



Department of Pesticide Regulation



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MEMORANDUM

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TO: Chuck Andrews, Chief **HSM-00014**
Worker Health and Safety Branch [HSM # assigned after original memo issuance]

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Worker Health and Safety Branch

DATE: January 7, 2000

SUBJECT: RECOMMENDED WORKER SAFETY MITIGATION MEASURES FOR
METHYL BROMIDE SOIL FUMIGATION REGULATIONS

The Worker Health and Safety (WH&S) Branch's mitigation recommendations for methyl bromide soil fumigation regulations were derived from the attached documents. The first document entitled, "Worker Safety Recommendations for Fumigant Handling Activities" is a table containing specific application methods and, if available, data from worker exposure monitoring studies. In many cases, this monitoring data was also used for making recommendations for permit conditions. The second document is a proposed table for California Code of Regulations (CCR) Section 6784 covering limitations on work hours. The majority of the data relied on was obtained from DPR's draft Risk Characterization Document (RCD) 99-02 for methyl bromide. The RCD contains exposure data from various studies submitted to, or collected by, DPR. Two of the recommended application methods (nontarpaulin/shallow/bedded - method 1, and tarpaulin/shallow/drip - method 12) were not based on data contained in the RCD, but obtained by WH&S. The exposure data has been adjusted for the maximum recognized application rate. It has also been adjusted for a 50 percent recovery factor as per current DPR policy for charcoal tube monitoring results (Biermann and Barry, 1999; Helliker, 1999). The RCD contains conservative estimates of the breathing zone airborne concentration obtained by calculating the 95th percentile airborne concentration (arithmetic mean plus [1.645 x standard deviation]).

Our mitigation recommendations cover selected application methods for which we have field monitoring data or are similar to methods for which we have data. We adopted the features of these methods (application rate maximums, injection depth, injection shank equipment design, and other engineering controls) as the basis for our recommendations. If applicable monitoring indicate additional mitigation is necessary to meet the DPR target exposure value for methyl bromide (210 ppb, 24-hour time-weighted average, TWA), we have calculated work hour restrictions as the final exposure control mitigation measure. These maximum recommended work times were determined by comparing the 95th percentile breathing zone concentration we calculated for each method with the target exposure value established by DPR.



The following formula was used to calculate the work time restrictions:

$$\text{Maximum work time} = [(210 \text{ ppb} \times 24 \text{ hours}) / (95^{\text{th}} \text{ percentile breathing zone concentration})]$$

For calculation of a 95th percentile when there was only one or two measurements, the standard deviation was assumed to be equal to that data point or the average of two data points. For three methods (nontarpaulin/deep/broadcast, tarpaulin/shallow/broadcast, tarpaulin/deep/broadcast) where the maximum recognized application rate is 400 pounds per acre, work time may be adjusted if the fumigant is applied at a lower application rate. This was considered since exposure values were adjusted (if necessary) to the maximum recognized application rate of 400 pounds per acre. Therefore, work times could be adjusted upwards if the application rate is reduced. This adjusted work time can be calculated using the formula:

$$\text{Adjusted work hours} = [(400 \text{ pounds/application rate}) \times \text{maximum work hours}]$$

The table is arranged by the application method numbers of the existing methyl bromide soil permit conditions. The table lists the features of each method (bed/broadcast, tarpaulin/nontarpaulin, injection depth - shallow/deep, air fan dilution system – yes/no, maximum application rate – lbs/acre, additional specifications, source of data and location of study and year, worker job functions, number of replicates of exposure measurement, the mean and standard deviation of the exposure data, and the 95th percentile of the exposure data).

The final column contains maximum work hours per day for each identified job task. As noted above, these work hours restrictions are based on staying within DPR's target exposure value for methyl bromide of 210 ppb, averaged over 24 hours.

Our overall recommendation for the maximum work hours per day for each recognized method is the value noted in the description following each method section or similar group of methods. In most cases, we have used the least of the calculated values for the work tasks. If applicable, this value was rounded to the next higher whole number.

The following is a summary of the recommended methods and the rationale for the choice of maximum work hours:

Nontarpaulin/Shallow/Bedded (Permit Condition Method 1).

Mitigation measures as in table (air fan dilution system on application tractor, 200 lb./acre maximum rate, rearward (swept-back) chisels, 10-inch minimum injection depth, closing shoes and roller). If used, the second tractor with cultipacker should follow close to application tractor. Work hour restrictions: Limit work hours to 4 hours per day based on analogy with tarpaulin/shallow/bedded method rather than on values in table. The monitoring data was not fully representative of recognized application method.

Nontarpaulin/Deep/Broadcast (Permit Condition Methods 2,3).

Mitigation measures as in table (400 lb./acre maximum rate, forward curved chisels and recognition of two methods - forward chisel, 20-inch injection depth and tractor equipped with an air fan dilution system or, 24-inch injection depth, closing shoes and roller. If used, the second tractor with cultipacker should follow close to application tractor. Do not recognize use of disc since exposure was considerably greater.

Work hour restrictions: Limit work hours to 4 hours per day based on method showing least control (range of data using air fan dilution system). Although three hours was the minimum time observed in one of the studies, the basic mitigation measure we recommend require additional engineering controls (use of closing shoes and roller) that should allow at least four hours. Since exposure values were adjusted to the maximum recognized application rate of 400 pounds per acre, it follows that longer acceptable work times could be allowed if the application rate is reduced. Consider longer work hours at reduced application rate using formula: Longer work hours = [(400 pounds application rate/lower application rate) x maximum work hours].

Tarpaulin/Shallow/Broadcast (Permit Condition Methods 4,5,6,7,8).

Mitigation measures as in table for method 4,5 and Method 6 as an alternate. Method 5 was identical to method 4 with the exception of a reduced application rate. Method 6 was developed after the Noble plow method was established and as an alternate method. For example, some applicators did not want to install an air fan dilution system in their air-conditioned enclosed cab since this would not be practical and might violate the safety features of the cab. Method 6 involves the use of rearward-curving chisels, closing shoes and roller and was considered to provide equivalent worksite control during application. Tarpaulin to be laid down simultaneously with fumigant injection by tarpaulin laying equipment mounted on application tractor. Do not recognize Methods 7,8 due to lack of data and no applicable surrogate data for winged chisel.

Work hour restrictions: Use the work hours resulting from worker monitoring conducted for Method 4 - limit work hours to 3 hours per day based on copilot and shoveler data. Since some exposure values were adjusted to the maximum recognized application rate of 400 pounds per acre, it follows that longer acceptable work times could be allowed if the application rate is reduced. Consider longer work hours at reduced application rate using formula: Longer work hours = [(400 pounds application rate/lower application rate) x maximum work hours].

Tarpaulin/Shallow/Bedded (Permit Condition Methods 9,9.1,10).

Mitigation measures as in table (250 lb./acre maximum rate and recognition of three methods – rearward-curved chisels and closing shoes and roller, or rearward-curved chisels and bed shaper, or rearward-curved chisels and combination bed former and shaper. For the first two methods, the tarpaulin must be laid down simultaneously with fumigant injection by tarpaulin laying equipment mounted on application tractor. If the latter is used, a second tractor can be used to apply the tarpaulin.

Work hour restrictions: Limit work hours to 4 hours per day based on required use of rearward curved chisels. The use of the rearward curved chisels should allow slightly longer copilot work hours than the three hours observed with conventional shanks. Separate vehicle allowed for tarpaulin laying based on monitoring conducted for Kennco Superbedder.

Tarpaulin/Deep/Broadcast (Permit Condition Methods 11,11.2).

Mitigation measures as in table (400 lb./acre maximum rate, forward-curved chisels, etc). No specific monitoring data but this method was considered to be comparable to tarpaulin/shallow/broadcast and nontarpaulin/deep/broadcast with regard to comparable methods and control of emissions. Recognize by analogy two methods – forward-curved chisels and air fan dilution system, or forward-curved chisels and closing shoes and roller without an air fan dilution system. In the same manner as for the tarpaulin/shallow/broadcast method, the tarpaulin should be laid down simultaneously with fumigant injection by tarpaulin laying equipment mounted on application tractor.

Work hour restriction: Limit work hours (by analogy to tarpaulin/shallow/broadcast method) to 3 hours per day. Since some exposure values were adjusted to the maximum recognized application rate of 400 pounds per acre, it follows that longer acceptable work times could be allowed if the application rate is reduced. Consider longer work hours at reduced application rate using formula: Longer work hours = [(400 pounds application rate/lower application rate) x maximum work hours].

Tarpaulin/Shallow/Drip System (Permit Condition Method 12).

Mitigation measures as in table and additional measures in current permit conditions.

Monitoring data collected by Worker Health and Safety.

Work hour restriction: Limit work hours to 2 hours per day based on monitoring data.

In addition to the above recommended application methods, we recommend the following procedure for tarpaulin removal:

Tarpaulin Removal.

Mitigation measures as in table. The tarpaulin should remain on the treated area for a minimum of 5 days. After this period, the tarpaulin should only be cut using a mechanized method (all terrain vehicle (ATV) or tractor with cutting wheel). After cutting, the field should be left a minimum of 24 hours to allow residual fumigant to dissipate. After this period of time, the tarpaulin can be removed.

Work hour restrictions: Limit work hours to 4 hours per day for cutting, 7 hours per day for pulling based on monitoring results in table.

Some methods are recognized due to similarities with methods for which there is monitoring data. For example, the use of closing shoes and roller was shown to provide an alternate method of exposure control compared to the use of conventional chisels and air fan dilution system. The use of closing shoes and roller methodology developed as applicators and monitoring personnel found alternative or better methods of providing exposure control. This is most evident in the monitoring conducted for broadcast, deep injection, non-tarpaulin treatments. The earliest monitoring studies involved application with conventional deep shanks and tractors equipped with air fan dilution systems. The air fan dilution system was developed to provide a positive means of diluting any fumigant containing air in the applicators working area with less contaminated air drawn from above the application tractor. Some of the later studies monitored applications with injection shanks followed by closing shoes and roller, which were found to provide better control by reducing the amount of fumigant escaping during the application process. These later studies used tractors without air fan dilution systems. The results of these studies and observations of researchers show both methods provide similar control. The use of closing shoes and roller help to minimize the escape of fumigant trailing from the injection points as the application proceeds. Better control of the process at the point of injection is a preferred control method as compared to general dilution of the fumigant- contaminated air in the workplace. This is an important alternative that allows the use of application rigs equipped with enclosed cabs. For many of these cabs, it is not feasible to install an air fan dilution system. A similar analogy was made between the use of the Noble plow and the use of rearward curving chisels. Observations and spot testing made by research monitoring personnel show equivalent or superior control of the application process using rearward curving chisels, closing shoes and roller. This also applies to bedded methods, using bed shapers or bed formers.

Several methods are not recommended due to lack of any comparable application exposure monitoring data for the type of application injection tool. These methods all use a winged chisel injection tool.

References:

- Biermann, H. W., and Barry, T. 1999. *Evaluation of charcoal tube and SUMMA canister recoveries for methyl bromide air sampling*. Environmental and Pest Management Branch, DPR. EH 99-02.
- Helliker, P. E. 1999. Status of methyl bromide permit conditions. A letter to interested parties. DPR. August 31.

**Methyl Bromide Soil Fumigation Regulations
 Worker Safety Recommendations for Fumigant Handling Activities**

Permit Method	Bed/Broadcast	Tarpaulin	Depth Shallow/Deep	Air Fan Dilution System	Maximum Rate (lbs)	Other Specifications	Data Sources, location and year of study	Workers	Exposure Reps	Adjusted Worksite Breathing Zone Concentration (ppb)			Maximum Work Hours/Day
										mean	SD	95 th %tile	
1	Bed	None	Shallow	Yes	200	rearward chisel 10 inch minimum closing shoes bed shaper	SM4096D TC4095.2 Kern, Monterey 1992	Applicator	4	416	250	828	6
								Cultipacker Driver	1	327	327	866	6

Nontarpaulin/Shallow/Bedded (Method 1). Mitigation measures: as above. Second tractor with cultipacker should follow close to application tractor.
 Work hour restrictions: Limit work hours to 4 hours/day based on analogy to tarpaulin/shallow/bedded method rather than on above values. Above monitoring data not fully representative of application method.

1.1	Broadcast	None	Shallow	Yes	200	winged chisel 15-18 inch depth press wheel	no data						
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Evaluation of Method 1.1: Do not recognize method – no data and no surrogate data for winged chisel.

2	Broadcast	None	Deep	Yes	400	forward chisel 20+ inch	Table 18, 1.b	Applicator	2	635	635	1680	3
							Draft RCD 99-02	Copilot	1	200	200	529	8+
							SM924096B Chowchilla, Shaftner 1992	Cultipacker Driver	1	410	410	1084	5
2	Broadcast	None	Deep	Yes	400	above plus closing shoes and press wheel	Table 18, 1.b	Applicator	1	240	240	635	8
							Draft RCD 99-02 SM 924096B Shaftner 1992	Cultipacker Driver	1	290	290	767	7
2	Broadcast	None	Deep	No	400	above plus closing shoes and press wheel but without air fan dilution system, with enclosed cab	Table 19, 1.c	Applicator	1	360	360	952	5
							Draft RCD 99-02 SR934100.1A1 Traver 1993	Disc Driver	1	2120	2120	5607	1
2	Broadcast	None	Deep	No	400	above plus closing shoes and press wheel but without air fan dilution system, with enclosed cab	Table 19, 1.c	Applicator	2	388	388	1027	5
							Draft RCD 99-02 SR934100.1A1	Cultipacker Driver	2	141	141	374	8+
							Hanford, Madera 1993	Supervisor	1	280	280	741	7
2	Broadcast	None	Deep	No	400	above but without air fan dilution system, with enclosed cab, closing shoes and roller, cultipacker	Table 20, 1.d	Applicator	1	30	30	79	8+
							Draft RCD 99-02 SM934104.1-2 Helm 1993	Cultipacker Driver	1	30	30	79	8+

3	Broadcast	None	Deep	No	400	forward chisel 24 inch depth closing shoes, roller	Closing shoes, roller considered equal to Noble plow and air fan dilution system	Applicator Cultipacker Driver					
<p>Nontarpaulin/Deep/Broadcast (Methods 2/3). Mitigation measures: as above. Recognize two methods - forward chisel, 20-inch depth and air fan dilution system or, 24-inch injection depth, closing shoes and roller. Second tractor with cultipacker should follow close to application tractor. Do not recognize use of disc. Work hour restrictions: Limit work hours to 4 hours/day based on range of data using air fan dilution system. Consider longer acceptable work time with reduced application rate.</p>													
4	Broadcast	Tarpaulin	Shallow	Yes	400	Noble plow 10 inch minimum	Table 13, 1.a Table 14, 1.a Table 15, 1.a Table 17, 1.a Draft RCD 99-02 SM924096A-D Hayward, Wasco, Salinas, Union City, Watsonville 1992	Applicator Copilot Shoveler Tarp removers	8 7 9 5	459 962 609 3341	404 629 557 2385	1124 1961 1525 7265	4 3 3 <1
5	Broadcast	Tarpaulin	Shallow	Yes	275	Noble plow 10 inch minimum	Same as 4 but lesser rate	Applicator Copilot Shovelers					
<p>Evaluation of Method 4/5: Recognize method as above except for tarpaulin removal – see below. Limit work hours to 3 hours/day.</p>													
6	Broadcast	Tarpaulin	Shallow	No	400	rearward chisel closing shoes, roller 10-15 inch depth	Closing shoes, roller considered equal to Noble plow and air fan dilution system	Applicator Copilot Shovelers					
<p>Evaluation of Method 6: Recognize method as above as an alternate to Method 4/5. Closing shoes and roller considered to provide equivalent worksite control during application. Use same as Method 4/5 - Limit work hours to 3 hours/day.</p>													
7	Broadcast	Tarpaulin	Shallow	Yes	400	winged chisel 10-15 inch depth	No data	Applicator Copilot Shovelers					
8	Broadcast	Tarpaulin	Shallow	Yes	200	winged chisel 10-15 inch depth	No data	Applicator Copilot Shovelers					
<p>Evaluation of Methods 7/8: Do not recognize methods – insufficient data and no applicable surrogate data for winged chisel.</p>													
<p>Tarpaulin/Shallow/Broadcast (Methods 4/5/6/7/8): Recognize method 4/5 as above and Method 6 as an alternate. The use of rearward-curving chisels, closing shoes and roller considered to provide equivalent worksite control during application. Tarpaulin to be laid down simultaneously with fumigant injection by tarpaulin laying equipment mounted on application tractor. Do not recognize Methods 7/8 due to lack of data and no applicable surrogate data for winged chisel. Work hour restrictions: Use same as Method 4/5 - Limit work hours to 3 hours/day based on copilot and shoveler data. Consider longer work hours at reduced application rate - 6 hours/day at 200 lb rate – prorate between.</p>													

9	Bed	Tarpaulin	Shallow	No	250	conventional shanks 8 inches depth	Table 21, 1.e Draft RCD 99-02 SM924096 C, M Santa Maria 1992	Applicator Copilot	1 2	330 432	330 432	873 1114	6 4
9	Bed	Tarpaulin	Shallow	No	250	conventional shanks plus closing shoes	Table 21, 1.e Draft RCD 99-02 SM924096 C, M Santa Maria 1992	Applicator Copilots	1 2	180 690	180 690	476 1825	8+ 3
9.1	Bed	Tarpaulin	Shallow	No	250	rearward chisel Colby Bed Shaper 6-15 inch depth	Considered equal to 9 - 1995 letter from Siemer & Assoc	Applicator Copilot Shovelers					
10	Bed	Tarpaulin	Shallow	No	250	Kenco Superbedder Application vehicle and tarpaulin laying vehicle	Table 22, 1.f Draft RCD 99-02 SM934104.1M Arvin 1993	Driver 1 (app) Applicator 1 Drip tape layer Driver 2 (tarp) Copilot (tarp)	1 1 1 1 2	120 180 270 20 142	120 180 270 20 142	317 476 714 53 377	8+ 8+ 7 8+ 8+
<p>Tarpaulin/Shallow/Bedded (Method 9/9.1/10). Mitigation measures: As above. Recognize three methods – rearward-curved chisels and closing shoes and roller, or rearward-curved chisels and bed shaper, or rearward-curved chisels and combination bed former and shaper. For the first two methods, the tarpaulin must be laid down simultaneously with fumigant injection by tarpaulin laying equipment mounted on application tractor. If the latter is used, a second tractor can be used to apply the tarpaulin.</p> <p>Work hour restrictions: Limit work hours to 4 hours/day based on use of rearward curved chisels which should allow slightly longer copilot work hours than observed with conventional shanks.</p>													
11	Broadcast	Tarpaulin	Deep	Yes	400	forward chisel 20+ inch depth	Non-tarp deep surrogate (See 2) and broadcast shallow tarpaulin (See 4)	Applicator Copilot Shovelers					
11.2	Broadcast	Tarpaulin	Deep	No	400	forward chisel 20+ inch depth closing shoes, tarp roll/roller	Closing shoes, roller considered equal to 11 – Great Valley and Siemer and Assoc 1995	Applicator Copilot Shovelers					
<p>Tarpaulin/Deep/Broadcast (Method 11/11.2). Mitigation measures: As above. No monitoring data but method considered to be comparable to broadcast tarpaulin shallow. Recognize by analogy two methods – forward-curved chisels and air fan dilution system, or forward-curved chisels and closing shoes and roller. Tarpaulin to be laid down simultaneously with fumigant injection by tarpaulin laying equipment mounted on application tractor.</p> <p>Work hour restriction: Limit work hours (by analogy to broadcast tarpaulin shallow) to 3 hours/day. Consider longer work hours at reduced application rate - 6 hours/day at 200 lb rate – prorate between.</p>													

12	Drip	Tarpaulin	Shallow	n/a	225	Drip system, Hot gas	DPR data – March 3, 1997 Memo (Fong and Gibbons to Donahue) Imperial 1997	Applicators	15	793	824	2149	2
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Tarpaulin/Shallow/Drip System (Method 12). Mitigation measures: Recognize as above and in existing permit conditions.
 Work hour restriction: Limit work hours to 2 hours/day

n/a	Broadcast Bedded	Tarpaulin	Either	n/a	n/a	Tarpaulin removal cut after 5 days remove after 24 hours	Table 24, 1.h Draft RCD 99-02 TC 211 Burrell, Corcoran	Cutter Puller	3 12	326 131	537 367	1210 734	4 7
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Tarpaulin Removal. Mitigation measures: Recognize as above. Tarpaulin cutting after 5 days by mechanized method (ATV or tractor with cutting wheel). Tarpaulin removal (pulling) after 24 additional hours.
 Work hour restrictions: Limit work hours to 4 hours/day for cutting, 7 hours/day for pulling.

Notes: Worksite breathing zone concentrations adjusted for maximum allowed rate and 50% recovery (Biermann and Barry, 1999; Helliker, 1999).
 Breathing zone concentration (95th percentile) based on arithmetic mean and 1.645 x the SD.
 For calculation of a 95th % tile when there is only one or two measurements, the standard deviation was assumed to be equal to that data point or the average of two data points.
 Maximum work hours/day = ((210 ppb x 24 hours)/(95th % tile))

Worker Health and Safety Branch
 Recommended maximum work hours for draft regulations

Section 6784 Table

Fumigation Handling Activities. No employee may work more than the hours specified below, in a 24-hour period, during the injection period and during the restricted entry interval.

<u>Fumigation Method/Activities</u>	<u>Maximum Work Hours in a 24-Hour Period</u>
<u>Nontarpaulin/Shallow/Bed</u> <u>Driving, Shoveling, and Copiloting</u>	<u>4</u>
<u>Nontarpaulin/Deep/Broadcast</u> <u>Driving, Shoveling, and Copiloting</u>	<u>4*</u>
<u>Tarpaulin/Shallow/Broadcast</u> <u>Driving, Shoveling, and Copiloting</u> <u>Tarpaulin Cutting</u> <u>Tarpaulin Pulling</u>	<u>3*</u> <u>4</u> <u>7</u>
<u>Tarpaulin/Shallow/Bed</u> <u>Driving, Shoveling, and Copiloting</u> <u>Tarpaulin Cutting</u> <u>Tarpaulin Pulling</u>	<u>4</u> <u>4</u> <u>7</u>
<u>Tarpaulin/Deep/Broadcast</u> <u>Driving, Shoveling, and Copiloting</u> <u>Tarpaulin Cutting</u> <u>Tarpaulin Pulling</u>	<u>3*</u> <u>4</u> <u>7</u>
<u>Drip System – Hot Gas</u> <u>Applicators</u> <u>Tarpaulin Cutting</u> <u>Tarpaulin Pulling</u>	<u>2</u> <u>4</u> <u>7</u>

* Work hours may be adjusted if the application rate is less than 400 pounds per acre using the formula: $((400 \text{ lbs/application rate}) \times \text{maximum work hours})$.