)	36	101
Dermal monitoring time (min)	330	590
Inhalation monitoring time (min)	330	589 [a]

a: This time difference with dermal monitoring time was caused by the stop of the pump for 1 minute to change batteries.

With the chemical residue analyzed in each sampling matrix, the dermal exposure and the air concentration were then calculated. Total dermal exposure (TDE) is the sum of the adjusted residues in the WBD, the face/neck wipe, and hand wash. The adjusted residues were derived from the actual measured values divided by the adjusting factors based on the recoveries. The airborne concentrations (µg/L) of simazine were calculated by dividing the adjusted residue (µg) recovered from the OVS tubes by the total volume of air (L) drawn by the personal air samplers (i.e., the flow rate in LPM multiplied by minutes in the inhalation monitoring period).

The unadjusted and adjusted results in these sampling matrices are summarized in Table 5. The dermal exposure and air concentrations are shown in Table 6 with extra calculations of unit dermal and inhalation exposure normalized by a.i. lb handled. TDE for mixer/loader M1 and M2 were 203 and 4,882 µg, respectively (Table 6). Corresponding adjusted air concentrations for them were 0.000364 and 0.00265 µg/L. The unit dermal and inhalation exposure numbers, which are the exposure dose normalized by the weight of a.i. handled, were not reported in the original study report. But for discussion purposes, they are calculated by the author of this memo and shown in Table 6. The unit dermal exposure is 2.81 and 22.31 µg/a.i. lb handled for M1 and M2, respectively. Corresponding unit inhalation exposure is 0.0278 and 0.1191 µg/a.i. lb handled, where the default inhalation rate of 16.7 L/min is used (Beauvais *et al*., 2007). This algorithm is shown in the footnote of Table 6.

All the calculations in deriving the adjusted values, recovery rates, analytical standard curves have been checked in a spreadsheet. The resulting values can be duplicated without any discrepancy.

Table 5. Dermal exposure and air concentration in the breathing zone for the two Mixer/Loaders in the exposure monitoring study

Replicates	Dosimetry	Matrix	Simazine residue unadjusted (µg/sample)	Simazine residue adjusted w/ recovery (µg/sample) [1]
M1	Whole body dosimeters	Lower arm	21.7860	19.6
		Upper Arm	5.6599	5.1
		Front Torso	14.2397	12.8
		Rear Torso	5.3379	4.8
		Lower Leg	6.0292	5.4
		Upper Leg	7.7067	6.9
		Total WBD [2]	NA	54.6
	Hand washes	Wash 1	53.4283	102
		Wash 2	31.0251	
	Face/neck wipes		39.0692	46.5
	Total dermal exposure [3]		NA	**203**
	OVS tubes		0.2729	**0.24 (3.64×10^{-4} µg/L)**
M2	Whole body dosimeters	Lower arm	636.7865	618
		Upper Arm	286.6549	279
		Front Torso	695.0899	675
		Rear Torso	183.9581	179
		Lower Leg	36.7721	33.2
		Upper Leg	189.4426	183
		Total WBD [2]	NA	1967
	Hand washes	Wash 1	100.9942	2844
		Wash 2	537.3000	
		Wash 3	1517.8566	
	Face/neck wipes		58.6296	70.8
	Total dermal exposure [3]		NA	**4882**
	OVS tubes		3.1515	**3.09 (2.65×10^{-3} µg/L)**

[1] Recovery adjustment factors are used as indicated in Table 3 based on different measured levels.

[2] WBD = Whole body dosimeter = sum of residues on lower and upper arm, front and back torso, and lower and upper leg.

[3] Total dermal exposure = WBD + hand washes + face/neck wipes

NA: Not directly calculated and reported.

Table 6. The unit dermal and inhalation exposure for the two Mixer/Loaders in the study and the generic unit exposure used by U. S. EPA and DPR

Replicate [1]	Active ingredient handled (lb)	Dermal exposure (µg)	Unit dermal exposure [2] (µg/lb ai handled)	Air concentration in the breathing zone (µg/L)	Unit inhalation exposure (µg/lb ai handled) [3]
M1	72.2	203	2.81	0.000364	0.0278
M2	218.8	4882	22.31	0.00265	0.1191
U. S. EPA [4]		NA	37.6	NA	0.219
DPR [5]		NA	491.2	NA	2.35

[1] M1 is the mixer/loader on Day 1 at Hillsboro, OR and M2 is the mixer/loader on Day 2 at Hood River, OR.

[2] The unit exposure is the exposure normalized by the weight of the active ingredient handled. These values were not calculated in the study report. They are calculated for discussion purposes.

[3] The unit inhalation exposure is calculated by: unit inhalation exposure (µg/lb ai handled) = [air concentration in the breathing zone (µg/L) × inhalation rate (L/min) × exposure time (min)] ÷ total ai handled (lb), where the default inhalation rate of 16.7 (L/min) is used (Beauvais *et al*., 2007).

[4] U.S. EPA's handler unit exposure surrogate reference table under the scenario of mixing/loading liquids with single layer clothing, gloves and no respirator (U.S. EPA, 2015).

[5] DPR's PHED under scenario 5 (Beauvais *et al*., 2007).

NA: not applicable.

Exposure Appraisal

To measure the exposure levels in the M/Ls with routes of dermal and inhalation exposure, this study utilized widely accepted methodologies to perform the field monitoring. Whole body dosimeters, face/neck wipes, and hand washes were used to study dermal exposure. For potential inhalation exposure, a personal air sampler connected with air pump was used to collect the air sample around the worker's breathing zone.

Quality assurance was done for each sampling matrix by fortifying with standard solutions made from the commercial formulation, mixed with water. The spiked samples were treated in the same way as the study dosimeters. All the recoveries for the fortification samples were satisfactory except the high spike level for face/neck wipe. But this recovery rate was not used to make any adjustment because none of the measured residues in face/neck wipes was found to be in the range of that spike level. The study report provided both the unadjusted and adjusted residue levels in each sampling matrix. As can be seen above in Table 5, adjusted values did not differ substantially from the unadjusted; the recovery values used as adjustment factors ranged from 68.7% to 111%. DPR's policy for making adjustment is that when the recovery rate is below 90%, adjustment to the raw data is needed (Beauvais, 2006). The AHETF adjusted all samples for recovery, including those with recoveries exceeding 100%, which included all of the WBD samples (adjustment factors 1.03 and 1.11 for the M/L results) and the OVS samples (adjustment factors 1.02 and 1.11). In this study, the M/L results would not change substantially if the DPR policy were implemented.

Comparing with the estimates used for pesticide handlers' exposures, the study has a similar magnitude with U.S. EPA's table for the same scenario in M/L. The study showed 2.81 and 22.31 µg/lb ai handled while the U.S. EPA table uses 37.6 µg/lb ai handled for the scenario of mixing/loading liquid with gloves (U.S. EPA, 2015). In contrast, DPR's PHED (Beauvais *et al*., 2007) uses the average value of 491.2 µg/lb ai handled (scenario 5). The unit inhalation exposure for the two M/Ls in the study were calculated by the author of this memo as 0.0278 and 0.1191 µg/ lb ai handled when the default inhalation rate of 16.7 L/min was used (Beauvais *et al*., 2007). In the U.S. EPA's unit exposure reference table, the average of 0.219 µg/lb ai handled is used for the same scenario (U.S. EPA, 2015). In DPR's PHED, the average of unit inhalation exposure is 2.35 µg/lb ai handled (Beauvais *et al*., 2007). Again, the calculated results from the study and the U.S. EPA's unit inhalation exposure value are in the same level of magnitude while the DPR's generic exposure number is much higher than both of them. These value comparisons are shown in Table 6.

As far as uncertainty is concerned in the study, one uncertainty is that it didn't provide the evidence to show the removal efficiency of the AOT solution in the hand washes and face/neck wipes. The assumption was that this solution was capable of the complete removal of simazine residue on hands and face/neck area. This assumption may not be true. If the removal is not complete, the actual exposure level on hands and face/neck could be underestimated. Another

uncertainty that can be seen in the study is that the dermal exposure on both feet was not considered. Even though the M/L wore shoes and the dermal exposure on feet would be in trace level, it would be complete to include it in the WBD by asking the workers wear cotton socks. The addition of socks to the WBD will increase the cost of the study, but it may be worth of trying a couple of replicates to show the dermal exposure on both feet is negligible.

Conclusions and Recommendations

The exposure monitoring study for the two replicates of M/L was performed under the GLP standards and the documentation of data collection and algorithm are transparent. All studied matrices had concurrent field spiked samples so that the need to make the adjustment with the recovery rates can be justified. The satisfactory recoveries of the fortification samples indicate the good stability of the studied a.i. residue in the study samples during the field monitoring and transportation. The result showed the TDE for the two M/Ls were 203 and 4,882 µg. Corresponding adjusted air concentrations for them were 0.000364 and 0.00265 µg/L. The unit dermal exposure was 2.81 and 22.31 µg/a.i. lb handled, respectively. The unit inhalation exposure is calculated by the author of this memo as 0.0278 and 0.1191 µg/a.i. lb handled,

For the future similar studies, the following aspects may be considered. It would be preferred to include a couple of replicates to wear cotton socks to show that the dermal exposure on both feet would be negligible so that no need for this extra dosimeter in the larger scale studies. As for the format of data reporting, the unit dermal exposure was not provided and would be useful; however, enough information was provided to allow it to be calculated.

In conclusion, the data collected from this study reflected the level of the dermal and potential inhalation exposure for workers who mix/load liquid products by open-pouring during normal work practices. The data are suitable to be used by DPR to replace the current generic database PHED in exposure assessment of agricultural pesticide handlers.

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