TERMITE CONTROL: RESULTS OF TESTING AT THE U. S. FOREST SERVICE

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Termiticides

Liquid termiticide treatments to soil continue as the most widely used method to protect wooden structures from attack by both native and Formosan subterranean termites, and have been the mainstay of the pest control industry for decades. The Wood Products Insect Research Project was located at Gulfport, MS, until 1995, and is now headquartered on the Mississippi State University Campus. However, field tests are still installed and maintained at the primary research sites in Arizona, Florida, Mississippi (Gulfport), and South Carolina, as well as at the Formosan subterranean termite research site on Midway Island. A new test site has also been established on Puerto Rico, and limited tests are still conducted at the U. S. Army Tropic Test Site in the Republic of Panama.

Several termiticides are currently registered by the U. S. EPA for use under and around wooden structures (Table 1). Two additional pyrethroids, cyfluthrin and deltamethrin, have been effective in field tests and may soon complete EPA registration. Five years of Premise tests were completed during 1997 and results were reported in the April 1998 issue of Pest Control (please refer to this article for details).

In Forest Service field sites, the ability of subterranean termites to penetrate termiticide-treated soil to attack pine blocks or boards is evaluated for at least five years, but tests often run much longer. Chlorpyrifos (Dursban, Equity, Tenure, Cyren, Navigator), cypermethrin (Demon, Prevail), fenvalerate (Tribute), and permethrin (Dragnet, Torpedo, Prelude) field tests were initiated from 1967 through 1980. Bifenthrin (Biflex), cyfluthrin (Tempo), deltamethrin (EC formulation), and imidacloprid (Premise) tests were initiated in 1986, 1987, 1988, and 1992, respectively[1]. Deltamethrin (DeltaGard TC; AgrEvo) will be marketed as a suspension concentrate with a planned general use rate of 0.125%, or at 0.25% for use under difficult-to-treat situations. These tests determine the years-of-effectiveness of currently marketed and potentially new termiticides as treatments to soil under long-term field conditions.

Ground-board and Concrete-slab Tests

In standard ground-board and concrete-slab tests in the United States, termiticides provided variable years of subterranean termite control depending on rates applied to the soil and test site location. Years of 100% control (as of November 1997) provided by each currently marketed termiticide active ingredient, applied at highest label rates under concrete slabs in our four primary test sites (Florida, Arizona, Mississippi, & South Carolina) are: chlorpyrifos 1.0%, 6-12 years (1971 four-site test), 21 years (1967

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[1]Mention of trade names does not imply U. S. Forest Service indorsement of any specific product over another.

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Mississippi test); cypermethrin 0.5%, 4-12 years; permethrin 1.0% (Dragnet FT), 5-15 years, (Torpedo, Prelude), 3-17+ years; fenvalerate 1.0%, 6-12 years; bifenthrin 0.125%, 2-11+ years; cyfluthrin 0.5%, 10+ years; and deltamethrin EC 125%, 4-9+ years. Premise under concrete slabs has provided excellent control of native subterranean termites in three of the four main test sites over five years, but some penetrations through soil occurred in Mississippi (PC, April 98). When termites forage in the Premise treated zone, lethal effects require some time to take effect. In some instances when termites were found foraging in the treated zone during one evaluation, they often were not present during the next evaluation. Like standard termiticides, Premise lasts longer when protected under concrete slabs than when placed in the exposed ground-board test situation.

The following examples help interpret Table 1. In Mississippi, 1.0% fenvalerate placed under concrete slabs in 1978 provided 100% control of subterranean termites for 10 years. Control then declined to 90% during the eleventh year, where it remained for one year before declining further to 70%. It remained at 70% for two years before falling to 60% effectiveness where it remained for two more years. By the next year it declined to 50%. In South Carolina, 1.0% permethrin (Torpedo) under concrete slabs was 100% effective in preventing penetration of subterranean termites through treated soil for six years. Control then declined to 90% during the seventh year, where it remained for one year before declining further to 80%. It remained at 80% for two years before declining to 70%, where it remained for one year. The next year it declined to 60%, where it remained for two years before declining to 50% where it remained for at least one year. The asterisk after the "1*" indicates that evaluation of this treatment stopped after one year at 50%. Thus, the total number of years that 1.0% permethrin (Torpedo) remained at 50% control was not recorded. Other asterisks found in the table indicate the same situation. Arrows between different percentage-of-effectiveness levels represent a greater than 10% loss in termite control since the previous evaluation. A dash in the table represents termite control percentages not yet observed.

Because termiticide field tests are installed during different years, a termiticide reported as 100% effective for a certain number of years is not necessarily less successful than one listed as 100% effective for a longer period. The periods of testing are simply different.

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Physical Barriers

Stainless Steel Mesh Field Tests

Termiticides used today are safe and pose little hazard to the environment or the people who depend on them to protect their homes and buildings. However, it is reasonable to investigate alternatives to insecticides for the control of subterranean termites. Some people are extra-sensitive to insecticides or would prefer to use non-insecticidal means to control termites.

In Australia, a high-quality, stainless steel mesh has been used with success beneath wooden structures to physically exclude subterranean termites, and thus, protect the structure from feeding damage. This mesh has been placed under many new homes and commercial buildings as a pre-construction barrier installation. Methods for post-construction application have also been developed. The success in Australia warranted testing of this material in the United States to evaluate its efficacy against subterranean termites.

Possible corrosion of the stainless steel mesh was also considered by the developer. Corrosion tests with stainless steel have been conducted world-wide and are documented in several publications (M. Romanoff, National Bureau of Standards, Circular 579, April 1957, U. S. Government Printing Office). The oxide layer on T-304 stainless steel, the grade designation of the mesh used in this test, prevents prolonged corrosion.

Tests conducted in Australia showed that T-304 stainless steel mesh placed in the most aggressive Sydney soils was not corroded even after 11 years (D. Hargreaves and C. B. Rolfe, Corrosion Australiasia 8(1): 10-13, 1983). In a ocean-side environment, there was no significant corrosion of T-304 stainless after 16 years. The application of stainless steel mesh under concrete floors and cavity walls may have a useful life of several decades, as claimed by the owners of the product, Termi-Mesh Australia.

Stainless steel mesh tests were installed in Arizona, Florida, Mississippi, and South Carolina during 1993. Three test methods were used to test its effectiveness as a barrier for preventing subterranean termites from reaching and attacking southern yellow pine blocks: (1) stainless steel mesh sleeve; (2) concrete block; and (3) concrete slab. Each method was replicated 20 times in each test site, resulting in 80 replicates per test method. In the sleeve method, an 18-inch-long, two-inch-by-four-inch pine board has a sleeve of stainless steel mesh wrapped around one end and approximately 15 inches up its length. The "sleeved" end is inserted vertically into termite-infested soil about nine inches deep. The concrete block method consists of a 15-by-15-inch square by eight-inch-high concrete building block that is wrapped underneath one open side and half way up around its four walls with stainless steel mesh. The block is placed horizontally on the soil and capped with a square plexiglass lid. Inside are two pine sapwood blocks on top of the mesh. A seven-inch-tall by four-inch-diameter PVC pipe is vertically inserted through carefully cut slits in the center of the mesh so its open bottom contacts the soil. The mesh is sealed around the PVC pipe with a stainless steel hose clamp. A pine sapwood block is placed inside the pipe and in contact with the soil, and the pipe is capped.

For the concrete slab test, a 24-by-24-inch square piece of mesh is placed on the soil and covered with standard polyethylene vapor barrier. A seven-inch-tall by four-inch-diameter PVC pipe is vertically held on top of the vapor barrier and a 21-by-21-inch square concrete slab, approximately two inches thick, is poured over the vapor barrier and around the pipe. The vapor barrier has a pre-cut, four-inch-diameter hole in its center that is located directly under the PVC pipe opening. After the concrete hardens, a pine sapwood block is placed inside the PVC pipe on top of the exposed stainless steel mesh, and the pipe is capped. Control plots were installed identically to the three test configurations, but without stainless steel.

After four-to-five years of testing, stainless steel mesh remains 100% successful as a barrier to subterranean termites (Table 2). Termites did not penetrate through the mesh, while non-protected wood in control plots was severely damaged. Efforts to market this product in the U. S. are underway in limited locations. Technicians will require training on proper installation. Tests with this new non-toxic termite barrier will continue for many years in our field sites and will be reported on after future evaluations.

Sand Barrier Field Tests

Sand barrier tests were installed in the four U. S. mainland test sites during 1991, and on Midway Island from 1988 through 1991. The two test methods in use against the Formosan termite on Midway are: (1) concrete-slab stake; and (2) concrete block. The concrete-block method is also being used against native termites on the mainland. After five-to-eight years of testing on Midway Island and seven years on the mainland, sand barriers varied in their effectiveness (Tables 3 & 4). On Midway, sand barriers placed under concrete slabs remained 100% effective for five years, but declined to 70% effectiveness within eight years. Also on Midway, concrete blocks partially filled with 2-, 4-, or 6-inch-thick sand barriers have remained 100% effective after five-to-seven years (1996). However, through 1995 there was no termite activity in control concrete blocks that contained only coral sand. The first control failures occurred during 1996, thus, the efficacy of sand barrier tests on Midway Island remains to be determined (Table 3). Midway Island was not visited in 1997, but a late 1998 evaluation is planned. Concrete-block tests on the mainland were 0-100% effective after five years, depending on the thickness of the sand barrier. Effectiveness of the two- and four-inch-thick barriers ranged from 0-70% and 30-90%, respectively. Six-inch-thick barriers were 80-100% effective in AZ, FL, and SC, but only 50% effective in MS. Control failures reached 100% within five years (Table 4).

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TABLE 1. Number of years that termiticides have been effective against native United States subterranean termites in concrete-slab (CS) and ground-board (GB) field tests through 1997

Termiticide and percent [AI]**	Test Method	Location and Percent Control: Arizona						Florida						Mississippi						South Carolina					
		100	90	80	70	60	50	100	90	80	70	60	50	100	90	80	70	60	50	100	90	80	70	60	50
		Years of control at each percent																							
Chlorpyrifos (1971)†																									
0.5	CS	4	2	→	→	2	→	7	→	1	1	1	→	3	→	4	→	→	1*	7	1	1	→	→	1*
1.0	CS	6	→	2	→	→	→	9	4	4	1	→	1*	11	4	→	1	→	→	12	→	→	2	→	1*
0.5	GB	3	→	→	→	1	→	3	→	1	→	1	→	2	1	→	1	→	→	6	→	→	→	→	→
1.0	GB	2	2	→	1	→	1*	7	→	→	→	→	→	4	→	2	→	1	→	8	1	→	→	→	1*
1.0	GB‡	--	--	--	--	--	--	--	--	--	--	--	--	5	→	1	→	1	→	--	--	--	--	--	--
1.0	CS‡	--	--	--	--	--	--	--	--	--	--	--	--	21	3	2	→	4+	--	--	--	--	--	--	--
Cypermethrin (1982)																									
0.125	CS	1	3	1	2	→	1*	1	1	1	2	1	1*	1	2	→	1	→	→	2	→	1	1	→	→
0.25	CS	4	→	1	→	→	1*	11	2	1	1+	--	--	3	2	1	→	→	1*	4	→	→	→	→	1*
0.5	CS	4	1	→	1	→	1*	5	5	2	3+	--	--	7	7	1+	--	--	--	12	→	→	3+	--	--
1.0	CS	8	2	→	3	2+	--	8	7+	--	--	--	--	6	9+	--	--	--	--	12	3+	--	--	--	--
1.0	GB	5	1	→	→	→	→	5	→	2	→	1	1*	5	→	1	→	1	→	5	1	→	1	2	1*
Fenvalerate (1978)																									
0.25	CS	8	2	1	4	→	1*	1	1	3	1	→	1*	2	1	→	1	→	1*	3	2	1	1	1	1*
0.5	CS	12	1	2	→	1	→	3	4	1	7	1	1*	7	→	2	→	1	1*	4	4	4	2	2	1*
1.0	CS	12	→	→	1	6+	--	6	13+	--	--	--	--	10	1	→	2	2	1*	6	7	→	1	5+	--
1.0	GB	7	1	1	→	→	1*	4	1	3	→	1	→	4	→	→	1	1	→	6	1	→	→	1	→
Permethrin - Dragnet FT (1978)																									
0.25	CS	8	2	3	2	→	→	2	→	2	→	1	2	1	1	→	→	1	→	→	→	→	2	1	→
0.5	CS	13	6+	--	--	--	--	4	→	2	13+	--	--	5	1	→	→	1	→	5	3	1	→	→	1*
1.0	CS	15	→	4+	--	--	--	15	4+	--	--	--	--	5	3	2	1	→	1*	10	1	5	1	→	1*
1.0	GB	9	2	→	3	1	1*	6	→	3	→	→	→	2	1	→	→	→	→	1	3	→	→	1	→
Permethrin - Torpedo (1980)																									
0.25	CS	9	→	1	2	→	1*	3	4	2	2	2	→	2	→	→	1	→	1*	→	→	→	1	1	1*
0.5	CS	11	2	3	1+	--	--	6	3	4	→	4+	--	4	1	→	→	1	→	1	3	3	→	1	→
1.0	CS	17+	--	--	--	--	--	17+	--	--	--	--	--	3	4	1	1	2	→	6	1	2	1	2	1*
0.5	GB	4	→	1	→	→	1*	4	→	→	1	→	→	1	→	1	→	→	→	1	→	→	→	→	→
1.0	GB	8	1	→	→	→	→	5	→	1	1	→	1*	2	→	→	→	1	1*	1	→	→	→	→	→

Termiticide and percent [AI]**	Test Method	Location and Percent Control																							
		Arizona						Florida						Mississippi						South Carolina					
		100	90	80	70	60	50	100	90	80	70	60	50	100	90	80	70	60	50	100	90	80	70	60	50
		Years of control at each percent																							
Bifenthrin - Biflex TC (1986)																									
0.031	CS	0	9	2+	–	–	–	4	7+	–	–	–	–	2	3	1	5+	–	–	2	2	3	4+	–	–
0.062	CS	11+	–	–	–	–	–	11+	–	–	–	–	–	7	→	2	1	1+	–	10	1+	–	–	–	–
0.125	CS	10	1+	–	–	–	–	9	2+	–	–	–	–	2	5	4+	–	–	–	11+	–	–	–	–	–
0.25	CS	11+	–	–	–	–	–	11+	–	–	–	–	–	11+	–	–	–	–	–	11+	–	–	–	–	–
0.5	CS	6	5+	–	–	–	–	11+	–	–	–	–	–	11+	–	–	–	–	–	11+	–	–	–	–	–
0.5	GB	10	1+	–	–	–	–	11+	–	–	–	–	–	11+	–	–	–	–	–	8	3+	–	–	–	–
Cyfluthrin - Tempo TC (1987)																									
0.125	CS	4	2	→	→	3	→	9	1+	–	–	–	–	2	2	5	1+	–	–	4	3	3+	–	–	–
0.25	CS	10+	–	–	–	–	–	10+	–	–	–	–	–	6	2	2+	–	–	–	10+	–	–	–	–	–
0.5	CS	10+	–	–	–	–	–	10+	–	–	–	–	–	10+	–	–	–	–	–	10+	–	–	–	–	–
1.0	CS	10+	–	–	–	–	–	10+	–	–	–	–	–	10+	–	–	–	–	–	10+	–	–	–	–	–
0.5	GB	5	1	1	→	→	1*	6	1	→	2	1+	–	5	→	1	1	→	1*	6	3	→	→	1+	–
1.0	GB	5	2	→	1	→	→	7	3+	–	–	–	–	4	2	4+	–	–	–	7	3+	–	–	–	–
Deltamethrin - EC Formulation (1988)																									
0.05	CS	1	→	1	3	→	→	3	1	3	2+	–	–	3	→	1	→	→	1*	2	2	→	→	1	1*
0.125	CS	5	→	→	3	→	1+	9+	–	–	–	–	–	4	→	2	1	1	→	7	2+	–	–	–	–
0.5	CS	9+	–	–	–	–	–	9+	–	–	–	–	–	9+	–	–	–	–	–	9+	–	–	–	–	–
1.0	CS	9+	–	–	–	–	–	9+	–	–	–	–	–	9+	–	–	–	–	–	9+	–	–	–	–	–
0.5	GB	2	5	1	1+	–	–	9+	–	–	–	–	–	2	4	→	2	1+	–	9+	–	–	–	–	–
1.0	GB	9+	–	–	–	–	–	9+	–	–	–	–	–	2	7+	–	–	–	–	9+	–	–	–	–	–

Non-treated monitoring plots: Percent attack on wooden blocks and boards in plots without termiticide treatments

	Arizona	Florida	Mississippi	South Carolina
CS	40% to 80%	70% to 100%	50% to 70%	50% to 100%
GB	20% to 90%	80% to 100%	80% to 90%	40% to 100%

* Evaluations stopped after one year at 50 percent effectiveness.
** The active ingredient [AI] concentration in the termiticide dilution applied to the soil.
† Year test initiated.
‡ Initial 1967 test in Mississippi only. Mention of a trade name does not imply Forest Service endorsement of any specific product.

NOTE: An arrow indicates a greater-than-10-percent loss in termite control since the preceding evaluation.
Dashes represent termite control percentages not yet observed.
A "+" after a number indicates that control did not decline below the indicated percent as of the most recent evaluation.
Percent attack on wood in non-treated monitoring plots is for 1996-1997. Wood in all original non-treated control plots has been destroyed, thus non-treated monitoring plots are used to assess continuing termite activity.

TABLE 2. STAINLESS STEEL MESH FIELD TESTS (4-5 year results through August, 1998)

Test Method	Percent Attack on Wooden Blocks																		
	FL					AZ					MS					SC*			
	94	95	96	97	98	94	95	96	97	98	94	95	96	97	98	94	95	96	97
SS-Mesh Plots																			
Concrete Block	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Concrete Slab	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sleeve	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Control Plots																			
Concrete Block	90	100	100	100	100	35	40	65	80	85	95	100	100	100	100	90	95	100	100
Concrete Slab	95	95	100	100	100	45	65	95	100	100	95	100	100	100	100	90	95	100	100
Sleeve	90	100	100	100	100	50	70	85	95	95	100	100	100	100	100	100	100	100	100

* South Carolina tests will be evaluated during October 1998

TABLE 3. SAND BARRIER TEST (MIDWAY ISLAND)

Test Method[1]	Percentage of Plots Not Penetrated							
	1989[2]	1990	1991	1992	1993	1994	1995	1996
SLAB-STAKE (1988)[3]	100	100	100	100	100	90	80	70
Control[4]	70	50	30	30	20	20	20	20
CONCRETE BLOCK								
2" (89)[3]	--	100	100	100	100	100	100	100
2" (90)	--	--	100	100	100	100	100	100
4" (89)	--	100	100	100	100	100	100	100
4" (90)	--	--	100	100	100	100	100	100
6" (91)	--	--	--	100	100	100	100	100
6" (91)	--	--	--	100	100	100	100	100
Controls[4]								100
2" (89-90)	--	100	100	100	100	100	100	100
4" (89-90)	--	100	100	100	100	100	100	100
6" (91)	--	--	--	100	100	100	100	80

[1] 20 replicates total for each method and barrier thickness
[2] Year of annual evaluation
[3] Year this phase of the test was initiated
[4] Control plots are cumulative percentages

The Formosan subterranean termite, *Coptotermes formosanus*, is the only subterranean termite on Midway Island

TABLE 4. SAND BARRIER TESTS (U. S. MAINLAND)

Concrete Block Method[1]	Percentage of Plots Not Penetrated					
	1992[2] 1[3]	1993 2	1994 3	1995 4	1996 5	1997 6
ARIZONA						
2"	95	80	70	70	70	70
4"	100	95	90	90	90	90
6"	100	95	95	95	95	95
Control[4]	80	10	0	0	0	0
FLORIDA						
2"	100	80	65	55	55	45
4"	100	90	85	85	85	85
6"	100	100	100	100	100	100
Control	20	0	0	0	0	0
MISSISSIPPI						
2"	100	50	20	5	0	0
4"	100	70	55	30	30	25
6"	100	85	65	55	50	40
Control	0	0	0	0	0	0
SOUTH CAROLINA						
2"	100	90	85	70	65	60
4"	100	100	95	90	90	90
6"	100	100	100	95	80	75
Control	0	0	0	0	0	0

[1] 20 replicates for each barrier thickness per site
[2] Year of annual evaluation
[3] Number of years in test
[4] Control plots are cumulative percentages