A Survey of the Warning Agent Concentration (chloropicrin) Present Immediately behind the Tarpaulin of Residences Undergoing Fumigation*

by

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April 27, 1990

HS-1654

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*A Report to the Structural Pest Control Board

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Introduction

In the fall of 1989, the Worker Health and Safety Branch (WH&S) of the California Department of Food and Agriculture (CDFA) received a request to assist the Structural Pest Control Board (SPCB) in determining the amount of warning agent typically present behind the tarpaulins of residences undergoing fumigation. The warning agent, chloropicrin, is required in all fumigations to ensure that structures are clear before fumigation begins and to provide a warning property to prevent overexposure of workers and others by making them aware of the presence of fumigant. Neither fumigant used for structural fumigation, methyl bromide or sulfuryl fluoride (Vikane), can be detected by odor, taste, or irritation at airborne levels of worker exposure concern. The request from the SPCB was prompted by concern over incidences of unauthorized entry into structures undergoing fumigation. Following such an incident, a reoccurring question is raised of whether sufficient warning agent was present to deter entry. Some of these unauthorized entries have resulted in fatal exposures to the fumigant. The request from the SPCB and response from CDFA is included in Appendix I.

Methods and Materials

A method was developed to collect a sample of the air from between the tarpaulin and the outside of the structure. The air present in this "innerspace" would present the first exposure to fumigant and warning agent experienced by someone involved in unauthorized entry. To obtain a sample of this air, a gas sampling needle (SKC West, Fullerton, CA., Catalog No. 231-9-12) was inserted through the tarpaulin. The needle was connected directly to a XAD-4 resin sorbent tube (SKC, No. 226-30-11-04). Chloropicrin was collected on the resin as a measured amount of the innerspace air was drawn out of the tarpaulined structure. The air was drawn through this sampling arrangement by a MSA C-210 sampling pump (Mine Safety Appliances Company, Pittsburgh, PA) with a four foot length of Tygon^{R} tubing. The rate of air sampled was determined using a Kurz Model 540S mass flow meter (Kurz Instruments, Monterey, CA) inserted in line between the air pump and the sampling tube. Samples were collected for sufficient time (approximately 7 minutes) to obtain a one liter sample of air. A one liter sample of this air will provide measurement to 0.030 ppm (30 ppb) given the minimum detection limit (MDL) for chloropicrin of the CDFA laboratory (0.15 ug/sample). After collection, resin tubes were capped and kept cool with ice until delivery to the CDFA Chemistry Laboratory Services for analysis[1].

The Sampling locations were chosen from the required Notice of Intents (NOIs) filed with the county Agricultural Commissioner's office within 24 hours of the planned fumigation. The initial goal was to obtain samples from a total of thirty locations from several areas of the state. This sampling was conducted without the knowledge of the structural pest control licensee making the application to maximize objectivity.

Typically, three samples of the innerspace air were collected at each sampling location. Sampling points at each location were chosen to coincide with possible points of unauthorized entry. These locations included the

area near the front door, rear door, and side entrance. If a separate (detached) garage was present, an additional sample was taken or one of the other samples omitted. Samples were collected approximately four feet from the bottom of the tarpaulin. See photographs of sampling equipment and sampling on pages 5, 6, and 7.

In addition to collecting samples for chloropicrin concentration, measurements were obtained of the methyl bromide concentration, at those sites where methyl bromide was applied. The measurements were obtained using a length-of-stain detector tube and hand pump (National Draeger, Pittsburgh, PA., Hydrocarbon Test, No. 6728261) calibrated to measure methyl bromide at concentrations expected to exist within fumigated structures[2]. Calibration of these tubes is shown in Appendix II.

Detailed notes and photographs were collected at each site. These are attached. See Appendix III.

Results and Discussion

Twenty seven structures were sampled. Most were single story, single family residences. Thirteen structures had been treated with sulfuryl fluoride and 14 had been treated with methyl bromide.

Eight sites were in Sacramento county, five in San Diego county, four in Orange county, six in Los Angeles county, three in Alameda county, and one in San Mateo county. Site locations are listed in Appendix IV.

Table 1 contains all the data generated by this work.

The concentration of warning agent measured by individual samples varied from none detected to 9.9 ppm. Figure 1 shows a distribution of all the chloropicrin sample concentration results, and separate distributions based on the fumigant applied. Figure 2 shows a distribution of the chloropicrin concentrations for the same groups when the samples from each site are treated as average values per site. In general, the chloropicrin concentrations were less at the sulfuryl fluoride treated structures compared to the methyl bromide treated structures.

Figure 3 shows the above data distribution compared to the concentration of chloropicrin theoretically possible based on the application rate of 1 ounce per 10,000 ft^3 or 15,000 ft^3 and also the theoretical expected level from use of a fumigant product formulated to contain 0.5 percent chloropicrin and applied at a rate of 1 pound per 1000 ft^3. Calculations to determine ppm from the fumigant application rate are contained in Appendix V. All sample concentrations were below the theoretical maximum amount. In an earlier study[3] conducted by the WH&S Branch, measurements of the concentration of chloropicrin **within** the structure were generally also observed to be less than the theoretical amount expected. However, almost all levels measured in the earlier study were higher than the concentrations measured in the innerspace area during this study. The earlier study measured the amount of chloropicrin in several structures for the entire course of the fumigation and the air sampled came from within the structure.

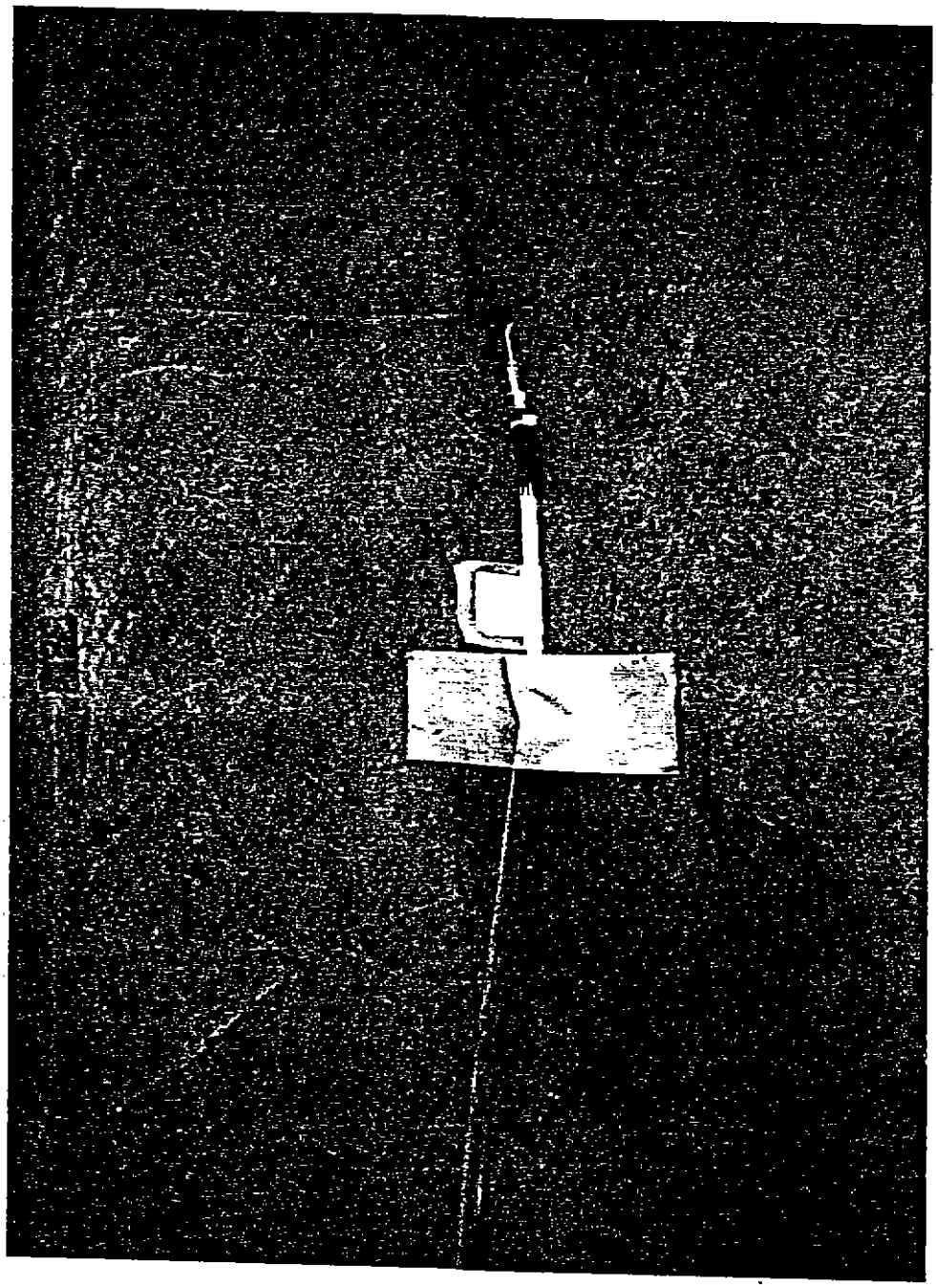
Figure 4 shows a comparison of the chloropicrin concentrations of all the samples and of the average value per site compared to recognized health

effects of exposure to this chemical[4]. In either case, about one third of the sites had values less than one ppm, approximating the OSHA PEL and perhaps the onset of eye irritation. About half of the sites contained levels above 4 ppm where continual exposure is considered incapacitating.

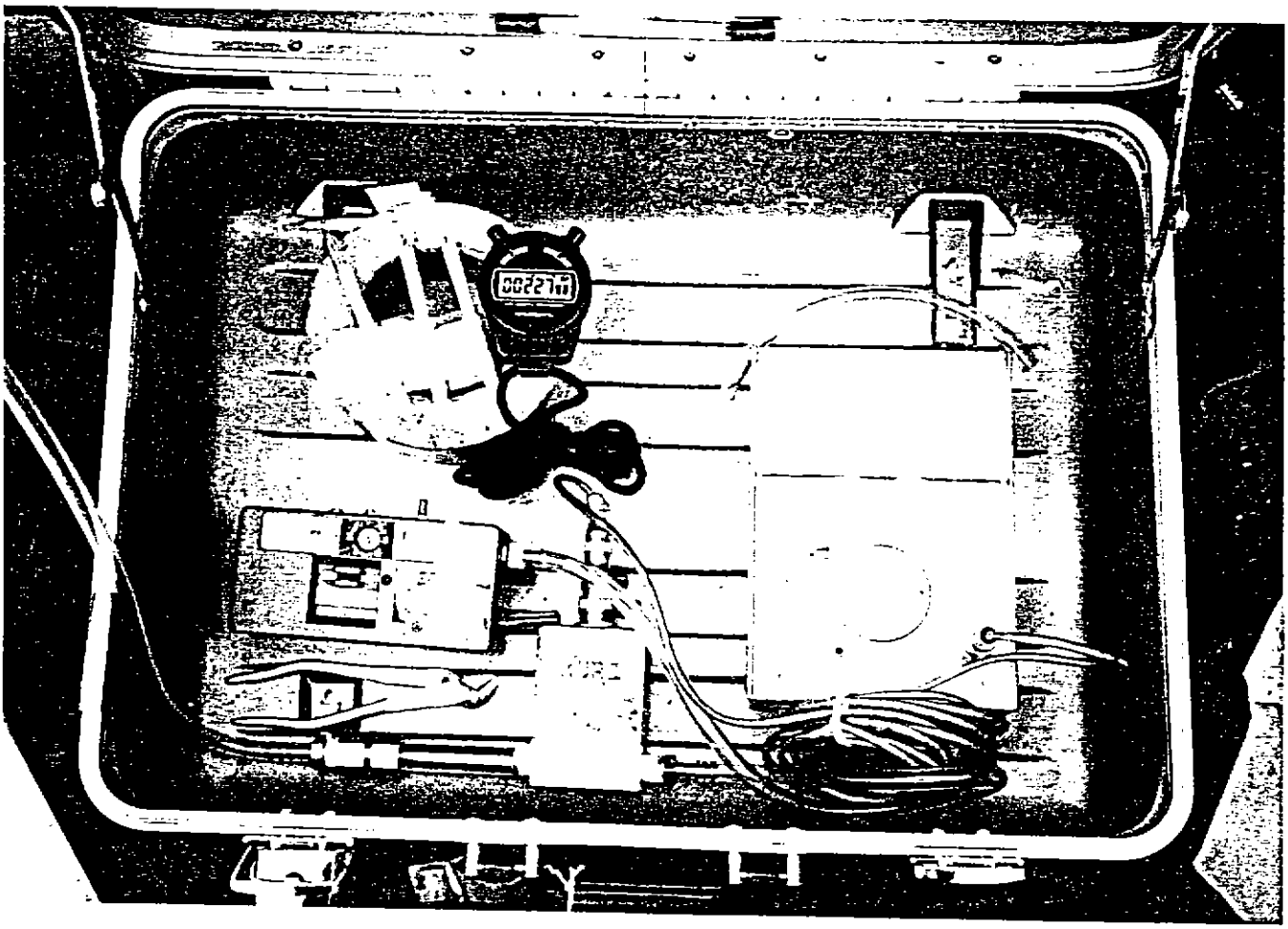
The time of application of the warning agent and application rate was obtained from the Standard Structural Fumigation Log submitted to the Structural Pest Control Board. This data and the time of our sampling and theoretical concentration of chloropicrin are tabulated in Table 2. Figure 5 shows a comparison of the individual site average chloropicrin concentration values compared to the time since the warning agent was introduced. This data is shown for all sites and by the fumigant used. In addition, the methyl bromide sites where chloropicrin was added as a separate step is noted. All other methyl bromide treated sites used a product formulated with chloropicrin. Chloropicrin is always added separately to sulfuryl fluoride applications. The data from the sulfuryl fluoride treated structures, where the warning agent is always added as a separate step, appears to show that considerable time is needed at some sites to fully vaporize the liquid chloropicrin to provide sufficient interior concentration to diffuse adequately into the exterior innerspace to eventually develop a warning level concentration. However, this observation does not appear evident from the limited number of methyl bromide sites where chloropicrin was added as a separate step. Another possibility might be the failure to add the warning agent or adding less than the recommended amount. For example, at Site 11, none of the three samples showed measureable levels of chloropicrin two hours after introduction of the fumigant. The other sites where some samples showed no measureable amounts (sites 16, 17) also had other samples showing measureable amounts. At least one sample with a measureable amount would indicate that some amount of chloropicrin was used.

Conclusions

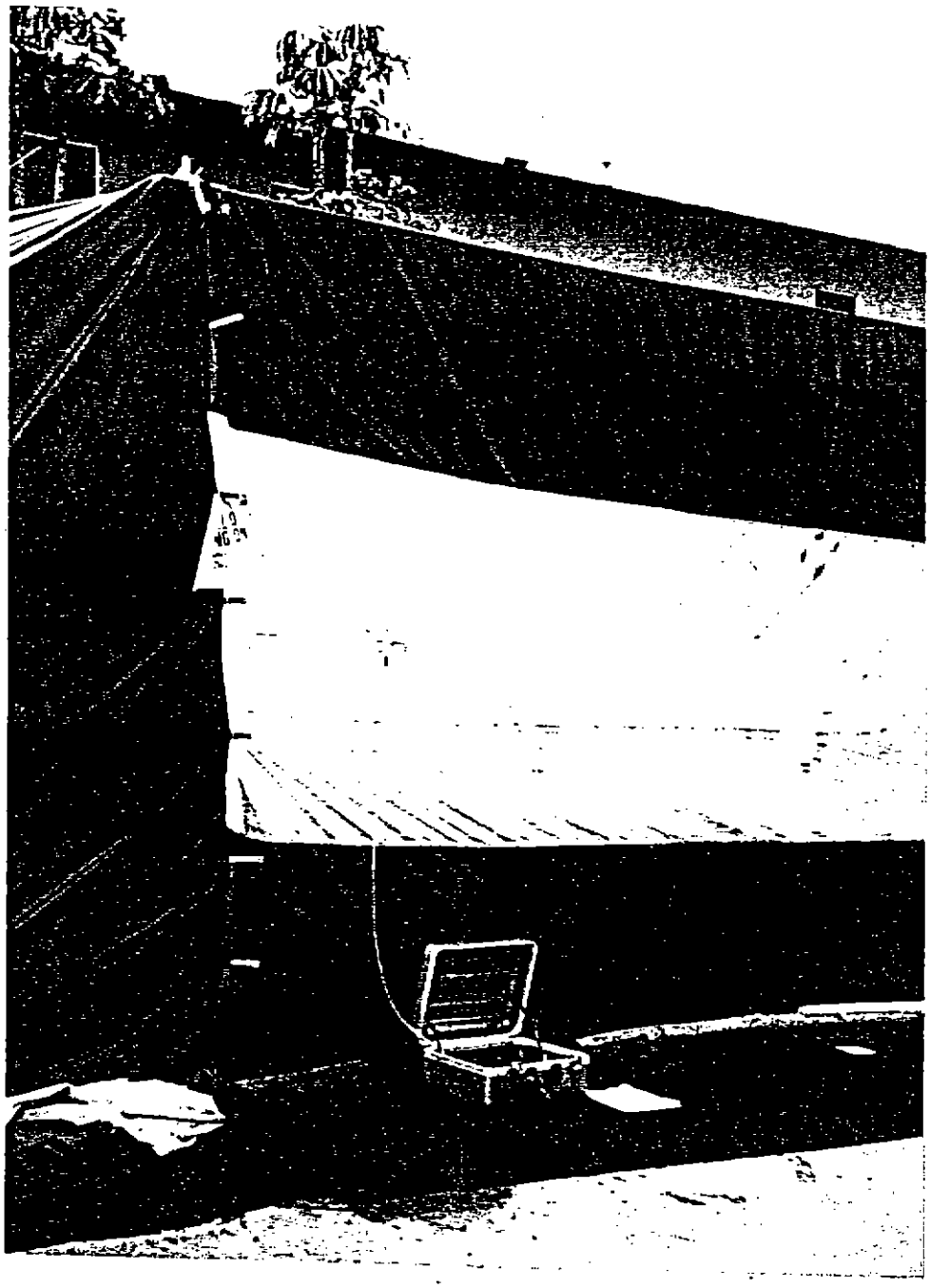
This work has shown that at certain times there may not be adequate warning agent present immediately behind the tarpaulin of a fumigated structure to deter entry. This is particularly apparent immediately following the start of the fumigation. Approximately half of the sites monitored up to 22 hours following application contained warning agent above 4 ppm, a level that might deter entry. The concentration of warning agent in the innerspace behind the tarpaulins was less than the theoretical amount, based on application rates, at all sites. The data from the sulfuryl fluoride treated structures, where the warning agent is always added as a separate step, appears to support a theory of gradual diffusion of the chloropicrin into the innerspace. However, with the limited data of this study, no correlation was seen between chloropicrin concentration and time since application. Diffusion into the innerspace may be inhibited by physical barriers. In addition, other processes not measured by this work may be affecting the concentration with time. The area immediately behind the tarpaulin may be one of the last places for the warning agent to reach and gradually increase in concentration.



Photograph showing sample collection with needle and sorbent tube.



Sampling equipment used for collection of samples.



Sampling equipment as used at sites.

TABLE 1

Sampling Results - Warning Agent Survey

Site/smpl/ location		ug/smpl	Volume (L)	ug/L	Cpic (ppm)	Cpic site mean	MeBr (ppm)
1/1	RS	2.6	0.720	3.6	0.5	0.8	
1/2	FD	3.6	0.575	6.2	0.9		
1/3	FD	6.5	1.050	6.2	0.9		
2/1	LS	0.7	0.550	1.2	0.2	0.2	~13,000
2/2	LS	1.2	1.120	1.0	0.2		~13,000
2/3	BK	ND*	-	-			
3/1	F	29.6	0.792	37.4	5.6	5.0	~13,000
3/2	RS	28.3	0.810	34.9	5.2		~11,000
3/3	LS	19.8	0.685	28.9	4.3		~8,000
3/4	BK	ND	-	-			
4/1	FD	38.2	0.792	48.2	7.2	7.5	
4/2	RS	42.7	0.675?	63.2	9.4**		
4/3	RD	37.6	0.810	46.4	6.9		
4/4	BK	ND	-	-			
4/5	RS	46.4	0.822	56.4	8.4		
5/1	F	28.8	0.889	32.4	4.8	4.3	~5,500
5/2	RS	27.7	0.945	29.5	4.4		~5,000
5/3	R	23.2	0.945	24.6	3.7		~4,200
5/4	BK	ND	-	-			
6/1	F	30.6	0.994	30.8	4.6	4.8	~2,750
6/2	RS	9.9	0.980?	10.1	1.5**		~2,750
6/3	LS	34.4	1.015	33.9	5.0		~3.750
7/1	F	10.4	0.945	11.0	1.6	1.5	~2,000
7/2	RS	9.7	0.945	10.3	1.5		~2,000
7/3	RP	10.3	0.980	10.5	1.6		~1,600
8/1	LF	33.2	1.085	30.6	4.6	4.7	~6,500
8/2	RS	33.5	1.085	30.9	4.6		~6,500
8/3	RP	34.6	1.085	31.9	4.8		~6,500
9/1	FD	6.6	0.875	7.5	1.1	1.2	
9/2	LS	7.7	0.875	8.8	1.3		
9/3	LR	7.3	0.910	8.0	1.2		
10/1	F	5.0	0.910	5.5	0.8	0.8	~750
10/2	RR	3.2	1.050	3.0	0.4		~600
10/3	LS	9.0	1.050	8.6	1.3		~600
11/1	FD	ND	1.050	0.1	0.02***	0.02	
11/2	RS	ND	1.050	0.1	0.02***		
11/3	RD	ND	1.050	0.1	0.02***		

TABLE 1
(continued)

Site/smpl/ location	ug/smpl	Volume (L)	ug/L	Cpic (ppm)	Cpic site mean	MeBr (ppm)
12/1 RS	44.6	1.050	42.5	6.3	6.6	
12/2 RD	32.2?	1.050	30.7	4.6**		
12/3 LS	48.4	1.050	46.1	6.9		
13/1 FD	28.2	1.050	26.9	4.0	6.3	
13/2 RD	42.7	1.050	40.7	6.1		
13/3 LD	61.0	1.050	58.1	8.7		
13/4 BK	ND	-	-	-		
14/1 FD	57.3	1.280	44.8	6.7	6.7	>13,000
14/2 RP	57.5	1.155	49.8	7.4		~2,750
14/3 R	46.3	1.155	40.1	6.0		~3,800
15/1 GF	19.7	1.050	18.8	2.8	2.6	~1,000
15/2 GF	33.9	1.050	32.3	4.8		~3,300
15/3 GF	0.6	1.050	0.6	0.1		ND
16/1 FD	0.2	1.050	0.2	0.03	0.04	
16/2 RP	0.4	1.050	0.4	0.06		
16/3 LSP	ND	1.050	0.2	0.02***		
17/1 FD	ND	1.075	0.2	0.02***	0.02	
17/2 RSD	ND	1.050	0.2	0.02***		
17/3 R	0.2	1.050	0.2	0.03		
18/1 FD	6.3	1.050	6.0	0.9	1.7	
18/2 R	7.7	1.050	7.3	1.1		
18/3 GF	22.0	1.050	21.0	3.1		
18/4 BK	ND	-	-	-		
19/1 FD	41.0	1.050	39.0	5.8	4.8	~5,200
19/2 GD	24.9	1.050	23.7	3.5		~1,000
19/3 RH	35.0	1.050	33.3	5.0		~1,700
20/1 FD	6.0	1.050	5.7	0.9	0.8	
20/2 LS	4.8	1.050	4.6	0.7		
20/3 RD	5.3	1.050	5.0	0.8		
21/1 FD	25.4	1.050	24.2	3.6	3.4	~1,000
21/2 RD	22.1	1.050	21.0	3.1		~1,000
21/3 LSD	24.8	1.050	23.6	3.5		~1,000
22/1 FD	43.8	1.050	41.7	6.2	6.4	~2,750
22/2 RD	48.4	1.050	46.0	6.9		~2,750
22/3 LR	43.6	1.050	41.5	6.2		~2,750

TABLE 1
(continued)

Site/smpl/ location	ug/smpl	Volume (L)	ug/L	Cpic (ppm)	Cpic site mean	MeBr (ppm)
23/1 FD	35.6	1.050	33.9	5.0	5.9	~3,200
23/2 RD	37.1	1.050	35.3	5.3		~2,750
23/3 G	51.5	1.050	49.0	7.3		~4,000
23/4 BK	ND	-	-	-		
24/1 FD	20.7	1.050	19.7	2.9	3.5	
24/2 RD	29.0	1.050	27.6	4.1		
24/3 BK	ND	-	-	-		
25/1 FD	69.5	1.050	66.2	9.9	7.0	
25/2 RD	40.8	1.050	38.8	5.8		
25/3 R	36.4	1.050	34.7	5.2		
26/1 FD	11.2	1.050	10.6	1.6	1.7	
26/2 R	11.8	1.050	11.2	1.7		
26/3 RRP	13.4	1.050	12.8	1.9		
27/1 FD	2.0	1.050	1.9	0.3	0.3	
27/2 RS	1.0	1.050	0.9	0.1		
27/3 RD	2.9	1.050	2.8	0.4		

NOTES TO TABLE 1:

* None Detected (ND) - Minimum Detectable Level (MDL) of the CDFA Laboratory for chloropicrin is 0.15 micrograms per sample.

** Sample not included in further data reduction because of some collection or analytical uncertainty.

*** Value based on laboratory minimum detectable limit (MDL). The amount reported is that amount that might have been present and not "seen" by sampling.

? Data with associated uncertainty

Site/smpl/location - Site number
Sampling Number
Sampling Location

Key for sampling location:

F - front of structure
D - door area
S - side of structure
RS - right side of structure
LS - left side of structure
R - rear of structure
P - porch/patio
G - garage
H - house
BK - sample blank

NOTES TO TABLE 1 (continued)

ug/smpl - micrograms of chloropicrin collected on resin tube sample. Provided by CDFA laboratory following analysis

Volume - volume of air passed through collection tube in liters (L).

ug/L - micrograms per sample divided by the amount of air passed through adsorbent collection media.

Cpic (ppm) - Chloropicrin airborne concentration calculated from the ug/L data according to the following conversion:

$$ppm = \frac{ug/L \times 24.45\ L/mole}{164\ g/mole}$$

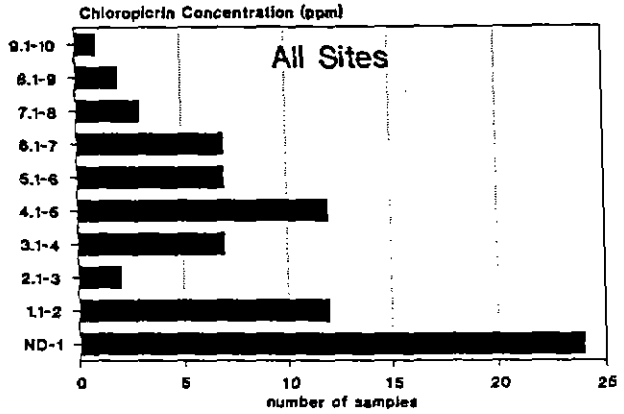
Cpic site mean - Average value of all samples per site.

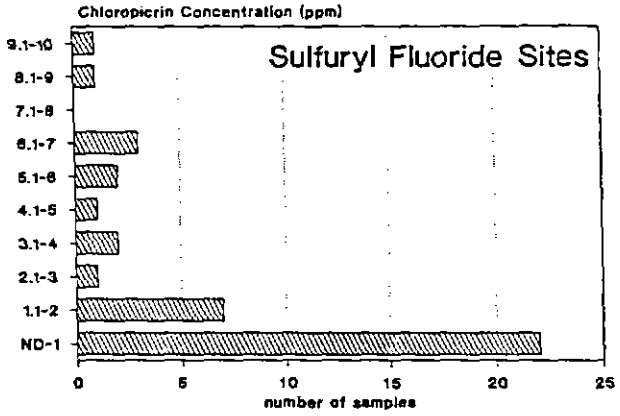
MeBr (ppm) - methyl bromide concentration at sampling location. Measurement with Draeger Tube at those sites treated with methyl bromide.

Figure 1

Distribution of Chloropicrin Concentrations

All Sites, All Values





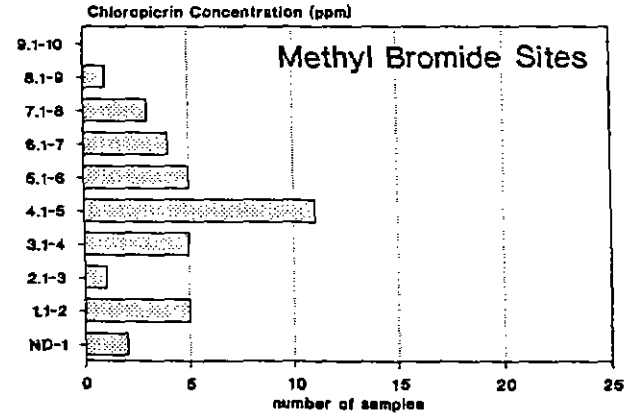
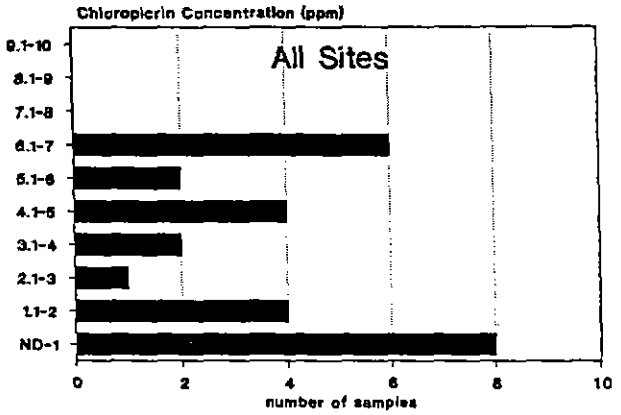
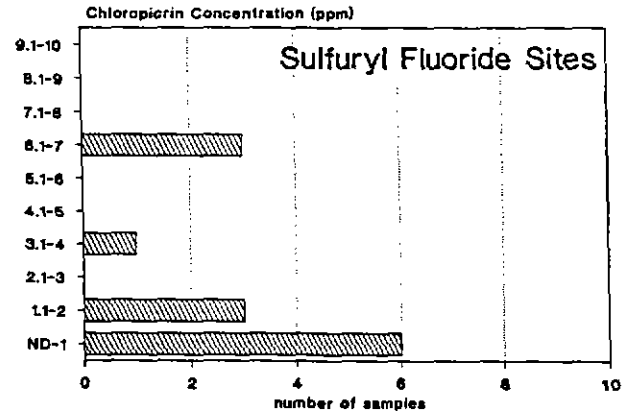


Figure 2

Distribution of Chloropicrin Concentrations Average Value per Site





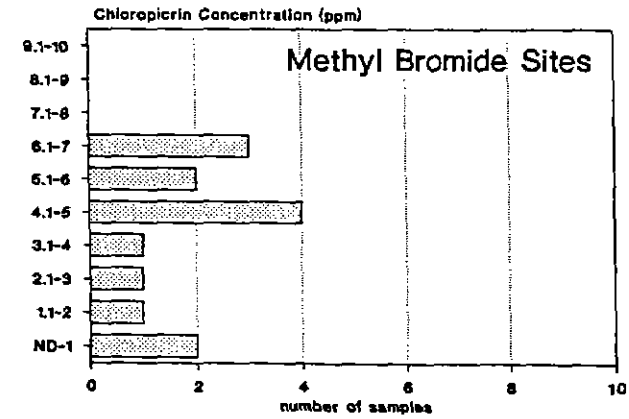


Figure 3

Distribution of Chloropicrin Concentrations Compared to Theoretical Concentrations (all sample values)

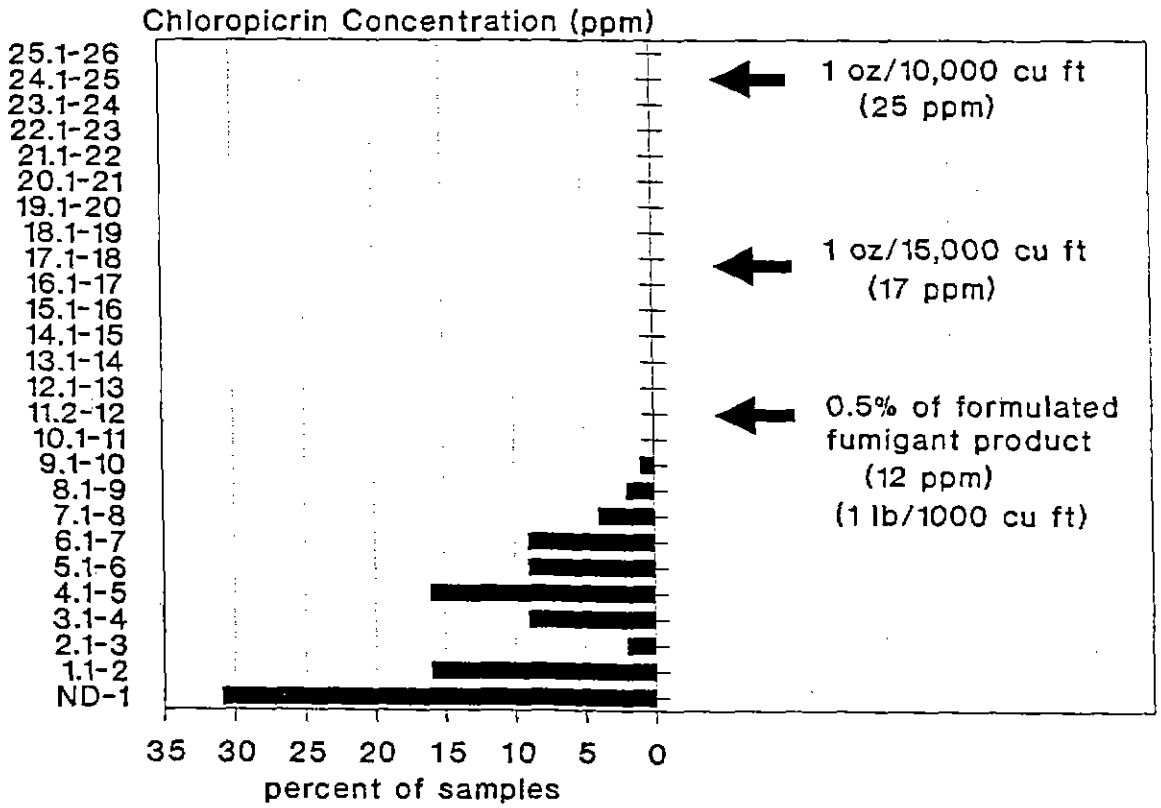
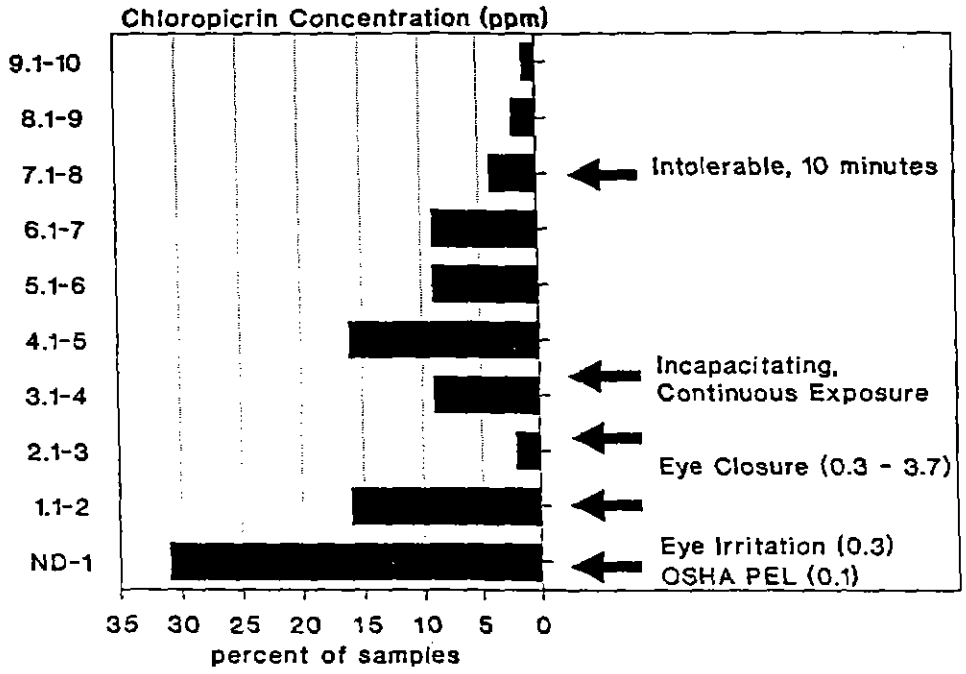


Figure 4

Comparison of Chloropicrin Concentrations and Recognized Health Effects, All Values



Average Chloropicrin Concentration per Site Compared to Recognized Health Effects

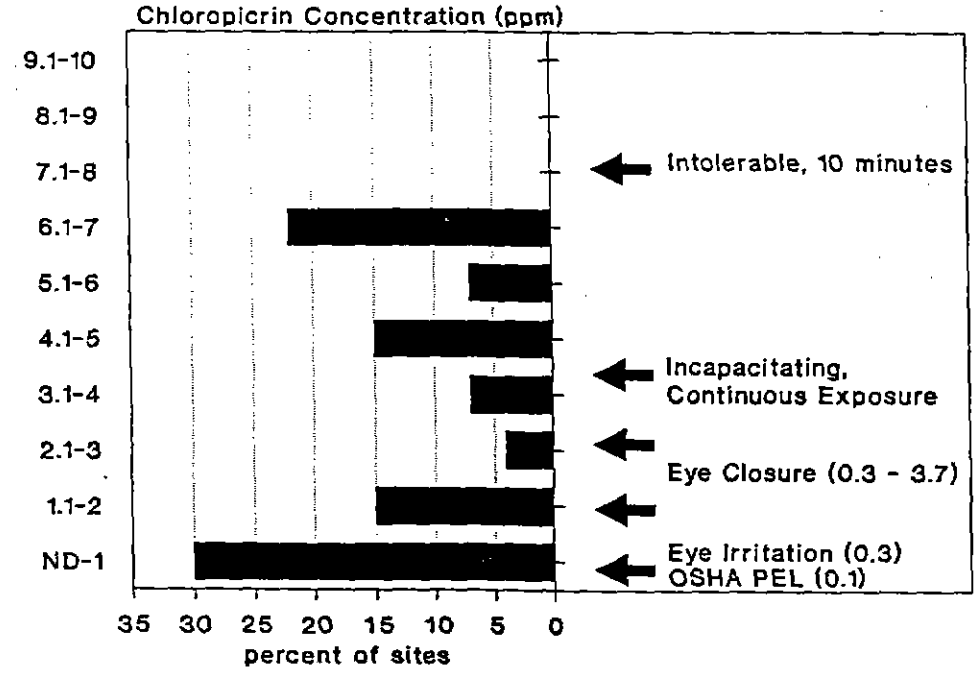


Figure 5

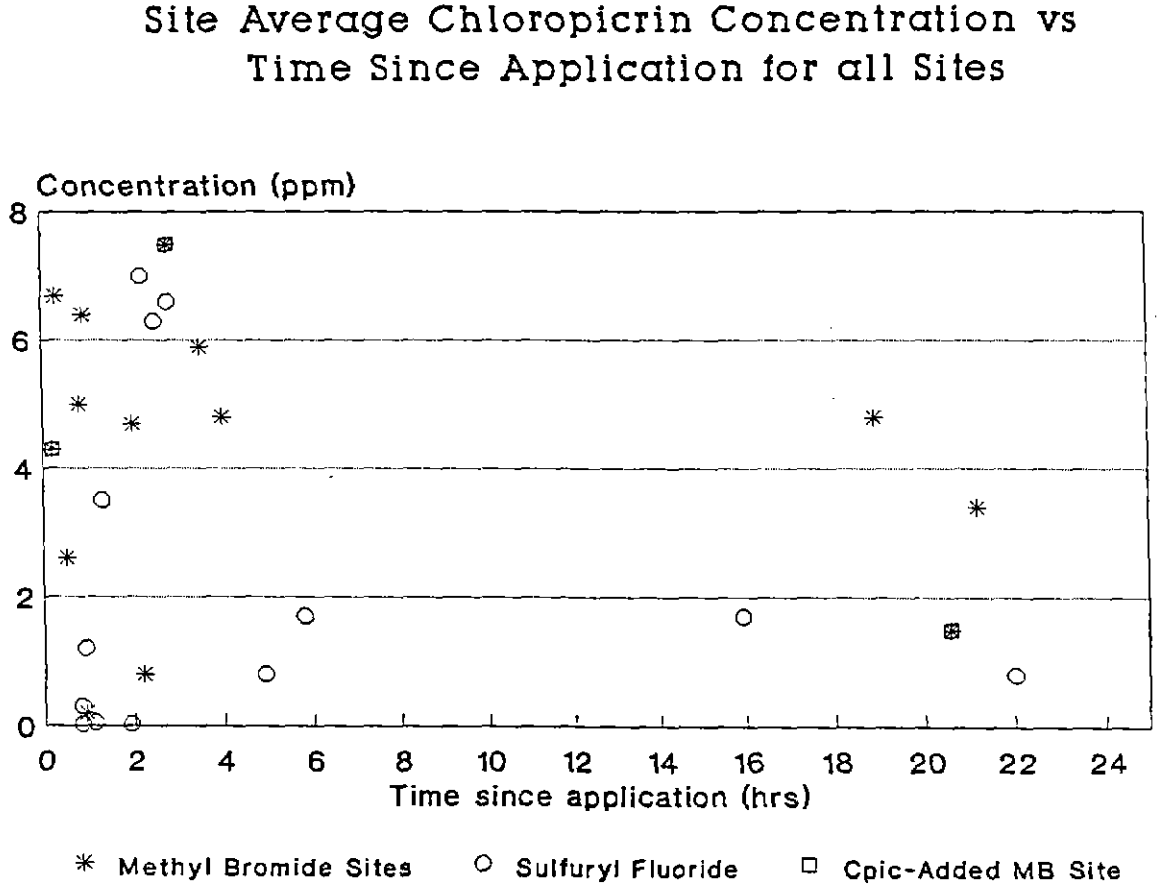

Site Average Chloropicrin Concentration vs
Time Since Application for all Sites
Concentration (ppm)
8
6
4
2
0
0
2
4
6
8
10
12
14
16
18
20
22
24
Time since application (hrs)
Methyl Bromide Sites
Sulfuryl Fluoride
Cpic-Added MB Site

TABLE 2

Time Since Introduction, Application Rates and Theoretical Concentrations of Chloropicrin - Arranged by Time Period Between Introduction and Sampling

Site Nmbr	Time Intro	Time Smpld	Time since (hrs)	Application Rate Fumigant ($lbs/1Kft^3$)	C-pic ($oz/10Kft^3$)	Theoretical C-pic (ppm)	Measured C-pic (ppm) Site mean
5	1315	1400	0.2	2.63	2	34	4.3
14	1020	1040	0.3	1.50	(0.50%)*	18	6.7
15	1315	1345	0.5	1.50	(0.50%)*	18	2.6
3	1300	1345	0.8	3.00	(0.25%)*	18	5.0
27	1430	1515	0.8	0.94	0.5	9	0.3
17	1500	1550	0.8	0.71	0.8	14	0.02
2	1400	1455	0.9	2.00	(0.50%)*	24	0.2
9	0905	1000	0.9	0.60	1.5	26	1.2
22	1100	1150	0.9	1.48	(0.50%)*	18	6.4
16	1400	1508	1.1	0.61	0.7	12	0.04
24	1230	1350	1.3	1.17	0.8	14	3.5
11	1150	1345	1.9	0.50	2	34	0.02
8	1100	1300	2.0	2.00	(0.25%)*	12	4.7
25	1350	1600	2.2	0.92	1	17	7.0
10	1000	1215	2.2	1.33	(0.50%)*	16	0.8
13	1330	1600	2.5	1.00	1	17	6.3
4	1130	1420	2.8	2.78	2	34	7.5
12	1145	1430	2.8	0.64	1	17	6.6
23	0900	1230	3.5	2.33	(0.50%)*	28	5.9
6	1000	1400	4.0	3.33	(0.50%)*	40	4.8
1	0900	1355	4.9	0.86	1	17	0.8
18	1145	1730	5.8	0.67	0.7	12	1.7
26	1700p	0850	15.9	0.91	1	17	1.7
19	1530p	0825	18.9	1.57	(0.50%)*	19	4.8
7	1425p	1100	20.6	2.53	2	34	1.5
21	1400p	1115	21.2	1.75	(0.50%)*	21	3.4
20	1130p	0930	22.0	1.00	0.5	9	0.8

* Fumigant formulated with chloropicrin

p Fumigant applied day prior to sampling

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ACKNOWLEDGMENTS

The authors of this report thank the following individuals from the Agricultural Commissioner's offices for their assistance in locating sampling sites. Phil Siebert of Sacramento County, John Blocker and Alicia Mariscal of San Diego County, Jim Wynn of Orange County, Paul Dufourd and Cinthia Werner of Los Angeles County, Robert Westin of Alameda County, and Jeff Garibaldi and Gail Raabe of San Mateo County.

The authors also thank David Conrad and Bill Fong of the California Department of Food and Agriculture Chemistry Services Branch for the analysis of the chloropicrin samples.

The authors also thank Charles Peterson, John Ellinger, Bob Ruebenson, Carl Smitley and Charles Alsky of the Structural Pest Control Board for assistance in locating fumigation logs for the various sites.

State of California

Department of Consumer Affairs

Memorandum

APPENDIX I

To : Dr. Robert Krieger, Chief
Department of Food and Agriculture
Worker Health & Safety Division
1220 N Street
Sacramento, CA 95814

Date : September 15, 1989

File No.:

Subject: FUMIGATION MONITORING

Telephone: ATSS ( )
( )

From : Structural Pest Control Board

The Board is concerned about the deaths that have resulted from fumigations performed by its licensees in recent years. I know that your department shares this concern.

We are attempting to determine actions that can be taken to eliminate such deaths. As the first step, the Board wants to find out if licensees are using proper amounts of chloropicrin by testing jobs in progress. In order to do this, we need your help! We do not have the necessary equipment and, therefore, ask that you join us in this testing with your equipment.

I have discussed this briefly with Dennis Gibbons, who expressed interest in the project. I would like to meet with you as soon as convenient for you so that we can discuss it further.

I will call you in the near future so that we can arrange a meeting.

Thank you.

Mary Lynn Ferreira

MARY LYNN FERREIRA
Registrar

MLF:cla

State of California

Memorandum

To : Mary Lynn Ferreira
Registrar
Structural Pest Control Board
Department of Consumer Affairs
1430 Howe Avenue, Suite 3
Sacramento, California 95825

Date : September 19, 1989

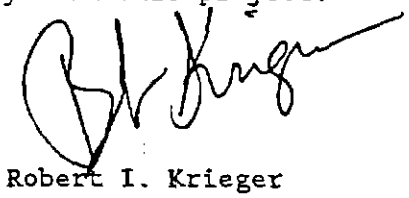
Place :

From : Department of Food and Agriculture - 1220 N Street, Room A-316
Sacramento, California 95814

Subject: Request for Assistance in Fumigation Monitoring

We are fully supportive of your attempts to discover ways of eliminating the accidental fatalities associated with structural fumigations. The testing you are planning appears to be an appropriate step. The amount of chloropicrin and how effective it is at deterring entry into tarpaulined-covered structures is an issue in which we have been involved in the past.

We can provide assistance for this testing and look forward to working with you on this project.



Robert I. Krieger
Chief/Staff Toxicologist
Worker Health and Safety Branch
(916) 445-8474

cc: Dennis Gibbons

SURNAME				
SO-106				

State of California

Memorandum

To : Doug Okumura, Chief
Pesticide Enforcement Branch

Date : November 16, 1989

Place : Sacramento

Phone: 445-8474

From : Department of Food and Agriculture - Robert I. Krieger, Chief/Supervising Toxicologist
Worker Health and Safety Branch

Subject: Deaths During Structural Fumigations

As noted at our meeting last week with representatives of the structural pest control industry, we have concerns about the fact that nine deaths have occurred in the past 22 months to persons who have illegally entered structures during fumigation. The rate is increasing because a total of 11 cases were reported during the previous seven years. Fumigated structures represent a unique source of pesticide exposure in that structural fumigation entails use of extremely toxic gases under appropriately well-controlled conditions. Persons illegally entering structures have been killed and police and emergency response personnel have been made ill as a consequence of excessive exposure.

The work that Dennis Gibbons, of my staff, assisted by Steve Mclean of yours, is presently involved in may provide insight into one of the variables involved in this issue. The data they are gathering of chloropicrin concentrations behind tarpaulins from ongoing fumigations will be very useful when deciding if there is presently adequate warning agent used to deter unauthorized entry during a typical fumigation. This work has just begun.

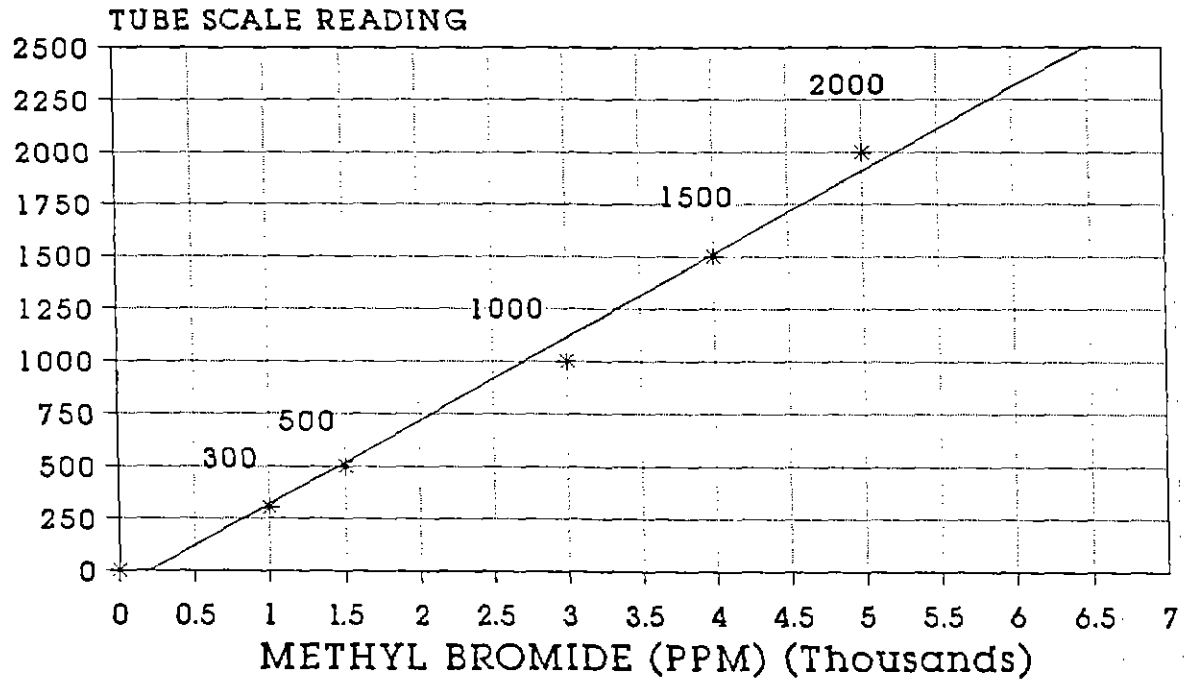
It is important that our Divisional response to the fumigation issue be documented in the Pesticide Illness Surveillance Program report. Are there any other activities of the Pesticide Use Enforcement Branch related to structural fumigation?

cc: Louise Mehler
Mike O'Malley
Dennis Gibbons
Steve Mclean

SURNAME

SO-106

METHYL BROMIDE CONCENTRATION USING PETROLEUM HYDROCARBON 100/a DRAEGER TUBES



TWO STROKES

APPENDIX IV

SITE LOCATIONS AND DATES

SITE NUMBER, ADDRESS, FUMIGANT, DATE SAMPLED

Site 1 - Alhambra Blvd, Sacramento, SF, 10/17/89
Site 2 - Second Ave.,Sacramento, MB, 10/17/89
Site 3 - Whitfield Street, Carmichael, MB, 11/09/89
Site 4 - Clark Street, Carmichael, MB, 11/17/89
Site 5 - Chesline Street, Citrus Heights, MB, 11/21/89
Site 6 - La Palmas, Sacramento, MB, 11/30/89
Site 7 - Maple Ave, Sacramento, MB, 12/7/89
Site 8 - Inyo, Sacramento, MB, 12/7/89
Site 9 - Polk Ave., San Diego, SF, 2/5/90
Site 10 - Duffy Way, Bonita, MB, 2/5/90
Site 11 - Parkway, Chula Vista, SF, 2/5/90
Site 12 - 4th St., National City, SF, 2/5/90
Site 13 - C St., Coronado, SF, 2/5/90
Site 14 - Sloop, Anaheim, MB, 2/6/90
Site 15 - Green St., Huntington Beach, MB, 2/6/90
Site 16 - Kiner St., Huntington Beach, SF, 2/6/90
Site 17 - Balmoral St., Huntington Beach, SF, 2/6/90
Site 18 - Obispo St., Long Beach, SF, 2/6/90
Site 19 - West 133rd St., Hawthorne, MB, 2/7/90
Site 20 - Sidlee St., Harbor City, SF, 2/7/90
Site 21 - Coldbrook St., Lakewood, MB, 2/7/90
Site 22 - Freckles St., Lakewood, MB, 2/7/90
Site 23 - Mayne St., Bellflower, MB, 2/7/90
Site 24 - Flagstone St., Pleasanton, SF, 2/8/90
Site 25 - Donald St., Hayward, SF, 2/8/90
Site 26 - Lahana St., Fremont, SF, 2/9/90
Site 27 - Elizabeth St., San Carlos, SF, 2/9/90

APPENDIX V

CALCULATIONS OF WARNING AGENT CONCENTRATION

Hand applied:

$$1 \text{ ounce}/10{,}000 \text{ ft}^3 \times 29.5 \text{ ml/oz} \times 1.635 \text{ g/ml} = 48.2 \text{ g}/10{,}000 \text{ ft}^3$$

and,

$$48.2 \text{ g}/10{,}000 \text{ ft}^3 \times 1000 \text{ mg/g} \times 35.3 \text{ ft}^3/\text{m}^3 = 170 \text{ mg/m}^3$$

then, $$\frac{170 \text{mg/m}^3 \times 24.45}{164} = 25 \text{ ppm}$$

If applied at rate of 1 ounce/15,000 ft^3, expected concentration would be 17 ppm.

When incorporated in the fumigant:

Application rate of 0.25 % and application rate is 3 pounds/1000 ft^3 of structure volume -

$$0.0025 \times 3 \text{ lbs}/1000 \text{ ft}^3 \times 454 \text{ g/lb} = 3.4 \text{ g}/1000 \text{ ft}^3$$

then,

$$3.4 \text{ g}/1000 \text{ ft}^3 \times 35.3 \text{ ft}^3/\text{m}^3 = 0.12 \text{ g/m}^3 \text{ or } 120 \text{ mg/m}^3$$

and,

$$\frac{120 \text{ mg/m}^3 \times 24.45}{164} = 17.9 \text{ ppm}$$

For other combinations:

Expected (theoretical) concentration (ppm) of warning agent

Fumigant Application Rate (lbs/1000 ft^3)	Chloropicrin Concentration (0.25 % product)	(0.5 % product)
1	6	12
1.5	9	18
2	12	24
3	18	36

APPENDIX V
(Continued)

CALCULATIONS OF FUMIGANT CONCENTRATION

Expected (theoretical) concentration of methyl bromide:

Application rate (lbs/1000 ft^3)	ppm	mg/m^3
3	12,400	49,600
2	8,200	32,800
1.5	6,200	24,800
1	4,100	16,400

Expected (theoretical) concentration for sulfuryl fluoride:

Application rate (lbs/1000 ft^3)	ppm	mg/m^3
4	16,000	64,000
2	8,000	32,000
1	4,000	16,000
0.5 (8 oz)	2,000	8,000
0.25 (4 oz)	1,000	4,000