TO: All Staff **HSM-08011**
Worker Health and Safety Branch

FROM: Joseph P. Frank, D.Sc., Senior Toxicologist *(original signed by J. Frank)*
Worker Health and Safety Branch
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DATE: December 31, 2008

SUBJECT: POLICY MEMORANDUM - DEFAULT INHALATION RETENTION/ABSORPTION VALUES TO BE USED FOR ESTIMATING EXPOSURE TO AIRBORNE PESTICIDES

This memorandum documents the default values for inhalation retention/absorption of airborne pesticides to be used in Department of Pesticide Regulation (DPR) exposure assessments.

In the conduct of exposure assessments involving airborne pesticides, the inhalation and retention of those pesticides is critical to the overall estimate of risk. Inasmuch as chemical specific data addressing the inhalation and absorption of airborne pesticides is often lacking, it is important to establish a realistic yet health protective approach to estimate the amount of pesticide actually absorbed. To this end, the attached memo documents a review of the available information for inhalation retention/absorption of vapors, dusts and aerosols. On the basis of this evaluation, the Worker Health and Safety Branch will assume 100% as the default inhalation retention/absorption value when adequate chemical specific data are not available. Deviations from this default will be justified in DPR exposure assessment documents.

If you have any questions concerning the attached policy, please contact Dr. Joseph P. Frank at jfrank@cdpr.ca.gov.

Policy Approved by:

(original signed by S. Edmiston)
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MEMORANDUM

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DATE: December 31, 2008

SUBJECT: RECOMMENDATIONS FOR DEFAULT VALUES FOR INHALATION RETENTION/ABSORPTION OF AIRBORNE PESTICIDES

This memorandum documents recommendations for default values, for inhalation retention/absorption of airborne pesticides, to be used in Department of Pesticide Regulation exposure assessments.

Estimation of exposures to fumigants and other volatile pesticides, which enter the body primarily through the inhalation route, engenders a unique series of problems and uncertainties (Pauluhn, 2003). Although airborne concentrations of pesticides can be measured readily, the translation of these levels to an absorbed dose is not simple. The situation is complicated by the fact that formulations of pesticides can involve solvents, emulsifiers, and particulate matter. Calculation of absorbed dose through the inhalation route involves assumptions about individual activity patterns, respiratory rates, and retention/absorption of chemicals (Landry *et al.*, 1983; USEPA, 1997). In practice, it is nearly impossible to separate the amount of chemical retained in the lungs from the amount absorbed into the body from the lungs. Consequently, the two processes are effectively combined. The U.S. Environmental Protection Agency (U.S. EPA) does not explicitly address retention/absorption in the various equations used for estimating exposure through the inhalation route (USEPA, 1997). Thus, U.S. EPA assumes 100% absorption/retention of inhaled gases and particles.

Vapors:

It has been reported that the mean value for human retention/absorption of organic and inorganic vapors is 49.17% (Ross *et al.*, 2001). An extensive examination of the published literature indicates that the range for human retention/absorption of chemical vapors is 5.7% to 95% (Table 1). Examination of the data in Table 1 indicates differences between laboratories in their determination of the percent retention/absorption for the same chemical. In the case of benzene, the difference between the lowest and the highest measured retention/absorption is 13%; trichloroethylene, 14%; styrene, 32%. Whether one is breathing through the nose or mouth can affect the percentage of vapor retention/absorption. Uptake can be greater (~5%) or less (~11%)

when breathing through the nose, rather than the mouth depending upon the chemical (Raabe, 1986). Physical exertion is another factor that can affect the retention/absorption of chemical vapors. The uptake of benzene diminished 13% when the ventilation frequency doubled during heavy exercise (Raabe, 1986). However, the concentration of an airborne chemical seemed to have little effect on the percentage of uptake [within the range of concentrations tested, Table 1].

In those instances when there are no chemical-specific data available, a default value for retention/absorption of pesticide vapors is needed for calculating an absorbed dose from measured air concentrations of a pesticide. Using an average value as a default may either overstate or understate the potential absorbed dose from airborne pesticides. As noted in Table 1, the highest measured percentage of uptake was 95%. However, considering the uncertainty of this value because of the various factors listed above, it seems prudent to adopt a default value of 100% for retention/absorption of pesticide vapors when chemical-specific data are lacking.

Table 1. Retention/Absorption of Chemical Vapors by Humans Under Laboratory Conditions.

Compound	Concentration	Absorption Avg. %	Reference
Acetone	127-131 ppm	14.4	2
Benzene	0.018 ppm	41.6	1
Benzene	57 ppm	47	2
Benzene	217	55	3
1,3-Butadiene (males)	2 ppm	45.6	4
1,3-Butadiene (females)	2 ppm	43.4	4
Chloroform	13 ppm	47.6	1
Cyclohexanone	101 mg/m3	58.6	5
Cyclohexanone	207 mg/m3	58.1	5
Cyclohexanone	406 mg/m3	57.3	5
p-Dichlorobenzene	2.5 ppm	56	6
N,N-Dimethylformamide	7.1 ppm	56.9	7
Ethyl Acetate	94-137 ppm	57.1	2
Ethyl Alcohol	103-140 ppm	13.8	2
Formaldehyde	0.013 ppm	80.7	1
Hexamethylene di-isocyanate	0.005-0.015 ppm	74.6	8
n-Hexane	87-122 ppm	5.7	2
Methyl Bromide	0.016 ppm	53.7	1
Methyl Iodide		72	22
Methyl Tertiary-butyl Ether	1.7 ppm	65.8	9
Octamethylcyclotetrasiloxane	10 ppm	12.1	10
Octamethylcyclotetrasiloxane	-	8	11
Styrene	15-99 ppm	95	12
Styrene	-	89	13
Styrene	-	84	14
Styrene	-	84	15
Styrene	-	71	16
Styrene	-	63	17
Toluene	98-130 ppm	36.6	2
Trichloroethylene	0.018 ppm	54.6	1
Trichloroethylene	316 ppm	55	2
Trichloroethylene	193 ppm	58	18
Trichloroethylene	68 ppm	46	19
Trichloroethylene	100 ppm	44	20
Trichloroethylene	100 ppm	53	21

References: 1) Raabe, 1986; 2) Nomiyama and Nomiyama, 1974; 3) Astrand, 1975; 4) Lin *et al*., 2001; 5) Mráz *et al.*, 1994; 6) Yoshida *et al.*, 2002; 7) Nomiyama *et al.*, 2001; 8) Monso *et al.*, 2000; 9) Lee *et al*., 2001; 10) Reddy *et al.*, 2003; 11) Uell *et al*., 1998; 12) Petreas *et al.*, 1995; 13) Fernandez and Caperos, 1977; 14) Pezzagno *et al.*, 1985; 15) Astrand *et al.*, 1974; 16) Wieczorek and Piotrowski, 1985; 17) Bergert and Nestler, 1991; 18) Bartonicek, 1962; 19) Monster *et al.*, 1976; 20) Vesterberg *et al*., 1976; 21) Astrand and Ovrum, 1976; 22) Morgan and Morgan, 1967.

Dusts and Aerosols:

Airborne particulate matter comes in a range of sizes. The depth to which particles penetrate airway passages and the lungs, as well as the percentage of particles retained is a function of the size of the particles (Koblinger and Hofmann, 1990; Ménache *et al.,* 1995; Philipson *et al.,* 2000; Brand *et al.,* 2002). There is less retention of larger particles (greater than 10µ in diameter; >PM10), and they do not penetrate as deeply. Particles depositing in the ciliated portions of the airways and lungs are carried out in mucous and swallowed (Svartengren *et al.,* 2001). Pesticides on those swallowed particles may be subsequently absorbed by the digestive tract. Residence time in the lungs varies for these particles. Ultrafine particles appear to be completely retained in the lungs (Wilson *et al.,* 1985; Anderson *et al.,* 1990; Roth *et al.,* 1994; Brown *et al.,* 2002).

Under field conditions, the size distribution of particulate matter is unlikely to be known. Further, the percentage of pesticide associated with a given size of particle will probably vary from one formulation to the next, and from one application to the next. Consequently, the relative contribution of each particle size to the absorbed dose will be unknown. The larger particles (> PM10) that do not penetrate deeply into the lungs are carried via muco-ciliary action into the digestive system, where absorption occurs at the rate of the oral route. The pharmacokinetics of pesticides on orally ingested particulates will be different than those on particulates settled in the lungs (Rozman and Klaassen, 1996). Orally ingested pesticides travel through the hepatic portal system to the liver before reaching the systemic circulation. Pesticides absorbed via the lungs go directly into the systemic circulation. From the point of view of a regulatory agency, it probably doesn't matter how much is absorbed through a given route. Sorting out the pharmacokinetic nuances would require additional studies that may not resolve all of the uncertainties.

In the case of aerosols, the same physical considerations apply that affect where solid particles deposit in the airways and lungs. Consequently, liquid droplets settle in the same portions of the airways and lungs that comparable size solid particulates do (Stahlhofen *et al.*, 1980, 1983). The size of liquid aerosol droplets, once generated, can change depending upon the hygroscopic nature of the droplet (Ferron *et al.*, 1985; Chan *et al*., 2002). Once the liquid droplet makes contact with the respiratory tract surface, it spreads out and coats the impacted surface. Those that land in areas serviced by the muco-cilliary "elevator" would also enter the digestive system for additional absorption (Weiss and Dorow, 1987). Operationally, in the absence of chemical-specific data, it is recommended that retention/absorption of both airborne liquid droplets and solid particulates through the inhalation route should be considered to be 100%.

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