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OFFICE OF  
PREVENTION, PESTICIDES AND  
TOXIC SUBSTANCES

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MEMORANDUM

SUBJECT: Review of Chloropicrin Incident Reports  
DP Barcode D306838., Chemical#081501

FROM: Jerome Blondell, Ph.D., Health Statistician  
Chemistry and Exposure Branch  
Health Effects Division (7509C)

Monica S. Hawkins, M.P.H., Environmental Health Scientist  
Chemistry and Exposure Branch  
Health Effects Division (7509C)

THRU: Francis B. Suhre, Chief  
Chemistry and Exposure Branch  
Health Effects Division (7509C)

TO: Charles Smith, Environmental Protection Specialist  
Reregistration Branch 2  
Health Effects Division (7509C)

BACKGROUND

The following data bases have been consulted for the poisoning incident data on the active ingredient Chloropicrin (PC Code: 081501):

1) OPP Incident Data System (IDS) - reports of incidents from various sources, including registrants, other federal and state health and environmental agencies and individual consumers, submitted to OPP since 1992. Reports submitted to the Incident Data System represent anecdotal reports or allegations only, unless otherwise stated. Typically no conclusions can be drawn implicating the pesticide as a cause of any of the reported health effects. Nevertheless, sometimes with enough cases and/or enough documentation risk mitigation measures may be suggested.

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2) Poison Control Centers - as the result of a data purchase by EPA, OPP received Poison Control Center data covering the years 1993 through 2001 for all pesticides. Most of the national Poison Control Centers (PCCs) participate in a national data collection system, the Toxic Exposure Surveillance System which obtains data from about 65 centers at hospitals and universities. PCCs provide telephone consultation for individuals and health care providers on suspected poisonings, involving drugs, household products, pesticides, etc.

3) California Department of Pesticide Regulation - California has collected uniform data on suspected pesticide poisonings since 1982. Physicians are required, by statute, to report to their local health officer all occurrences of illness suspected of being related to exposure to pesticides. The majority of the incidents involve workers. Information on exposure (worker activity), type of illness (systemic, eye, skin, eye/skin and respiratory), likelihood of a causal relationship, and number of days off work and in the hospital are provided.

4) National Institute of Occupational Safety and Health's Sentinel Event Notification System for Occupational Risks (NIOSH SENSOR) performs standardized surveillance in seven states from 1998 through 2002. States included in this reporting system are Arizona, California, Florida, Louisiana, Michigan, New York, Oregon, Texas, and Washington. Reporting is very uneven from state to state because of the varying cooperation from different sources of reporting (e.g., workers compensation, Poison Control Centers, emergency departments and hospitals, enforcement investigations, private physicians, etc.). Therefore, these reports should not be characterized as estimating the total magnitude of poisoning. The focus is on occupationally-related cases not residential or other non-occupational exposures. However, the information collected on each case is standardized and categorized according the certainty of the information collected and the severity of the case.

## CHLOROPICRIN REVIEW

### I. Incident Data System

#### Incident#1868-24

A pesticide incident occurred in 1986, when a truck driver opened the doors to a trailer that had the product in it and was exposed to fumes. The driver reported nausea, vomiting, and eye irritation. No further information on the disposition of the case was reported.

#### Incident#1868-59

A pesticide incident occurred in 1986, when a man inhaled the product. Later that day, he reported chest pain. No further information on the disposition of the case was reported.

#### Incident#2621-3 and #3377-19 California

A pesticide incident occurred in 1995, when soil was fumigated on a strawberry field.

The field was tarped and there was no sign of rips in the tarp. Investigation of the application by the County Agricultural Commissioner found no violations of applicable pesticide laws and regulations. The product drifted about 200 feet toward a residential complex during an inversion which kept the chloropicrin from dispersing. Fifty-five individuals were exposed to the product. Twenty-four of the individuals were observed and released. Five were treated by an on-site physician and released and three individuals were treated at the hospital. The individuals receiving treatment reported eye irritation, headache, nausea, and dizziness. In response to this incident the CAC put in place permit conditions for all chloropicrin applications which require that applications be discontinued by 2:00 p.m. and that only one injection machine operate at a time. No further information on the disposition of the case was reported.

#### Incident#3000-1

A pesticide incident occurred in 1996, when two workers were exposed to 0.2 ppm (eight hour Time Weighted Average) of the product during an air monitoring study. They reported transient eye irritation during tarp removal. The application rate employed in this study was reported to be "much higher" than what was used in commercial applications. No further information on the disposition of the case was reported.

#### Incident#3519-1

A pesticide incident occurred in 1996, when several dock workers at a trucking terminal were exposed to the product. The workers were treated at the hospital but specific symptoms were not mentioned. No further information on the disposition of the case was reported.

#### Incident#4463-1

A pesticide incident occurred in 1996, when a worker, who did not wear personal protective equipment or have certification for restricted use pesticides, applied the product to fumigate a seed storage facility. The worker reported severe eye irritation. Adjacent to the facility, office workers reported eye irritation. No further information on the disposition of the case was reported.

#### Incident#5003-1 California

A pesticide incident occurred in 1997, when a home was treated with the product by a pest control operator. A woman reported itchy eyes and skin after re-entering the home. No further information on the disposition of the case was reported.

#### Incident#5358-1

A pesticide incident occurred in 1997, when several workers treated a wood utility pole about seventy-five to eighty feet from a post office. The product traveled through uncapped risers and filtered into the building. The post office workers reported teary eyes. No further information on the disposition of the case was reported.

#### Incident#5461-1

A pesticide incident occurred in 1997, when five lots of nitrogen cylinders became

contaminated with the product. Pressurized cylinders of nitrogen were used to power a dentist's equipment. Patients within the office reported burning eyes. No further information on the disposition of the case was reported.

#### Incident#5989-1 California

A pesticide incident occurred in 1997, when an employee came into contact with two tablespoons of chloropicrin on their arm and glove. He reported coughing and difficulty breathing and was treated on-site by a paramedic. No further information on the disposition of the case was reported.

#### Incident#11748-4 California

A pesticide incident occurred in 1990, when a newspaper article in California discussed fumigation tarps that were torn by children who were playing in the same area. Seven individuals, who live near the strawberry field, were treated at the hospital after being exposed to the product. Specific symptoms were not mentioned. No further information on the disposition of the case was reported.

#### Incident#11959-1 California

A pesticide incident occurred in 2001, when fumigation lines were cleared and the product was released and drifted into the eyes of workers. The workers reported watery and burning eyes. No further information on the disposition of the case was reported.

#### Incident#13856-2 and #13980-16 California

A pesticide incident occurred in 1996, when a pool maintenance serviceman opened a container of the product and inhaled the fumes. The serviceman reported shortness of breath, dizziness, and coughing up green sputum. He was hospitalized for nine days between two different hospitals and was diagnosed with chemical pneumonitis. No further information on the disposition of the case was reported.

#### Incident#14651-1 and Incident#14885-45

A pesticide incident occurred in 2003, when an applicator applied the product to a forty acre field. The product drifted toward a housing complex one-quarter mile away and 124 individuals left their homes. The individuals reported eye irritation, difficulty breathing, nausea, and vomiting. No further information on the disposition of the case was reported.

## II. Poison Control Center Data - 1993 through 2001

Results for the years 1993 through 2001 are presented below for occupational and non-occupational reports involving adults and older children. There were insufficient numbers for children under age six to warrant a detailed analysis. Cases involving exposures to multiple products or unrelated outcome are excluded. Tables 1-3 present the hazard information for chloropicrin compared with all other pesticides on six measures: percent with symptoms, percent

with moderate, major, or fatal outcome, percent with major or fatal outcome, percent of exposed cases seen in a health care facility, and percent hospitalized and percent seen in a critical care facility. Table 1 reports the number of cases on which the data derived in Tables 2-3 are based. Table 2 presents this information for occupational cases, Table 3 for non-occupational cases involving adults and older children.

Table 1. Number of chloropicrin exposures reported to the Toxic Exposure Surveillance System (AAPCC), number with determined outcome, number seen in a health care facility for occupational and non-occupational cases (adults and children six years and older) and for children under six years of age only, 1993-2001 .

Subgroup	Exposures	Outcome determined	Seen in Health Care Facility
Occupational: adults and older children	36	23	25
Non-occupational: adults and older children	104	50	22
Children under age six	5	3	1

Table 2. Comparison between chloropicrin and all pesticides for percent cases with symptomatic outcome (SYM), moderate or more severe outcome (MOD), life-threatening or fatal outcome (LIFE-TH), seen in a health care facility (HCF), hospitalized (HOSP), or seen in an intensive care unit (ICU) reported to Poison Control Centers, 1993-2001 for occupational cases only.

Pesticide	SYM*	MOD*	LIFE-TH*	HCF*	HOSP*	ICU*
Chloropicrin	100%	43.5%	0%	69.4%	4.00%	0.0%
All Pesticides	86.1%	19.6%	0.681%	45.6%	6.14%	2.40%
Ratio	1.16	2.22	0.0	1.52	0.65	0.0

\* Symptomatic cases based on those cases with a minor, moderate, major, or fatal medical outcome. Denominator for SYM, MOD, and LIFE-TH is the total cases where medical outcome was determined. Denominator for HCF is all exposures. Denominator for HOSP and ICU is all cases seen in a health care facility.

Table 3. Comparison between chloropicrin and all pesticides for percent cases with symptomatic outcome (SYM), moderate or more severe outcome (MOD), life-threatening or fatal outcome (LIFE-TH), seen in a health care facility (HCF), hospitalized (HOSP), or seen in an intensive care unit (ICU) reported to Poison Control Centers, 1993-2001 for non-occupational cases involving adults and older children.

Pesticide	SYM*	MOD*	LIFE-TH*	HCF*	HOSP*	ICU*
Chloropicrin	88.0%	4.00%	0.0%	21.2%	4.54%	0.0%
All Pesticides	68.4%	11.0%	0.408%	15.3%	6.89%	2.95%
Ratio	1.28	0.38	0.0	1.29	0.73	0.0

\* Symptomatic cases based on those cases with a minor, moderate, major, or fatal medical outcome. Denominator for SYM, MOD, and LIFE-TH is the total cases where medical outcome was determined. Denominator for HCF is all exposures. Denominator for HOSP and ICU is all cases seen in a health care facility.

There were insufficient numbers of cases to evaluate the hazard among children less than six years old. Occupational exposures to chloropicrin were more likely to result in moderate medical outcome and hospital facility visits than other pesticides, but for non-occupational exposures only minor symptoms were more likely as were health care visits. There were no exposures with major medical outcome or that required attention in a critical care unit.

### III. California Data - 1982 through 2002

Detailed descriptions of 45 cases submitted to the California Pesticide Illness Surveillance Program (1982-2002) were reviewed. In 45 of these cases, chloropicrin was used alone or was judged to be responsible for the health effects. Only cases with a definite, probable or possible relationship were reviewed. Chloropicrin ranked 45<sup>th</sup> as a cause of systemic poisoning in California based on data for 1982 through 2002. Table 4 presents the types of illnesses reported by year. Table 5 gives the total number of workers that took time off work as a result of their illness and how many were hospitalized and for how long.

Table 4. Cases Due to Chloropicrin in California Reported by Type of Illness and Year, 1982-2002.

Year	Illness Type					Total
	Systemic <sup>a</sup>	Eye	Skin	Respiratory <sup>b</sup>	Combination <sup>c</sup>	
1982	4	3	-	-	-	7
1983	-	1	-	-	-	1
1984	-	10	-	-	-	10
1985	-	-	-	-	-	-

Year	Illness Type					
	Systemic <sup>a</sup>	Eye	Skin	Respiratory <sup>b</sup>	Combination <sup>c</sup>	Total
1986	1	-	-	-	-	1
1987	1	2	-	-	-	3
1988	-	-	-	-	-	-
1989	1	2	-	1	2	6
1990	-	1	-	-	-	1
1991	-	-	-	-	-	-
1992	-	-	-	-	-	-
1993	-	-	-	-	-	-
1994	-	-	-	-	-	-
1995	13	2	-	-	1	16
1996	-	-	-	-	-	-
1997	-	-	-	-	-	-
1998	-	-	-	-	-	-
1999	-	-	-	-	-	-
2000	-	-	-	-	-	-
2001	-	-	-	-	-	-
2002	-	-	-	-	-	-
<b>Total</b>	<b>20</b>	<b>21</b>	<b>-</b>	<b>1</b>	<b>3</b>	<b>45</b>

<sup>a</sup> Category includes cases where skin, eye, or respiratory effects were also reported.

<sup>b</sup> Category not used until 1990. Prior respiratory cases classified as systemic.

<sup>c</sup> Category includes combined irritative effects to eye, skin, and respiratory system.

Table 5. Number of Persons Disabled (taking time off work) or Hospitalized for Indicated Number of Days After Chloropicrin Exposure in California, 1982-2002.

Time period	Number of Persons Disabled	Number of Persons Hospitalized
One day	-	2
Two days	2	2
3-5 days	-	-
6-10 days	-	-
more than 10 days	-	-
Unknown	8	2
Indefinite	-	-

The majority of complaints due to chloropicrin involved eye irritation and tearing, consistent with its previous use as 'tear gas'. The primary systemic symptoms were breathing difficulty, chest pain, nausea, and headache

#### IV. NIOSH SENSOR state reports

Other than the California cases summarized above, there were 38 persons affected by chloropicrin in Florida and two in Oregon. Of the 38 Florida cases, 30 occurred during a single event when chloropicrin and methyl bromide escaped from a structural application and contaminated a building across the street.

Among the agriculturally-related cases, there was one case that occurred when a farm worker removed a tarp from a tomato field and required hospitalization. Two cases resulted while riding a tractor and unintentionally inhaling the fumes. Two relatively mild cases resulted when chloropicrin drifted to a home near the farm. A farm laborer was affected in an undescribed case that occurred because he was not supplied protective equipment. One of the two cases in Oregon involved a farm laborer with dermal contact.

#### V. Scientific Literature

TeSlaa et al. (1986) reported on a home that was fumigated for bats from the basement. Three to four weeks later new occupants moved in. The family dog, which stayed in the basement at night developed lacrimation, difficulty breathing, and coughing. The dog was diagnosed with chemically-induced bronchitis and pneumonia by a veterinarian. The mother, father and two children (7 year-old boy and 10 year-old girl) experienced runny noses, lacrimation, and coughing. Six weeks after application, 30 ppb levels of chloropicrin were found in dining room air.



Goldman et al. (1987) examined reports of acute symptoms in persons living near a strawberry field in California treated with methyl bromide and chloropicrin in 1984. The combination of warm temperature and an air inversion resulted in numerous complaints to the local health department. Homes within two miles of the strawberry field and control homes further away were identified and surveyed by telephone along with a review of local emergency room records. A total 134 households were interviewed for a response rate of 68%. Eleven percent could not be reached and 21% refused to participate. The emergency room survey identified 32 persons with incident-related symptoms of eye irritation, sore throat, headache, shortness of breath, and coughing. One six-year old child was hallucinating. Several of the workers called to the scene to give emergency assistance became symptomatic and received emergency room treatment including four fire fighters, a sanitarian, and three police/patrol officers. In the 134 households there were 71 adults and 23 children with reported illnesses after the application. Of these, 32 adults and 4 children in 26 households reported symptoms consistent with exposure to fumigants on the three days following application. The authors found that symptoms were possibly attributable to methyl bromide in 7 adults, and more likely due to chloropicrin in 31 adults and 5 children (some adults and children had symptoms due to both compounds). Thirty percent of adults who lived within a half mile of the treated field reported possible chloropicrin symptoms, while 14% of adults from one half mile to one mile also reported such symptoms. Greater than one mile away 5-8% of the 190 adults interviewed reported possible symptoms. For those with chloropicrin-type symptoms the following frequencies were reported among the 31 adults: eye irritation (65%), throat irritation (45%), and nose irritation (23%). Also consistent with chloropicrin exposure were headache (48%) and cough (29%). The authors report that the fumigants were apparently applied properly and according to regulations but that atmospheric conditions (the inversion and high temperature) led to higher ambient air levels than usual. The authors concluded that this incident "highlights the need for larger buffer zones between areas where highly toxic airborne agents are being applied and residential areas. Notification of local health and emergency response agencies and the local community is imperative."

Prudhomme et al. (1999) summarized three cases in California where employees at a freight transportation company were exposed to chloropicrin while attempting to unload a trailer truck. The factory from which the shipment came admitted that overfilled containers had allowed chloropicrin residue to evaporate. The duration of exposure decreased from greater than one minute for the first employee to less than 15 seconds for the third. All three experienced immediate symptoms of eye irritation, nausea, lethargy and headache. Following these initial complaints were symptoms of musculoskeletal pain (especially chest pain) associated with elevated levels of creatine phosphokinase (CP) in two of the three cases. Both the severity of symptoms and the change in CP levels appeared to follow a dose-response relationship.

The Centers for Disease Control (in press, 2004) reported on an agricultural pest control company who applied 100% chloropicrin at a concentration of 80 pounds/acre to 34 acres of fallow land in California in 2003. It was injected 17 to 18 inches into the soil. Residents that

lived about one-quarter mile from the land reported irritant symptoms that evening. The next day, chloropicrin was applied again and firefighters that responded to a 911 call reported eye irritation. It was applied with a 60-foot, chloropicrin-free buffer zone around the perimeter of the field. In-person interviews were conducted at 35 households and a day care center about one-quarter mile from the treated field a few days later. The investigation revealed that 165 individuals who ranged in age from three months to 63 years old reported eye (tearing in 82%, eye pain or burning in 54%), upper respiratory symptoms (cough in 32%, difficulty breathing in 16%, other upper respiratory irritation 13%), and other symptoms (vomiting 22%, headache 25%). Eleven days later, a physician treated nine individuals and seven reported persistent respiratory symptoms. Some individuals were not interviewed which likely lead to an undercount. A retrospective air dispersion model estimated exposures of 0.20 ppm with peak concentrations estimated above 1 ppm. As a result of this incident, the County Agricultural Commissioner prohibited applications within one-quarter mile of occupied structures and mandatory use of a heavy-duty tarp or water seal for applications within one-half mile of such structures.

#### VI. Comparison of chloropicrin with other soil fumigants

Data from incident review for the leading soil fumigants were compared to determine whether it was possible to distinguish level of hazard. For this section of the review Poison Control Center data and California data were the principle sources of data that permitted a comparison. A key limitation of these comparisons is the absence of denominator data on the population at risk. It is difficult to make comparisons between chemicals with widely vary patterns and volume of use. Data on the number of applications in California from 1984-88 and 1990-2002 were totaled and used as a surrogate measure for population at risk.

#### Poison Control Center comparison for fumigants

Poison Control Center data is summarized below across fumigants. Table 6 presents the denominators used in the proportionate analysis. Tables 7 and 8 present the ratios, measures of hazard, for occupational and non-occupational exposures among adults and older children, respectively. There was insufficient data to warrant a comparison with dazomet or metam-potassium.

Table 6. Number of fumigant exposures reported to the Toxic Exposure Surveillance System (AAPCC), number with determined outcome, number seen in a health care facility for occupational and non-occupational cases (adults and children six years and older), 1993-2001 .

Chemical	Exposures*	Outcome determined*	Seen in Health Care Facility*
Methyl Bromide	288/353	174/178	178/126

Chemical	Exposures*	Outcome determined*	Seen in Health Care Facility*
Metam-sodium	74/154	55/78	43/60
Chloropicrin	36/104	23/50	25/22
Telone	19/38	9/17	11/18
Dazomet	9/35	6/24	6/1

\* Total for occupational/total for non-occupational reports for older children and adults.

Note the relatively few occupational incidents related to dazomet are insufficient to warrant further analysis in the tables below.

Table 7. Ratio comparing fumigants and all pesticides for percent cases with symptomatic outcome (SYM), moderate or more severe outcome (MOD), life-threatening or fatal outcome (LIFE-TH), seen in a health care facility (HCF), hospitalized (HOSP), or seen in an intensive care unit (ICU) reported to Poison Control Centers, 1993-2001 for occupational cases only. (Observed number of reports shown in parentheses)

Pesticide	SYM*	MOD*	LIFE-TH*	HCF*	HOSP*	ICU*
All Pesticides	86.1%	19.6%	0.681%	45.6%	6.14%	2.40%
MeBr Ratio**	1.01 (151)	2.08 (68)	3.71 (4)	1.31 (160)	2.27 (22)	2.38 (9)
Metam-sodium Ratio***	1.05 (64)	1.72 (24)	2.07 (1)	1.24 (56)	0.58 (2)	0.74 (1)
Chloropicrin Ratio***	1.16 (23)	2.22 (10)	0.0	1.52 (25)	0.65 (1)	0.0
Telone Ratio***	1.03 (8)	2.84 (5)	0.0	1.27 (11)	0.0	0.0

\* Symptomatic cases based on those cases with a minor, moderate, major, or fatal medical outcome. Denominator for SYM, MOD, and LIFE-TH is the total cases where medical outcome was determined. Denominator for HCF is all exposures. Denominator for HOSP and ICU is all cases seen in a health care facility.

\*\* Based on 1993-98 data and corresponding rates for all pesticides which are very close to the values reported in the first row for the years 1993-2001.

\*\*\* To obtain the percent for a particular pesticide multiply the percent for all pesticides in a column by the respective ratio. For example, the percent symptomatic cases with metam-sodium is  $86.1\% \times 1.05 = 90\%$  and the percent cases with moderate outcome would be  $19.6 \times 1.72 = 34\%$ .

Table 8. Comparison between methyl bromide and all pesticides for percent cases with symptomatic outcome (SYM), moderate or more severe outcome (MOD), life-threatening or fatal outcome (LIFE-TH), seen in a health care facility (HCF), hospitalized (HOSP), or seen in an intensive care unit (ICU) reported to Poison Control Centers, 1993-2001 for non-occupational cases involving adults and older children. (Observed number of reports shown in parentheses)

Pesticide	SYM*	MOD*	LIFE-TH*	HCF*	HOSP*	ICU*
All Pesticides	68.5%	10.5%	0.36%	16.4%	6.24%	2.67%
MeBr Ratio**	1.16 (141)	1.98 (37)	1.56 (1)	2.30 (109)	2.64 (18)	2.40 (7)
Metam-sodium Ratio***	0.72 (58)	0.93 (12)	2.08 (1)	2.89 (95)	0.0	0.0
Chloropicrin Ratio***	1.29 (44)	0.36 (2)	0.0	1.38 (22)	0.66 (1)	0.0
Telone Ratio***	1.38 (17)	4.04 (8)	13.6 (1)	3.27 (20)	0.0	0.0

\* Symptomatic cases based on those cases with a minor, moderate, major, or fatal medical outcome. Denominator for SYM, MOD, and LIFE-TH is the total cases where medical outcome was determined. Denominator for HCF is all exposures. Denominator for HOSP and ICU is all cases seen in a health care facility.

\*\* Based on 1993-98 data and corresponding rates for all pesticides which are very close to the values reported in the first row for the years 1993-2001.

\*\*\* To obtain the percent for a particular pesticide multiply the percent for all pesticides in a column by the respective ratio. For example, the percent symptomatic cases with metam-sodium is  $86.1\% \times 1.05 = 90\%$  and the percent cases with moderate outcome would be  $19.6 \times 1.72 = 34\%$ .

Insufficient numbers of children under age six were exposed to fumigants and reported to Poison Control Centers to warrant analysis. Methyl bromide exposures shows a clear pattern of increased risk of severe effects, including major medical outcome and care in an ICU, beyond that required for other fumigants and far beyond that required for all pesticides. This was especially true for workers exposed occupationally, who experienced a two-fold increase risk of moderate or more serious poisoning and a 3.7-fold risk of major medical outcome than did workers exposed to all pesticides. There were four occupational cases with major or life-threatening medical outcome and all four cases were reported to have second or third degree burns to the skin, but no neurological symptoms. The one non-occupational case with major outcome was reported to have a seizure and coma. Of the 641 exposures to methyl bromide included in the above analysis, 32% occurred in California. It is not possible to say how many of

these cases overlap the reports from the California Pesticide Illness Surveillance Program described below. It is likely, however, that much of this increased risk was due to methyl bromide use in structural applications rather than agricultural fumigation because the overwhelming majority of Poison Center contacts relate to residential exposures.

Occupational exposures to other fumigants were more likely to result in moderate medical outcome than other pesticides and there were increased visits to a health care facility. However, requirements for hospitalization and critical care was generally much less than other pesticides. This finding suggests that other fumigants do require increased medical care but that the care for moderate or minor effects are readily treated with the patient being released the same day. All three, metam-sodium, chloropicrin, and telone, were less likely than methyl bromide to require serious medical attention such as hospitalization or result in major medical outcome.

Although the numbers of dazomet cases was small, it tended to follow the same pattern as the other fumigants. A total of 48 dazomet reports were reported to Poison Control Centers from 1993 through 2001. Nine of these were occupational of which six were seen in a health care facility and six were classified as having minor medical outcome. Four exposures were reported in children less than six years old. There were insufficient numbers to warrant additional analysis of either the occupational cases or the children under six.

There were 35 non-occupational exposures with just one seen in a health care facility. One of these 35 cases was classified as having a moderate medical outcome (with effects to the eyes and respiratory system) and 23 case was classified as having minor medical outcome. Of the 35 reports, the most common symptoms reported were dermally-related. Too few cases were reported to warrant detailed comparisons of dazomet with other pesticides. However, the pattern of symptoms, consistent with reports from other sources, suggest that dazomet is a dermal irritant.

#### California data comparison of soil fumigants

The most severe methyl bromide cases (17 deaths) resulted from its use in structural fumigation. For the purposes of this review those uses were excluded. This section compares the data for agricultural uses of fumigants only. Metam-sodium is responsible for a large number of reports, primarily because of cluster poisonings involving two or more bystanders. There were 16 such incidents from 1982 through 2001 with five of the 16 involving 10 bystanders or more. Metam-sodium accounted for nine percent of the nearly 1,000 drift-related cases reported in California from 1994 through 1997. It accounted for 22% of the incidents involving clusters of 10 or more people during the same time period. Two of the 13 incidents (15%) that involved drift of one-quarter mile or more were due to metam-sodium from 1994 through 1997.

Table 9. Cases Due to Agricultural use of methyl bromide, metam-sodium, chloropicrin, Telone and dazomet in California Reported by Type of Illness and Year, 1982-2002.

Year	Illness Type					Total
	Systemic <sup>a</sup>	Eye	Skin	Respiratory <sup>b</sup>	Combination <sup>c</sup>	
Methyl Bromide	70	15	64	3	3	155
Metam-sodium*	244	60	81	10	59	454
Chloropicrin	20	21	-	1	3	45
Telone	10	14	17	1	7	49
Dazomet	-	-	2	-	-	2

<sup>a</sup> Category includes cases where skin, eye, or respiratory effects were also reported.

<sup>b</sup> Category not used until 1990. Prior respiratory cases classified as systemic.

<sup>c</sup> Category includes combined irritative effects to eye, skin, and respiratory system.

\* Does not include incident data for 2002. In that year California reported 151 systemic illnesses and 230 eye, skin, and respiratory effects for a total of 381 due to metam-sodium. Also excludes 435 cases due to train car derailment resulting in spill into Sacramento River in 1991.

Table 10. Total number of persons disabled (taking time off work) for indicated number of days after metam-sodium, chloropicrin, telone, and dazomet exposure in California, 1982-2002.

Time period	Number of Persons Disabled				
	Methyl bromide*	Metam-sodium*	Chloropicrin	Telone	Dazomet
1 day	7	12	-	4	-
2 days	9	4	2	4	-
3-5 days	14	16	-	2	-
6-10 days	12	7	-	-	-
> 10 days	10	5	-	-	-
Unknown	24	138	8	5	-
Indefinite	7	-	-	-	-

\* Data for methyl bromide cover 1982-1999. Data for metam-sodium cover 1982-2001.

Table 11. Total number of persons disabled (taking time off work) or hospitalized for indicated

number of days after metam-sodium, chloropicrin, telone, and dazomet exposure in California, 1982-2002.

Time period	Number of Persons Hospitalized				
	Methyl bromide*	Metam-sodium*	Chloro-picrin	Telone	Dazomet
1 day	-	-	2	-	-
2 days	2	1	2	-	-
3-5 days	2	-	-	1	-
6-10 days	1	-	-	-	-
> 10 days	1	-	-	-	-
Unknown	1	-	2	-	-
Indefinite	-	-	-	-	-

\* Data for methyl bromide cover 1982-1999. Data for metam-sodium cover 1982-2001.

Chloropicrin and Telone show a very similar pattern in tables 10 and 11 below, except that chloropicrin is much more likely to effect the eyes and telone the skin. The number of reports due to dazomet is insufficient to warrant conclusions. The unusually low number of dazomet cases corresponds to the relatively low use. From 1982 through 2002, California reported an annual average of 6,882 non-structural applications of methyl bromide, 2,586 applications of metam-sodium, 3,697 applications of chloropicrin, 2,302 applications of Telone, and just 64 applications of dazomet. Note that the totals for 1982-83 were not available and, therefore were estimated based on values for 1984-85. Similarly, there was no usage data report for 1989, so the average of 1988 and 1990 was used as an estimate. Estimated use of metam-sodium appears to have been much lower for the years 1982-1988, suggesting either much lower use, or an artifact of the incomplete reporting during those years.

Using the above estimates of applications per year it is possible to compare the number of illness per 1,000 applications. For methyl bromide, chloropicrin, Telone, and dazomet the number of illnesses per 1,000 applications range from 0.6 to 1.5. However, for metam-sodium there were 9.1 illnesses per 1,000 applications, about 10 times the average for the other fumigants. This appears to relate to its unusual ability to drift long distances and cause symptoms in residential areas near agricultural fields. On the other hand, methyl bromide demonstrated much longer period of time off for workers who sustained serious illnesses, most often as a result of skin injuries. Surprisingly, 10 of the 13 reports of workers taking 10 days or more off work were due to agricultural use of methyl bromide rather than structural use.

In summary, based on California data, methyl bromide has a higher severity of poisoning than other fumigants. Metam-sodium has a higher rate of poisoning per number of applications, about ten times that of other fumigants due to its potential to drift. However, these illnesses are typically mild to moderate in severity.

## VII. Conclusion

Soil fumigation with chloropicrin in California has resulted in widespread adverse effects to nearby neighborhoods in 1984 (Goldman et al. 1987), 1995 (Incident#2621-3 and #3377-19), and 2003 (Centers for Disease Control and Prevention, in press). Buffer zones of one-quarter to one-half mile have been imposed as a result. The symptoms of chloropicrin exposure are principally lacrimation (tearing of the eyes), irritation to throat, headache, coughing, and difficulty breathing. Symptoms usually subside shortly after exposure ends and can often be treated on site without the need for attention at a medical facility. An air monitoring study conducted for the registrant (Incident#3000-1) demonstrated that when two workers were exposed to 0.2 ppm (eight hour Time Weighted Average) chloropicrin, they reported transient eye irritation during tarp removal. In an incident that occurred in 2003, 165 individuals reported symptoms who lived near a field that had two applications (Centers for Disease Control and Prevention, in press). A retrospective air dispersion model estimated exposures of 0.20 ppm with peak concentrations estimated above 1 ppm during this incident.

## VIII. Recommendations

Buffer zones and heavy duty tarps or water sealed tarps are recommended for field fumigation with chloropicrin. Notification of local health and emergency response agencies and the local community of applications that occur near residential sites is advised. Certification requirements for all handlers of chloropicrin is recommended.

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cc: Chloropicrin file (081501)  
Diana Locke, HED (7509C)  
Pat Dobak, SRRD (7508C)