Longevity of Chloropicrin and Vapam in Controlling Internal Decay in Creosoted Douglas-fir Timbers Above Ground*

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1. Introduction

In a previous study (T. L. HIGHLEY and W. E. ESLYN, 1982), we reported on the ability of the fumigants, Vapam and chloropicrin, to eradicate internal decay in large, horizontal Douglas-fir timbers. The timbers were deeply checked, creosoted curbing used above water on a Navy pier in the Seattle, Washington, area. Comparison of the viability of fungi isolated from the timbers before and after fumigation showed that both Vapam and

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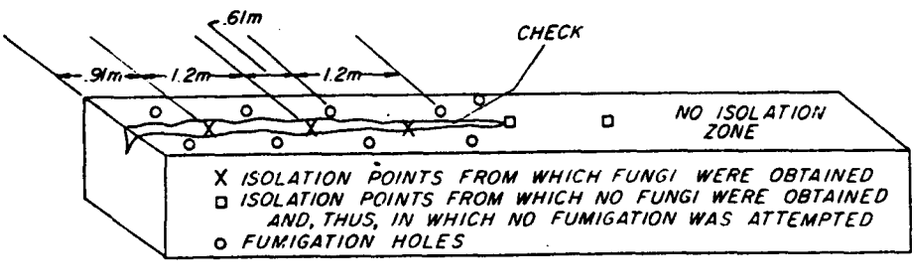
chloropicrin completely eradicated decay from the timbers within 16 months after treatment. The fumigants were less effective against nondecay fungi. At the time of this study, another set of creosoted Douglas-fir timbers without checks and internal decay was implanted with decay fungi and fumigated with Vapam and chloropicrin. The purpose of the tests was to determine if these important wood-products decay fungi vary in their tolerance to Vapam and chloropicrin. Unfortunately, this study was thwarted by destruction of the fungal cultures by vandals.

Increment core samples were taken from the timbers 7 years after fumigation. Isolations were made from decayed timber samples to determine the ability of residual fumigant to prevent reinvasion by decay fungi. Bioassays were also conducted on cores removed from both these timbers and the undecayed timbers to determine if inhibitive quantities of fumigant remained in the wood.

2. Materials and Methods

2.1 Timbers with internal decay

Timber selection, fungal isolation, and fumigation are described in detail in a previous study (T. L. HIGHLEY and W. E. ESLYN, 1982). Briefly, increment-core samples were collected from creosoted Douglas-fir timbers (0.18 m × 0.20 m; length 6.1 m to 9.1 m) with internal decay, and cultured in the laboratory to determine the location of decay (Fig. 1).



ML85 5599

Fig. 1. Fungal isolation points and location of holes for decayed timber fumigation. Vapam was applied only in holes 0.61 m apart while chloropicrin was applied in holes 0.30 m or 0.61 m apart. (ML85 5599)

Twelve infected timbers were treated with Vapam (33% sodium-N-methyldithiocarbamate), and 10 timbers with chloropicrin (trichloronitromethane). Vapam was poured into four equally spaced holes (131 ml/lineal meter) located 0.61 m from an infection site, or poured into infected checks (229 ml/lineal meter). The lineal distance between holes was 1.22 m. Chloropicrin was poured from a pressurized tank (118 or 236 ml/lineal meter) into holes located 0.30 m or 0.61 m from an infected area. In both Vapam and chloropicrin treatments, each treatment hole was immediately plugged with a treated wood dowel.

Viability of fungi isolated 7 years after fumigation was used as the criterion for determining the ability of the fumigants to eliminate decay. A bioassay with the wood decay fungus *Gloeophyllum trabeum* was used to reveal residual fumigant. Twelve-cm increment-core samples were taken from timbers at distances of 0.30 m, 0.61 m, and 1.22 m from the fumigant holes and placed immediately into screwcap tubes (16 mm × 150 mm). The cores were sterilized, placed into screwcap tubes containing malt-agar-slants inoculated with *G. trabeum,* and incubated at 27°C and 70% relative humidity until growth of the assay fungus in tubes containing untreated control cores reached the end of the tube. Inhibition of fungal growth was used as the measure of residual fumigant.

2.2 Timbers without decay

Creosoted Douglas-fir timbers without decay, from the same area as timbers with internal decay and having minimal checking were selected for the study. Eight or 16 holes (1.9 cm in diameter by 15.2 cm deep; about 3.1 cm apart in either direction) were drilled into the top of the timbers at their midsection (Fig. 2). The fumigants were applied as previously described and holes immediately plugged with rubber stoppers. A bioassay of increment cores was used to reveal residual fumigant at various distances from the fumigation holes (see above).

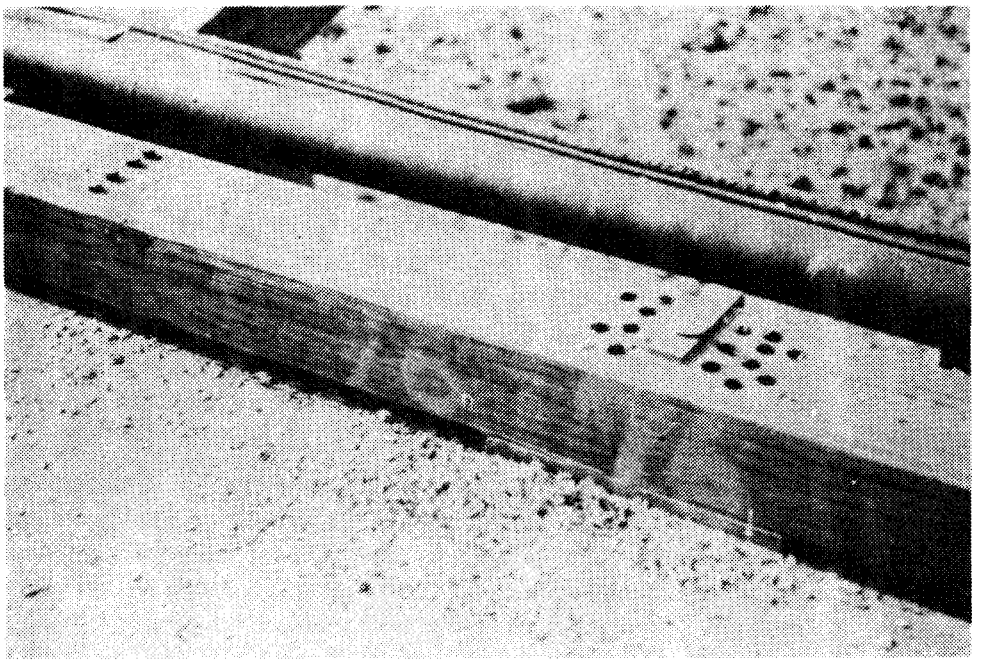


Fig. 2. Arrangement of holes for fumigants in undecayed Douglas-fir timbers (M870024).

3. Results and Discussion

Fumigation with chloropicrin and Vapam effectively prevented the reestablishment of decay fungi in large, horizontal Douglas-fir timbers (Tab. 1). After 7 years, no decay fungi were isolated from chloropicrin-treated timbers; Vapam-treated timbers contained some decay fungi. Vapam applied to checks was the least effective treatment against reestablishment of decay fungi.

Table 1: Fungal invasion of Douglas-fir timbers with internal decay 7 years after fumigation with chloropicrin and Vapam.

Treatment	Fumigant concentration (ml/lineal meter)	Percent of cores free of decay fungi after fumigation	Percent of cores free of mold fungi after fumigation
Chloropicrin (in holes)	118	100.0	33.3
Chloropicrin (in holes)	236	100.0	71.4
Vapam (in check)	229	76.9	38.5
Vapam (in holes)	131	87.5	25.0

In other studies, Vapam has been shown to be less effective than chloropicrin in preventing reinfection of decay fungi in fumigated poles. J. J. MORELL and M. E. CORDEN (1985) found reinvasion of Vapam-treated Douglas-fir poles by decay fungi 5 years after treatment, although the fungal population was much smaller in these poles compared to untreated poles. After 15 years, these authors have isolated almost no decay fungi from chloropicrin-treated poles. R. A. ZABEL et al. (1982) reported that southern pine poles treated with Vapam were reinvaded by decay fungi only 2 years after treatment, whereas no decay fungi were isolated from chloropicrin-treated southern pine poles.

Bioassay of increment cores taken from decayed timbers at various distances from the fumigation holes showed that chloropicrin was much more persistent than Vapam (Tab. 2). Only results from the chloropicrin-treated timbers are shown in Table 2 because no fungistatic effect was detected in any cores from Vapam-treated timbers. Residual fungistatic effect in chloropicrin-treated timbers was detected as far as 1.2 m from the fumigation holes. A. R. ZOHORA and M. E. CORDEN (1985) reported high concentrations of chloropicrin in Douglas-fir poles 33 months after treatment, but they did not detect any high concentrations of Vapam in the Vapam-treated poles. However, despite the absence of fungistatic concentrations of Vapam, decay fungi were eliminated. In our study we also found minimal invasion

Table 2: Fungistatic effect of cores extracted from internally decayed Douglas-fir timbers 7 years after fumigation with chloropicrin.

Chloropicrin concentration (ml/linealmeter)	Sampling distance from fumigation site (meters)	Inhibition of assay fungus[1]	Chloropicrin concentration (ml/linealmeter)	Sampling distance from fumigation site (meters)	Inhibition of assay fungus[1]
118	0.15	1	236	0.03	0
	.31	0		.15	2
	.61	3		.31	3
	1.2	3		.61	3
				1.2	0
118	.15	3	236	Check[2]	0
	.31	3		.15	1
	.61	1		.31	1
	1.2	2		.61	1
				1.2	1
118	.15	1	236	Check[2]	2
	.31	0		.15	3
	.61	3		.31	3
				.61	3
118	Check[2]	0	236	.15	3
	.15	2		.31	1
	.31	3		.61	2
	.61	3		1.2	0
	1.2	3			
118	.15	2	236	.15	3
	.31	3		.31	3
	.61	0		.61	3
				1.2	0
				Check[2]	3

[1] No inhibition of fungal growth, 0. Slight to moderate Inhibition of fungal growth, 1. Severe inhibition of fungal growth, limited to inoculum, 2. No fungal growth, 3.
[2] Sampled from cheek approximately 5 cm from fumigation hole.

by decay fungi in Vapam-treated timbers 7 years after treatment despite the absence of fungistatic concentrations of Vapam.

Nondecay fungi and bacteria could play a role in decreasing recolonization by decay fungi, particularly in Vapam-treated timbers where residual fungistatic concentrations of the fumigant appear depleted. Isolation of nondecay fungi and bacteria from fumigated wood has been frequently reported (R. D. GRAHAM, 1973; T. L. HIGHLEY and W. E. ESLYN, 1982; R. A. ZABEL et al., 1982). We found that only chloropicrin applied at the highest concentration effectively controlled nondecay fungi (Tab. 1). These organisms deserve further study, particularly to determine if they possess antagonistic properties that might be applicable in biological control. Thus, the nondecay fungi isolated from fumigated timbers will be screened to determine their antagonism toward important wood decay fungi.

Although residual fungistatic concentrations of chloropicrin in the decayed timbers were detected as far as 1.2 m from the fumigation holes, the distribution of chloropicrin was not uniform. Sometimes fungistatic effect was less in cores taken close to the fumigation holes (Tab. 2). In a study of chloropicrin-treated Douglas-fir poles, J. J. MORELL and M. E. CORDEN (1985) reported that 15 years after treatment the fumigant appeared to be moving up and out of the wood from the groundline fumigation site. A similar movement of chloropicrin from the fumigation site might be occurring in the Douglas-fir timbers in our study.

The results of bioassay from cores removed from undecayed Douglas-fir timbers, that were treated with chloropicrin in holes drilled in clusters about the center top, are given in Table 3. Seven years following treatment, fungistatic concentrations of chloropicrin were detected in cores up to a distance of 1.2 m from the fumigation center.

Efficacy of the chloropicrin treatment varied between different, Douglas-fir timbers (Tabs. 2 and 3). T. C. SCHEFFER and R. D. GRAHAM (1975) also found that efficacy of fumigation varied between different Douglas-fir poles. P. A. COOPER et al. (1974) discuss factors influencing process of fumigation of wood, such as permeability, grain direction, temperature, moisture content, and the presence or absence of decay pockets or checks.

Like decayed timbers, cores from undecayed timbers fumigated with Vapam did not have a residual fungistatic effect 7 years after treatment. In a previous study (W. E. ESLYN and T. L. HIGHLEY, 1985), we found that the effectiveness of Vapam against various decay fungi implanted in horizontal Douglas-fir timbers had markedly decreased by 16 months after treatment. Likewise, T. C. SCHEFFER and R. D. GRAHAM (1975) found that no residual vapors of Vapam remained in Douglas-fir poles 20 months after treatment.

Table 3 : Fungistatic effect of cores extracted from undecayed Douglas-fir timbers after fumigation with chloropicrin.

Treatment	Chloropicrin concentration (ml/lineal meter)	Sampling distance from fumigation (meters)	Inhibition of assay fungus[1]
	615	0.31	3
		.61	3
		1.2	1
	615	.31	3
		.61	3
		1.2	2
	615	.31	3
		.61	3
		1.2	2
	898	.31	3
		.61	3
		1.2	3
	898	.31	3
		.61	1
		1.2	2
	898	31	1
		.61	1
		1.2	2

[1] No inhibition of fungal growth, 0. Slight to moderate inhibition of fungal growth, 1. Severe inhibition of fungal growth, limited to inoculum, 2. No fungal growth, 3.

4. Conclusions

The high residual fugistatic effects of chloropicrin and the minimal effects of Vapam in Douglas-fir timbers after 7 years agree with effects reported for Douglas-fir poles (J. J. MORELL and M. E. CORDEN, 1985; A. R. ZAHORA and M. E. CORDEN, 1985). Thus, chloropicrin promises to provide more and longer lasting protection than Vapam in large, horizontal Douglas-fir timbers. Retreatment cycles of at least 14 years are recommended for Douglas-fir poles (G. G. HELSING et al., 1984), and based on our findings in the study reported here, a similar retreatment cycle seems reasonable for horizontal Douglas-fir timbers. Although a retreatment cycle of 10 years is recommended for Vapam in Douglas-fir poles, our results support a shorter retreatment schedule for horizontal Douglas-fir timbers. We recommend a 5-year cycle of retreatment to prevent reinfection.

5. Summary

The persistence, movement, and effectiveness of chloropicrin and Vapam (sodium N-methyl dithiocarbamate) in large, horizontal Douglas-fir timbers were evaluated 7 years after fumigation. Chloropicrin prevented reestablishment of decay fungi; reinvasion occurred in some Vapam-treated timbers. Residual fungistatic effect was detected up to 1.2 m from the fumigation site in chloropicrin-treated timbers but not in Vapam-treated timbers.

Zusammenfassung

Wirksamkeitsdauer von Chlorpikrin und Vapam bei der Bekämpfung von Pilzbefall in mit Steinkohlenteeröl behandelten Holzbalken

Dauerhaftigkeit, Wanderung und Wirksamkeit von Chlorpikrin (Trichlornitromethan) und Vapam (Natrium N-methyldithiocarbamat) in Douglasien-Balken wurden 7 Jahre nach einer Bohrlochtränkung bestimmt. Chlorpikrin verhinderte einen erneuten Befall durch holzzerstörende Pilze. Ein Neubefall trat in einigen mit Vapam behandelten Balken auf. Eine pilzhemmende Wirkung wurde bis 1,2 m von den Bohrlöchern in mit Chlorpikrin behandelten Balken festgestellt, jedoch nicht in den mit Vapam behandelten.

Résumé

Durabilité de l'effet de chloropicrine et Vapam dans le traitement curatif fongicide de madriers traités à la créosote

Durabilité, migration et efficacité de chloropicrine (trichloronitrométhane) et Vapam (N-méthyldithiocarbamate de sodium) ont été déterminés sur des madriers de Douglas, sept ans après un traitement par inoculation. Chloropicrine empêche une nouvelle attaque par champignons lignivores. Une nouvelle infestation s'est manifestée sur quelques madriers traités par Vapam. Un effet inhibitif a été constat6 sur les madriers traités à la chloropicrine, jusqu'à 1,2 m des trous d'inoculation, mais rien dans ceux traités par Vapam.

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