# HUMAN PESTICIDE EXPOSURE ASSESSMENT

(For Section 3 New Active Ingredient Registration)

# FENPROPATHRIN

(Danitol™ 2.4 EC Spray for Use on Cotton; Tame™ 2.4 EC Spray for Use in Greenhouses)

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## ABSTRACT

This worker exposure assessment is written to be an integral part of the Department's risk characterization document for registration of the new active ingredient fenpropathrin on cotton (Danitol™ 2.4 EC) and on greenhouse crops (Tame™ 2.4 EC). The toxicological endpoint of prime concern for fenpropathrin is tremor, an acute as well as a subacute effect observed in several animal studies. The absorbed daily dosages from dermal exposure were calculated for cotton scouts, greenhouse harvesters, and workers handling fenpropathrin in California greenhouses and cotton fields. Surrogate data were used for the dosage calculations. The daily dosages calculated for these agricultural workers varied greatly, ranging downward from 57.1 μg per kilogram of body weight for cotton scouts to 0.35 μg/kg for greenhouse workers mixing/loading (less than a gallon of) the 2.4 EC spray product under open pour loading. Inhalation exposures were not estimated for these workers given that fenpropathrin has low vapor pressure. The results of an animal study indicated that the 10-hour dermal absorption of fenpropathrin in the rat (and hence presumably in humans as well) was approximately 32%. A review of the animal metabolism studies revealed that the oral bioavailability of fenpropathrin in the rat could be between 60 and 100%.

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## I. INTRODUCTION

An exposure assessment for fenpropathrin was first performed by the Worker Health and Safety Branch (WH&S) of the California Department of Pesticide Regulation (DPR) in February, 1992 (Frank and Carr, 1992). At that time the new active ingredient (AI) was considered for a limited, emergency exemption (Section 18) use on tomatoes to control whiteflies in Riverside and Imperial Counties. Fenpropathrin is now under review by the Department for full use in greenhouses and on cotton via the new AI (Section 3) registration request. This exposure assessment is written to be an integral part of the Department's risk characterization document for use of fenpropathrin under this request. Results and information contained in the present exposure assessment document may also be used as the starting point for developing mitigation measures if exposure to this pesticide is found to cause excessive risk. The toxicological endpoint of prime concern for fenpropathrin is tremor (Frank and Carr, 1992), an acute as well as a subacute effect observed in several animal studies (MedTox, 1993).

## II. PHYSICAL AND CHEMICAL PROPERTIES

Fenpropathrin (Rody™, Danitol™, Tame™, Meothrin™, Ortho Danitol™, S-3206, WL 41706; α-cyano-3-phenoxy-benzyl 2,2,3,3-tetramethyl-cyclopropane-carboxylate; CAS Registry No. 64257-84-7; molecular weight 349.4; molecular formula $C_{22}H_{23}NO_3$) is an insecticide/miticide which has been synthesized for the control of a wide range of insect pests (e.g., whiteflies, lepidopterous larvae, leaf miners, leafworms, and bollworms) and mites (except rust mites) on field crops, cotton, ornamentals, vegetables, vines, citrus fruit, and glasshouse crops. Its technical grade is commercially available as a yellow-brown liquid or solid with a faint characteristic odor. Fenpropathrin, a member of the synthetic pyrethroid family, is readily decomposed in alkaline solutions and is subject to oxidation and loss of activity when exposed to light and air. The vapor pressure of fenpropathrin is 9.7 x $10^{-6}$ mm Hg at 25ºC with a specific gravity of 1.15 at 25ºC. The compound has a melting point of 45 - 50ºC, a boiling point of 377ºC, and an octanol (η-octyl alcohol) - water partition coefficient of 1.19 x $10^{5}$ at 23ºC. Although fenpropathrin has low solubility in water (0.33 mg/L at 25ºC), it is readily soluble in xylene, cyclohexanone, methanol, and several other organic solvents (Worthing, 1991; The Royal Society of Chemistry, 1990; Chevron Chemical Corporation, 1984).

## III. U.S. EPA/CALIFORNIA STATUS

Technical fenpropathrin was first registered with the U.S. EPA in December, 1989. To this date, its registration with the U.S. EPA in various formulations has been for non-food greenhouse use only (Loracca, 1992). A number of Experimental Use Permits (EUP) were approved by DPR in June, 1986, following their issuance by the U.S. EPA, for experimental (Section 5) use on cotton and grapes in California. These EUP expired in 1989. In 1992, DPR also performed a risk assessment for fenpropathrin to be used on tomatoes in California (Frank and Carr, 1992). That risk assessment was performed in response to a Section 18 use request by the Imperial County Whitefly Management Committee (El Centro, California). On June 14, 1993, the SB-950 Adverse Effects Advisory Panel of Cal/EPA placed fenpropathrin into the high priority grouping for risk assessment.

## IV. FORMULATION/INTENDED USE PATTERN

The only fenpropathrin products currently under review in California are Danitol ™ 2.4 EC Spray and Tame™ 2.4 EC Spray. Both of these emulsifiable concentrate products are identical in formulation and are manufactured by Sumitomo Chemical Company in behalf of Valent (USA) Corporation. Danitol 2.4 EC Spray and Tame 2.4 EC Spray are now under review for use on cotton and on greenhouse crops, respectively, via Section 3 registration request.

Each gallon of the liquid formulation contains 2.4 lb of fenpropathrin. For use on cotton, the label specifies that a maximum of 0.3 lb AI be applied per acre, and that no more than 0.8 lb AI (equivalent to 3 applications) per acre be applied in a season. The label also specifies that during each application, the concentrate used must be diluted with a minimum of 10 gallons of water per acre for ground sprays, or 5 gallons of water per acre for aerial sprays. Although the preharvest interval is 21 days, there is no specification on the label for the minimum interval between successive applications.

For use on greenhouse crops (including plants, shrubs, and trees), the label specifies that a maximum concentration of 0.3 lb AI diluted in 100 gallons of water be used in each application, for up to 3 successive applications without rotating to a nonpyrethroid product (to avoid potential for resistance). There is also no specification for the minimum interval between successive applications. The minimal reentry interval for greenhouse harvesters is 24 h post-application.

## V. USAGE IN CALIFORNIA

There have been no fenpropathrin products registered in California except for the recently-approved Section 18 use of Danitol 2.4 EC on tomatoes in 1993. According to an interim usage report by Brian Danker of the Orange County Agriculture Commissioners Office (personal communication), approximately 46.9 lb of fenpropathrin were used (on tomatoes) in California in 1993. The total number of acres treated in Orange County (as well as in California) in 1993, under a total of three permits, was 252.

## VI. LABEL PRECAUTIONS

Both Danitol 2.4 EC Spray and Tame 2.4 EC Spray are labeled as Toxicity Category I (Danger), federally registered pesticides. The statement of practical treatment advises that no vomiting be induced if the victim accidentally swallows the product. For eye or dermal contact, the labels recommend flushing with plenty of water. If poisoning is through inhalation, the victim needs to be immediately removed from the contaminated area and, if necessary, to be given artificial respiration. In all cases, medical attention should be sought as soon as possible. Workers are required to wear protective clothing or to use personal protective equipment as specified for Toxicity Category I pesticides.

## VII. WORKER ILLNESSES

Partly for the reason stated in Section V, there have been no worker illnesses reported in California as related to fenpropathrin exposure. Nor has there been any epidemiological study reported for fenpropathrin. Also no illnesses have been reported from handling fenpropathrin in four of the six other states where the chemical is currently registered, as verified through calls made recently by Marylou Verder-Carlos of WH&S; the other two states have not responded as of this date.

## VIII. DERMAL TOXICITY/SENSITIZATION

Several acute dermal toxicity studies on fenpropathrin were submitted for health hazard evaluation. These studies were all found to have followed an acceptable protocol (MedTox, 1993). The following acute toxicities were summarized.

Acute dermal $LD_{50}$ (in mg/kg) of technical fenpropathrin (with chemical purity > 90%) were 1,600 in male rats, 870 in female rats, 740 in male mice, 920 in female mice, and > 2,000 in male and female rabbits (Institute for Biological Science, 1979a; Sumitomo Chemical Company, 1980a; International Research and Development Corporation, 1981). For 2.4 EC fenpropathrin (with chemical purity of 30.8%), the acute dermal $LD_{50}$ was also found > 2,000 in male and female rabbits, as no mortalities were observed from applying this topical dose to their intact skin for 24 h (Kiplinger, 1992a). Acute oral $LD_{50}$ of technical fenpropathrin were expectedly lower in the above species, ranging from 49 in female rats to 675 in male rabbits (Sumitomo Chemical Company, 1983; 1982; 1980b; 1980c; Institute for Biological Science, 1979b). The acute oral $LD_{50}$ of the 2.4 EC spray in male and female rats was 66 (Kiplinger, 1992b). Acute oral $LD_{50}$ are listed here primarily for comparison purposes.

According to a study (Kiplinger, 1992c) submitted by the registrant, the 2.4 EC spray was determined not to be a dermal sensitizer to guinea pigs. That guinea pig study was considered by WH&S (1993) to have followed an acceptable protocol.

## IX. ANIMAL METABOLISM

An animal study (Chevron Chemical Company, 1980a) was submitted for metabolism evaluation, in which a single oral dose ($^{14}C$-benzyl ring with radiopurity > 99.5%) of 1.5 mg/kg in corn oil was administered to each of 6 male and 6 female Charles River CD rats. Both this study and the study discussed below were reviewed in greater detail and found acceptable by MedTox (1993).

Excretion of the test compound was found to be rapid in both sexes, with 57% and 40% of the applied dose being eliminated in urine and feces, respectively, within 48 h after treatment. This observation suggested that the oral bioavailability of fenpropathrin in the rat is between 60 and 100%, since all or a portion of the 40% being eliminated in feces could be from the oral dose that was never absorbed. No significant difference in urinary or fecal excretion was observed between the two sexes. An insignificant amount (0.005%) of the applied dose was found in expired air. The average recoveries of radioactivity were, acceptably, 104% in male rats and 97% in female rats.

Further investigation (Chevron Chemical Company, 1980b) on the metabolic fate of the test material revealed a rapid metabolism of fenpropathrin through cleavage at the ester bond by rats *in vivo*. Two (non-conjugate type) metabolites were produced as a result of this cleavage: cyclopropane-carboxylic acid (partly as glucuronide) and 3-phenoxybenzyl moiety. The study also showed that prior to cleavage, about half of the dose underwent aryl hydroxylation to afford *r*-hydroxyl-fenpropathrin, part (actual quantity not given) of which was excreted in the bile (based on a bile duct cannulation study with a single female rat) as a conjugate and the remaining portion cleaved and eliminated in urine as a sulfate of 3-( *r*-hydroxyphenoxy) benzoic acid and as tetramethyl-cyclopropane carboxylic acid glucuronide. A small amount (actual quantity not given) of the unchanged parent compound was found hydroxylated at one of the methyl groups of the cyclopropane-carboxylate moiety in the *trans*-orientation to the carboxyl group; the resultant *trans*-hydroxyl-fenpropathrin was eliminated in the bile as a conjugate, and deconjugated in the feces. A portion of this resultant metabolite was seen cleaved to 2-*trans*-hydroxymethyl-2-methyl-3,3-dimethyl cyclopropane carboxylic acid which was eliminated in the urine.

## X. DERMAL/INHALATION ABSORPTION

A rat study of fenpropathrin in 2.4 EC formulation (Johnson *et al.*, 1991) was submitted for evaluation of dermal absorption, in which a high (1,250 $\mu g/cm^2$), a medium (62.5 $\mu g/cm^2$), or a low (1.25 $\mu g/cm^2$) dose was applied to a 24 $cm^2$ clipped (unabraded) skin area on the animal's dorsal trunk. The animals (of ~ 250 grams) were individually housed in polycarbonate metabolism cages. The sacrifice times for various animal groups were: 0.5, 1, 2, 4, 10, or 24 h after exposure. The following specimens were analyzed for total radioactivity of $^{14}C$, which was labeled at the benzylic carbon: urine, feces, cage rinse, application site washes, protective appliances, non-application and application site skin, blood, and residual carcasses. A summary of this dermal absorption study and the evaluation of its results were presented in a review by WH&S (Thongsinthusak, 1994), in which an absorption value of 32% from the 10-hour exposure low dose group was recommended for use to estimate absorbed dosage of persons exposed to fenpropathrin. This absorption value was hence used for dosage calculations throughout this exposure assessment.

Another rat study of fenpropathrin (Valent USA, 1989) submitted earlier for evaluation of dermal absorption was not considered in this exposure assessment primarily because the chemical tested was of technical grade, which is not the formulation under review. In this earlier study a high (373 $\mu g/cm^2$) or a low (45 $\mu g/cm^2$) dose was applied to a 12 $cm^2$ shaved dorsal trunk of animals weighing over 450 grams. The dermal absorption values calculated for the high and the low dose group were, respectively, 13.8 and 17.1%. The low dose in this earlier study is comparable to the medium dose used in the more recent study cited above. Although the absorption values for the two doses were found comparable, a dose of 45 - 63 $\mu g/cm^2$ is much greater than the expected worker exposure and hence was not considered here for dermal absorption.

Compared to potential dermal exposure, inhalation exposure to fenpropathrin should be quantitatively trivial for workers handling the chemical. This assumption is based in part on the fact that fenpropathrin has low vapor pressure, and in part on the observation by Wolfe (1976) where the potential inhalation exposure measured for a variety of pesticides was < 1% of total potential exposure (see also subsection below on exposure assessment for greenhouse applicators). Where the small amount of inhalation exposure is considered to be biologically significant, perhaps due to the larger surface area of the respiratory tract, the default inhalation absorption of 50% can be used for dosage calculation (Thongsinthusak *et al*., 1993).

## XI. DISLODGEABLE FOLIAR RESIDUES

The dissipation data for fenpropathrin dislodgeables on cotton or on greenhouse crops are not available. As discussed below, the levels of fenpropathrin dislodgeables used in this exposure assessment for cotton and greenhouse crops were estimated using the dissipation curve or rate observed earlier from the same fenpropathrin formulation applied to grapes (Chevron Chemical Company, 1985).

## XII. WORKER EXPOSURE

Several groups of agricultural workers are of potential concern in the assessment of worker exposure to fenpropathrin. Workers may be exposed to fenpropathrin when they mix/load the insecticide and apply it to cotton or to crops in commercial greenhouses. Cotton scouts are also subject to occupational exposure from contact with dislodgeable fenpropathrin residues that might have accumulated on treated cotton foliage. Exposure to fenpropathrin does not seem to be a concern here for cotton harvesters, given that a preharvest interval of 21 days is required. The same consideration cannot be made for the greenhouse harvesters (or for the other greenhouse field workers), however, since according to the product label they are permitted to enter treated areas after 24 h post-application.

### Application to Cotton

No measurements of worker exposure to fenpropathrin from cotton use were made available to WH&S. Accordingly, the exposures to fenpropathrin calculated below for workers handling fenpropathrin were based on exposure rates for other pesticides compiled in a U.S. EPA draft document (Lunchick, 1988). Both the average and the highest reported rates were used to calculate, respectively, the expected daily exposures and (presumably) the upper-bounds.

The average rates taken from the U.S. EPA database were simply the arithmetic means weighted by the number of workers, rather than by the number of replicates, involved in the surrogate studies. The main reason for taking this approach was that in some studies replicates were measured primarily to ensure reproducibility, whereas in other studies they represented measurements for the same workers handling pesticides at different sites, with modified operation procedures, or in different days. In addition, some of the studies presented only average exposure estimates for workers without giving individual replicate values. Weighted geometric means were not used as the average rates here primarily because the operation procedures, the study protocols, and the pesticides involved were found to be so variable (or incomparable) that the underlying *composite* statistical distribution could not be reasonably assumed to be lognormal. For cotton scouts, the surrogate exposures were based on the dislodgeable foliar residues (DFR) data provided by the registrant on the 2.4 EC spray applied to grapes (Chevron Chemical Company, 1985), and on a set of transfer factors (Dong, 1990) derived from a series of field studies by Ware *et al*. (1973; 1974; 1975).

The daily exposures and absorbed daily dosages for workers handling fenpropathrin are presented in Table 1; and those for cotton scouts, in Tables 2 and 3. For comparison purposes, also included in Table 1 are the exposure and dosage estimates for cotton scouts under the extreme-case scenario. Inhalation exposures were not estimated for workers in this exposure assessment because of the assumptions made in Section X. The 32% dermal absorption was assumed in all calculations of absorbed dosages, as mentioned earlier. Some of the assumptions used in the exposure calculations were consistent with common practice and hence are mentioned as table footnotes only. Others that require clarification or appear to be unique to cotton-based fenpropathrin exposure are discussed below, along with a brief description of the calculations involved.

The surrogate exposure rates used to calculate the dermal exposures for handlers are footnoted in Table 1. These rates were adjusted for clothing protection or for protection from required loading or application equipment. Because fenpropathrin as used is a Toxicity Category I pesticide, flagmen and ground applicators are required *either* to wear coveralls over work clothes and full-body chemical-resistant clothing, respectively, *or* to be in an enclosed cab while handling the chemical. The default protection factor used for full-body clothing is 95% whereas that used for closed cab or coveralls is 90%. The lower of the two factors was used in this assessment to adjust for personal protective equipment. A closed system is also required for mixing/loading chemicals in this toxicity category. The application and usage rates assumed for fenpropathrin were the maximum label rates, which are also footnoted in the table. Both the usage rates and the number of days exposed per year are somewhat lower than those assumed earlier for imidacloprid used on cotton under Section 18 (Dong, 1993). In that exposure assessment for imidacloprid, the yearly exposure duration and the daily usage were assumed to be 50 days in one year and 1,000 acres per day for mixing/loading prepared enough to be sprayed by two airplanes. These differences are due to the expectation that for emergency exemption use, a crisis is normally involved which could entail relatively more usage or exposure frequency.

Table 1. Daily Dermal Exposure and Absorbed Daily Dosage for Cotton Scouts (without Gloves) and for Workers Handling Fenpropathrin in California Cotton Fields[a]

| Job Class | No. of Days Exposed per Year[b] | Dermal Exposure (mg/kg BW/day)[c,d,e] | Absorbed Dosage (μg/kg BW/day)[f] | Average Dosage (μg/kg BW/day) Seasonal[g] | Annual | Lifetime Dosage (μg/kg BW/day)[h] |
|---|---|---|---|---|---|---|
| Aerial Application | | | | | | |
| Mixer/Loaders | 40 | 0.016 (0.045; n = 13) | 5.12 (14.40) | 4.40 | 0.56 | 0.32 |
| Pilots | 40 | 0.005 (0.016; n = 12) | 1.47 ( 5.05) | 1.26 | 0.16 | 0.09 |
| Flagmen | 40 | 0.013 (0.075; n = 11) | 4.00 (24.00) | 3.44 | 0.44 | 0.25 |
| Ground Application | | | | | | |
| Mixer/Loaders | 20 | 0.003 (0.007; n = 13) | 0.80 ( 2.24) | 0.69 | 0.04 | 0.03 |
| Applicators | 20 | 0.010 (0.076; n = 15) | 3.12 (24.21) | 2.68 | 0.17 | 0.10 |
| Cotton Scouts | 40 | 0.075 (0.178) | 24.04 (57.09) | 20.67 | 2.63 | 1.51 |

[a] for workers wearing personal protective equipment as specified on the label or as required for Toxicity Category I pesticides (see text for discussion).

[b] as used in an earlier exposure assessment by WH&S for bifenthrin on cotton (Dong *et al.*, 1991).

[c] based on the maximum labeled application rate of 0.3 lb AI per acre and on the following usage rates as used in an earlier exposure assessment by WH&S for bifenthrin on cotton (Dong *et al.*, 1991): 100 and 625 acres/day for ground and aerial application, respectively; and 5 work hours/day.

[d] based on the following average (and the highest) exposure rates taken from the surrogate database provided by the U.S. EPA (Lunchick, 1988), *after adjustment for 0.3 lb AI handled/acre and for clothing protection or protection from required loading/application equipment*: 0.0019 (0.0055) mg for aerial or ground mixer/loaders under a *closed* system, 0.07 (0.24) mg/h for pilots, 0.19 (1.14) mg/h for flagmen, and 0.147 (1.15) mg/h for ground applicators; and for cotton scouts, see Table 3 under the *extreme-case* scenario.

[e] based on an average male body weight (BW) of 76 kg (see text for discussion).

[f] based on a dermal absorption of 32% (see Section X).

[g] for a 14-day seasonal period during which a person is expected to be working 6 days per week.

[h] based on the assumption that a worker would handle the same chemical or come into contact with its foliar dislodgeables continuously for 40 years during his lifetime (70 years).

Table 2. Potential Daily Dermal Exposure by Body Part for California Workers Scouting Maturing Cotton Treated with Fenpropathrin Following Three Successive Applications[a,b]

| Days Post-Application | Predicted DFR ($\mu g/cm^2$)[c] | *Potential* Daily Dermal Exposure, mg[d]<br>Bare Hands | Upper Body | Lower Body |
|---|---|---|---|---|
| 1 | 0.47 (1.12) | 2.69 (6.39) | 2.89 (6.86) | 27.31 (64.85) |
| 2 | 0.42 (0.98) | 2.38 (5.61) | 2.55 (6.02) | 24.10 (56.91) |
| 3 | 0.37 (0.86) | 2.10 (4.92) | 2.25 (5.28) | 21.26 (49.93) |
| 4 | 0.32 (0.76) | 1.85 (4.32) | 1.99 (4.64) | 18.76 (43.88) |
| 5 | 0.29 (0.67) | 1.63 (3.80) | 1.75 (4.08) | 16.56 (38.53) |
| 6 | 0.25 (0.59) | 1.44 (3.34) | 1.55 (3.58) | 14.60 (33.87) |
| 7 | 0.22 (0.52) | 1.27 (2.94) | 1.36 (3.15) | 12.89 (29.80) |
| 10 | 0.15 (0.35) | 0.87 (2.00) | 0.94 (2.15) | 8.85 (20.33) |
| 14 | 0.09 (0.21) | 0.53 (1.21) | 0.57 (1.30) | 5.37 (12.29) |
| 21 | 0.04 (0.09) | 0.22 (0.51) | 0.24 (0.55) | 2.23 ( 5.19) |

[a] daily dermal exposure for the unprotected whole body is simply the sum of the individual potential dermal exposures calculated for the above three body parts.

[b] under a conservative assumption that the minimum interval between applications is 3 days; these estimates for scouting after the third application would have been approximately 25% less if the interval were 7 days, as suggested by the registrant (but not so specified on the product label).

[c] based on surrogate data (after adjustment for application rate) from the same spray formulation applied to grape leaves, as provided by the registrant (Chevron Chemical Company, 1985), and assuming a minimum reentry interval of 24 h; in parentheses are the upper 95% *prediction* limits of the DFR (dislodgeable foliar residues) projected from log-linear regression of the surrogate residues on time (see Figure 1 and discussion in text).

[d] based on 6 h per day [see discussion in text] and on the following transfer factors (in µg/h dermal residues per $\mu g/cm^2$ DFR, two sides): 950 for bare hands; 1,020 for clothed upper body; and 9,640 for clothed lower body (Dong, 1990) of male workers; see footnote *c* above for estimates listed in parentheses.

An average male body weight (BW) of 76 kg was used for cotton scouts and for workers handling fenpropathrin in cotton fields because male body surface area was used for extrapolation of dermal exposure in the surrogate studies. Table 1 indicates that the cotton scouts appeared to have attained both the highest (0.18 mg/kg BW) and the highest *average* (0.08 mg/kg BW) daily dermal exposure. Exposure for mixing/loading and application by ground boom equipment was assumed to be approximately the sum of the individual task exposures, since the applicators were expected to work only up to 5 h per day (because of the maximum daily acreage assumed). For aerial application, mixing/loading, flying, and flagging were assumed to be done by different workers.

As noted earlier, the surrogate exposures for cotton scouts were based on a series of transfer factors derived from the field studies by Ware *et al*. (1973, 1974, 1975). The procedure used for the computation of these surrogate exposures was described elsewhere (Dong *et al.*, 1991). The *potential* daily exposures for cotton scouts, as shown in Table 2, were estimated from the geometric mean transfer factors (in μg/h dermal residues per μg/cm$^2$ foliar dislodgeables) computed for bare hands (950), the clothed upper body (1,020), and the clothed lower body (9,640) of male cotton scouts. The potential dermal transfer factor for the whole body of cotton scouts is simply the sum of these three individual geometric mean transfer factors. The potential daily dermal exposures for cotton scouts by body part, as provided in Table 2, were prepared primarily for risk mitigation purposes.

The cotton-based fenpropathrin DFR, from which their corresponding hourly dermal exposures were estimated, were predicted from a log-linear regression analysis conducted by the registrant, who used actual field data from the same 2.4 EC formulation applied to grapes (Chevron Chemical Company, 1985). Figure 1 presents a graphic view of the fenpropathrin DFR predicted at various time points for a single application (based on an application rate of 0.2 lb AI/acre). The predicted DFR after three successive applications are presented in Table 2. These DFR were predicted from the log-linear regression presented in Figure 1 (after

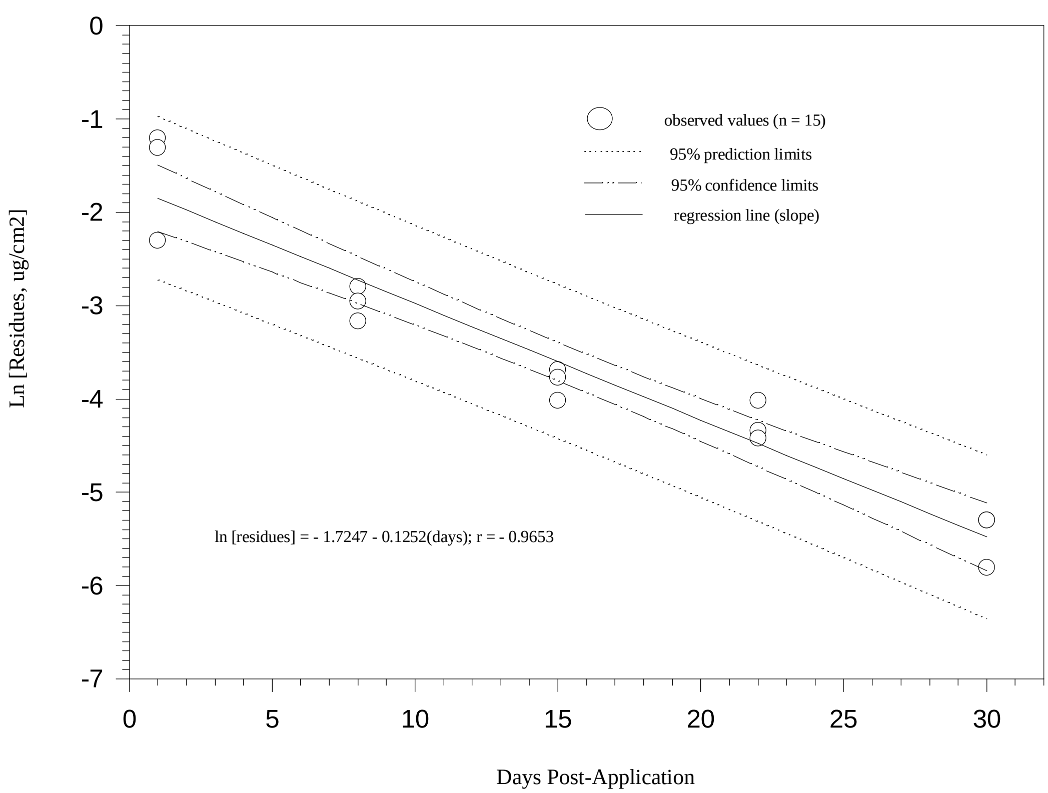


Figure 1. Dissipation of Fenpropathrin (at 0.2 lb/acre) on Grape Leaves
(as Surrogate on Foliage of Cotton and Greenhouse Crops)

adjustment for the proper application rate and for the carry-over effect from successive applications). Also included in Table 2 in parentheses are the DFR projected from the upper 95% *prediction* limits (see Figure 1), the latter were calculated using the scientific graphing software *SigmaPlot*ä (Jandel Scientific, 1993).

Note that the dissipation of foliar dislodgeables is primarily a *chemical*-, rather than a *crop*-, specific phenomenon. The DFR data provided by the registrant were hence considered more appropriate surrogates than those from bifenthrin applied to cotton (Dong *et al.*, 1991), although both sets of data were later found to yield comparable estimates of dermal exposure for cotton scouts. This later supplemental finding suggests that both the initial deposition and the dissipation of pyrethroid dislodgeables are not as sensitive to the higher pH on cotton foliage or to other related environmental factors (e.g., humidity) as originally speculated.

The daily dermal exposures for cotton scouts wearing a long-sleeved shirt and a pair of long pants, with (chemical-resistant) or without gloves, are presented in Table 3. The percentage of clothing permeation for the three body parts was assumed to be 10, which has been the default value adopted by WH&S unless there is evidence to the contrary (Thongsinthusak *et al*., 1993). Note that although cotton scouts are considered field workers, their scout activity is not as labor intensive as harvesting and hence is likely to entail less clothing penetration under otherwise the same exposure scenario.

The time that a cotton scout is expected to be in actual contact with treated cotton foliage was assumed to be 6 h per day. This scout exposure time appears to be reasonable, in that each day cotton scouts are almost always required to travel between fields that may be miles apart. A typically unexpressed assumption involved here is that the scout would be exposed to cotton fields (up to 12 fields per day) that were each treated for up to 3 times with fenpropathrin. In reality this exposure scenario is unlikely to occur on any given day. The probability of its occurrence for more than one day running is even further remote because no single pyrethroid has captured more than 30% of the cotton acreage.

Table 3. Daily Dermal Exposure and Absorbed Daily Dosage for California Workers Scouting Maturing Cotton Treated with Fenpropathrin[a,b]

| Days Post-Application Dosage[d] | With Gloves | | Without Gloves | |
|---|---|---|---|---|
| | Dermal Exposure[c] | Absorbed Dosage[d] | Dermal Exposure[c] | Absorbed |
| 1 | 0.043 (0.103) | 13.85 (32.88) | 0.075 (0.178) | 24.04 (57.09) |
| 2 | 0.038 (0.090) | 12.21 (28.84) | 0.066 (0.157) | 21.22 (50.11) |
| 3 | 0.034 (0.079) | 10.78 (25.31) | 0.059 (0.137) | 18.74 (43.96) |
| 4 | 0.030 (0.069) | 9.52 (22.23) | 0.052 (0.121) | 16.51 (38.65) |
| 5 | 0.026 (0.061) | 8.38 (19.54) | 0.046 (0.106) | 14.57 (33.94) |
| 6 | 0.023 (0.054) | 7.41 (17.18) | 0.040 (0.093) | 12.84 (29.81) |
| 7 | 0.020 (0.047) | 6.53 (15.12) | 0.036 (0.082) | 11.37 (26.23) |
| 10 | 0.014 (0.032) | 4.51 (10.32) | 0.024 (0.056) | 7.79 (17.89) |
| 14 | 0.009 (0.019) | 2.74 ( 6.23) | 0.015 (0.034) | 4.72 (10.82) |
| 21 | 0.004 (0.008) | 1.14 ( 2.65) | 0.006 (0.014) | 1.98 ( 4.59) |

[a] for workers wearing long-sleeved shirt and long pants, with (chemical-resistant) or without gloves.

[b] under a conservative assumption that the minimum interval between applications is 3 days; these estimates for scouting after the third application would have been approximately 25% less if the interval were 7 days, as suggested by the registrant (but not so specified on the product label); in parentheses are exposures and dosages estimated from the upper 95% *prediction* limits of the DFR (dislodgeable foliar residues) projected from log-linear regression of the surrogate foliar residues on time (see Figure 1 and Table 2).

[c] in mg/kg BW/day; based on dermal exposures of hands, upper body, and lower body of male workers, as listed in Table 2, on a 10% clothing permeation (as common practice), and on an average male body weight (BW) of 76 kg (see text for discussion).

[d] in µg/kg BW/day; based on a dermal absorption of 32% (see Section X).

The maximum DFR that a cotton scout could be exposed to after 3 applications of Danitol 2.4 EC was calculated to be 1.12 $\mu g/cm^2$, as shown in Table 2. Table 3 also suggests that the dermal exposure for a cotton scout could be as high as 0.18 mg/day per kilogram of body weight, if the scout were to be exposed immediately after the third application to cotton (in the same field and not wearing gloves). As shown in Tables 1 and 3, for a cotton scout with work clothing but not wearing gloves, the daily dosage could be as high as 57.1 µg per kilogram of body weight. It is of note that according to the product label or clothing requirements for Toxicity Category I pesticides, cotton scouts are not required to wear any gloves as they are not considered as workers *handling chemicals in the field*.

<u>Application to Greenhouse Crops</u>

Measurements of exposure to fenpropathrin again were not made available to WH&S for applicators, mixer/loaders, or harvesters working in greenhouses. Accordingly, the exposures to fenpropathrin calculated below were also from exposure rates for other pesticides available in the literature. These exposure rates were based on use scenarios as close to those specified for fenpropathrin as they could be found.

The (arithmetic) mean (3.9 mg/lb AI) and the highest (7.5 mg/lb AI) exposure rates observed for fluvalinate by Stamper *et al*. (1989a) were used to estimate the dermal exposures of greenhouse applicators handling fenpropathrin. These exposure rates were based on those observed in two male and two female applicators spraying fluvalinate to growing chrysanthemums and African violets with a 6-nozzle handgun, and were adjusted for a default total clothing penetration of 1% (≈ 0.5% = [10% from normal work clothing] x [5% from rainsuit], since Tame 2.4 EC Spray is a Toxicity Category I insecticide).

In using the exposure rate observed by Stamper *et al*., it was assumed that fenpropathrin might also be applied with a 6-nozzle handgun type sprayer. The (average) exposure rate observed by Stamper *et al*. (1989b) for a greenhouse applicator *drench* applying fluvalinate with a single-nozzle, low pressure handgun was expectedly much lower (by about five-fold), so were those observed for the other pesticides in both of their studies cited above. The exposure rates submitted by the registrant (Meikle and Baugher, 1992) for other pesticides from other greenhouse applicator studies, including the one conducted by WH&S for abamectin (Rech *et al*., 1988), were also shown to be much lower.

In this exposure assessment, the maximum amount of fenpropathrin that a greenhouse applicator or mixer/loader would handle daily was assumed to be 0.9 lb. This suggests that up to 300 gallons of the fenpropathrin spray dilution (i.e., 0.3 lb in 100 gallons of water) could be used per day by the applicator. According to the studies reported by O'Connell *et al*. (1987) and by Rech *et al*. (1988), as many as 300 gallons of a spray dilution could be applied to greenhouse crops during a single application. There is no restriction on the product label for the amount of spray dilution used per acre of greenhouse crops. The amount of spray dilution to be used during a single application depends largely on the size of the greenhouse (or of the crops) treated, the application equipment used, and the density or structure of the foliage canopy involved. This amount is likely to be below 200 gallons in many cases, rather than the maximum quantity of 300 gallons estimated above.

Although Tame 2.4 EC is a Toxicity Category I pesticide, a closed system is not required for mixing/loading the product if its usage is limited to one gallon or less per day, as this would be the case here. Accordingly, only greenhouse workers mixing/loading under open pour loading were considered here; and the exposure rate for them was determined to be negligibly lower, compared to that for greenhouse applicators. Even using the rate for mixing/loading in the cotton field, the average and the highest exposure rates were estimated to be, respectively, about 0.127 and 0.367 mg/lb AI handled. These exposure rates were extrapolated from those footnoted in Table 1 for a closed system, based on a default 95% reduction of exposure from open pour loading. Although the equipment for mixing/loading may vary between cotton and

Table 4. Daily Dermal Exposure for California Workers (with Gloves) Harvesting Greenhouse Crops Treated with Fenpropathrin Following Three Successive Applications[a,b]

| Days Post-Application | Predicted DFR[c,d], µg/cm$^2$ | Dermal Exposure mg/kg BW/day[e,f] | Absorbed Dosage µg/kg BW/day[g] |
|---|---|---|---|
| 4 h | 1.28 (1.92) | 0.052 (0.078) | 16.69 (25.04) |
| 1 | 1.14 (1.71) | 0.093 (0.139) | 29.74 (44.60) |
| 2 | 1.01 (1.51) | 0.082 (0.123) | 26.26 (39.39) |
| 3 | 0.89 (1.33) | 0.072 (0.108) | 23.13 (34.69) |
| 4 | 0.79 (1.18) | 0.064 (0.096) | 20.52 (30.78) |
| 5 | 0.69 (1.04) | 0.057 (0.085) | 18.09 (27.13) |
| 6 | 0.61 (0.92) | 0.050 (0.075) | 16.00 (24.00) |
| 7 | 0.54 (0.81) | 0.044 (0.066) | 14.09 (21.13) |
| 10 | 0.37 (0.56) | 0.030 (0.046) | 9.74 (14.61) |
| 14 | 0.23 (0.34) | 0.018 (0.028) | 5.91 (8.87) |
| 21 | 0.09 (0.14) | 0.008 (0.011) | 2.44 (3.65) |

[a] daily dermal exposure for harvesters wearing normal work clothing and gauntlet (elbow-length) gloves.

[b] under a conservative assumption that the minimum interval between successive applications is 3 days; these estimates for harvesters after the third application would have been approximately 25% less if the interval were 7 days, as suggested by the registrant (but not so specified on the product label).

[c] based on the dissipation *rate* (i.e., the *slope* of log-linear regression) calculated earlier (Chevron Chemical Company, 1985) for the same formulation on grape leaves and assuming a minimum reentry interval of 4 h (i.e., until the sprays have dried); the initial deposition for fenpropathrin on greenhouse crops was assumed to be 0.6 µg/cm$^2$ (two sides) per 0.6 lb AI diluted in 200 gallons of water, under the assumption that this amount of the spray dilution would be the average usage for greenhouse crops.

[d] in parentheses are the DFR (dislodgeable foliar residues) projected using 0.9 µg/cm$^2$ (two sides) per 0.9 lb AI diluted in 300 gallons of water as the initial deposition for fenpropathrin on greenhouse crops, under the assumption that 300 gallons of the spray dilution would be sufficient to cover an acre of greenhouse crops, which is taken to be the reasonable maximum size of a greenhouse [see discussion in text].

[e] based on harvesters working 8 h per day, except for the first day, and on the dermal transfer factor of 700 µg/h dermal residues per µg/cm$^2$ foliar dislodgeables (two-sides), after adjustment for 90% clothing protection from wearing gauntlet elbow-length gloves [see discussion in text]; the maximum number of hours worked on the first day was assumed to be 4 h (until the sprays have dried, calculated here in the event that harvesters can enter treated areas sooner through special mitigation); in parentheses are the daily exposure estimates extrapolated from DFR predicted under assumptions made in footnote *d* above.

[f] based on an average male/female body weight (BW) of 68.7 kg (see text for discussion).

[g] based on a dermal absorption of 32% (see Section X); in parentheses are the daily dosage estimates extrapolated from DFR predicted under assumptions made in footnote *d* above.

greenhouse use, the exposures from mixing/loading the 2.4 EC fenpropathrin between the two types of application are not expected to be too different.

For greenhouse harvesters, the transfer rate of 7,000 μg/h *potential* dermal exposure (primarily from the bare hands) per μg/cm$^2$ dislodgeable foliar residues (two-sides) was used. This transfer rate represented the average of those observed recently by Brouwer *et al*. (1992) for male and female greenhouse workers cutting carnations sprayed with chlorothalonil and thiophanate-methyl.

Table 4 lists both the foliar dislodgeables predicted for fenpropathrin on greenhouse crops and the exposures and dosages that were extrapolated from these residues (using the above transfer rate). The DFR were estimated from using the initial deposition of 0.6 μg/cm$^2$ (per 0.6 lb AI/acre applied) and from using the dissipation *rate* (see Figure 1) calculated for fenpropathrin on grape leaves (Chevron Chemical Company, 1985). Further assumptions for prediction of these DFR are footnoted in the table. Also included in Table 4 in parentheses are the DFR predicted from using the initial deposition of 0.9 μg/cm$^2$ (per 0.9 lb AI/acre applied). The basis for the initial deposition of 0.6 μg/cm$^2$ assumed for 0.6 lb/acre applied was given in a literature review submitted by the registrant (Meikle and Baugher, 1992), although their estimate was somewhat lower (0.42 μg/cm$^2$ per 0.6 lb/acre applied). The initial deposition assumed here was not inconsistent with those observed by O'Connell *et al*. (1987) or by Rech *et al*. (1988) for greenhouse crops treated at similar rates. As a matter of fact, the average initial DFR measured for two of the six pesticides by O'Connell *et al*. were even greater than 0.1 μg/cm$^2$ per 0.1 lb AI/acre applied.

Although the surrogate DFR used here were not specific to those measured in a greenhouse setting, they were found to be quite comparable to those measured for bifenthrin (which is also a synthetic pyrethroid) applied to greenhouse grown chrysanthemums and roses, as noted in a concurrent review by Dong (1994). The highest average initial deposition of bifenthrin found on the greenhouse grown flowers was 0.76 μg/cm$^2$ (two-sides), which resulted from using a spray concentration of 0.2 lb AI diluted in 100 gallons of water and was measured from its third application made 21 days after its second. Table 4 shows that the highest *average* DFR surrogate used for fenpropathrin on greenhouse crops was 1.28 μg/cm$^2$ (two-sides), which was based on a spray dilution of 0.3 lb AI per 100 gallons of water and was projected after adjustment for apparently a greater carry-over effect (because of the much shorter total interval of 6 days assumed for the three successive applications).

As shown in Table 4, the maximum DFR that a harvester could be exposed to after 3 applications of the 2.4 EC spray was estimated to be 1.9 μg/cm$^2$. The maximum dermal exposure and absorbed dosage that a harvester wearing gauntlet (elbow-length) gloves could experience after 3 applications were, respectively, 0.14 mg/kg BW/day and 44.6 μg/kg BW/day.

Greenhouse applicators sometimes are required to work within an enclosed structure using a high pressure handgun. Under these different work conditions, their daily inhalation exposure to fenpropathrin is expected to be higher than that of their counterparts applying the same chemical in cotton fields. Potential inhalation exposure of up to 80 μg/day can be estimated from the study by Stamper *et al*. (1989a) for an *unmasked* greenhouse applicator spraying 0.9 lb fluvalinate (which has a vapor pressure comparable to that of fenpropathrin) with a high pressure handgun in an enclosed structure. This potential exposure can be translated to an absorbed daily dosage of 0.6 μg per kilogram of body weight if the default inhalation absorption of 50% is used.

Table 5 summarizes the dermal exposures and absorbed dosages for greenhouse workers handling fenpropathrin under the extreme-case scenario. For comparison purposes, also included in Table 5 are the extreme-case exposures and dosages calculated for greenhouse harvesters reentering treated areas. An average male/female body weight of 68.7 kg was used for exposure calculations here because a number of female greenhouse workers were included in the surrogate studies from which the exposure or the transfer rate was derived. Other assumptions used in the exposure assessment for greenhouse workers are also footnoted in Table 5.

As shown in Table 5, the daily dermal exposure could be as high as 0.1 mg/kg BW for an applicator who, while wearing full-body clothing, would spray fenpropathrin to greenhouse crops using a 6-nozzle, high pressure handgun in an enclosed structure. Based on this dermal exposure, the maximum daily dosage for this worker could be as high as 31.3 μg per kilogram of body weight. The maximum daily exposure and dosage for a greenhouse worker mixing/loading fenpropathrin under open pour loading is expectedly trivial, approximately 30 times less.

The exposure estimates listed in Tables 1 and 5 show that among all workers considered, cotton scouts would (still) experience, respectively, the highest (0.18 mg/kg BW) and the highest *average* (0.08 mg/kg BW) daily dermal exposure. These daily dermal exposures were estimated for cotton scouts reentering a treated field as early as day 1 without wearing gloves.

Table 5. Daily Dermal Exposure and Absorbed Dosage for Greenhouse Workers Handling Fenpropathrin and for Harvesters (with Gauntlet Gloves) Reentering Treated Areas[a]

| Job Class | Dermal Exposure (mg/kg BW/day)[b] | Absorbed Dosage (µg/kg BW/day)[c] | Seasonal Dosage (µg/kg BW/day)[d] | Lifetime Dosage (µg/kg BW/day)[e] |
|---|---|---|---|---|
| Applicators | 0.034 (0.098)[f] | 10.88 (31.32) | 9.36 | 3.73 |
| Mixer/loaders | 0.001 (0.005)[g] | 0.35 ( 1.55) | 0.30 | 0.12 |
| Harvesters | 0.093 (0.139)[h] | 29.74 (44.60) | 25.52 | 10.20 |

[a] for workers wearing personal protective equipment as specified on the label or as required for Toxicity Category I pesticides.

[b] based on an average male/female body weight (BW) of 68.7 kg (see text for discussion).

[c] based on a dermal absorption of 32% (see Section X).

[d] for a 14-day seasonal period during which a person is expected to be working 6 days per week.

[e] based on three-fifths of the base period (i.e., 219 days per year) and on the assumption that a worker would handle the same chemical or come into contact with its foliar dislodgeables continuously for 40 years during his or her lifetime (70 years).

[f] based on the arithmetic mean (and the highest) exposure rate of 3.9 (7.5) mg/lb AI observed by Stamper *et al.* (1989a) for fluvalinate and on the average (and the highest) daily usage of 200 (300) gallons of spray dilution containing a total of 0.6 (0.9) lb fenpropathrin AI [see discussion in text].

[g] based on the average (and the highest) exposure rate of 0.127 (0.367) mg/lb AI used in cotton fields under open pour loading and on the average (and the highest) daily usage of 200 (300) gallons of spray dilution containing a total of 0.6 (0.9) lb fenpropathrin AI [see Table 1 and discussion in text].

[h] based on the extreme case in Table 4.

## XIII. REFERENCES


Brouwer, R., Brouwer, D.H., Tijssen, S.C.H.A., and van Hemmen, J.J. 1992. Pesticides in the cultivation of carnations in greenhouses: Part II. Relationship between foliar residues and exposures. *Am Ind Hyg Assoc J* 53:582-587.

Chevron Chemical Company. 1980a. Metabolism of WL 41706 in mammals: The fate of ($^{14}$C) WL 41706 in the rat. California Department of Pesticide Regulation Registration Document No. 50489-003.

Chevron Chemical Company. 1980b. Metabolic fate of ( $^{14}$C) WL 41706 in the rat. California Department of Pesticide Regulation Registration Document No. 50489-003.

Chevron Chemical Company. 1984. Physicochemical properties. California Department of Pesticide Regulation Registration Document No. 50489-001.

Chevron Chemical Company. 1985. Dissipation of dislodgeable fenpropathrin (active ingredient in Danitol 2.4 EC) residues from grape leaves. California Department of Pesticide Regulation Registration Document No. 50489-015.

Dong, M.H. 1990. Dermal transfer factor for cotton scouts. Memorandum to John H. Ross within the Worker Health and Safety Branch, California Department of Pesticide Regulation, dated 06/08/90.

Dong, M.H. 1993. Human pesticide exposure assessment (for Section 18 use on cotton) - Imidacloprid. HS-1682. Worker Health and Safety Branch, California Department of Pesticide Regulation.

Dong, M.H. 1994. Document Review: Dislodgeable foliar residues (of bifenthrin) from application to (greenhouse grown) chrysanthemums and roses. Worker Health and Safety Branch, California Department of Pesticide Regulation, dated 04/06/94.

Dong, M.H., Thongsinthusak, T., and Ross, J.H. 1991. Human exposure assessment for bifenthrin. HS-1561. Worker Health and Safety Branch, California Department of Pesticide Regulation.

Frank, J.P. and Carr, W.C. 1992. Health risk assessment: Fenpropathrin (Danitol ™) - Section 18 emergency exemption for use on tomatoes. Medical Toxicology Branch, California Department of Pesticide Regulation.

Institute for Biological Science. 1979a. Acute dermal toxicity of S-3206 in rats. California Department of Pesticide Regulation Registration Document No. 50489-006.

Institute for Biological Science. 1979b. Acute oral toxicity of S-3206 in rats. California Department of Pesticide Regulation Registration Document No. 50489-006.

International Research and Development Corporation. 1981. Acute dermal toxicity ($LD_{50}$) study in rabbits. California Department of Pesticide Regulation Registration Document No. 50489-040.

Jandel Scientific. 1993. SigmaPlot for Windows: Scientific Graphing Software. P. O. Box 7005, San Rafael, California.

Johnson J. D., Mahon C. R., and Killinger J. M. 1991. Dermal absorption of $^{14}C$-fenpropathrin in Danitol®using male Sprague-Dawley rats. California Department of Pesticide Regulation Registration Document No. 50489-098.

Kiplinger, G.R. 1992a. Acute dermal toxicity study in albino rats with Danitol 2.4 EC (Formulation CC-17228). California Department of Pesticide Regulation Registration Document No. 50489-096.

Kiplinger, G.R. 1992b. Acute oral toxicity study in albino rats with Danitol 2.4 EC (Formulation CC-17228). California Department of Pesticide Regulation Registration Document No. 50489-096.

Kiplinger, G.R. 1992c. Skin sensitization study in albino guinea pigs with Danitol 2.4 EC (Formulation CC-17228). California Department of Pesticide Regulation Registration Document No. 50489-096.

Loracca, G. 1992. Personal communication between Tareq Formoli of the Worker Health and Safety Branch (California Department of Pesticide Regulation) and the U. S. Environmental Protection Agency on 02/11/92.

Lunchick, C. 1988. A summary of surrogate worker exposure data prepared in anticipation of dinoseb cancellation hearings, U. S. Environmental Protection Agency Office of Pesticide Programs (Washington DC).

MedTox. 1993. Data package summary and recommendation sheet - Fenpropathrin. Medical Toxicology Branch, California Department of Pesticide Regulation, dated 05/06/93.

Meikle, S.B. and Baugher, D.G. 1992. Margin of safety based on surrogate exposure models for workers reentering ornamentals in greenhouses, shadehouses, nurseries, and landhouses treated with Danitol® 2.4 EC Spray (fenpropathrin) insecticide-miticide. California Department of Pesticide Regulation Registration Document No. 50489-099.

O'Connell, L., Fong, H.R., Cooper, C., Maykowski, R., and Wroe, M. 1987. A study to establish degradation profiles for six pesticides (triforine, endosulfan, chlorothalonil, sulfotep, dodemorph acetate, and daminozide) used on ornamental foliage in San Diego County, during fall 1986. HS-1400. Worker Health and Safety Branch, California Department of Pesticide Regulation.

Rech, C., Bissell, S., del Valle, M. 1988. Potential dermal and respiratory exposure to abamectin during greenhouse applications. HS-1491. Worker Health and Safety Branch, California Department of Pesticide Regulation.

Stamper, J.H., Nigg, H.N., Mahon, W.D., Nielsen, A.P., and Royer, M.D. 1989a. Pesticide exposure to greenhouse handgunners. *Arch Environ Contam Toxicol* 18:515-529.

Stamper, J.H., Nigg, H.N., Mahon, W.D., Nielsen, A.P., and Royer, M.D. 1989b. Pesticide exposure to greenhouse drencher. *Bull Environ Contam Toxicol* 42:209-217.

Sumitomo Chemical Company. 1980a. Acute oral toxicity of S-3206 in rabbits. California Department of Pesticide Regulation Registration Document No. 50489-039.

Sumitomo Chemical Company. 1980b. Acute oral toxicity of S-3206 technical in mice. California Department of Pesticide Regulation Registration Document No. 50489-006.

Sumitomo Chemical Company. 1982. Acute oral toxicity of S-3206 in rats. California Department of Pesticide Regulation Registration Document No. 50489-037.

Sumitomo Chemical Company. 1983. Acute oral toxicity of S-3206 (91.8%) in rats. California Department of Pesticide Regulation Registration Document No. 50489-007.

The Royal Society of Chemistry. 1990. *The Agrochemicals Handbook*. Cambridge, England: Thomas Graham House, Second Edition.

Thongsinthusak, T. 1994. Review Memorandum: Dermal absorption of $^{14}C$-fenpropathrin in Danitol®using male Sprague-Dawley rats, Worker Health and Safety Branch, California Department of Pesticide Regulation, dated 05/13/94.

Thongsinthusak, T., Ross, J. H., and Meinders, D. 1993. Guidance for the preparation of human pesticide exposure assessment documents. HS-1612, Worker Health and Safety Branch, California Department of Pesticide Regulation.

Valent (USA) Corporation. 1989. Percutaneous absorption of fenpropathrin technical (SX-1491) in adult male rats - revised final. California Department of Pesticide Regulation Registration Document No. 50489-076.

Ware G. W., Morgan, D. P., Estesen, B. J., Cahill, W. P., and Whitacre, D. M. 1973. Establishment of reentry intervals for organophosphate-treated cotton fields based on human data: I. Ethyl- and methyl parathion. *Arch Environ Contam Toxicol* 1:48-59.

Ware G. W., Morgan, D. P., Estesen, B. J., and Cahill, W. P. 1974. Establishment of reentry intervals for organophosphate-treated cotton fields based on human data: II. Azodrin, ethyl and methyl parathion. *Arch Environ Contam Toxicol* 2:117-129.

Ware G. W., Morgan, D. P., Estesen, B. J., and Cahill, W. P. 1975. Establishment of reentry intervals for organophosphate-treated cotton fields based on human data: III. 12 to 72 hours post-treatment exposure to monocrotophos, ethyl- and methyl parathion. *Arch Environ Contam Toxicol* 3:289-306.

WH&S. 1993. Data package recommendation sheet - Fenpropathrin (I.D. No. 138381-N; DPR Registration Document No. 50489-096). Worker Health and Safety Branch, California Department of Pesticide Regulation, dated 06/29/93.

Wolfe, H.R. 1976. Field Exposure to Airborne Pesticides. *In* Lee R.E., Jr. (*Ed*.): *Air Pollution from Pesticides and Agricultural Processes*. Cleveland, OH: CRC Press, Chapter 5.

Worthing C.R., *Ed*. 1991. *The Pesticide Manual - A World Compendium*. Old Woking, Surrey: The British Crop Protection Council, Ninth Edition.