Department of Pesticide Regulation

Mary-Ann Warmerdam
Director

Edmund G. Brown Jr.
Governor

MEMORANDUM

TO: George Farnsworth
Environmental Program Manager I
Worker Health and Safety Branch

HSM-10009
(Revised on March 1, 2010 approved by S. Edmiston)

FROM: Michael O'Malley, M.D., M.P.H. *(original signed by M. O'Malley)*
Medical Consultant
(916) 445-4281

Harvard Fong, CIH *(original signed by H. Fong)*
Senior Industrial Hygienist
(916) 445-4211

DATE: Revised - March 1, 2011
(Original date September 1, 2010)

SUBJECT: SUMMARY OF MEDICAL AND INDUSTRIAL HYGIENE INFORMATION, METHYL BROMIDE EXPOSURE ASSOCIATED WITH COLD STORAGE FACILITY NEAR THE PORT OF LONG BEACH

In mid-April, Worker Health and Safety (WHS) was informed by Enforcement Branch staff that there were some air residue problems associated with the pier-side fumigation of Chilean grapes (which later expanded to include kiwis). A worker illness (a private industry produce inspector) had been reported and the doctor linked the illness with potential exposure to methyl bromide off-gassing from fumigated fruit in a cold storage facility. Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) 6(a)(2m) adverse effects disclosure from Chemtura reported two possible illnesses.

Once the cold storage facility was made aware of the produce inspectors' illnesses, the facility initiated monitoring for methyl bromide utilizing a photo ionization detector (PID). The PID was indicating very high levels (+100 ppm) of methyl bromide were coming off the recently arrived, fumigated fruit. However, given the location of the cold storage (oil refinery across the parking lot) and the non-specificity of the PID, these results should be heavily discounted.

Subsequently, the facility (located in Carson, California) started Draeger colorimetric tube testing and was measuring up to 30 ppm methyl bromide in the arriving trailers loaded with fumigated fruit. On noting the high levels in the trailers and at the Carson storage facility, a 9-hour aeration protocol was instituted by the fumigation company and the terminal operator (vs. standard 4-hour aeration as required by Condition 14 of the Recommended Permit Conditions Manual).

Medical Documentation

Case # 1 (documentation based on a telephone interview with the affected worker, review of medical records):

The patient is a 22-year-old who had no significant prior medical problems. He lives in the Fresno area, employed by a wholesale produce shipping company as a quality inspector.

Between the end of December, 2009 and the middle of March, 2010, the patient worked in a cold storage facility in Carson, California, 6 miles from the Port of Long Beach. Produce received from South America and elsewhere is treated with methyl bromide at the port and released to storage facilities after aeration. He was there approximately 3 or 4 days each week, working long shifts inside the cold storage area doing quality inspections of produce that belonged to his company.

At the end of January or the beginning of February he began experiencing unusual symptoms, but could not pinpoint the exact date the symptoms began. Most notably, he had trouble walking. He also had trouble concentrating and some problems with dizziness, and visual focus, like tunnel vision. After discussing his symptoms with a colleague having similar problems, he returned to the Fresno area to have a medical evaluation and request a blood bromide test from his primary care provider. Despite his balance problems while walking and his visual symptoms, he felt he did not have a problem driving and on March 13 drove approximately 200 miles from Carson back to Fresno. Although he made the trip without incident, he subsequently stopped driving because he did not feel he could drive safely.

He initially saw his personal physician and was prescribed medication (AntiVert) for symptoms of dizziness. He also saw an occupational medicine specialist in Fresno. The examination performed there was unremarkable except for problems related to walking and balance. He had difficulty maintaining balance while standing upright with his eyes closed (Romberg test). He had difficulty maintaining balance while standing on one leg. He was also unable to walk one foot in front of the other (tandem walk test). When interviewed on April 29, 2010 by Department of Pesticides Regulation's (DPR's) medical consultant, he stated that he had largely recovered and was hoping to return to work shortly. Blood testing on March 18, 2010, showed a serum bromide level of 4.4 mg/dl (equivalent to 44 mg/l or 44 ppm). The reference range is less than 0.5 mg/dl (5 mg/L or 5 ppm).

The average half-life of serum bromide reported in an observational study and an experimental study, with a combined total 44 subjects, varied from 10.4 to 14 days. In 2 cases reports, with a total of 4 subjects, the half-life varied from 14-16 days. Assuming first order (exponential) elimination kinetics, the serum bromide is described by the equation: $Br(t)=Br_0*e^{-kt}$, where Br(t)= level of serum bromide at time t (in days), k= constant with a calculated valued of 0.125,

corresponding to a half-life of 12 days. Based upon the measured bromide level of 44 ppm on March 28, the estimated serum bromide on March 13, 2010 (his last day worked in cold storage), was 58.7 ppm.

Case # 2 (documentation based upon telephone interview with the patient, medical records review):

Case #2 is a 52-year-old produce inspector. He worked side-by-side with case #1 in the same cold storage facility, but does not work for the same employer. He is an independent contractor, doing quality inspections for a variety of shippers and packers. He lives in the Bakersfield area, but between December, 2009 and February, 2010 he commuted to the Carson cold storage facility, usually working 4-5 days before returning to Bakersfield each week.

Similar to case # 1, he noticed the gradual onset of non-specific symptoms beginning in January and February. He initially sought treatment from his primary care physician in Bakersfield on February 22, 2010. (He had been off of work approximately 10 days at that point.) He had upper respiratory symptoms and a productive cough the previous week that had begun to resolve by the time of his appointment. He also reported experiencing decreased libido, lightheadedness, feeling mentally "slow" and experienced trouble speaking. This included slurring of words and expressive aphasia (loss of the ability to produce spoken or written language). On examination, he had elevated blood pressure (170/120 mm Hg), despite having no prior history of hypertension. He had difficulty walking with one foot in front of the other (tandem walk test) and showed some drift of the right hand with supination. He was unable to retain memory of 3 objects (e.g. "apple, book and pencil") for 5 minutes (a standard clinical test of short-term memory).

His primary care physician felt that he probably had suffered a stroke and recommended hospital observation and treatment. He declined hospitalization but was followed up closely in the primary care clinic. A magnetic resonance imaging (MRI) study on February 23, 2010 was normal except for bilateral sinusitis. His blood chemistry and complete blood count (CBC) were normal except for borderline elevation of his blood urea nitrogen and mildly increased blood glucose on a non-fasting blood test. He was treated with a sulfa antibiotic for his sinusitis and lisinopril for his blood pressure. He was seen again for follow-up on February 24th and noted to have continued problems with lightheadedness. A referral was made to neurology.

When he was seen on March 3, 2010 he reported continued lightheadedness, some chest pressure relieved by "belching" and also described having a 15 minute episode of rapid heart rate several days earlier. He had a negative examination except for a faint cardiac murmur. He was prescribed omeprazole for possible esophagitis. When seen on March 24th he had continued symptoms of lightheadedness. A notation was made regarding restrictions on driving, bicycling,

swimming or other activities which may be a danger to himself or other people. He was not able to work.

Laboratory testing from March 1 through March 12, 2010 was negative for rheumatoid arthritis panel, systemic lupus, San Joaquin Valley fever, the tumor marker carcinoembryonic antigen (CEA), morning and afternoon cortisol levels, serum lipase and serum amylase, Helicobacter pylori antibodies and prostate specific antigen (PSA). An echocardiogram was within normal limits. He had a negative evaluation for a norepinephrine secreting adrenal tumor (pheochromocytoma) and for a gastrointestinal lesion producing serotonin (carcinoid tumor).

During the middle of March, we spoke with case # 1 who called to check on his health. During the course of this conversation, they realized that their symptoms were remarkably similar. They began to carefully consider the possible work place exposures that could account for the apparent common pattern of illness. Upon learning that case # 1 had tested positive for blood bromide he requested that the test be run on him as well. A blood sample, collected on March 20, 2010 (approximately 30 days since he last worked at the cold storage facility, according to his best recollection), was received at National Medical Services (NMS) labs on March 23, 2010. It showed a serum bromide level of 1.5 mg/deciliter (15 mg/l or 15 ppm). The estimated bromide level on February 18 (30 days previously, the day he lasted worked in cold storage according to his best recollection), was 84.9 ppm. As with case # 1, this calculation assumed first order (exponential elimination kinetics) and an elimination half-life of 12 days.

Commentary:

The laboratory reference range for serum bromide is less than 0.5 mg/deciliter (5 ppm or 5 mg/L), based upon expected population values. Levels of serum bromide more than 500 ppm are toxic in themselves, producing a condition called “brominism” (poisoning associated with inorganic bromide). But the toxicity of intact methyl bromide is far greater than the toxicity of the measured bromide residue in the serum as illustrated by the selected cases from the medical literature summarized by the table included in Appendix 1. Although both cases had typical symptoms of methyl bromide intoxication, the exposure was not initially suspected.

Brief summary of medical findings:

Two cases of cumulative, gradual onset (subacute) poisoning with methyl bromide occurred in a Southern California cold storage facility. The level in case # 1 was slightly greater than 1/3 the level associated with a fatal acute poisoning (120 mg/L) in San Mateo County in 1992. The other case had also elevated serum bromide despite being tested until approximately 5 weeks after last exposure. Assuming first order elimination kinetics, the level immediately after his last exposure was probably higher than that measured in case # 1.)

These sentinel cases prompted an industrial hygiene investigation to determine whether similar exposures might be widespread.

Industrial Hygiene Investigation

Standard for methyl bromide exposures:

The American Conference of Government Industrial Hygienists (ACGIH) set the current threshold limit value (TLV) for methyl bromide in occupational settings at 1 ppm, as a Time Weighted Average (TWA), to prevent pulmonary edema and serious neurotoxicity.[1] Additionally, the Department of Industrial Relations, Division of Occupational Safety and Health (Cal/OSHA) also cites a TWA of 1 ppm as the Permissible Exposure Limit (PEL), with a ceiling (do not exceed) level of 20 ppm. The present Federal/OSHA exposure standard is a 20 ppm ceiling value.

This 1 ppm value derives from application of a safety factor to a lowest-observable-effect-level (LOEL) in a study of workers who developed "mild systemic poisoning when exposed for two weeks to concentrations generally less than 35 ppm". Although the human dose-response curve is not known with precision, animal studies do indicate that methyl bromide has a steep, sigmoidal dose-toxicity curve following short-term inhalation exposures,[2] with a relatively narrow range between exposures producing no observable effect and those producing a fatal outcome.

Industrial Hygiene Response:

A WHS industrial hygienist traveled to the Port of Los Angeles, Long Beach three times, April 13th, April 18th and April 21st, to conduct colorimetric tube air sampling of post-fumigation grapes treated dockside at the harbor.

Previous to this on-site visit, Los Angeles County Agricultural Commissioner (LA CAC) had been alerted to the suspected pesticide-related illnesses noted in the previous discussion. According to the LA CAC, the illnesses had a Carson cold storage facility in common and this facility was involved in the cold storage of fumigated Chilean grapes. The United States Department of Agriculture (USDA) requires these imported grapes to be fumigated with methyl bromide, either at the point of origin (Chile in this case) or at the port of entry (Long Beach on the west coast). Dockside fumigation at the harbor involves Berth 54/55, which have specially designed fumigation shrouds capable of fumigating hundreds of pallets at a time (1 pallet is approximately 90 lugs of grapes and weighs about 2,000 pounds). The shrouds are suspended over lattice markings on the floor, defining the interior and perimeter of each fumigation area

---

[1] American Conference of Government Industrial Hygienists: Documentation of Threshold Limit Values and Biological Exposure Indices; ACGIH, Cincinnati, Ohio; 1986

[2] Hayes WJ and Laws ER. Handbook of Pesticide Toxicology. Academic Press. San Diego, 1991 pp 668-671

(called "grids"). There are six rectangular grids in Berth 55, with each grid covering approximately 5,000 ft^2. The shroud assemblies also house the aeration ducts and fumigant application lines (See Photo Set ONE).

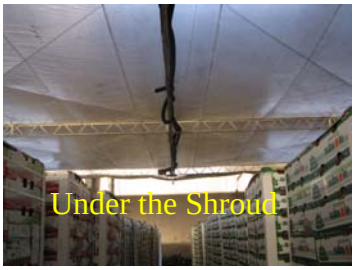

Photo Set ONE:

The berths and the Carson cold storage facility are approximately 6 miles apart, and no illnesses attributed to methyl bromide exposure at the dockside fumigation area have been reported during this time.

Dockside Fumigation Procedures:

Ships bringing in palletized fruit unload on the dock adjoining the berth and the pallets are placed on their assigned grid location (each pallet-sized location on the grid has an alpha-numeric coordinate to facilitate later identification for outbound transport). Each grid has an "alley", approximately 4 feet in width, running the length of the long axis. No fruit is placed in the alleys. Between each grid there are pathways, separating the grid loads by about 15 feet, which allow transit of forklifts. Examples of an alley, an empty grid and a pathway are show in Photo Set TWO.

Photo Set TWO:

Once the grid is completed with its load of produce, the fumigation shroud assembly (FSA) is lowered into place and sandsnakes are positioned along the plastic shroud's contact with the concrete floor, creating a seal. Gas introduction lines and monitoring lines are positioned within the FSA and then methyl bromide is injected into the FSA's interior. Depending on the

temperature of the fruit, the application rate is either 3 lbs. per 1,000 ft^3 (warm fruit, > 50°F) or 4 lbs. per 1,000 ft^3 (cold fruit, <50°F). Injection takes approximately 15 minutes and actual fumigation takes 3 hours. During the course of the fumigation, a USDA official monitors the fumigant concentration using a Fumiscope®, to ensure federal fumigation protocols are followed.

After the fumigation phase is completed and the terminal reading is taken by USDA, the overhead aeration exhaust fans are powered up and, under standard conditions, run between two to three hours. The sandsnakes are removed from the middle of the long axis on each side of the grid and the shroud is propped up, to allow fresh air to flow into the grid (Photo Three). After the initial mechanical aeration, all the sandsnakes are removed and the shrouds are lifted. A further one-hour passive-assist (fans located at ground level, blowing into the alleys, see Photo Set Four) aeration is then conducted. Once the general air concentration drops below 5 ppm (label requirement), the fruit is released for transportation.

Photo THREE: Initiation of Aeration

Photo Set FOUR: Passive-assist aeration fans

Industrial Hygiene Air Monitoring:

Air sampling on April 13th was conducted to determine if there were potentially hazardous concentrations of methyl bromide degassing from the pallets of fruit as they set at the dockside berths. Air sampling was conducted using a Sensidyne® aspirating pump connected to Sensidyne® methyl bromide sampling colorimetric tubes (product 157SB). These colorimetric tubes have a measurement range of 0.4 to 80 parts per million (ppm) methyl bromide. The relative standard deviation is between 10% to 15%, depending on the measuring range used. Sampling was conducted as directed on the direction sheet that accompanied each box set of sampling tubes (five sampling tube sets per box). Air is drawn through the colorimetric tube by pulling the piston stroke-handle until it locks. Depending on the air concentration, more than one stroke of the piston may be necessary to register a color change in the tube. If the initial stroke resulted in non-detect, a second stroke would be performed. If the result was non-detectable or very low, two more strokes would be done and the final reading made, taking into account the required adjustments specified in the directions. Samples were drawn from the alleys, pathways and working faces (where forklifts were removing pallets) of the grids. Air was also sampled in the center of an empty grid as a control.

Results for these April 13th samples are in Attachment II, Table 1. Samples drawn from various locations in and around the grids showed concentrations as high as 5 ppm and no samples, other than the center of the empty grid, yielded non-detects (<0.4 ppm). Also, one trailer was sampled before it left the berths. Unlike the 3 to 4 hour aeration normally employed, a longer nine hour aeration period had been instituted, as an attempt to reduce potential exposures to workers downstream of the fumigation procedures. This longer aeration had been initiated by the applicator

However, based on the illnesses at the cold storage facility, the potential exposure situations extended beyond the employees at the dockside berths. The fruit was apparently degassing during transport and in the cold storage facilities.

Three tractor/trailers loaded with fruit were met at the Carson cold storage facility parking lot and air samples were drawn from the rear of the load, through the small aeration door located on the larger trailer door. Note that, because of an oversight of identifying the trailer, none of these trailers could be definitely identified as the one that had been initially sampled back at the berths. These samples indicated internal trailer air parcel concentrations in excess of 10 ppm, and as high as 20 ppm. Resampling of one trailer after the main doors had been opened for more than 5 minutes showed that the concentration dropped precipitously, down to 2.5 ppm (Attachment II, Table 3). Trailer sampling, both aeration door and main door, is shown in Photo Set FIVE.

Photo Set FIVE: Sampling air in trailers

The final staging site for the fruit, before it enters the consumer distribution chain, is cold storage. An air sample drawn from the Carson facility loading dock air parcel showed 2 ppm; a sample from the cold storage room (designated in the tables as Chiller C1) into which the fruit was loaded was 4 ppm (Attachment II, Table 4). It should be noted that the cold storage loading docks, unlike many produce loading docks, are tightly sealed, to reduce loss of cold air (See Photo Set SIX). Air exchange with the outside appears minimal, and this is also the case for the cold storage areas.

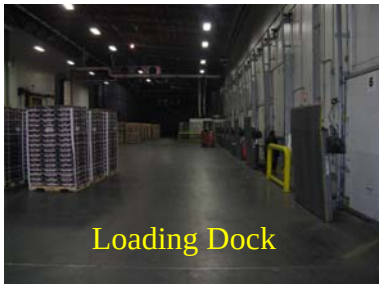

Photo Set SIX:

After analysis and consultation at DPR, a second sampling series was scheduled for the following week, starting on April 19th. Air samples were again taken at the dockside berths. Fruit had been loaded onto the grids and fumigated. We were present for the actual fumigation phase and observed the FSAs in their operational positions over the pallets of fruit. The majority of the produce was grapes, but kiwi fruit was also present. As before, the produce was fumigated, the fumigation observed by USDA, and at the end of the fumigation it was subject to aeration.

Once again, air samples were drawn from the alleys, pathways and working faces. Alley samples ranged from non-detectable to 8 ppm; pathways were non-detectable (a noticeable breeze, not present on April 13th, may have swept any fumigant away); and working faces were negligible (Attachment II, Table 1). Though most of the produce was under 9 hour aeration requirements, one grid was only aerated for 4 hours to investigate if the 9-hour aeration had a measurable effect

on the degassing. Table One compares the alley concentrations of the 9-hour aeration versus the 4-hour aeration.

9-Hour Aeration	**4-Hour Aeration**
High = 5 ppm (n = 2)	High = 8 ppm (n = 1)
Low = 0.4 ppm	Low = 1.2 ppm
Mean = 1.8 ppm (n = 16)	Mean = 2.9 (n = 7)

Table One: Comparison of alley gas concentrations affected by length of aeration
(n) = number of alley samples taken

DPR was not able to replicate the 8 ppm high measured following the 4-hour aeration. Thus if that value is removed from the mean calculation, the resulting mean is 2.1 ppm. DPR was able to replicate the 5 ppm high value of the 9-hour aeration.

Further sampling was conducted in the trailers after they were loaded (trailers were loaded with 18 to 20 pallets of fruit) but before they sealed for transport from the dockside berths. Samples were drawn from inside the trailer by reaching along the gap between the side of the trailer and the loaded pallets. This was identified as "inside, side of load" sampling, as opposed to sampling at the open door face of the trailer (see Photo Set Seven). In all samples from the 4-hour aeration pallet loads, before the trailer doors were closed, there were detectable levels of methyl bromide (2 ppm/2.5 ppm/5.5 ppm) in the three sampled trailers. Only one of the three trailers loaded with 9-hour aeration fruit has a detectable level of fumigants (0.5 ppm). Loading took between 15 to 20 minutes. After loading and sampling, the trailer doors were shut and the trailers loaded with 4-hour aeration pallets were sent to the Carson cold storage facility.

Photo Set Seven: Inside, Side of Load Air Sampling

It took approximately 25 to 30 minutes for the tractor-trailers to arrive at the Carson site. Initial sampling was through the small aeration door. The trailer designated #1, loaded with 20 pallets of 4-hour aeration grapes, was 15 ppm, dropping to 2.5 ppm (inside, side of load sampling) after the main doors were open for 20 minutes. Trailer #2, with 18 pallets of 4-hour aeration grapes, was 10 ppm at the aeration door and <0.4 ppm twenty-five minutes later. Trailer #3, with 11

pallets of 4-hour aeration grapes and 5 pallets of 9-hour aeration kiwis, was 11 ppm at the aeration door; 4 ppm twenty-five minutes later at the side of the load and then, after a further 20 minute aeration, 2.5 ppm. No 9-hour aeration loads of grapes were sampled.

Inside the Carson cold storage, air samples were taken at the previously sampled (April 13th) sites of the loading dock and Chiller C1. The 4-hour aeration loads had not yet been unloaded. This time the loading dock was <0.4 ppm and Chiller C1 was 2 ppm (Appendix II, Table 4).

Since the trailers and the cold storage were beginning to appear as major sites of high fumigant concentration, and only a small portion of the fumigated fruit is cold stored in the Los Angeles area, we decided to follow shipments being sent to a San Joaquin Valley cold storage facility, specifically in Tulare County. On April 21, three trailers loaded in the morning with 9-hour aeration produce were sampled at the berths. Only one trailer (designated F2) had a detectable level of 1 ppm inside on the side of the load. Two of the trailers, F1 and F2, traveled with both aeration doors (front and rear of the trailer) closed. Trailer F3 had both aeration doors opened for the 215 mile trip. These tractor-trailers left the Los Angeles area late in the morning and at arrived in Tulare County around 1600 hours. The trailer F1 had 10 ppm at the aeration door and 4 ppm inside on the side of the load twenty minutes later; trailer F2 had 20 ppm at the aeration door and 4 ppm on the side of the load twenty minutes later; trailer F3 was <0.4 ppm at the aeration door and 4 ppm inside, twenty minutes later. These limited samples suggest that even though in-transit aeration appears to reduce fumigant levels within the trailer, the benefit to the confined air mass is transient and the rate of degassing is unaffected.

An air sample drawn from the Tulare cold storage facility itself was 7 ppm.

From the samples drawn throughout this project, further investigation appear necessary to resolve the potentially hazardous conditions generated by the degassing fruit, especially in areas where general dilution ventilation is not available. However, on-site observations do suggest the following potential contributors to the degassing issue:

1. Excessive packaging of grapes (plastic lined grape lugs, paper liners and SO2 emitters within plastic liner and then grape bunches sealed in limited ventilation plastic bags) prevents air flow from directly contacting the berries (see Photo Set EIGHT).

Photo Set EIGHT: Grape lug packing materials

2. Tight stacking of adjoining pallets reduces air flow through and around the stacked produce.

3. Insufficient air flow throughout the shrouded volume caused by limited air intakes (see Photo THREE).

4. Lugs constructed of corrugated cardboard, resulting in fumigant potentially trapped within the corrugations.

5. Lack of dilution air in cold storage.

Recommendations:

The margin of safety for fumigation of imported produce with methyl bromide appears to be inadequate for cumulative exposure to personnel working for prolonged periods. Additional studies should be performed to ensure that produce leaving the Port of Long Beach does not present a hazard to warehouse workers or others likely to work around or handle fumigated produce in confined areas. If additional studies confirm an inadequate margin of safety, mitigation measures need to be developed and confirmed as adequate by studies.

Appendix 1: Selected Cases from the Medical Literature from Various Types of Methyl Bromide Treatments

Year	Circumstances of Exposure	Initial measured serum bromide (mg/L or ppm)	Reference
1958	Chronic exposure to fumigation crews during construction project in Australia	55-80	Rathus, EM, Landy PJ. BJIM, 1960
1969	10 cases of poisoning reported in California workers, including 6 with blood bromide measurements (described below by case numbers used in the original journal report): (#1) A fork-lift driver and a laborer in a processing facility where methyl bromide was used to fumigate almonds developed jaundice, problems with motor coordination, malaise and apathy. He had elevated blood bromide and changes in liver function when hospitalized. A year after being hospitalized he had normal liver function, but had partial disability because of persistent "neurasthenia" (a medical term, no longer in common use, describing non-specific central nervous symptoms, usually including absence of motivation). (#2) A food processing plant employee, worked on an almond sorting belt, 50 ft from a fumigation operation in a warehouse. She developed acute symptoms that included mental confusion, hallucinations, vertigo, and loss of leg control. She was not able to return to work because of persistent psychiatric symptoms. (#6) A laborer ate lunch next to a box car being ventilated after fumigation with methyl bromide; he developed a moderately severe headache after work and then tonic-clonic seizures that caused a respiratory arrest 20 minutes later. Blood bromide levels were markedly elevated at autopsy. (#7) A laborer worked in a nut processing operation where methyl bromide used as a commodity fumigant, adjacent to his work station. No specific accidental exposure was reported, but he developed trouble concentrating, fatigue, loss of libido, anxiety, general depression. He was unable to return to work for 6 months because of depression and inability to carry out his usual tasks. (#8) The foreman of an almond processing operation, responsible for fumigation, became ill with chest pain and difficulty breathing 4 hours after leaving work. He developed tonic-clonic seizures the following morning and did not regain consciousness. (#10) A worker in a raisin processing operation was assigned to clean fumigation chambers. He was found sitting on the floor at work, in a confused state, then suddenly lost consciousness. He had persistent tonic-clonic seizures and died after 10 days in the hospital. A blood bromide taken on his second day in the hospital was marked elevated.	(#1) 150 (#2) 220 (#6) 400 (#7) 120 (#8) 50 ppm at autopsy (#10) 250	Hine, C; JOM 1969
1991-1992	Residual methyl bromide inside San Mateo apartment complex after building cleared for re-occupancy caused status epilepticus, liver failure and renal failure in a tenant who spent the night inside the structure. Most other tenants spent the night elsewhere after experiencing acute irritation related to chloropicrin.	120	O'Malley, Lancet, 1997

Year	Circumstances of Exposure	Initial measured serum bromide (mg/L or ppm)	Reference
1997	Methyl bromide seeped through underground conduits from a fumigated building to an adjacent guest house on the same property. The patient developed refractory seizures, intermittent fever, and multiorgan system failure before dying 19 days after exposure.	270	Horowitz, Albertson, O'Malley, Swenson. Clinical Toxicology, 1998
2002, 2003	A 30 year-old man employed for 3 years fumigating fruit with methyl bromide developed progressive difficulty walking and tingling in his extremities over a 1 month period. MRI showed strikingly symmetric brainstem and cerebellar lesions and his blood bromide was 29 mg/L. His symptoms improved after 1 month off work. Seven months later became ill again, with more severe neurological symptoms including agitation and hallucinations. His blood bromide at that time was 43 mg/L.	29-43	Geyer, MD, PhD; Herbert H. Schaumburg, MD; and Steven Herskovitz, Neurology, 2006
2008	A 24-year-old man who worked in a warehouse of imported vegetables fumigated with methyl bromide presented with unstable gait, vertigo and paresthesia of both feet, for two weeks. He had a history of chronic exposure to methyl bromide for three years.	81.8	Suwanlaong, Phanthumchinda, J Thai Medical Association, 2008

Appendix II: Methyl Bromide Air Monitoring Results

Table 1: Methyl Bromide Results after Aeration of Commodity Fumigated at the Dockside Fumigation Facility[a]

Location	Date	Time	Grid Identification	Aeration Time (hrs)	Result (ppm)	Notes
Alley[b]	April 13	0715	---[c]	9	2.5	One fan at end of alley
		0728	---[c]	9	2	“
		0735	---[c]	9	2	“
		0830	---[c]	9	5	Fans removed
	April 19	1700	1	9	1	Fans moved into alley 10 m
		1700	6	9	2	Fans moved into alley 10 m, kiwi
		1710	2	9	1	Fans moved into alley 10 m
		1710	5	9	<0.4	Fans moved, partial grid
		1725	2	9	0.6	Between end and fan intake (5m in)
		1745	4	4	1.4	
		1805	4	4	8	Fans Removed
		1815	1	9	0.4	Fans removed, worked stack
		1820	4	4	1.2	Between end and center
		1825	4	4	3.5	Fan returned
		1830	4	4	2.5	
		1855	4	4	2	Fan removed
		1900	4	4	1.8	Wind speed measured 3 to 13 mph
	April 21	0805	3	9	0.5	
		0815	6	9	1	
		0815	1	9	0.6	No fans/Kiwis and Grapes
		0850	6	9	5	
		0850	1	9	1.4	No fans
		0900	3	9	3	
Pathway	April 13	0750	---[c]	9	5	No discernable air movement
Pathway 1-2	April 19	1725	---[c]	9	<0.4	Breezy
Pathway 4-5		1730	---[c]	4	<0.4	Breezy
Pathway 5-6		1747	---[c]	9	<0.4	Grid 5 partially removed, breezy
Control Sample	April 13	0755	3	NA	<0.4	Empty grid
Control sample	April 19	1755	3	NA	<0.4	Empty grid
Working Face	April 13	0758	---[c]	9	2	Indentation (pallet removed from grid)
		0825	---[c]	9	1	Pallets just prior to sample collection
	April 19	1755	1	9	0.8	
		1755	4	4	0.6	
	April 21	0820	3	9	<0.4	
		0855	3	9	<0.4	

[a] All results are from using Sensydine detector tubes with a minimum level of detection of 0.4 ppm and a variability of ± 15%.

[b] Alley sampling, unless noted otherwise, was from center of alley, underneath aeration tubing.

[c] Grid identification not recorded.

Table 2: Methyl Bromide Results of Truck Monitoring at Dockside Fumigation Facility[a]

Trailer #/Sampling Location	Date	Time	Aeration Time (hrs)	Result (ppm)	Notes
W / Inside, side of load	April 13	0845	9	1	Loaded 22 pallets
1 / Inside, side of load	April 19	1820	4	2.5	Loaded 20 pallets
2 / Inside, side of load	April 19	1840	4	5.5	Loaded 18 pallets
3 / Inside, side of load	April 19	1920	4	2	Loaded 17 pallets
A / Inside, side of load	April 19	1840	9	<0.4	Loaded, no count available
B / Inside, side of load	April 19	1850	9	0.5	Loaded, no count available
C / Inside, side of load	April 19	1700	9	<0.4	Loaded, no count available

[a] All results are from using Sensidyne detector tubes with a minimum level of detection of 0.4 ppm and a variability of ± 15%.

Table 3: Methyl Bromide Results of Truck Monitoring at Carson Cold Storage Facility[a]

Trailer #/Sampling Location	Date	Time	Trailer Location	Aeration Time (hrs)	Result (ppm)	Notes
X / Rear aeration door	April 13	0940	Outside cold storage	9	13	21 pallets in truck
Y / Rear aeration door	April 13	1000	Outside cold storage	9	14	21 pallets in truck
Z / Rear aeration door	April 13	1020	Outside cold storage	9	20	21 pallets in truck
1 / Rear aeration door	April 19	1955	Outside cold storage	4	15	20 pallets in truck
2 / Rear aeration door	April 19	2000	Outside cold storage	4	10	18 pallets in truck
3 / Rear aeration door	April 19	2005	Outside cold storage	4/9	11	12 pallets grapes, 5 kiwi in truck. Grapes 4 hours and kiwis 9 hours aeration.
X / Rear trailer door open, sample at open face	April 13	0950	Outside cold storage	9	2.5	21 pallets in truck, door open 5 minutes
1 / Inside, side of load[b]	April 19	2015	Outside cold storage	4	2.5	20 pallets in truck
2 / Inside, side of load	April 19	2025	Outside cold storage	4	<0.4	18 pallets in truck
3 / Inside, side of load	April 19	2030	Outside cold storage	4/9	4	12 pallets grapes, 5 kiwi in truck. Grapes 4 hours and kiwis 9 hours aeration.
3 / Inside, side of load	April 19	2050	Outside cold storage	4/9	2.5	12 pallets grapes, 5 kiwi in truck. Grapes 4 hours and kiwis 9 hours aeration.
X Inside, side of load	April 13	1030	Inside cold storage	9	1.4	90% unloaded
Y Inside, side of load	April 13	1055	Inside cold storage	9	2.5	0% unloaded
Y Inside, side of load	April 13	1115/	Inside cold storage	9	2.5	50% unloaded

[a] All results are from using Sensidyne detector tubes with a minimum level of detection of 0.4 ppm and a variability of ± 15%.

[b] All sampling “inside, side of load” done with all rear trailer doors open.

Table 4: Methyl Bromide Results from Sampling Inside Cold Storage Facilities[a]

Facility/Sampling Location	Date	Time	Aeration Time (hrs)	Result (ppm)	Notes
Carson area/Loading Dock	April 13	1040	9	2	
Carson area/Loading Dock	April 19	2055	9	<0.4	4-hour aeration loads not included
Carson area/Chiller C1	April 13	1110	NA	4	
Carson area/Chiller C1	April 19	2055	9	2	4-hour aeration loads not included
Tulare Co./Loading Dock	April 21	1710	NA	7	Heavily loaded with fruit.

[a] All results are from using Sensidyne detector tubes with a minimum level of detection of 0.4 ppm and a variability of ± 15%.

Table 5: Methyl Bromide Results from Sampling of Long Haul Trailers following Commodity Fumigation[a]

Trailer # / Sampling Location	Trailer Location	Aeration Doors During Transit	Date	Time	Aeration Time (hrs)	Result (ppm)
F1 / Inside, side of load	Harbor	Not applicable	April 21	1015	9	<0.4
F1 / At aeration door[b]	Storage	Closed		1536	9	10
F1 / Inside, side of load[b]	Storage	Closed		1555	9	4
F2 / Inside, side of load	Harbor	Not applicable	April 21	1035	9	1
F2 / At aeration door	Storage	Closed		1620	9	20
F2 / Inside, side of load	Storage	Closed		1640	9	4
F3 / Inside, side of load	Harbor	Not applicable	April 21	1100	9	<0.4
F3 / At aeration door	Storage	Open		1605	9	<0.4
F3 / Inside, side of load	Storage	Open		1615	9	4

[a] All results are from using Sensidyne detector tubes with a minimum level of detection of 0.4 ppm and a variability of ± 15%.

[b] Sampling at "aeration door" was done with arm inserted into trailer through rear aeration door; sampling "inside, side of load" was done with all rear trailer doors open; after 10 to 20 minutes of open trailer door aeration.