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Comparison of Wood Preservatives in Stake Tests

2011 Progress Report

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Abstract

This report covers stake test results primarily from Southern Pine 2- by 4- by 18-in. sapwood, treated by pressure and nonpressure processes and installed by Forest Products Laboratory employees and cooperators in decay and termite exposure sites at various times since 1938 at Saucier, Mississippi; Madison, Wisconsin; Bogalusa, Louisiana; Lake Charles, Louisiana; Jacksonville, Florida; and the Canal Zone, Panama. Also included in the tests at Saucier, Mississippi, are smaller pine stakes and those of treated and untreated plywood, particleboard, modified woods, laminated paper plastic, pine infected with *Trichoderma* mold, plus other selected wood species such as oak, Douglas-fir, and Engelmann spruce. Southern Pine untreated control stakes have had an average life of about 1 year in the Canal Zone, 1.8 to 3.6 years in Mississippi, Florida, and Louisiana, and about 6 years in Wisconsin. Superficial treatments by 3-min dipping and brushing with preservatives such as coal-tar creosote and petroleum oils containing copper naphthenate, zinc naphthenate, and pentachlorophenol have added from a few months to 4 years to the life of the untreated stakes. When appropriate preservative retention levels are applied, creosote, pentachlorophenol, and selected waterborne salt preservatives provide excellent protection. This publication also contains information regarding the future inspection status of the test plots.

Keywords: Preservatives, wood preservatives, pressure treated, nonpressure treated, Southern Pine, average life

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Crankcase oils may contain chlorinated naphthalenes, which have been reported to contribute to "X-disease" (hyperkeratosis) in cattle. These oils are therefore not recommended for preservative treatment of wood with which cattle may come in contact.

Acknowledgments

This research note is a continuation of progress reports by the same title issued periodically from 1950 to 1962 as Report No. 1761 and as FPL–RN–02 since 1963. Several past and current Forest Products Laboratory employees initiated the studies reported herein. These individuals are recognized in notes following the appropriate tables. The authors of this publication express their appreciation to the Economics and Statistics Research, the Research Facilities Engineering, and the Harrison Experimental Forest staffs for their contributions to the success of this publication.

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Comparison of Wood Preservatives in Stake Tests

2011 Progress Report

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Introduction

For centuries, wood has been one of the most common and easiest to use construction materials. It is used practically everywhere—in housing and agricultural buildings and as posts, utility and telephone poles, railroad ties, wharves, and piling. Wood is also a renewable material. Although we have consumed tremendous volumes of wood for centuries, the United States is growing more wood volume than it is harvesting.

Wood is a biological material and as such it is subject to decay and insect and marine borer attack. These agents are nature's way of recycling wood in the natural ecosystem. Without nature's recycling system, wood and other cellulose-based materials, such as grass, leaves, and agricultural field residues, would literally bury us. However, when wood is used in a more or less permanent application, it must be protected from biological degradation. Destruction can be prevented by a number of individual methods or a combination of methods.

Results of an international termite exposure test in 1930 (Hunt and Snyder) indicated that exposing 2- by 4- by 18-in. pine sapwood stakes treated with various wood preservatives is an effective method to test the protection provided against decay and termite attack. During 1938, the USDA Forest Service, Forest Products Laboratory (FPL), in cooperation with others, began treating test stakes of Southern Pine sapwood with several preservatives for installation at the Harrison Experimental Forest at Saucier, Mississippi. Replicate stakes were treated for installations at Madison, Wisconsin; Bogalusa, Louisiana; Jacksonville, Florida; and the Canal Zone, Panama. Since 1938, additional preservatives have been added to these tests, principally at the Saucier, Mississippi, station. Also installed at that station were stakes of treated and untreated modified-wood products, such as plywood, impreg, compreg, staypak, papreg, laminated acetylated wood, cyanoethylated wood, wood with thiamine destroyed, chemically modified wood, wood infected with *Trichoderma* mold, embedded fiberboard (western hemlock strands in Portland cement), particleboard, and incised and unincised wood.

In 1967, another stake installation that included 11 standard wood preservatives was made in cooperation with the Wood Products Insect Laboratory, Gulfport, Mississippi, at Lake Charles, Louisiana. The area is infested by the destructive Formosan termite, *Coptotermes formosanus*, and stakes installed were used for comparison with the stakes at the Harrison Experimental Forest in Saucier, Mississippi.

Stake tests are useful for screening out ineffective preservative materials. Stake test results can be used to further explore the preservative properties of materials that show promise in laboratory toxicity tests. However, limitations of these accelerated field tests must be recognized. Test results should not be considered as a substitute for actual service tests on full-size products such as ties, poles, or posts. Furthermore, results obtained in these stake tests are applicable only under the set of conditions existing in the particular test. Factors such as exposure, preservative retention, preservative distribution, heartwood volume, and size (surface area in relation to total volume) influence the performance of treated wood. In addition, the stakes in this test are not subjected to loading, or inspected for structural capacity, as would be the case for in-service structural members.

This publication is primarily a progress report on the condition of the modified-wood products and stakes treated with various preservatives and oils at the time of the 2000 through 2011 inspections. The stake tests at Panama were completed with a final inspection in January 1956. Those at Jacksonville were terminated in December 1960, and those at Bogalusa in December 1958. Progress reports showing the condition of the test stakes in 1947 and during the years 1949 to 1969, 1971, 1973, 1975, 1977, 1979, 1981, 1983, 1985, 1987, 1991, 1995, and 2000 have been published (Hunt and Snyder 1930, Blew 1948). In addition, this publication contains information regarding the future inspection status of the test plots.

Preservatives and Modified-Wood Products Tested

Table 1 lists the preservatives and products tested and notes existing preservative specifications in cases where specifications have been issued. Table 1 also refers to Tables 2 to

76, in which test data are listed for the various materials. Formulations of treating solutions and descriptions of the various test materials are generally given in the tables. Additional information as to the source and composition of the various materials can, in most cases, be furnished upon request to the FPL.

Selection and Treatment of Stakes

For the most part, the stakes were 2- by 4- in. (nominal) by 18-in. Southern Pine, uniformly seasoned, surfaced on four sides, and selected for freedom from heartwood, wane, objectionable knots, and other visible defects. Ten installations included solid-sawn stakes of smaller size for comparison purposes (Tables 6, 35, 37, 42, 45, 54, 56, 57, 59, 68). Before treatment, a number, either stamped on the ends or marked with lumber crayon, identified the stakes. The stakes of modified wood, with one or two exceptions, were 4 by 18 in. with variable thickness.

All preservative treatments were by pressure impregnation unless indicated. Waterborne preservatives were applied by using the full-cell process, unless noted. Preservative oils were applied by either empty-cell or full-cell methods (toluene dilution), depending upon the retention level required. Complete penetration is desirable and usually noted in the pressure treatment used. For this reason, heartwood material was avoided in the Southern Pine stakes unless noted (Tables 5 and 51). In most cases, preservative retention levels were computed for individual stakes from the difference in weight before and after treatment. Surplus preservative was permitted to drain from the stakes before the final weight measurements were taken. Experience or exploratory treatments indicated the correct treating schedule or the treating solution concentration necessary to produce the desired preservative retention. Twenty 2- by 4-in. stakes were treated for each test variable, from which 10 acceptable stakes were selected for installation. By discarding those stakes with retention levels greater or less than desired, the 10 stakes selected by this procedure were usually found to have preservative retention levels within the desired 10% range. The stakes not acceptable for the test provided material for checking preservative penetrations. For stakes treated in liquefied petroleum gas (LPG) (Tables 42 and 45), it was impractical to follow this general procedure. These stakes were treated at a commercial plant in the presence of an FPL representative, and retention levels were determined from the analysis of either sections of test stakes or additional matched stakes included for that purpose.

The test stakes were usually identified by a numbered metal tag nailed (riveted in the case of thin modified-wood products) to the wide face approximately 2 in. from the top of the stake.

Installation and Inspection of Stakes

The stakes at Madison, Wisconsin, and Saucier, Mississippi, were installed in plots by the randomized-block method (Fisher and Yates 1938). The stakes were set in the ground in an upright position with about half their length (9 in.) in the ground. The soil in the plot at the Harrison Experimental Forest, Saucier, Mississippi, is Poarch fine sandy loam, with 5% to 12% slope, a pH of 4.85, and an average annual rainfall of 62 in. That area was partially cleared of trees, mostly scrub oak and gallberry with a few longleaf and slash pine, before the stakes were installed; the ground cover is now mostly wiregrass. Until late 1956, the Madison, Wisconsin, plot was located in an area of clay loam soil with a pH of 6.5 that was partially shaded by various hardwood trees and sumac, with an average annual rainfall of 31 in. In October 1956, it was necessary to move the stakes to a new test plot near Madison with similar soil, but without the overstory of trees or shrubs. The soil at Bogalusa, Louisiana, was sandy loam, and that at Jacksonville, Florida, was sandy. Both plots were partially shaded. The plot at Lake Charles, Louisiana, was located on an open area partially covered with broom sedge and marsh grass. The top 10 in. of soil was sandy with some streaks of clay; underneath was heavy muck and a high water level.

The 1970, 1974, and 1984 inspections at Lake Charles, Louisiana, and the final inspection of stakes installed at the Canal Zone during January 1956 were made by representatives of the Wood Products Insect Laboratory, Gulfport, Mississippi, and the FPL. Representatives from the Chapman Chemical Company and the FPL did the final inspections of the stakes at Jacksonville and Bogalusa in 1960 and 1962, respectively. FPL representatives inspected the Madison and Saucier installations.

During these inspections, the stakes are removed individually, scraped to facilitate inspection, examined, and returned to their original place unless their condition indicates removal. Prior to 1985 the stakes were given a numerical and letter rating according to the following decay and termite attack scale:

Decay	Termite attack
1 No decay	A No attack
2 Slightly soft or suspicious	B Nibbles or trials
3 Partial or limited decay	C Limited attack (penetration)
4 Severe decay	D Heavy attack
5 Removed because of decay [a]	E Removed because of termite attack [a]

[a]50% or more of cross section destroyed.

In 1985, field data were recorded using a portable computer. It was desirable to convert to a numeric-numeric rating system that would compare with the previous rating system

and allow for some refinement. All ratings from 1991 to the present were made using the following rating scale:

Grade no.	Description of condition	
	Decay grades	Termite grades
10	Sound. Suspicion of decay permitted.	Sound. 1 to 2 small nibbles permitted
9	Trace decay to 3% of cross section	Slight evidence of feeding to 3% of cross section
8	Decay from 3% to 10% of cross section	Attack from 3% to 10% of cross section
7	Decay from 10% to 30% of cross section	Attack from 10% to 30% of cross section
6	Decay from 30% to 50% of cross section	Attack from 30% to 50% of cross section
4	Decay from 50% to 75% of cross section	Attack from 50% to 75% of cross section
0	Failure	Failure

In Tables 2 to 76, stakes listed as "Trace" or "None" had an inspection rating of one of the following: 10-10, 10-9, 9-10, or 9-9. Stakes listed as "Serviceable but showing some decay" had one of the following inspection ratings: 8−10, 7−10, 6−10, 4−10, 8−9, 7−9, 6−9, or 4−9. Those listed as "Degraded but showing some termite attack" were field rated on the basis of 10−3, 10−7, 10−6, 10−4, 9−8, 9−7, 9−6, or 9−4. Stakes listed as "Degraded but showing some decay and termite attack" were given one of the following ratings: 8−8, 8−7, 8−6, 8−4, 7−8, 7−7, 7−6, 7−4, 6−3, 6−7, 6−6, 6−4, 4−8, 4−7, 4−6, or 4−4. Under the previous rating system, stakes showing limited and heavy decay, termite attack, or both are grouped together. In stakes that show some deterioration but are not necessarily seriously decayed, unnecessary emphasis is sometimes placed on these ratings. Therefore, in making comparisons between preservatives, only the stakes actually destroyed should be considered.

For stakes classified as "Destroyed by decay fungi and termites," both forms of deterioration must be rated at least with severe decay or heavy attack (4 or D) in the inspection. In other words, a stake rated in the inspection as 7-0 would be considered destroyed by termites rather than by decay and termites, while one rated as 0-7 would be considered as destroyed by decay. Therefore, the system used in the tables for rating the destroyed stakes emphasizes the major factor or factors responsible for damage, but ignores those that may have been noted but have not seriously contributed to destruction.

Tables 2 to 76 give the condition of the stakes at their most recent inspection. Table 77 is a summary of results obtained at the Mississippi site on 2- by 4-in. pine stakes treated with wood preservatives that are or were in general use.

Results

The following summarizes the results of the stake tests thus far.

Untreated Stakes

The untreated 2- by 4-in. Southern Pine sapwood stakes had an average life of 1.2 years in the Canal Zone, Panama; 1.8 to 2.4 years at Saucier, Mississippi, Bogalusa, Louisiana, and Jacksonville, Florida; and 4 to 6 years at Madison, Wisconsin. At Lake Charles, Louisiana, 90% of the untreated control stakes were destroyed by Formosan termites, giving an average life of 2.3 years. Untreated 3/4-in. pine sapwood stakes in Mississippi had an average life of 1.4 to 2.1 years.

The untreated Douglas-fir plywood stakes installed at Saucier, Mississippi, had an average life of about 1 to 4 years. Those glued with phenolic and urea-resin glues have lasted somewhat longer than those glued with casein glue, which had an average life of 1 year. The stakes cut from Douglas-fir lumber and of thickness similar to that of the plywood had an average life of slightly more than 2 years. Untreated plywood stakes of yellow birch, sweetgum, and tangile had an average life of less than 2 years.

Untreated plywood stakes of Engelmann spruce heartwood had average lives of 2.6 years and 3.2 years for Mississippi and Wisconsin, respectively. Untreated Douglas-fir heartwood plywood stakes had average lives of 3.2 years and 5.5 years for Mississippi and Wisconsin, respectively. Southern Pine plywood stakes that contained about equal amounts of heartwood and sapwood had an average life of 2.8 and 5.8 years in Mississippi and Wisconsin, respectively (Table 51).

Pressure-Treated Stakes

In the more recent installations and those with the more effective preservatives, only a limited number of stakes have thus far been removed, and the average life of stakes in these tests cannot be determined. Estimates of average life were made for preservatives with significant failures at the time of the termination of several installations (Tables 2 to 5, 8, 12, 18, 38). In the Canal Zone, stakes treated with several retention levels of chromated zinc arsenate (CZA) were destroyed during the 15-1/3 years of exposure. Stakes with 0.22 lb/ft^3 CZA (oxide basis) had an average life of 9.2 years, and those with approximately 0.69 lb/ft^3 (oxide basis) had an average life of 15.3 years. Stakes treated with CZA to retention levels of 0.22 to 0.70 lb/ft^3 (oxide basis) have had 100% failures in Wisconsin after 51-1/2 years, and in Mississippi 100% failures have been noted with retention levels of 0.33, 0.44, and 0.58 lb/ft^3 (Table 4; similar comparison in Table 20).

Of the waterborne preservatives in tests that contain copper and arsenic (24 to 61 years in Mississippi), the formulations of ammoniacal copper arsenate (ACA) (Table 14) and chromated copper arsenate (CCA) (Tables 15, 20, 47) are better performers with only 30% failures using retention levels of 0.29 lb/ft^3 (oxide basis) or 20% using 0.44 lb/ft^3 or greater for CCA, and only 12% using retention of

0.51 lb/ft³ or greater for ACA. Again, the overall performance of the arsenic-containing preservatives (Table 20) is better in Mississippi than in Wisconsin.

Stakes treated with ammoniacal copper borate to retention levels of 0.17, 0.22 and 0.33 lb/ft³ (oxide basis) have had 94%, 94% and 56% failure, respectively, in Mississippi after 34 years of in test. In contrast, the ACA-treated stakes show 100% failure at the 0.17 lb/ft³ retention level and 95% failure at the 0.23 lb/ft³, and only 35% failure at the 0.33 lb/ft³ retention level for the same exposure (Table 52).

Results thus far on installations of pentachlorophenol with similar retention levels and different hydrocarbon solvents (Tables 17, 42, and 45) show better performance with solutions containing the heavy solvents such as heavy gas oil, lube oil extract (Table 17), No. 4 aromatic oil (Table 22), and AWPA P9 heavy petroleum solvent (Tables 42 and 45) than with volatile LPG or light oils such as Stoddard solvent (mineral spirits) (Tables 17 and 42). Preservatives such as rosin amine-D-pentachlorophenate (Tables 22 and 23), tributyltin oxide (Tables 36 and 41), and copper-8-quinolinolate (Tables 38 and 43) also show better performance with the heavy petroleum solvent than the light Stoddard solvent (mineral spirits). The previously mentioned heavy petroleum solvents have the following properties:

Petroleum oils	API gravity 60°F	Flash point (PMCC) (°F)	Viscosity SUS at 100°F	Penta solvency at 75°F	Distribution (°F)		
					IBP	50%	EP
Heavy gas oil, No. 101	08.3	345	167.4	20–22	600	700	734
Lube oil extract	05.1	295	196.4	28–30	440	696	736
AWPA P9, heavy	23.8	225	38.4	15	480	538	647
No. 4 aromatic	06.8	230	72.6	10+	458	592	Cracked (85%)

Pentachlorophenol retention levels of 0.47 lb/ft³ and less are showing deterioration on the 3/4-in. stakes after 17 years in test in Mississippi. The stakes treated to retention levels of 0.34, 0.38, 0.50, 1.30, and 1.84 lb/ft³ of a water-soluble form of copper-8-quinolinolate had average lives of 3.3, 3.8, 4.6, 6.2, 7.3, and 8.6 years, respectively (Table 54).

Coal-tar creosotes installed in Mississippi during 1940 and 1941 (Tables 4 to 6) have shown better performance than those installed in 1948 (Tables 18 and 19) (Baechler and others 1978). In the latter installation, 10 coal-tar creosotes with a retention of approximately 8 lb/ft³ showed 60% to 80% failure after 20 years, and the average life was determined or estimated at 14 to 21 years. Creosotes installed earlier than 1941 showed 60% to 90% failures in 48½ to 49½ years for a similar retention, which could show an average life in excess of 50 years.

Stakes pressure treated with the fire-retarding formulation containing ammonium phosphate and ammonium sulfate lasted, on an average, only 2 to 3 years in Mississippi. With these ammonium salts plus borax and boric acid, the stakes installed in 1943 lasted on the average about 4 years. The fire-retarding formulation with borax and boric acid alone has provided protection against decay and termites for an average of about 6 years (Table 13). The addition of zinc chloride and chromium compounds to combinations of boron and ammonium salts in fire retardants improved protection against decay fungi and termites (Table 25). An exterior-type fire retardant containing urea, dicyandiamide, formaldehyde, and phosphoric acid in 2- by 4- by 18-in. stakes treated at retention levels of 2.8 lb/ft³, 6.0 lb/ft³ and 9.5 lb/ft³ had an average life of 4.8, 9.7 and 15.4 years, respectively. Termites caused failures at lower retentions (Table 53).

The results of stake tests in Mississippi showed copper naphthenate provided greater protection than zinc naphthenate with similar retention levels (Table 7).

Rosin amine-D-pentachlorophenate in Stoddard solvent performed less satisfactorily than pentachlorophenol with that solvent and similar retention levels. Products from naval stores such as rosin oil, oleo resin, and drop liquor concentrate with petroleum solvents appear to have limited value as preservatives but are improved by the addition of pentachlorophenol. Urea (Table 10) has also shown limited protection. Stakes pressure treated with 5.8 lb/ft³ had an average life of 9.1 years in Mississippi. Other products showing limited preservative value in the retention levels used are acrylonitrile (cyanoethylation), ammonium hydroxide (thiamine destruction), amyl phenyl acetate, capric acid, copper-8-quinolinolate (in Stoddard solvent), diamyl phenol, DDT, dodecyl amine, nickel stearate, and tributyltin oxide (in Stoddard solvent).

An indication of the influence of size in test stakes is noted in Table 6. With a coal-tar creosote retention of approximately 8 lb/ft³, 1/2-in.-square stakes were destroyed after 21-1/2 years with an average life of 17 years, 1-in.-square stakes after 39-1/2 years with an average life of 23.6 years, 1-1/2-in.-square stakes after 33-1/2 years with an average life of 26.6 years, and 2- by 4-in. stakes showed 70% failure after 54-1/2 years.

Note that aspen particleboard stakes treated with CCA showed less degradation than those stakes treated with pentachlorophenol in light solvents. Stakes treated to 0.22, 0.40, and 0.82 lb/ft³ of pentachlorophenol showed failures of 100, 100, and 70% respectively, and only the low retention level (0.26 lb/ft³) of CCA showed 100% failure after 25-1/2 years in test (Table 49). Untreated stakes of aspen particleboard showed an average life of 2.4 years.

Nonpressure-Treated Stakes

Southern Pine stakes and Douglas-fir plywood stakes treated by superficial applications, such as brushing and brief dipping in coal-tar creosote and solutions of pentachlorophenol,

copper naphthenate, or zinc naphthenate, have generally lasted 1 to 4 years longer than the untreated control stakes (Tables 7, 8). However, stakes dipped for 15 min in coal-tar creosote had a life of about 8 years in Mississippi (Table 4).

For the plywood stakes in which the veneer was treated by dipping or lengthy soaking in the preservatives before gluing, the results have generally been more favorable than for plywood similarly treated after gluing. In the Canal Zone, stakes soaked 18 h in solutions of pentachlorophenol or mixtures of chlorinated phenols lasted 5 to 10 years. In the United States, the stakes soaked 18 h in these solutions lasted 8 to 16 years (Table 5). However, Douglas-fir plywood stakes treated by brushing, dipping, and 18-h soaking in chloro-2-phenylphenol solution lasted only a few months longer than the untreated plywood control stakes. Douglas-fir plywood stakes treated by soaking 18 h in pentachlorophenol solution had a life of 5 years, while those similarly treated with coal-tar creosote have an estimated average life of 24 years (Table 8).

At the Mississippi site, pine stakes treated by soaking in urea solution lasted about 1 to 1-1/2 years longer than the control stakes, and those similarly treated with urea-formaldehyde solution lasted about 2 to 4 years longer than the controls (Table 10). Pine stakes with increased retention levels of copper chromate and copper arsenate applied by double-diffusion have continued to perform well after 55 years in Mississippi. Failures thus far have been found primarily in the copper chromate system with 33% and 67% failed (Table 9).

Modified-Wood Stakes

Plywood stakes impregnated with phenolic resin (impreg) and impregnated and compressed (compreg) have been considerably more resistant to decay and termite attack than have untreated plywood of the same species. Plywood stakes with a low resin content have had an average life of approximately 7 years and those with a high resin content have lasted 12 years. In Douglas-fir, plywood stakes with phenolic-resin-impregnated faces and untreated cores, an average life of about 3.5 years has been obtained, and somewhat better results have been noted when the edges of the plywood have been protected with a phenolic-resin coating. Southern Pine 2- by 4-in. stakes impregnated with a low resin content had an average life of 12 years, and those with a greater content of phenolic resin have lasted somewhat longer (Table 3).

Laminated paper plastic made with phenolic resin has shown limited resistance to decay and termite attack, with the life of the stakes averaging about 6 to 8 years. Heat-stabilized birch and maple plywood (staypak) stakes have lasted about 4 to 6 years. The staypak with veneer of 1/16-in. thickness has performed better than that with 1/8-in. veneer, presumably because the thinner veneer permits a better distribution of the phenolic-resin adhesive in the plywood (Table 11).

Acetylated birch (laminated veneer) has had reasonably good resistance to decay and termite attack with an average life of 17.5 years in Mississippi. Deterioration has been caused primarily by decay fungi (Table 14).

Butylene oxide stakes treated to 17% to 22% weight gain had an average life of 4.7 years, and those treated to 37% to 40% weight gain had an average life of 12.2 years. Almost 67% of the butylene oxide stakes treated to 31% weight gain are showing attack and 33% have failed after 17 to 21 years in test. Propylene oxide-modified stakes had an average life of 2.2 to 6.2 years, depending on the chemical loading (Table 50). Stakes, ¾-in., treated with butylene oxide to 33.2% weight gain had an average life of 3.5 years (Table 56).

Status of FPL–RN–02 Research Plots

The FPL maintains 77 field research plots on the Harrison Experimental Forest in Saucier, Mississippi. The objective of these plots is to evaluate the performance of wood products exposed to natural environmental challengers. Many plots are approaching 65 years of age, and as a whole they represent an investment of millions of research dollars. Many older plots cannot be duplicated or replaced because several of the preservatives initially used have been discontinued or banned by the U.S. Environmental Protection Agency.

Recommendations for the 77 existing stake plots at the Harrison Experimental Forest were made in 1995 by the FPL and are summarized in the following list. For plots that were closed, the stakes remain in the ground at the site, but inspections were discontinued, and the database maintained in archival records. For the plots that remain open, stakes will be evaluated every fifth year.

Status of FPL-RN-02 research plots

Status[a]	Table	Plot	Installed	Last inspected	Status[a]	Table	Plot	Installed	Last inspected
C	2	2	1939	1966	C	40	58	1960	1978
C	3	3	1940	1967	K	41	56	1960	2009
C	4	4	1940	2000	C	42	59	1961	2000
C	5	5	1941	1996	K	43	62	1963	2008
C	6	6	1941	1996	C	44	63	1963	2000
C	7	7	1942	1992	C	45	61	1963	1998
C	8	8	1942	1963	C	46	66	1967	1997
C	9	9	1942	1997	K	47	67	1967	2007
C	10	10	1946	1960	K	48	68	1971	2011
C	11	11	1942	1950	K	49	70	1973	2008
C	12	12	1943	1963	C	50	71	1974	1995
C	13	13	1943	1950	K	51	72	1975	2009
K	14	14	1944	2004	K	52	73	1975	2009
K	15	15	1945	2005	K	53	74	1976	1993
C	16	16	1945	1996	K	54	75	1976	1993
C	17	20	1948	1998	K	55	78	1978	2008
C	18	24	1948	1992	C	56	79	1979	1989
C	19	25	1948	1998	K	57	80	1980	2009
K	20	28	1949	2010	C	58	81	1980	2000
C	21	26	1949	1995	K	59	82	1980	2009
C	22	27	1949	1999	C	60	83	1981	2000
C	23	34	1952	1997	K	61	84	1981	2011
C	24	33	1952	1997	K	62	85	1981	2011
C	25	35	1952	1997	C	63	86	1982	1996
C	26	32	1952	2002	C	64	87	1982	1996
C	27	36	1952	1993	C	65	88	1982	1996
C	28	37	1952	2000	C	66	89	1982	1996
C	29	38	1953	1992	C	67	90	1982	1999
C	30	40	1954	1995	C	68	92	1983	1995
C	31	41	1954	1995	C	68	93	1983	1995
C	32	42	1954	1995	C	69	94	1984	2000
C	33	44	1956	1981	K	70	95	1984	2009
K	34	47	1956	2011	C	71	96	1984	1996
C	35	48	1957	2000	K	72	97	1985	2009
C	36	53	1958	1967	K	73	98	1985	2010
C	37	55	1959	1989	K	74	99	1987	2007
C	38	54	1958	1968	K	75	100	1988	2008
K	39	57	1960	2009	C	76	101	1989	1998

[a]C indicates maintain archives, plot closed. K indicates keep plot open, study will continue.

Units of Measure

Measurement values in this document are reported in English units. The following provides equivalent International System (SI) units of measure:

English unit	Conversion factor	SI unit
inc h (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
pounds per cubic foot (lb/ft^3)	16.02	kilograms per cubic meter (kg/m^3)
$T_{\circ F}$	$T_{\circ C} = (T_{\circ F} - 32)/ 1.8$	$T_{\circ C}$

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Hunt, G.M.; Snyder, T.E. 1930. An international termite exposure test. In: Proceedings of the American Wood-Preservers. Association, January 28−30. 318−334. [Annual progress reports published in the above Proceedings each year from 1930 to 1949, 1952, 1956, 1957 (final report).]

Table 1–Index to materials tested

Material	Previous or existing specification or AWPA[a] reference	Table number
Chemical		
Acid copper chromate	Fed. Spec. TT-W-546; AWPA P5	15, 16, 46, 47
Acrylonitrile	–	36
Aldrin	–	41
Ammonical copper arsenate	Fed. Spec. TT-W-549; AWPA P5	14, 47, 51, 52, 55, 72
Ammonical copper borate	–	52
Ammonical copper zinc arsenate	–	62
Ammonium hydroxide	–	36
Ammonium sulfate-phosphate	Navy Spec. 51C38	13
Amyl phenyl acetate	–	14
Basic zinc chloride	–	26
Basilit UA	–	30
Boliden salt S-25	–	24
Borax-boric acid	Navy Spec. 51C38	13
Capric acid	–	14
Chloro-2-phenylphenol	–	5, 8
Chromated copper arsenate	Fed. Spec. TT-W-550; Type I; AWPA P5; AWPA P5, Type A	15, 47
Chromated copper arsenate	Fed. Spec. TT-W-550; Type II; AWPA P5, Type B	20, 47
Chromated copper arsenate	Fed. Spec. TT-W-550; Type III; AWPA P5, Type C	48, 49, 41, 55, 57, 72 73, 74
Chromated copper fluoride (CFK)	–	59
Chromated zinc arsenate	Formerly in Fed. Spec. TT-W-538; AWPA P5	4, 24
Chromated zinc chloride	Fed. Spec. TT-W-551; AWPA P5	2, 16, 25, 35, 47
Chromated zinc chloride, copperized	Formerly in Fed. Spec. TT-W-562; AWPA P5	31
Chromated zinc chloride (FR)	AWPA P10, Type B	25
Copper arsenate	AWPA Proc. 1941; pp. 23-31	9
Copper carbonate	–	74
Copper chromate	AWPA Proc. 1941; pp. 23-31	9
Copper-chrome boron (CB)	U.S. Patent No. 3,007,844	46
Copper-chrome-phosphorus	–	48
Copper formate	–	34
Copper naphthenate	AWPA P8	7, 12, 16, 17, 29
Copper oxide	–	74
Copper-8-quinolinolate	AWPA P8	38, 43, 54, 61
Creosote, coal-tar	Fed. Spec. TT-C-645; AWPA P1	4, 5, 6, 8, 16, 17, 18, 19 20, 31, 35, 47, 63, 66
Creosote, coal-tar (English)	–	18, 19
Creosote, coal-tar (low temperature)	–	28
Creosote, coal-tar (Texas lignite)	–	32
Creosote-coal tar solution	Fed. Spec. TT-C-650; AWPA P2	18, 47, 70
Creosote-petroleum solution	Fed. Spec. TT-W-568	18, 47, 70
Creosote-low xylene insolubles	–	75
Creosote toluene	–	6

Table 1–Index to materials tested–cont.

Material	Previous or existing specification or AWPA[a] reference	Table number
Chemical–continued		
Heptadecyltrimethyltetra-hydropyrimidine (HTTP)	–	44
KP (copper oxide and chlorophenol)	–	35
Lignite-tar extracts	–	39
Mercuric chloride	–	12
Minalith	AWPA P10, Type C	25
Nickel-chromium-arsenic salt	–	15
Nickel-sterate	–	14
Oleo resin	–	27
Paraffin	–	32
Pentachlorophenol	Fed. Spec. TT-W-570; AWPA P8	5, 8, 12, 16, 17, 22, 23, 27, 29, 31, 32 33, 41, 42, 43, 45, 47, 49, 54, 58, 60, 61, 63, 64, 65, 68, 69, 71, 76
Petroleum oils (various types)	–	17, 18, 21, 23, 45, 69, 76
Phenyl mercury oleate	–	12
Phenol-formaldehyde	–	67
Pyresote	AWPA P10, Type D	25
Rosin amine D copper acetate complex	–	27
Rosin amine D pentachlorophenate	–	22, 23
Rosin oil	–	27
Sodium pentachlorophenate	–	2, 5
Sodium tetrachlorophenate	–	2
Tetrachlorophenol	–	65, 69
Toluene	–	6,
Tributyltin oxide	–	36, 41, 61
Urea	–	10
Zinc-arsenate-chromium salts	–	20
Zinc chloride	–	2, 4, 20, 26
Zinc naphthenate	–	7, 8
Modified woods, particleboard, plywood		
Acetylated wood	–	14
Butylene oxide	U.S. Patent No. 3,985,921	50, 56
Cyanoethylated wood	–	36
Embedded fiberboard	–	40
Epichlorohydrin	–	50
Heat-stabilized wood (staypak)	–	11
Impreg and compreg	–	3
Laminated paper plastic (papreg)	–	11
Mold-infected wood	–	31
Particleboard	–	49
Plywood	–	3, 8, 16, 33, 51
Propylene oxide	U.S. Patent No. 3,985,921	50
Wood with thiamine destroyed	–	36

[a]American Wood Preservers' Association.

Table 2–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with chlorinated phenols and with fluor chrome arsenate phenol–Type A, zinc chloride, and chromated zinc chloride after 15 to 28 years in test. Stakes placed in test at Barro Colorado Island, Canal Zone, September 1938; Bogalusa, Louisiana, December 1939; Jacksonville, Florida, January 1939; Harrison Experimental Forest, Saucier, Mississippi, December 1938; and Madison, Wisconsin, November 1939 (Plot 2)

						Condition of stakes December 1966[c] (%)									
							Serviceable but showing some–			Destroyed by–					
		Retention of salts[a] (lb/ft^3)			Number in test[b]	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed		Average life
Preservative	Location	Minimum	Maximum	Average									Number	%	(year)
Sodium pentachlorophenate	Canal	0.24	0.28	0.26	10	–	–	–	–	–	–	100	10	100	6.9
	LA	0.24	0.28	0.26	10	–	–	–	–	10	–	90	10	100	9.2
	FL	0.25	0.28	0.26	9	–	–	–	–	11	–	89	9	100	14.2
	MS	0.24	0.28	0.26	10	–	–	–	–	10	20	70	10	100	11.9
	WI	0.24	0.28	0.26	10	–	–	–	–	100	–	–	10	100	12.5
	Canal	0.45	0.54	0.50	10	–	–	–	–	–	20	80	10	100	11.2
	LA	0.45	0.53	0.49	10	–	–	–	–	30	–	70	10	100	10.7
	FL	0.46	0.55	0.50	10	–	–	–	–	–	–	8	8	80	20.0[d]
	MS	0.44	0.54	0.49	10	–	–	–	–	10	–	90	10	100	19.2
	WI	0.44	0.53	0.49	10	–	–	–	–	100	–	–	10	100	16.4
	Canal	0.69	0.81	0.75	10	–	–	–	–	10	20	70	10	100	11.7
	LA	0.69	0.85	0.75	10	–	–	–	–	10	–	90	10	100	15.6
	FL	0.68	0.82	0.74	10	–	–	–	40	10	–	50	6	60	20.0[d]
	MS	0.69	0.84	0.77	10	–	–	–	–	40	–	60	10	100	21.6
	WI	0.67	0.81	0.76	10	–	–	–	–	100	–	–	10	100	21.0
	Canal	0.92	1.06	0.98	10	–	–	–	–	–	10	90	10	100	14.3
	LA	0.93	1.09	0.99	10	–	–	–	–	10	–	90	10	100	16.2
	FL	0.92	1.08	0.98	10	–	–	–	60	10	–	30	4	40	–
	MS	0.93	1.09	0.97	10	–	–	–	–	20	–	80	10	100	25.0
	WI	0.86	1.01	0.90	10	–	–	–	–	100	–	–	10	100	23.4
Sodium tetrachlorophenate	Canal	0.24	0.27	0.25	10	–	–	–	–	–	60	40	10	100	4.8
	LA	0.23	0.27	0.25	10	–	–	–	–	20	–	80	10	100	8.1
	FL	0.23	0.28	0.25	9	–	–	–	–	22	–	78	9	100	11.3
	MS	0.23	0.27	0.25	10	–	–	–	–	–	10	90	10	100	10.7
	WI	0.24	0.27	0.25	10	–	–	–	–	100	–	–	10	100	11.4
	Canal	0.47	0.56	0.51	10	–	–	–	–	–	20	80	10	100	9.9
	LA	0.46	0.55	0.50	10	–	–	–	–	20	–	80	10	100	10.9
	FL	0.47	0.55	0.52	10	–	–	–	–	–	–	100	10	100	15.3
	MS	0.48	0.58	0.52	10	–	–	–	–	–	–	100	10	100	15.1
	WI	0.47	0.55	0.52	10	–	–	–	–	100	–	–	10	100	14.5

Table 2–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with chlorinated phenols and with fluor chrome arsenate phenol–Type A, zinc chloride, and chromated zinc chloride after 15 to 28 years in test. Stakes placed in test at Barro Colorado Island, Canal Zone, September 1938; Bogalusa, Louisiana, December 1939; Jacksonville, Florida, January 1939; Harrison Experimental Forest, Saucier, Mississippi, December 1938; and Madison, Wisconsin, November 1939 (Plot 2)–cont.

						Condition of stakes December 1966[c] (%)									
							Serviceable but showing some–			Destroyed by–					
		Retention of salts[a] (lb/ft^3)			Number in				Decay and			Decay fungi and	Total removed		Average life
Preservative	Location	Minimum	Maximum	Average	test[b]	Good	Decay	Termite attack	termite attack	Decay fungi	Termite attack	termite attack	Number	%	(year)
Sodium tetrachlorophenate (continued)	Canal	0.70	0.83	0.76	10	–	–	–	–	–	–	100	10	100	13.1
	LA	0.71	0.83	0.77	10	–	–	–	–	30	–	70	10	100	11.9
	FL	0.68	0.83	0.76	9	–	–	–	–	–	11	89	9	100	16.8
	MS	0.68	0.82	0.75	10	–	–	–	–	–	–	100	10	100	19.7
	WI	0.67	0.81	0.75	9	–	–	–	–	100	–	–	9	100	16.7
Fluor chrome arsenate phenol – Type A	Canal	0.18 (0.11)	0.22 (0.14)	0.20 (0.12)	10	–	–	–	–	–	100	–	10	100	2.9
	LA	0.19 (0.12)	0.22 (0.14)	0.20 (0.12)	10	–	–	–	–	50	–	50	10	100	9.6
	FL	0.18 (0.11)	0.21 (0.13)	0.20 (0.12)	10	–	–	–	–	50	–	50	10	100	13.9
	MS	0.18 (0.11)	0.21 (0.13)	0.20 (0.12)	10	–	–	–	–	10	50	40	10	100	10.2
	WI	0.13 (0.08)	0.22 (0.14)	0.20 (0.12)	10	–	–	–	–	100	–	–	10	100	13.8
	Canal	0.28 (0.17)	0.33 (0.20)	0.30 (0.19)	10	–	–	–	–	–	30	70	10	100	6.4
	LA	0.28 (0.17)	0.32 (0.20)	0.30 (0.19)	10	–	–	–	–	20	–	80	10	100	13.7
	FL	0.29 (0.18)	0.32 (0.20)	0.30 (0.19)	10	–	–	–	–	100	–	–	10	100	15.4
	MS	0.29 (0.18)	0.32 (0.20)	0.30 (0.19)	10	–	–	–	–	10	–	90	10	100	18.0
	WI	0.27 (0.17)	0.30 (0.19)	0.28 (0.17)	10	–	–	–	–	100	–	–	10	100	16.5
	Canal	0.53 (0.33)	0.66 (0.41)	0.60 (0.37)	10	–	–	–	–	40	–	60	10	100	14.2
	LA	0.56 (0.35)	0.64 (0.40)	0.60 (0.37)	10	–	–	–	–	50	–	50	10	100	15.6
	FL	0.57 (0.35)	0.65 (0.40)	0.61 (0.38)	10	–	–	–	–	100	–	–	10	100	17.3
	MS	0.57 (0.35)	0.65 (0.40)	0.61 (0.38)	10	–	–	–	–	60	–	40	10	100	24.1
	WI	0.59 (0.36)	0.68 (0.42)	0.65 (0.40)	10	–	–	–	–	100	–	–	10	100	16.0
Sodium pentachlorophenate and sodium chloride[e]	Canal	0.52	0.55	0.54	10	–	–	–	–	–	30	70	10	100	8.7
	LA	0.46	0.53	0.49	10	–	–	–	–	–	–	100	10	100	13.3
	FL	0.48	0.54	0.50	10	–	–	–	50	10	–	40	5	50	–
	MS	0.46	0.53	0.49	10	–	–	–	–	–	–	100	10	100	16.3
	WI	0.46	0.53	0.50	10	–	–	–	–	100	–	–	10	100	16.8
Zinc chloride	Canal	0.44 (0.26)	0.53 (0.32)	0.47 (0.28)	10	–	–	–	–	–	30	70	10	100	3.9
	LA	0.45 (0.27)	0.55 (0.33)	0.50 (0.30)	10	–	–	–	–	30	–	70	10	100	8.2
	FL	0.45 (0.27)	0.53 (0.32)	0.49 (0.29)	10	–	–	–	–	20	–	80	10	100	12.9
	MS	0.45 (0.27)	0.54 (0.32)	0.50 (0.30)	10	–	–	–	–	40	–	60	10	100	15.4
	WI	0.45 (0.27)	0.53 (0.32)	0.49 (0.29)	10	–	–	–	–	100	–	–	10	100	18.3

Table 2–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with chlorinated phenols and with fluor chrome arsenate phenol–Type A, zinc chloride, and chromated zinc chloride after 15 to 28 years in test. Stakes placed in test at Barro Colorado Island, Canal Zone, September 1938; Bogalusa, Louisiana, December 1939; Jacksonville, Florida, January 1939; Harrison Experimental Forest, Saucier, Mississippi, December 1938; and Madison, Wisconsin, November 1939 (Plot 2)–cont.

						Condition of stakes December 1966[c] (%)									
							Serviceable but showing some–			Destroyed by–					
		Retention of salts[a] (lb/ft^3)			Number in test[b]	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed		Average life
Preservative	Location	Minimum	Maximum	Average									Number	%	(year)
Zinc chloride (continued)	Canal	0.70 (0.42)	0.82 (0.49)	0.76 (0.45)	10	–	–	–	–	–	–	100	10	100	3.9
	LA	0.70 (0.42)	0.78 (0.47)	0.74 (0.44)	10	–	–	–	–	40	–	60	10	100	12.1
	FL	0.71 (0.42)	0.82 (0.49)	0.76 (0.45)	10	–	–	–	–	40	–	60	10	100	13.5
	MS	0.70 (0.42)	0.79 (0.47)	0.74 (0.44)	10	–	–	–	–	20	10	70	10	100	16.7
	WI	0.65 (0.39)	0.87 (0.52)	0.75 (0.45)	9	–	–	–	–	100	–	–	9	100	18.9
	Canal	0.94 (0.56)	1.08 (0.64)	1.00 (0.60)	10	–	–	–	–	–	40	60	10	100	4.0
	LA	0.94 (0.56)	1.08 (0.64)	1.01 (0.60)	10	–	–	–	–	70	–	30	10	100	11.6
	FL	0.95 (0.57)	1.08 (0.64)	1.02 (0.61)	10	–	–	–	–	20	–	80	10	100	15.2
	MS	0.94 (0.56)	1.07 (0.64)	1.01 (0.60)	10	–	–	–	–	10	–	90	10	100	17.3
	WI	0.93 (0.56)	1.13 (0.68)	1.02 (0.61)	10	–	–	–	–	100	–	–	10	100	19.0
	Canal	1.40 (0.84)	1.62 (0.97)	1.49 (0.89)	10	–	–	–	–	–	10	90	10	100	7.3
	LA	1.44 (0.86)	1.63 (0.97)	1.52 (0.91)	10	–	–	–	–	40	–	60	10	100	11.1
	FL	1.41 (0.84)	1.62 (0.97)	1.50 (0.89)	10	–	–	–	–	20	–	80	10	100	15.7
	MS	1.43 (0.85)	1.63 (0.97)	1.52 (0.91)	10	–	–	–	–	50	–	50	10	100	17.9
	WI	1.36 (0.81)	1.74 (1.04)	1.59 (0.94)	10	–	–	–	–	100	–	–	10	100	18.7
Chromated zinc chloride	Canal	0.45 (0.28)	0.55 (0.34)	0.49 (0.30)	10	–	–	–	–	–	–	100	10	100	4.9
	LA	0.46 (0.28)	0.55 (0.34)	0.49 (0.30)	10	–	–	–	–	40	10	50	10	100	8.6
	FL	0.45 (0.28)	0.53 (0.33)	0.48 (0.30)	8	–	–	–	–	25	–	75	8	100	14.3
	MS	0.45 (0.28)	0.55 (0.34)	0.49 (0.30)	10	–	–	–	–	30	10	60	10	100	14.2
	WI	0.43 (0.26)	0.53 (0.33)	0.46 (0.29)	10	–	–	–	–	100	–	–	10	100	16.2
	Canal	0.70 (0.43)	0.81 (0.50)	0.76 (0.47)	10	–	–	–	–	–	–	100	10	100	7.2
	LA	0.70 (0.43)	0.80 (0.49)	0.76 (0.47)	10	–	–	–	–	40	–	60	10	100	10.6
	FL	0.73 (0.45)	0.81 (0.50)	0.77 (0.47)	9	–	–	–	–	11	–	89	9	100	15.9
	MS	0.72 (0.44)	0.81 (0.50)	0.76 (0.47)	10	–	–	–	–	40	–	60	10	100	20.2
	WI	0.70 (0.43)	0.86 (0.53)	0.80 (0.49)	10	–	–	–	–	100	–	–	10	100	14.7
	Canal	0.95 (0.48)	1.11 (0.68)	1.02 (0.63)	10	–	–	–	–	10	–	90	10	100	6.6
	LA	0.93 (0.57)	1.07 (0.66)	1.00 (0.62)	10	–	–	–	–	40	–	60	10	100	11.9
	FL	0.96 (0.59)	1.09 (0.67)	1.03 (0.63)	10	–	–	–	10	20	–	70	9	90	17.0[d]
	MS	0.96 (0.59)	1.09 (0.67)	1.03 (0.63)	10	–	–	–	–	50	–	50	10	100	20.1
	WI	0.89 (0.55)	1.13 (0.70)	1.02 (0.63)	10	–	–	–	–	100	–	–	10	100	18.3

Table 2–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with chlorinated phenols and with fluor chrome arsenate phenol–Type A, zinc chloride, and chromated zinc chloride after 15 to 28 years in test. Stakes placed in test at Barro Colorado Island, Canal Zone, September 1938; Bogalusa, LA, December 1939; Jacksonville, Florida, January 1939; Harrison Experimental Forest, Saucier, Mississippi, December 1938; and Madison, Wisconsin, November 1939 (Plot 2)–cont.

						Condition of stakes December 1966[c] (%)									
							Serviceable but showing some–			Destroyed by–					
		Retention of salts[a] (lb/ft^3)			Number in test[b]	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed		Average life
Preservative	Location	Minimum	Maximum	Average									Number	%	(year)
Untreated controls	Canal	–	–	–	10	–	–	–	–	–	100	–	10	100	0.7
	LA	–	–	–	10	–	–	–	–	20	20	60	10	100	2.9
	FL	–	–	–	10	–	–	–	–	–	10	90	10	100	2.8
	MS	–	–	–	10	–	–	–	–	–	70	30	10	100	2.9
	WI	–	–	–	10	–	–	–	–	100	–	–	10	100	5.7

[a]Retention values in parentheses are based on preservative oxides.

[b]Ten stakes were originally installed at each test station; this number has since been reduced either because of failure to locate the stakes at the time of inspection or because of damage by fire.

[c]Final inspection at Canal Zone, January 1956; at Louisiana, December 1958; at Florida, December 1960; at Wisconsin, October 1964; and at Mississippi, December 1966.

[d]Estimate based on percentage of stakes remaining after final inspection.

[e]Retention values based on sodium pentachlorophenate only. Sodium chloride added was equal to 20% of weight of sodium pentachlorophenate in solution.

This study was initiated by R. M. Wirka.

Table 3–Condition of plywood stakes and resin-impregnated stakes set January 1940 on Harrison Experimental Forest, Saucier, Mississippi, after about 27 years in test (Plot 3)

Group	Stake number	Treatment	Approximate average retention (lb/ft^3)	Number in test	Condition of stakes January 1967 (%)									Average life (year)
						Serviceable but showing some–			Destroyed by–			Total removed		
					Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Number	%	
								Plywood[a]						
1	1-1-40 to 1-10-40	Each ply impregnated with a 50% aqueous solut of phenolic resin, slowly dried, and cured for 1 day at 220°F. Bonded with phenolic-resin film	10	8	–	–	–	–	38	–	62	8	100	12.4
2	2-1-40 to 2-10-40	Same as group 1 except that a 25% solution was used	5	10	–	–	–	–	60	–	40	10[c]	100	6.9
3	3-1-40 to 3-10-40	Face plies impregnated as in group 1 and bondec to an untreated core with phenolic-resin film	10[b]	10	–	–	–	–	–	100	–	10[c]	100	3.3
4	4-1-40 to 4-10-40	Face plies impregnated as in group 2 and bondec to an untreated core with phenolic-resin film	5[b]	10	–	–	–	–	–	100	–	10[c]	100	3.5
5	5-1-40 to 5-10-40	Same as group 2 except that edges of specimens were given a protective treatment by dipping in a phenolic resin containing 15% alcohol	10[b]	10	–	–	–	–	20	80	–	10[c]	100	4.9
6	6-1-40 to 6-10-40	Same as group 4 except that edges were protecte as in group 5	5[b]	9	–	–	–	–	22	44	33	9[c]	100	9.4
7	7-1-40 to 7-1-40	Untreated plies bonded with phenolic-resin film	–	10	–	–	–	–	–	70	30	10	100	1.9
8	8-1-40 to 8-10-40	Untreated plies bonded with hot-press urea resin	–	10	–	–	–	–	–	70	30	10	100	1.9
9	9-1-40 to 9-10-40	Untreated plies bonded with casein glue (FPL formula 4B)	–	8	–	–	–	–	–	88	12	8[d]	100	1.0
10	10-1-40 to 10-10-40	Untreated plies (yellow birch) bonded with phenolic-resin flim	–	10	–	–	–	–	10	30	60	10	100	1.9
11	11-1-40 to 11-10-40	Untreated controls–solid wood (1/4 by 4 by 18 in.)	–	10	–	–	–	–	–	80	20	10	100	2.4

Table 3–Condition of plywood stakes and resin-impregnated stakes set January 1940 on Harrison Experimental Forest, Saucier, Mississippi, after about 27 years in test (Plot 3)–cont.

Group	Stake number	Treatment	Approximate average retention (lb/ft^3)	Number in test	Condition of stakes January 1967 (%)									Average life (year)
					Good	Serviceable but showing some–			Destroyed by–			Total removed		
						Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Number	%	
					Stakes (Impreg)[e]									
12	12-1-40 to 12-10-40	Impregnated same as group 1	10	10	–	10	–	10	50	–	30	8	80	19.5[f]
13	13-1-40 to 13-10-40	Impregnated same as group 2	5	10	–	–	–	–	50	–	50	10	100	11.7
14	14-1-40 to 14-10-40	Controls–untreated	–	10	–	–	–	–	–	80	20	10	100	2.5
					Compressed Plywood (Compreg)[g]									
15	15-1-40 to 15-3-40	Douglas-fir–all plies impregnated as in group 1, dried and assembled without the use of glue on a hot press at 330°F and 1,000-lb. pressure per square inch	10	3	100	–	–	–	–	–	–	–	–	–
	15-4-40 to 15-6-40	Yellow-poplar–all plies impregnated and compressed the same as for Douglas-fir	10	3	–	–	–	–	1	–	2	3	100	19.6

[a]Specimens in groups 1 to 9 were three-ply Douglas-fir; in group 10, yellow birch. Specimens were 1/4 by 4 by 18 in. and made of 1/16-in. faces and a 1/8-in. core. Specimens in group 11 were solid Douglas-fir, 1/4 by 4 by 18 in.

[b]Increase based on treated faces.

[c]Deterioration principally in cores.

[d]Some separation of plies had also occurred.

[e]Specimens are Southern Pine sapwood, 2 by 4 nominal by 18 in.

[f]Based on estimated life of 2 remaining stakes.

[g]Douglas-fir and yellow-poplar specimens made of 15-1/15-in. plies, compressed to a thickness of 3/8 in. Specimens were 3/8 by 4 by 14 in.

NOTE–Stakes remaining after the 1952 inspection were taken up and reset in the same general area.

This study was initiated by R. M. Wirka.

Table 4–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with chromated zinc arsenate (Boliden salts), zinc chloride, and coal-tar creosote after 15 to 60 years in test. Stakes placed in test at Madison, Wisconsin, September 1940; Harrison Experimental Forest, Saucier, Mississippi, June 1940; and Barro Colorado Island, Canal Zone, September 1940 (Plot 4)

					Condition of stakes January 2000[a] (%)									
						Serviceable but showing some–			Destroyed by–					
		Average retention (lb/ft^3)		Number in test	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed		Average life
Preservative	Location	Oil	Dry salt[b]									Number	%	(year)
Zinc chloride	WI	–	0.50 (0.30)	10	–	–	–	–	100	–	–	10	100	14.8
	MS	–	0.50 (0.30)	10	–	–	–	–	60	–	40	10	100	14.2
	Canal	–	0.49 (0.29)	10	–	–	–	–	–	–	100	10	100	3.0
	WI	–	1.03 (0.61)	10	–	–	–	–	100	–	–	10	100	19.8
	MS	–	1.02 (0.61)	10	–	–	–	–	60	10	30	10	100	14.4
	Canal	–	1.01 (0.60)	10	–	–	–	–	–	–	100	10	100	3.6
	WI	–	1.51 (0.90)	10	–	–	–	–	100	–	–	10	100	22.3
	MS	–	1.51 (0.90)	10	–	–	–	–	60	–	40	10	100	18.1
	Canal	–	1.49 (0.89)	10	–	–	–	–	–	–	100	10	100	4.5
Chromated zinc	WI	–	0.33 (0.22)	10	–	–	–	–	100	–	–	10	100	19.6
arsenate	MS	–	0.33 (0.22)	10	–	–	–	–	30	–	70	10	100	33.0
(Boliden salts)[c]	Canal	–	0.33 (0.22)	10	–	–	–	–	–	–	100	10	100	9.2
	WI	–	0.44 (0.29)	10	–	–	–	–	100	–	–	10	100	26.1
	MS	–	0.44 (0.29)	9	–	–	–	–	11	–	89	9	100	39.3
	Canal	–	0.44 (0.29)	10	–	–	–	–	30	10	60	10	100	11.6
	WI	–	0.60 (0.40)	9	–	–	–	–	100	–	–	10	100	24.9
	MS	–	0.58 (0.38)	10	–	–	–	–	60	–	40	10	100	51.7
	Canal	–	0.58 (0.38)	10	–	–	–	–	60	40	–	10	100	14.6
	WI	–	0.78 (0.52)	10	–	–	–	–	100	–	–	10	100	34.6
	MS	–	0.78 (0.52)	10	–	–	–	70	10	–	20	3	30	–
	Canal	–	0.78 (0.52)	10	–	–	–	–	100	–	–	10	100	15.1
	WI	–	1.06 (0.70)	9	–	–	–	–	100	–	–	10	100	36.2
	MS	–	1.06 (0.70)	10	–	–	–	10	–	–	–	–	–	–
	Canal	–	1.05 (0.69)	10	–	–	–	–	100	–	–	10	100	15.3

Table 4–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with chromated zinc arsenate (Boliden salts), zinc chloride, and coal-tar creosote after 15 to 60 years in test. Stakes placed in test at Madison, Wisconsin, September 1940; Harrison Experimental Forest, Saucier, Mississippi, June 1940; and Barro Colorado Island, Canal Zone, September 1940 (Plot 4)–cont.

					Condition of stakes January 2000[a] (%)									
						Serviceable but showing some–			Destroyed by–					
		Average retention (lb/ft^3)		Num-ber in				Decay and			Decay fungi and	Total removed		Average life
Preservative	Location	Oil	Dry salt[b]	test	Good	Decay	Termite attack	termite attack	Decay fungi	Termite attack	termite attack	Number	%	(year)
Coal-tar creosote	WI	4.3	–	10	–	–	–	–	100	–	–	10	100	37.9
	MS	4.2	–	10	–	–	–	–	60	–	40	10	100	17.8
	Canal	4.3	–	10	–	–	–	–	40	–	60	10	100	13.4
	WI	8.0	–	7	–	71	–	–	29	–	–	2	29	–
	MS	8.0	–	10	–	–	–	10	40	–	50	9	90	–
	Canal	8.0	–	10	–	60	–	10	30	–	–	3	30	19[d]
	WI	11.8	–	9	33	67	–	–	–	–	–	–	–	–
	MS	11.8	–	10	–	10	–	40	20	–	30	5	50	–
	Canal	11.8	–	10	–	60	–	–	40	–	–	4	40	18[d]
	WI	16.3	–	9	33	56	–	–	11	–	–	1	11	–
	MS	16.5	–	10	–	10	–	80	10	–	–	1	10	–
	Canal	16.5	–	10	–	90	–	10	–	–	–	–	–	–
	WI	1.8[e]	–	10	–	–	–	–	100	–	–	10	100	12.4
	MS	1.8[e]	–	10	–	–	–	–	10	30	60	10	100	7.7
	Canal	1.8[e]	–	10	–	–	–	–	–	80	20	10	100	4.8
	WI	0.71[f]	–	10	–	–	–	–	100	–	–	10	100	8.4
	MS	0.76[f]	–	10	–	–	–	–	–	50	50	10	100	4.2
	Canal	0.76[f]	–	10	–	–	–	–	–	90	10	10	100	2.5
Untreated controls	WI	–	–	10	–	–	–	–	100	–	–	10	100	6.2
	MS	–	–	10	–	–	–	–	–	50	50	10	100	2.2
	Canal	–	–	10	–	–	–	–	–	90	10	10	100	1.1

[a]Final inspection at Canal Zone, January 1956.

[b]Retention values in parentheses are based on preservative oxides.

[c]Retention based upon total anhydrous salts: ZnSO4 + H3AsO4 + Na2HAsO4 + Na2Cr2O7.

[d]Estimate based upon percentage of stakes remaining after final inspection.

[e]15-min dip at room temperature.

[f]Brush treatment, two coats.

This study was initiated by R. M. Wirka.

Table 5–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with chlorinated phenols and coal-tar creosote after 15 to 55 years in test. Stakes placed in test at Barro Colorado Island, Canal Zone, Feburary 1941; Bogalusa, Louisiana, March 1941; Jacksonville, Florida, March 1941; and Harrison Experimental Forest, Saucier, Mississippi, February 1941 (Plot 5)

		Retention of preservative[a] (lb/ft^3)				Condition of stakes January 1996[c] (%)									
							Serviceable but showing some–			Destroyed by–					
Preservative	Location	Minimum	Maximum	Average	Number in test[b]	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed (Number)	Total removed (%)	Average life (year)
Sodium pentachlorophenate	Canal	0.23	0.27	0.25	10	–	–	–	–	–	60	40	10	100	6.4
	LA	0.23	0.26	0.25	10	–	–	–	–	10	–	90	10	100	10.0
	FL	0.23	0.36	0.25	9	–	–	–	–	–	–	100	10	100	14.5
	MS	0.23	0.36	0.25	10	–	–	–	–	20	–	80	10	100	16.9
	Canal	0.31	0.34	0.33	10	–	–	–	–	–	10	90	10	100	10.9
	LA	0.31	0.34	0.33	10	–	–	–	–	–	–	100	10	100	10.4
	FL	0.32	0.34	0.33	8	–	–	–	–	–	12	88	8	100	16.4
	MS	0.31	0.34	0.33	10	–	–	–	–	20	–	80	10	100	19.5
	Canal	0.47	0.55	0.51	10	–	–	–	–	–	20	80	10	100	12.9
	LA	0.48	0.54	0.51	10	–	–	–	–	–	–	100	10	100	15.5
	FL	0.47	0.54	0.50	10	–	–	–	50	–	–	50	5	50	21.0[d]
	MS	0.47	0.55	0.51	10	–	–	–	–	10	–	90	10	100	21.3
	Canal	0.73	0.81	0.77	10	–	–	–	–	50	20	30	10	100	14.3
	LA	0.72	0.82	0.77	8	–	–	–	50	–	–	50	4	50	22.0[d]
	FL	0.72	0.83	0.77	10	–	–	–	80	–	–	20	2	20	27.0[d]
	MS	0.72	0.83	0.77	10	–	–	–	–	–	–	100	10	100	26.2
	Canal	0.92	1.09	0.99	10	–	–	–	–	70	–	30	10	100	14.2
	LA	0.92	1.09	0.99	7	–	–	–	57	–	–	43	3	43	22.0[d]
	FL	0.91	1.10	0.99	9	–	–	–	100	–	–	–	0	0	–
	MS	0.93	1.08	0.99	10	–	–	–	20	30	–	50	8	80	–
Sodium pentachlorophenate and sodium chromate; chemical ratio 3.24:1	Canal	0.41	0.47	0.44	10	–	–	–	–	–	20	80	10	100	11.1
	LA	0.41	0.47	0.44	10	–	–	–	–	–	–	100	10	100	15.6
	FL	0.40	0.47	0.44	9	–	–	–	44	–	–	56	5	56	20.3[d]
	MS	0.40	0.47	0.44	10	–	–	–	–	–	–	100	10	100	23.0
Sodium pentachlorophenate and borax 1:0.76 chemical ratio	Canal	0.54	0.62	0.58	10	–	–	–	–	–	–	100	10	100	12.8
	LA	0.54	0.62	0.58	9	–	–	–	–	11	–	89	9	100	11.3
	FL	0.53	0.62	0.57	8	–	–	–	–	–	–	100	10	100	17.9
	MS	0.54	0.61	0.58	10	–	–	–	–	20	–	80	10	100	21.0
1:2 chemical ratio	Canal	0.71	0.80	0.75	10	–	–	–	–	–	–	100	10	100	12.2
	LA	0.71	0.81	0.75	10	–	–	–	–	10	–	90	10	100	9.9
	FL	0.72	0.82	0.76	10	–	–	–	–	–	–	100	10	100	12.9
	MS	0.71	0.80	0.75	10	–	–	–	–	–	–	100	10	100	18.8

Table 5–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with chlorinated phenols and coal-tar creosote after 15 to 55 years in test. Stakes placed in test at Barro Colorado Island, Canal Zone, Feburary 1941; Bogalusa, Louisiana, March 1941; Jacksonville, Florida, March 1941; and Harrison Experimental Forest, Saucier, Mississippi, February 1941 (Plot 5)

Preservative	Location	Retention of preservative[a] (lb/ft^3) Minimum	Maximum	Average	Number in test[b]	Condition of stakes January 1996[c] (%) Serviceable but showing some– Good	Decay	Termite attack	Decay and termite attack	Destroyed by– Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	%	Average life (year)
1:1.52 chemical ratio	Canal	0.78	0.88	0.83	10	–	–	–	–	50	–	50	10	100	13.0
	LA	0.77	0.88	0.82	10	–	–	–	–	30	–	70	10	100	10.0
	FL	0.79	0.86	0.82	9	–	–	–	–	–	–	100	10	100	16.7
	MS	0.79	0.87	0.83	10	–	–	–	–	–	–	100	10	100	18.9
1:3 chemical ratio	Canal	0.91	1.06	0.98	10	–	–	–	–	–	–	100	10	100	11.5
	LA	0.90	1.07	0.98	10	–	–	–	–	10	–	90	10	100	8.9
	FL	0.92	1.05	0.98	10	–	–	–	–	–	–	100	10	100	13.2
	MS	0.92	1.06	0.98	10	–	–	–	–	10	–	90	10	100	16.1
1:2.27 chemical ratio	Canal	1.00	1.19	1.09	10	–	–	–	–	–	–	100	10	100	12.7
	LA	1.01	1.16	1.09	10	–	–	–	–	20	–	80	10	100	9.9
	FL	1.01	1.18	1.09	10	–	–	–	–	–	–	100	10	100	18.6
	MS	1.01	1.18	1.09	10	–	–	–	–	–	–	100	10	100	18.6
1:1.50 chemical ratio	Canal	1.17	1.32	1.25	10	–	–	–	–	10	–	90	10	100	12.8
	LA	1.17	1.32	1.25	10	–	–	–	–	–	–	100	10	100	14.6
	FL	1.17	1.32	1.25	10	–	–	–	20	10	–	70	8	80	16.5[d]
	MS	1.17	1.33	1.25	10	–	–	–	–	10	10	80	10	100	20.9
5% pentachlorophenol	Canal	4.0	5.4	4.7	10	–	–	–	–	40	–	60	10	100	13.0
in fuel oil[e]	LA	4.0	5.4	4.8	10	–	–	–	–	–	–	100	10	100	16.6
	FL	4.0	5.6	4.8	10	–	–	–	40	–	–	60	6	60	20.0[d]
	MS	4.2	5.4	4.7	10	–	–	–	–	–	–	100	10	100	21.0
	Canal	8.6	10.5	9.6	10	–	–	–	–	30	–	70	10	100	14.4
	LA	8.4	10.9	9.6	7	–	–	–	57	–	–	43	3	43	23.0[d]
	FL	8.8	10.5	9.6	9	–	–	–	67	–	–	33	3	33	24.0[d]
	MS	8.6	10.5	9.6	10	–	–	–	–	10	–	90	10	100	27.2
	Canal	14.0	16.5	15.3	10	–	–	–	40	10	–	50	6	60	15.0[d]
	LA	14.2	16.3	15.3	7	–	–	–	100	–	–	–	–	–	–
	FL	14.2	16.3	15.3	10	–	–	–	100	–	–	–	–	–	–
	MS	14.0	16.3	15.3	10	–	–	–	50	10	–	40	5	50	–
	Canal	18.6	21.5	20.1	10	–	–	–	100	–	–	–	–	–	–
	LA	18.2	21.7	20.1	7	–	–	–	100	–	–	–	–	–	–
	FL	18.2	21.7	20.1	9	–	22	–	78	–	–	–	–	–	–
	MS	18.2	21.9	20.0	9	–	–	–	89	–	–	11	1	11	–

Table 5–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with chlorinated phenols and coal-tar creosote after 15 to 55 years in test. Stakes placed in test at Barro Colorado Island, Canal Zone, Feburary 1941; Bogalusa, Louisiana, March 1941; Jacksonville, FL, March 1941; and Harrison Experimental Forest, Saucier, Mississippi, February 1941 (Plot 5)

		Retention of preservative[a] (lb/ft^3)				Condition of stakes January 1996[c] (%)									
							Serviceable but showing some–			Destroyed by–					
Preservative	Location	Minimum	Maximum	Average	Number in test[b]	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
3% pentachlorophenol + 2% chloro-2-phenylphenol in fuel oil[e]	Canal	4.2	5.8	4.9	10	–	–	–	–	20	–	80	10	100	12.6
	LA	4.4	5.8	4.9	10	–	–	–	–	–	–	100	10	100	14.2
	FL	4.4	5.8	4.9	9	–	–	–	22	–	–	78	7	78	20.0[d]
	MS	4.2	5.8	4.9	10	–	–	–	–	–	–	100	10	100	19.2
	Canal	9.1	10.9	10.0	10	–	–	–	–	50	–	50	10	100	13.7
	LA	9.1	10.9	10.0	6	–	–	–	67	–	–	33	2	33	24.7[d]
	FL	8.9	11.0	10.0	8	–	–	–	75	–	–	25	2	25	25.3[d]
	MS	8.9	11.0	10.0	10	–	–	–	–	10	–	90	10	100	24.4
	Canal	14.2	16.3	15.4	10	–	–	–	10	10	–	80	9	90	12.0[d]
	LA	13.8	16.3	15.3	6	–	–	–	100	–	–	–	–	–	–
	FL	13.8	16.3	15.3	9	–	–	–	100	–	–	–	–	–	–
	MS	14.4	16.1	15.3	10	–	–	–	–	40	–	60	10	100	31.9
Coal-tar creosote, grade 1	Canal	3.5	6.7	4.7	10	–	–	–	10	90	–	–	9	90	12.0[d]
	LA	3.3	6.7	4.6	6	–	–	–	33	–	–	67	4	67	22.0[d]
	FL	3.3	6.5	4.7	9	–	–	–	33	33	–	33	6	67	19.0[d]
	MS	3.5	6.5	4.6	10	–	–	–	–	40	–	60	10	100	21.3
	Canal	8.4	11.6	10.0	10	–	60	–	20	10	–	10	2	20	20.0[d]
	LA	8.6	11.2	10.0	4	–	–	–	75	–	–	25	1	25	26.6[d]
	FL	8.6	11.4	10.0	10	–	–	–	90	10	–	–	1	10	–
	MS	8.4	11.4	10.0	10	–	–	–	10	60	–	30	9	90	–
	Canal	13.5	15.4	14.4	10	10	90	–	–	–	–	–	–	–	–
	LA	13.5	15.9	14.5	6	50	17	17	17	–	–	–	–	–	–
	FL	13.5	15.9	14.4	9	22	56	–	22	–	–	–	–	–	–
	MS	13.3	16.1	14.5	10	–	–	–	100	–	–	–	–	–	–
Fuel oil[e]	Canal	8.2	11.9	9.9	10	–	–	–	–	–	60	40	10	100	5.9
	LA	8.4	11.7	9.8	10	–	–	–	–	40	–	60	10	100	8.4
	FL	8.2	11.7	9.8	8	–	–	–	–	12	–	88	8	100	9.7
	MS	8.2	11.7	9.8	10	–	–	–	–	20	10	70	10	100	6.3
	Canal	18.2	21.0	19.4	10	–	–	–	–	–	30	70	10	100	7.8
	LA	18.2	21.4	19.4	10	–	–	–	–	50	–	50	10	100	11.9
	FL	18.2	21.4	19.4	9	–	–	–	–	–	–	100	10	100	12.4
	MS	18.0	21.9	19.4	10	–	–	–	–	30	10	60	10	100	9.1

Table 5–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with chlorinated phenols and coal-tar creosote after 15 to 55 years in test. Stakes placed in test at Barro Colorado Island, Canal Zone, Feburary 1941; Bogalusa, Louisiana, March 1941; Jacksonville, Florida, March 1941; and Harrison Experimental Forest, Saucier, Mississippi, February 1941 (Plot 5)

		Retention of preservative[a] (lb/ft^3)				Condition of stakes January 1996[c] (%)									
							Serviceable but showing some–			Destroyed by–					
Preservative	Location	Minimum	Maximum	Average	Number in test[b]	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed (Number)	Total removed (%)	Average life (year)
5% pentachlorophenol in fuel oil[e] and naphtha 3-min dip	Canal	0.5	1.4	0.8	10	–	–	–	–	–	90	10	10	100	2.7
	LA	0.5	1.2	0.8	10	–	–	–	–	30	–	70	10	100	4.2
	FL	0.5	1.2	0.8	8	–	–	–	–	12	–	88	8	100	5
	MS	0.5	1.2	0.8	10	–	–	–	–	10	20	70	10	100	3.2
18-h soak	Canal	2.1	2.6	2.4	10	–	–	–	–	–	–	100	10	100	9.1
	LA	2.1	2.8	2.4	9	–	–	–	–	33	–	67	9	100	8.4
	FL	2.1	3.0	2.4	10	–	–	–	–	–	–	100	10	100	11.9
	MS	1.9	3.0	2.4	10	–	–	–	–	–	–	100	10	100	12.9
5% pentachlorophenol in soybean oil, naphtha and fuel oil [e,f] 3-min dip	Canal	0.7	1.2	0.9	10	–	–	–	–	–	100	–	10	100	3.3
	LA	0.5	1.2	0.9	10	–	–	–	–	50	–	50	10	100	3.9
	FL	0.5	1.6	0.9	7	–	–	–	–	–	14	86	7	100	5.4
	MS	0.7	1.2	0.9	10	–	–	–	–	–	60	40	10	100	4.9
18-h soak	Canal	2.3	3.7	2.8	10	–	–	–	–	–	–	100	10	100	10.4
	LA	2.1	3.9	2.8	10	–	–	–	–	30	–	70	10	100	7.6
	FL	2.3	3.2	2.7	10	–	–	–	–	–	–	100	10	100	12.2
	MS	2.3	3.5	2.8	10	–	–	–	–	–	–	100	10	100	16.3
18-h soak[g]	Canal	1.1	3.0	2.3	10	–	–	–	–	–	30	70	10	100	7
	LA	1.8	2.6	2.3	10	–	–	–	–	20	–	80	10	100	6.3
	FL	1.8	2.8	2.3	8	–	–	–	–	12	–	88	8	100	9.8
	MS	1.1	2.8	2.2	10	–	–	–	–	10	10	80	10	100	11.9
3% pentachlorophenol + 2% chloro-2-phenylphenol in naphtha and fuel oil 3-min dip	Canal	0.9	1.6	1.2	10	–	–	–	–	–	100	–	10	100	2.3
	LA	0.9	1.6	1.2	10	–	–	–	–	40	–	60	10	100	4.1
	FL	0.7	1.6	1.2	10	–	–	–	–	10	10	80	10	100	5
	MS	0.5	1.8	1.2	10	–	–	–	–	20	20	60	10	100	5.3
18-h soak	Canal	2.5	4.0	3.1	10	–	–	–	–	–	10	90	10	100	9
	LA	2.5	4.0	3.1	10	–	–	–	–	10	–	90	10	100	7.2
	FL	2.3	3.9	3.1	8	–	–	–	–	12	–	88	8	100	10.8
	MS	2.6	4.4	3.1	10	–	–	–	–	–	–	100	10	100	13.8

Table 5–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with chlorinated phenols and coal-tar creosote after 15 to 55 years in test. Stakes placed in test at Barro Colorado Island, Canal Zone, Feburary 1941; Bogalusa, Louisiana, March 1941; Jacksonville, FL, March 1941; and Harrison Experimental Forest, Saucier, Mississippi, February 1941 (Plot 5)

						Condition of stakes January 1996[c] (%)									
							Serviceable but showing some–			Destroyed by–					
		Retention of preservative[a] (lb/ft^3)			Number in test[b]				Decay and termite attack			Decay fungi and termite attack	Total removed		Average life
Preservative	Location	Minimum	Maximum	Average		Good	Decay	Termite attack		Decay fungi	Termite attack		Number	%	(year)
3% pentachlorophenol + 2% chloro-2-phenylphenol in solvent of 80% mineral spirits and 20% moisture repellant 3-min dip	Canal	0.5	0.9	0.8	10	–	–	–	–	–	90	10	10	100	1.6
	LA	0.5	0.9	0.7	10	–	–	–	–	30	–	70	10	100	3.9
	FL	0.5	0.9	0.8	10	–	–	–	–	20	10	70	10	100	2.8
	MS	0.5	0.9	0.8	10	–	–	–	–	20	30	50	10	100	3.6
18-h soak	Canal	2.1	5.8	3.4	10	–	–	–	–	–	90	10	10	100	4.8
	LA	2.3	4.6	3.4	10	–	–	–	–	–	–	100	10	100	9.2
	FL	2.3	4.9	3.4	10	–	–	–	–	20	–	80	10	100	9.6
	MS	2.3	5.1	3.4	10	–	–	–	–	20	10	70	10	100	12.7
Untreated controls	Canal	–	–	–	10	–	–	–	–	–	100	–	10	100	1.2
	LA	–	–	–	10	–	–	–	–	50	20	30	10	100	2.4
	FL	–	–	–	10	–	–	–	–	10	20	70	10	100	1.8
	MS	–	–	–	10	–	–	–	–	30	40	30	10	100	2.4

[a]Based upon weight of dry chemical for sodium pentachlorophenate alone or mixed with other chemicals and on weight of solution for other treatments. Values for stakes originally installed.

[b]Ten stakes were originally installed in test. This number has since been reduced either because of failure to locate the stakes at the time of the inspection or because of damage by fire.

[c]Final inspection at Canal Zone, January 1956; at Jacksonville, FL, November 1960; and at Bogalusa, LA, December 1962.

[d]Estimate based upon percentage of stakes remaining after final inspection.

[e]Purchased and reported earlier as No. 2 fuel oil but has since been found to have a distillation range lower than that for typical No. 2 fuel oils.

[f]Solvent contained 1 part soybean oil and 9 parts each of fuel and naphtha by volume.

[g]Specimens contained some heartwood.

This study was initiated by R. M. Wirka.

Table 6–Condition of Southern Pine stakes of different sizes treated with coal-tar creosote, toluene, and creosote-toluene mixtures after 54-1/2 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, May 1951 (Plot 6)

				Condition of stakes January 1996 (%)									
					Serviceable but showing some–			Destroyed by–					
Preservative	Stake size (in.)	Average retention (lb/ft^3)	Number in test	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
Coal-tar creosote	1/2 by 1/2 by 18	7.8	8	–	–	–	–	88	–	12	8	100	17.1
	1 by 1 by 18	8.0	10	–	–	–	–	40	–	60	10	100	23.6
	1-1/2 by 1-1/2 by 18	7.9	10	–	–	–	–	50	–	50	10	100	26.6
	2 by 4 nominal by 18	3.3	10	–	–	–	–	10	–	90	10	100	24.9
		7.8	10	–	–	–	30	20	–	50	7	70	–
		13.2	10	–	–	–	80	10	–	10	2	20	–
Toluene	2 by 4 nominal by 18	29.5	10	–	–	–	–	–	90	10	10	100	2.2
Coal-tar creosote													
11.25% by weight in toluene	2 by 4 nominal by 18	3.4[a]	10	–	–	–	–	30	–	70	10	100	19.1
25.2% by weight in toluene	2 by 4 nominal by 18	8.1[a]	10	–	–	–	30	40	–	30	7	70	–
39.0% by weight in toluene	2 by 4 nominal by 18	12.6[a]	10	10	–	–	90	–	–	–	–	–	–

[a]Creosote only.

This study was initiated by R. M. Wirka.

Table 7–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with copper naphthenate and zinc naphthenate after about 50 years in test. Stakes placed in test at Madison, Wisconsin, October 1941, and on the Harrison Experimental Forest, Saucier, Mississippi, February 1942 (Plot 7)

					Condition of stakes October 1992[a] (%)									
						Serviceable but showing some–			Destroyed by–					
Preservative	Treatment	Location	Average retention[b] (lb/ft^3)	Number in test[c]	Good	Decay	Termite attack	Decay and Termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
Zinc naphthenate solution 17% (2% zinc metal)	Brush, one coat	MS	0.6 (0.012)	10	–	–	–	–	–	20	80	10	100	2.9
		WI	0.5 (0.010)	10	–	–	–	–	100	–	–	10	100	6.4
	Dip, 3 min	MS	1.0 (0.020)	10	–	–	–	–	–	40	60	10	100	2.2
		WI	0.9 (0.018)	10	–	–	–	–	100	–	–	10	100	7.7
1% (0.12% zinc metal)	Pressure	MS	9.9 (0.012)	10	–	–	–	–	50	–	50	10	100	11.2
		WI	9.7 (0.011)	10	–	–	–	–	100	–	–	10	100	19.1
2.5% (0.29% zinc metal)	Pressure	MS	10.3 (0.030)	10	–	–	–	–	50	–	50	10	100	15.0
		WI	9.8 (0.029)	10	–	–	–	–	100	–	–	10	100	21.9
5.0% (0.59% zinc metal)	Pressure	MS	10.2 (0.060)	10	–	–	–	–	60	–	40	10	100	13.5
		WI	10.3 (0.061)	10	–	–	–	–	100	–	–	10	100	22.6
7.5% (0.88% zinc metal)	Pressure	MS	10.4 (0.092)	10	–	–	–	–	60	–	40	10	100	19.7
		WI	10.0 (0.088)	9[d]	–	–	–	–	100	–	–	9	100	30.8
Copper naphthenate solution 17.5% (2% copper metal)	Brush, one coat	MS	0.5 (0.010)	10	–	–	–	–	20	50	30	10	100	3.7
		WI	0.5 (0.010)	10	–	–	–	–	100	–	–	10	100	8.6
	Dip, 3 min	MS	0.7 (0.014)	10	–	–	–	–	–	40	60	10	100	5.2
		WI	0.8 (0.015)	10	–	–	–	–	100	–	–	10	100	9.8
1% (0.11% copper metal)	Pressure	MS	10.3 (0.012)	10	–	–	–	–	80	–	20	10	100	15.9
		WI	10.3 (0.012)	8	–	–	–	–	100	–	–	8	100	25.5
2.5% (0.29% copper metal)	Pressure	MS	10.2 (0.029)	10	–	–	–	–	40	–	60	10	100	21.8
		WI	9.6 (0.027)	4	–	–	–	–	100	–	–	4	100	34.5
5.0% (0.57 copper metal)	Pressure	MS	10.6 (0.061)	10	–	–	–	–	80	–	20	10	100	27.1
		WI	10.6 (0.061)	6	17	–	–	–	83	–	–	5	83	28.7[e]
7.5% (0.86% copper metal)	Pressure	MS	9.6 (0.082)	10	20	–	–	–	60	–	20	8	80	29.6[e]
		WI	9.8 (0.084)	3	–	–	–	–	100	–	–	3	100	35.4
Untreated controls	–	MS	–	10	–	–	–	–	–	30	70	10	100	1.8
	–	WI	–	10	–	–	–	–	100	–	–	10	100	4.9

[a]Last inspection in Mississippi was 1985.

[b]Number in parentheses is the retention based on zinc or copper metal.

[c]Ten stakes were originally installed. This number has been reduced for causes other than decay or insect attack.

[d]Average retention based on nine stakes.

[e]Estimate based upon percentage of stakes remaining after final inspection.

This study was initiated by J. Oscar Blew.

Table 8–Condition of treated five-ply exterior Douglas-fir plywood stakes (approximately 1/2 by 4 by 18 in.) at final inspection after approximately 22 years of exposure. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, February 1942 (Plot 8)

Preservative	Treatment		Average retention (lb/ft^3)	Number in test[a]	Condition of stakes December 1963 (%)									
						Serviceable but showing some–			Destroyed by–			Total removed		Average life
					Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Number	%	(year)
Coal-tar creosote	Brush, one coat	Oil	1.4	30	–	–	–	–	27	27	27	30	100	6.1
	Dip, 3 min	Oil	1.9	30	–	–	–	–	17	20	63	30	100	9.4
	Soak, 18 h	Oil	5.6	30	–	7	–	47	27	–	20	14	47	24.0[b]
	Pressure	Oil	5.9	30	–	–	–	70	20	–	10	9	30	27.0[b]
	Pressure	Oil	12.2	29	28	38	7	28	–	–	–	–	–	–
Pentachlorophenol solution[c]														
5%	Brush, one coat	Solution	0.9	30	–	–	–	–	10	60	30[d]	30	100	2.8
	Dip, 3 min	Solution	1.3	30	–	–	–	–	13	60	27	30	100	3.3
	Soak, 18 h	Solution	3.2	30	–	–	–	–	3	33	63	30	100	5.0
1.11%	Pressure	Solution	26.3	30	–	–	–	–	20	–	80[e]	30	100	11.1
2.25%	Pressure	Solution	26.3	30	–	–	–	23	10	7	60	23	77	19.0[b]
Zinc naphthenate solution[f]														
4.8% (0.55% zinc)	Brush, one coat	Solution	0.7	30	–	–	–	–	10	30	60	30	100	2.1
	Dip, 3 min	Solution	1.1	30	–	–	–	–	7	54	40	30	100	2.0
	Soak, 18 h	Solution	3.0	30	–	–	–	–	13	43	43	30	100	2.9
1.11% (0.13% zinc)	Pressure	Solution	25.5	30	–	–	–	–	13	20	67	30	100	5.3
2.25% (0.25% zinc)	Pressure	Solution	25.6	30	–	–	–	–	13	7	80	30	100	8.9
Chloro-2-phenylphenol solution[f]														
5%	Brush, one coat	Solution	0.9	30	–	–	–	–	10	50	40	30	100	2.2
	Dip, 3 min	Solution	1.2	30	–	–	–	–	17	47	37	30	100	2.4
	Soak, 18 h	Solution	2.9	30	–	–	–	–	13	60	27	30	100	2.6
Untreated controls	–	–		30	–	–	–	–	20	40	40[e]	30	100	1.8

[a]Of the 30 panels tested for each treatment, three sets contained 10 specimens; each set was selected from material contributed by a different manufacturer.

[b]Estimate based on condition of stakes at final inspection.

[c]Solvent contined 1 part pine oil and 12 parts Stoddard-type solvent by volume.

[d]Two stakes showed some delamination.

[e]One stake showed some delamination.

[f]Stoddard-type solvent used.

NOTE: The stakes remaining in test after the 1950 inspection were taken up and reset in the same general area.
This study was initiated by J. Oscar Blew and R. M. Wirka.

Table 9–Condition of Southern Pine states (2 by 4 in. nominal by 18 in.) treated with copper arsenate and copper chromate by the double-diffusion process after about 55 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, February 1942 (Plot 9)

	Calculated retention of chemical[a] (lb/ft^3)				Num-ber in test[b]	Condition of stakes January 1997 (%)									
							Serviceable but showing some–				Destroyed by–					
Treatment	Copper as $CuSO_4$	Chromium as Na_2CrO_4	Arsenic as Na_2HasO_4	Total		Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
6-day soak in 10.6% copper sulfate solution plus															
6-day soak in 9.8% sodium arsenate solution	0.66 (0.33)	–	0.59 (0.36)	1.25 (0.69)	10	70	20	10	–	–	–	–	–	–	–
12-day soak in 9.8% sodium arsenate solution	0.66 (0.33)	2.58 (1.59)	0.75 (0.46)	1.41 (0.79)	10	60	30	10	–	–	–	–	–	–	–
12-day soak in 11.8% sodium chromate solution	0.66 (0.33)	–	–	3.24 (1.92)	10	80	–	–	–	10	–	10	2	20	–
3-day soak in 10.6% copper sulfate solution plus															
6-day soak in 9.8% sodium arsenate solution	0.88 (0.44)	–	0.55 (0.34)	1.43 (0.78)	10	30	70	–	–	–	–	–	–	–	–
6-day soak in 11.8% sodium chromate solution	0.88 (0.44)	1.57 (0.97)	–	2.45 (1.41)	9	67	–	–	–	22	11	–	3	33	–
3-day soak in 5.3% copper sulfate solution plus															
6-day soak in 4.9% sodium arsenate solution	0.31 (0.15)	–	0.17 (0.10)	0.48 (0.25)	9	–	67	–	–	22	–	11	3	33	–
6-day soak in 5.9% sodium chromate solution	0.31 (0.15)	0.50 (0.31)	–	0.81 (0.46)	9	33	–	–	–	33	–	33	6	67	–
Untreated controls	–	–	–	–	10	–	–	–	–	–	20	80	10	100	1.9

[a]Retention values in parentheses are oxides (CuO - CrO_3 - As_2O_5).

[b]Ten stakes originally installed; eliminated stakes removed for causes other than decay or insect attack.

This study was initiated by R. H. Baechler.

Table 10–Condition of urea-treated Southern Pine stakes (2 by 4 in. nominal by 18 in.) after about 14 to 19 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, February 1942 and December 1946, and at Madison, Wisconsin, April 1942 (Plot 10)

Treatment	Location	Total retention of urea or solids[a] (lb)	Average retention of urea or solids[a] (lb/ft^3)	Number in test	Condition of stakes late in 1960 (%)							Total removed		Average life (year)
					Good	Serviceable but showing some– Decay	Termite attack	Decay and termite attack	Destroyed by– Decay fungi	Termite attack	Decay fungi and termite attack	Number	%	
							Installed 1942							
2-day soak[b]	MS	4.7	3.4	10	–	–	–	–	–	10	90	10	100	3.4
	WI	4.7	3.4	10	–	–	–	–	100	–	–	10	100	8.1
4-day soak[b]	MS	6.9	5.0	10	–	–	–	–	–	20	80	10	100	3.3
	WI	6.9	5.0	10	–	–	–	–	100	–	–	10	100	8.0
6-day soak[b]	MS	10.2	7.4	10	–	–	–	–	–	20	80	10	100	2.9
	WI	10.2	7.4	10	–	–	–	–	100	–	–	10	100	6.0
B_1[c] (thermosetting) 2-day soak	MS	9.9	7.1	10	–	–	–	–	–	20	80	10	100	4.5
	WI	9.9	7.1	10	–	–	–	–	100	–	–	10	100	12.5
B_1[c] (thermosetting) 4-day soak	MS	11.2	8.1	10	–	–	–	–	–	–	100	10	100	5.1
	WI	11.2	8.1	10	–	–	–	–	100	–	–	10	100	13.2
B_1[c] (thermosetting) 6-day soak	MS	11.7	8.4	10	–	–	–	–	–	10	90	10	100	5.6
	WI	11.7	8.4	10	–	–	–	–	100	–	–	10	100	15.2
Untreated controls	MS	–	–	10	–	–	–	–	–	20	80	10	100	1.8
	WI	–	–	10	–	–	–	–	100	–	–	10	100	4.8
							Installed 1946							
Urea resin, pressure[d]	MS	–	5.8	10	–	–	–	–	10	–	90	10	100	9.1

[a]Calculated total retention of urea or solids for 22 stakes.

[b]Treating solution made up to 1.15 parts of urea to 1.00 part of water by weight.

[c]Solution made up of 380 parts urea, 344 parts of 37% formaldehyde solution, 231 parts water, 6 parts sodium hydroxide, and 39 parts borax by weight.

[d]Treated with buffered urea-formalin mix (2 to 1 formaldehyde-urea ratio) at a resin solids content of 30%.

This study was initiated by Harvey H. Smith and J. Oscar Blew.

Table 11–Condition of high-strength laminated paper plastic (papreg) stakes (1/8 by 4 by 14 in.) and heat stabilized plywood (staypak) stakes (4 by 18 in.) of several thicknesses after 7 to 8 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi (Plot 11)

Stake number	Composition	Number in test	December 1950 stakes destroyed by– Decay fungi Number	Decay fungi %	Termite attack Number	Termite attack %	Decay fungi and termite attack Number	Decay fungi and termite attack %	Average life (year)
	Laminated Paper Plastic (Papreg)–Installed December 2, 1942								
1 to 10	37.0% phenolic resin[a] + 2% hardener, 4.7% volatile matter	10	7	70	–	–	3	30	7.4
11 to 20	31.0% phenolic resin[a] + 2% hardener, 4.4% volatile matter	10	2	20	1	10	7	70	5.6
21 to 30	41.0% phenolic resin[a] + 2% hardener, 4.6% volatile matter	10	7	70	–	–	3	30	8.0
31 to 40	37.0% phenolic resin[a] + 2% hardener, 4.7% volatile matter with surface sheets using 42.6% phenolic resin,[a] 4.6% volatile matter[b]	10	7	70	–	–	3	30	7.2
41 to 50	37.0% phenolic resin[a] + 0.5% oleic acid, 4.7% volatile matter	10	4	40	1	10	5	50	7.7
	Heat-Stabilized Plywood (Staypak)–Installed June 4, 1943								
19-1 and 19-2	20 plies 1/16-in. birch bonded with phenolic resin and compressed to thickness of 1/2 in.; specific gravity 1.37	2	–	–	1	50	1	50	4.5
	Heat-Stabilized Plywood (Staypak)–Installed December 6, 1943								
s-1 to s-5	32 plies 1/16-in. birch bonded with phenolic resin and compressed to thickness of 1 in.; specific gravity 1.33	5	–	–	–	–	5[c]	100	5.6
21-1 to 21-5	10 plies 1/8-in. maple bonded with phenolic resin and compressed to thickness of 5/8 in.; specific gravity 1.36	5	–	–	–	–	5	100	4.3

[a]Alcohol-soluble.

[b]Single surface sheet on each side, coated side out.

[c]Heavy swelling at edges due to moisture absorption.

This study was initiated by A. H. Rauch and J. Oscar Blew.

Table 12–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with phenyl mercury oleate, pentachlorophenol, copper naphthenate, and mercuric chloride at final inspection after 20 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, December 1943 (Plot 12)

				Condition of stakes December 1963 (%)									
					Serviceable but showing some–			Destroyed by–					
Preservative	Treatment	Average retention of solution (lb/ft^3)	Number in test	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
Phenyl mercury oleate (percentage in naptha solvent)													
0.4	3-min dip	1.4	10	–	–	–	–	–	20	80	10	100	3.7
0.4	18-h soak	3.2	10	–	–	–	–	10	30	60	10	100	4.9
0.4	Pressure	5.9	10	–	–	–	–	–	10	90	10	100	6.7
0.4	Pressure	12.1	10	–	–	–	–	30	–	70	10	100	8.8
0.2	18-h soak	3.1	10	–	–	–	–	10	30	60	10	100	4.4
0.2	Pressure	6.0	10	–	–	–	–	–	30	70	10	100	5.6
0.2	Pressure	11.8	10	–	–	–	–	–	30	70	10	100	6.2
0.1	18-h soak	3.6	10	–	–	–	–	–	40	60	10	100	4.4
0.1	Pressure	5.9	10	–	–	–	–	–	30	70	10	100	4.6
0.1	Pressure	11.6	10	–	–	–	–	–	40	60	10	100	5.1
0.4[a]	3-min dip	1.2	10	–	–	–	–	–	60	40	10	100	3.9
0.1[a]	18-h soak	6.0	10	–	–	–	–	–	20	80	10	100	5.5
0.1[a]	Pressure	6.1	10	–	–	–	–	10	40	50	10	100	6.2
0.1[a]	Pressure	12.0	10	–	–	–	–	–	10	90	10	100	8.4
Pentachlorophenol (5.0% in pine-oil naphtha (1:12) solvent	Pressure	12.1	10	–	–	–	40	20	–	40	6	60	20.0[b]
Copper naphthenate (0.5% copper metal in naphtha solvent)	Pressure	13.1 (0.066)[c]	10	–	–	–	70	20	–	10	3	30	25.0[b]
Mercuric chloride (1.0% in water)	3-min dip dry salt	0.014	10	–	–	–	–	–	50	50	10	100	4.8
	18-h soak dry salt	0.072	10	–	–	–	–	–	20	80	10	100	7.5
Untreated controls	–	–	10	–	–	–	–	–	60	40	10	100	2.0

[a]Solution contained 16% solids as a water repellent.

[b]Estimate based on percentage of stakes remaining after final inspection.

[c]Retention values in parentheses are based on copper metal.

NOTE: The stakes remaining in test after the 1952 inspection were taken up and reset in the same general area.
This study was initiated by J. Oscar Blew.

Table 13–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with fire-retardant chemicals after 7 years in test. Stakes placed in test December 1943 on the Harrison Experimental Forest, Saucier, Mississippi, and inspected December 1950 (Plot 13)

Treating chemicals	Retention of dry salt (lb/ft^3)	Number in test	December 1950 stakes destroyed by– Termite attack Number	Termite attack %	Decay fungi and termite attack Number	Decay fungi and termite attack %	Average life (year)
Ammonium sulfate, 78 parts; ammonium phosphate, 19 parts; sodium dichromate, 3 parts (by weight)	3.01	10	5	50	5	50	2.4
	6.17	10	6	60	4	40	3.4
Ammonium phosphate, 10 parts; ammonium sulfate, 60 parts; borax, 10 parts; boric acid, 20 parts (by weight)	2.98	10	4	40	6	60	3.9
	6.19	10	2	20	8	80	4.3
Borax, 60 parts; boric acid, 40 parts (by weight)	3.01	10	3	30	7	70	6.0
	6.29	10	6	60	4	40	6.5
Untreated controls	–	10	2	20	8	80	2.2

This study was initiated by J. Oscar Blew.

Table 14–Condition of Southern Pine sapwood stakes (2 by 4 in. nominal by 18 in.) treated with various chemicals and of laminate acetylated yellow birch sapwood stakes (0.4 by 3-1/2 by 15-3/4 in.) after 60 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, December 1944 (Plot 14)

Preservative[a]	Average retention of preservative or dry salt (lb/ft^3)	Number in test[b]	Condition of stakes February 2004 (%)									
			Good	Serviceable but showing some–			Destroyed by–			Total removed		Average life (year)
				Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Number	%	
Pine stakes												
Ammoniacal copper arsenate (Fed. Spec. TT-W-549) (percentage in solution)												
0.612 (0.59)[c]	0.25 (0.24)	9	–	–	–	–	78	–	22	9	100	38.7
1.29 (1.24)	0.53 (0.51)	9	44	44	–	–	12	–	–	1	12	–
2.57 (2.48)	1.01 (0.97)	10	100	–	–	–	–	–	–	–	–	–
3.21 (3.10)	1.29 (1.25)	9	100	–	–	–	–	–	–	–	–	–
Amyl phenyl acetate (percentage in Stoddard solvent)												
0.37	0.10	10	–	–	–	–	–	–	100	10	100	6.7
0.93	0.03	10	–	–	–	–	–	–	100	10	100	8.5
1.85	0.50	10	–	–	–	–	–	40	60	10	100	10.0
Capric acid (percentage in Stoddard solvent)												
0.37	0.10	10	–	–	–	–	10	30	60	10	100	5.0
0.90	0.25	10	–	–	–	–	10	20	70	10	100	5.3
1.76	0.50	10	–	–	–	–	–	10	90	10	100	5.5
Diamyl pheno (percentage in Stoddard solvent)												
0.37	0.10	10	–	–	–	–	–	10	90	10	100	5.8
0.90	0.25	10	–	–	–	–	–	10	90	10	100	8.4
1.76	0.51	10	–	–	–	–	–	10	90	10	100	11.4
DDT (Dichloro-diphenyl-trichloroethane) (percentage in Stoddard solvent)												
1.25	0.35	10	–	–	–	–	100	–	–	10	100	7.1
2.70	0.74	10	–	–	–	–	70	–	30	10	100	9.0
Dodecyl amine (percentage in Stoddard solvent)												
0.37	0.10	10	–	–	–	–	–	20	80	10	100	5.4
0.93	0.25	10	–	–	–	–	–	–	100	10	100	5.7
1.85	0.50	10	–	–	–	–	–	10	90	10	100	6.8
Nickel stearate (percentage in coal-tar naphtha)												
0.33	0.10	10	–	–	–	–	10	–	90	10	100	5.6
0.93	0.27	10	–	–	–	–	30	–	70	10	100	4.9
1.85	0.52	10	–	–	–	–	10	10	80	10	100	5.5
Untreated controls	–	10	–	–	–	–	–	40	60	10	100	2.1
Yellow birch (laminated)[d]												
Acetylated	–	10	–	–	–	–	90	–	10	10	100	17.5
Untreated controls	–	10	–	–	–	–	10	10	80	10	100	2.7

[a]All stakes except laminated yellow birch were pressure treated.

[b]Ten stakes originally installed; eliminations were for mechanical damage or causes other than decay or insect attack.

[c]Ammoniacal copper arsenate solution and retention figures in parentheses are oxides (CuO and As_2O_5).

[d]Prepared from six-ply, parallel-laminated, acetylated 1/16-in. veneer glued with hot-press phenolic resin. Average acetyl content 19.2% based upon ovendry weight of wood. Untreated controls prepared from untreated veneer.

NOTE: The stakes remaining in test after the 1952 inspection were reset in the same general area.

This study was initiated by A. H. Rauch and J. Oscar Blew.

Table 15–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with acid copper chromate, chromated copper arsenate type I, and nickel-arsenic-chromium salts after 60 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, December 1945 (Plot 15)

Preservative	Average retention[a]	Number in test	Condition of stakes March 2005 (%)									Average life
			Serviceable but showing some–				Destroyed by–			Total removed		
					Termite	Decay and termite	Decay	Termite	Decay fungi and termite			
	(lb/ft^3)		Good	Decay	attack	attack	fungi	attack	attack	Number	%	(year)
Acid copper chromate (Fed. Spec. TT-W-546)												
	0.25 (0.13)	10	–	–	–	–	10	30	60	10	100	11.6
	0.51 (0.26)	10	–	–	–	20	60	–	20	8	80	–
Chromated copper arsenate type I (Fed. Sepc. TT-W-550)	0.75 (0.37)	10	10	10	10	10	60	–	–	6	60	–
	0.26 (0.15)	10	–	–	–	–	20	10	70	10	100	28.7
	0.50 (0.29)	10	–	20	–	50	30	–	–	3	30	–
Nickel-arsenic-chromium salts[b]	0.78 (0.44)	10	60	–	10	10	20	–	–	2	20	–
	0.26 (0.16)	10	–	–	–	–	10	30	60	10	100	17.4
	0.50 (0.32)	10	–	–	–	–	20	10	70	10	100	41.2
Untreated controls	0.77 (0.50)	10	–	–	–	40	60	–	–	6	60	–
	–	10	–	–	–	–	10	30	60	10	100	3.2

[a]Retention values in parentheses based on preservative oxides.

[b]Nickel sulfate ($NiSO_4$ $6H_2O$), 5.5 parts; sodium arsenate ($NaHAsO_4$ $12H_2O$), 4.0 parts; arsenic acid (H_3AsO_4), 1.5 parts; and sodium dichromate ($Na_2Cr_2O_7$ $2H_2O$), 3.0 parts).

Table 16–Condition of Douglas-fir plywood stakes treated with several wood preservatives, either before or after gluing of the veneer, after 51 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, December 1945 (Plot 16)

		Plywood[a]				Condition of stakes January 1996 (%)									
							Serviceable but showing some–			Destroyed by–					
Preservative	Treatment	Number of plies	Veneer thickness (in.)	Average retention[b,c] (lb/ft^3)	Number in test	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
						Plywood from Veneer Treated Before Gluing									
Coal-tar creosote	Pressure	13	1/16	40.9	10	80	–	–	20	–	–	–	–	–	–
	Pressure	7	1/8	30.9	9	56	11	11	22	–	–	–	–	–	–
	Heating and 1-hour cold bath[d]	7	1/8	12.6	10	–	–	–	–	10	20	70	10	100	10.2
	24-hour cold soak	13	1/16	12.9	10	30	40	10	20	–	–	–	–	–	–
	24-hour cold soak	7	1/8	8.4	9	–	11	–	89	–	–	–	–	–	–
	10-second dipping	13	1/16	5.1	9[g]	–	56	11	22	–	–	–	–	–	–
	10-second dipping	7	1/8	4.6	9	–	22	–	67	–	–	–	–	–	–
Copper naphthenate,	Pressure	13	1/16	15.5 (0.31)	9	67	22	–	11	–	–	–	–	–	–
2% copper metal	Pressure	7	1/8	10.2 (0.20)	10	30	30	–	40	–	–	–	–	–	–
in coal-tar naphtha	Heating and 1-hour cold bath[d]	7	1/8	6.7 (0.13)	9	11	11	–	67	11	–	–	1	11	–
	24-hour cold soak	13	1/16	10.1 (0.20)	10	–	40	–	60	–	–	–	–	–	–
	24-hour cold soak	7	1/8	6.2 (0.12)	10	–	–	–	70	20	–	10	3	30	–
	10-second dipping	13	1/16	4.2 (0.084)	10	–	20	–	80	–	–	–	–	–	–
	10-second dipping	7	1/8	2.8 (0.056)	10	–	–	–	–	50	–	50	10	100	32.5
Pentachlorophenol,	Pressure	13	1/16	21.4	9	–	22	11	67	–	–	–	–	–	–
5% in No. 2	Pressure	7	1/8	18.2	10	–	–	–	50	30	–	20	5	50	–
fuel oil	Heating and 1-hour cold bath[d]	7	1/8	10.3	10	–	–	–	30	10	–	60	7	70	–
	24-hour cold soak	13	1/16	7.4	9	–	–	–	33	44	–	22	6	67	–
	24-hour cold soak	7	1/8	4.8	10	–	–	–	–	10	10	80	10	100	23.1
	10-second dipping	13	1/16	4.9	10	–	–	–	10	30	–	60	9	90	–
	10-second dipping	7	1/8	1.0	10	–	–	–	–	10	–	90	10	100	15.8
Chromated	Pressure	13	1/16	1.02[e] (0.62)	6	–	–	–	50	17	–	33	3	50	–
zinc chloride	Pressure	7	1/8	1.06[e] (0.65)	10	–	–	–	–	–	40	60	10	100	25.8
	Heating and 1-hour cold bath[d]	7	1/8	0.98 (0.60)	10	–	–	–	–	–	50	50	10	100	10.3
	24-hour steeping	13	1/16[f]	1.07 (0.65)	8	–	–	–	88	–	–	12	1	12	–
	24-hour steeping	13	1/16	1.84 (1.12)	8[g]	–	–	13	50	25	–	12	3	27	–
	24-hour steeping	7	1/8[f]	0.59 (0.36)	10	–	–	–	–	–	10	90	10	100	17.0
	24-hour steeping	7	1/8	1.30 (0.79)	10	–	–	–	–	10	20	70	10	100	23.6
	10-second dipping	13	1/16[f]	0.61 (0.37)	10	–	–	–	–	30	10	60	10	100	22.7
	10-second dipping	13	1/16	0.66 (0.40)	10	–	–	–	–	10	–	90	10	100	22.1
	10-second dipping	7	1/8	0.35 (0.21)	10	–	–	–	–	–	20	80	10	100	10.8
Acid copper	Pressure	13	1/16	0.76 (0.38)	9[g]	–	–	22	67	11	–	–	1	11	–
chromate	Pressure	7	1/8	0.79 (0.39)	9	11	–	–	67	22	–	–	2	22	–
	Heating and 1-hour cold bath[d]	7	1/8	1.07 (0.53)	10	–	–	–	60	30	–	10	4	40	–
	24-hour steeping	13	1/16[f]	0.88 (0.44)	9	44	11	33	11	–	–	–	–	–	–
	24-hour steeping	13	1/16	1.89 (0.94)	10	40	–	40	20	–	–	–	–	–	–
	24-hour steeping	7	1/8	0.54 (0.27)	9	22	11	22	33	11	–	–	1	11	–
	24-hour steeping	7	1/8	1.32 (0.65)	10	20	10	20	50	–	–	–	–	–	–
	10-second dipping	13	1/16	0.87 (0.43)	10	–	–	–	70	30	–	–	3	30	–
	10-second dipping	13	1/16	0.61 (0.30)	9	–	11	–	44	44	–	–	4	44	–
	10-second dipping	7	1/8	0.27 (0.13)	10	–	–	–	–	20	–	80	10	100	18.4
	10-second dipping	7	1/8	0.38 (0.19)	10	–	–	–	–	30	10	60	10	100	22.2

Table 16–Condition of Douglas-fir plywood stakes treated with several wood preservatives, either before or after gluing of the veneer, after 51 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, December 1945 (Plot 16)

						Condition of stakes January 1996 (%)									
		Plywood[a]				Serviceable but showing some–				Destroyed by–					
Preservative	Treatment	Number of plies	Veneer thickness (in.)	Average retention[b,c] (lb/ft^3)	Number in test	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
						Plywood Treated After Gluing									
Coal-tar creosote	Pressure	5	1/8	19.6	10	70	10	10	10	–	–	–	–	–	–
	Hot bath, 1-h, and cold bath, 1-h	5	1/8	2.0	10	20	–	–	80	–	–	–	–	–	–
	24-h cold soak	5	1/8	5.3	10	–	–	–	–	20	30	50	10	100	11.3
	10-s dipping	5	1/8	1.0[e]	8[g]	–	–	–	–	–	50	50	8	100	5.4
Copper naphthenate, (2% copper metal) in coal-tar naphtha	Pressure	5	1/8	2.9 (0.058)	10	–	–	–	–	50	10	40	10	100	18.9
	Hot bath, 1-h, and cold bath, 1-h	5	1/8	1.2 (0.024)	10	–	–	–	–	60	–	40	10	100	12.8
	24-h cold soak	5	1/8	1.1 (0.022)	10	–	–	–	–	50	–	50	10	100	13.8
	10-s dipping	5	1/8	0.4 (0.008)	10	–	–	–	–	60	–	40	10	100	10.5
Pentachlorophenol, 5% in No. 2 fuel oil	Pressure	5	1/8	12.5	10	–	–	–	20	30	–	50	8	80	–
	Hot bath, 1-h, and cold bath, 1-h	5	1/8	2.1	10	–	–	–	–	–	40	60	10	100	8.3
	24-h cold soak	5	1/8	2.0	10	–	–	–	–	20	10	70	10	100	8.3
	10-s dipping	5	1/8	0.7	10	–	–	–	–	10	20	70	10	100	7.8
Chromated zinc chloride	Pressure	5	1/8	0.62[e] (0.038)	10	–	–	–	–	40	–	60	10	100	17.9
	24-h steeping	5	1/8	0.35 (0.21)	10	–	–	–	–	10	30	60	10	100	8.2
	10-s dipping	5	1/8	0.03 (0.02)	10	–	–	–	–	–	50	50	10	100	4.0
Acid copper chromate	Pressure	5	1/8	0.46 (0.23)	10	10	–	–	10	50	–	30	8	80	–
	24-h steeping	5	1/8	0.28 (0.14)	10	–	–	–	–	10	40	50	10	100	5.3
	10-s dipping	5	1/8	0.06 (0.03)	10	–	–	–	–	10	60	30	10	100	8.2
None	Untreated	13	1/16	–	10	–	–	–	–	–	50	50	10	100	3.7
	Untreated	7	1/8	–	10	–	–	–	–	–	60	40	10	100	3.6

[a]Plywood glued with hot-press phenolic-resin adhesive.
[b]Oils or dry salt absorbed by 21-by 38-in. plywood panel. Stakes were cut from plywood panels after treatment, and all exposed edges of stakes were soaked in the preservative before stakes were installed.
[c]Retention values in parentheses based on preservative oxides or copper metal.
[d]Veneer heated in dryer and then submerged for 1 h in unheated preservative.
[e]Approximate values.
[f]Veneer treated prior to drying.
[g]Specimens delaminated and were eliminated from test.

Table 17–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with various petroleum oils, pentachlorophenol solution, copper naphthenate solutions, coal-tar creosote, and mixtures of these preservatives after about 50 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, and at Bogalusa, Louisiana, April 1948 (Plot 20)

Oil or preservative	Location	Average retention (lb/ft^3)	Number in test[a]	Condition of stakes January 1998[b] (%)							Total removed		Average life (year)
					Serviceable but showing some–			Destroyed by–					
				Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Number	%	
Unfortified petroleum oil													
Commercial aromatic solvent	MS	4.1	10	–	–	–	–	10	–	90	10	100	2.3
(Mid-United States)	LA	4.1	10	–	–	–	–	–	20	80	10	100	2.9
Stoddard solvent (Mid-United States)	MS	4.0	10	–	–	–	–	10	20	70	10	100	2.1
	LA	4.0	10	–	–	–	–	10	20	70	10	100	2.8
No. 2 fuel oil (Mid-United States)	MS	4.1	10	–	–	–	–	10	10	80	10	100	4.4
	LA	4.0	10	–	–	–	–	70	–	30	10	100	4.1
Heavy thermal side cut	MS	4.2	10	–	–	–	–	–	10	90	10	100	3.4
(Mid-United States)	LA	4.2	10	–	–	–	–	30	–	70	10	100	4.6
No. 200 diesel oil (West Coast)	MS	4.0	10	–	–	–	–	20	10	70	10	100	4.8
	LA	4.0	10	–	–	–	–	70	–	30	10	100	4.6
Catalytic gas-base oil (West Coast)	MS	4.0	10	–	–	–	–	40	–	60	10	100	7.6
	LA	4.0	10	–	–	–	–	40	–	60	10	100	7.6
	MS	8.0	10	–	–	–	–	30	–	70	10	100	14.6
	LA	8.0	10	–	10	–	50	20	–	20	4	40	–
	MS	12.0	10	–	–	–	–	40	–	60	10	100	17.1
	LA	11.9	10	–	25	–	63	12	–	–	1	12	–
No. 300 fuel oil (West Coast)	MS	4.2	10	–	–	–	–	90	–	10	10	100	7.1
	LA	4.2	10	–	–	–	20	80	–	–	8	80	6.5[c]
No. 400 fuel oil (West Coast)	MS	4.2	10	–	–	–	–	80	–	20	10	100	5.8
	LA	4.2	10	–	–	–	–	90	–	10	10	100	5.5
Light gas oil (Mid-United States)	MS	4.1	10	–	–	–	–	50	–	50	10	100	6.7
	LA	4.1	10	–	–	–	–	60	–	40	10	100	6.0
Denver No. 3 blend (50-50 topped crude	MS	4.0	10	–	–	–	–	60	–	40	10	100	6.4
residual and recycled overhead gas oil)	LA	4.0	10	–	–	–	–	80	–	20	10	100	5.9
Heavy gas oil (Mid-United States)	MS	4.0	10	–	–	–	–	100	–	–	10	100	12.9
	LA	4.0	10	–	–	–	60	40	–	–	4	40	–
	MS	7.9	10	–	–	–	10	90	–	–	9	90	–
	LA	7.9	9	–	33	–	67	–	–	–	–	–	–
	MS	12.1	10	–		–	20	80	–	–	8	80	–
	LA	12.1	5	60	40	–	–	–	–	–	–	–	–
Lube oil extract (Texas)	MS	4.1	10	–	–	–	–	100	–	–	10	100	12.0
	LA	4.2	8	–	–	–	63	25		12	3	37	–

Table 17–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with various petroleum oils, pentachlorophenol solution, copper naphthenate solutions, coal-tar creosote, and mixtures of these preservatives after about 50 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, and at Bogalusa, Louisiana, April 1948 (Plot 20)–cont.

				Condition of stakes January 1998[b] (%)									
					Serviceable but showing some–			Destroyed by–					
Oil or preservative	Location	Average retention (lb/ft^3)	Number in test[a]	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed: Number	Total removed: %	Average life (year)
Fortified petroleum oils and mixtures													
Commercial aromatic solvent (Mid-	MS	4.2	10	–	–	–	–	–	–	100	10	100	10.9
United States with 5% pentachlorophenol)	LA	4.2	10	–	–	–	–	10	–	90	10	100	8.6
Stoddard solvent (Mid-United States)	MS	4.0	10	–	–	–	–	10	–	90	10	100	13.7
with 5% pentachlorophenol	LA	4.0	10	–	–	–	–	20	–	80	10	100	8.8
No 2 fuel oil (Mid-United States)	MS	4.0	10	–	–	–	–	10	10	80	10	100	14.9
with 5% pentachlorophenol	LA	3.8	10	–	–	–	20	–	–	80	8	80	12.5[c]
Heavy thermal side cut (Mid-United States)	MS	4.0	10	–	–	–	–	20	–	80	10	100	14.0
with 5% pentachlorophenol	LA	4.0	10	–	–	–	–	10	–	90	10	100	10.6
No. 200 diesel oil (West Coast)	MS	4.1	10	–	–	–	–	10	–	90	10	100	17.0
with 5% pentachlorophenol	LA	4.1	10	–	–	–	50	–	–	50	5	50	–
Catalytic gas-base oil (West Coast)	MS	4.2	10	–	–	–	–	–	–	100	10	100	16.3
with 5% pentachlorophenol	LA	4.1	8	–	–	–	88	12	–	–	1	12	–
	MS	8.0	10	–	–	–	–	10	–	90	10	100	20.7
	LA	7.9	8	–	12	–	88	–	–	–	–	–	–
	MS	12.0	10	–	–	–	–	30	–	70	10	100	30.2
	LA	12.0	9	–	56	–	44	–	–	–	–	–	–
No. 300 fuel oil (West Coast) with	MS	4.0	10	–	–	–	–	80	–	20	10	100	14.6
with 5% pentachlorophenol	LA	4.1	8	–	12	–	50	12	–	25	3	37	–
No. 400 fuel oil (West Coast) with	MS	4.2	10	–	–	–	–	40	–	60	10	100	13.9
with 5% pentachlorophenol	LA	4.2	9	–	–	–	22	22	–	56	7	78	12.5[c]
Light gas oil (Mid-United States)	MS	4.0	10	–	–	–	–	–	–	100	10	100	15.6
with 5% pentachlorophenol	LA	4.2	10	–	–	–	50	–	–	50	5	50	–
Denver No. 3 blend (50-50 topped crude residual	MS	4.0	10	–	–	–	–	70	–	30	10	100	19.5
and recycled overhead gas oil) with 5% pentachl	LA	4.0	7	–	–	–	86	14	–	–	1	14	–
Heavy gas oil (Mid-United States)	MS	4.1	9	–	–	–	11	44	–	44	8	89	–
with 5% pentachlorophenol	LA	4.1	8	–	12	–	88	–	–	–	–	–	–
	MS	7.9	10	–	–	10	10	60	–	20	8	80	–
	LA	7.9	6	–	33	–	67	–	–	–	–	–	–
	MS	12.0	10	–	–	–	80	20	–	–	2	20	–
	LA	12.0	5	60	–	–	40	–	–	–	–	–	–

Table 17–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with various petroleum oils, pentachlorophenol solution, copper naphthenate solutions, coal-tar creosote, and mixtures of these preservatives after about 50 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, and at Bogalusa, Louisiana, April 1948 (Plot 20)–cont.

				Condition of stakes January 1998[b] (%)									
					Serviceable but showing some–			Destroyed by–					
Oil or preservative	Location	Average retention (lb/ft^3)	Number in test[a]	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
Fortified petroleum oils and mixtures													
Lube oil extract (Texas)	MS	4.2	10	–	–	–	–	90	–	10	10	100	28.5
with 5% pentachlorophenol	LA	4.2	8	–	–	–	100	–	–	–	–	–	–
Catalytic gas-base oil (West Coast) with copper	MS	4.2	10	–	–	–	–	70	10	20	10	100	14.3
naphthenate (0.5% copper metal)	LA	4.2	10	–	10	–	60	10	–	20	3	30	–
Catalytic gas-base oil (West Coast) with copper	MS	4.4	8	–	–	–	–	75	–	25	8	100	17.4
naphthenate (0.75% copper metal)	LA	4.2	8	12	12	–	62	12	–	–	1	12	–
Coal-tar creosote	MS	4.1	10	–	–	–	–	70	–	30	10	100	14.2
	LA	4.1	10	–	–	–	50	40	–	10	5	50	–
Coal-tar creosote, 50%, and catalytic gas-base oil (West	MS	4.1	10	–	–	–	–	50	–	50	10	100	16.2
Coast) with 5% pentachlorophenol, 50% by volume	LA	4.1	8	–	–	–	62	–	–	38	3	38	–
Coal-tar creosote, 50%, and catalytic gas-base oil	MS	4.2	10	–	–	–	–	90	–	10	10	100	18.9
(West Coast) with copper naphthenate (0.5% copper metal), 50% by volume	LA	4.3	10	–	–	–	90	10	–	–	1	10	–
Coal-tar creosote, 25%, and catalytic gas-base oil	MS	4.1	10	–	–	–	–	90	–	10	10	100	14.6
(West Coast) with copper naphthenate (0.75% copper metal) , 75% by volume	LA	4.2	8	–	–	–	50	38	–	12	4	50	–
Catalytic gas-base oil (West Coast) with	MS	4.2	10	–	–	–	–	20	10	70	10	100	24.9
5% pentachlorophenol, 50%, and catalytic gas-base oil (West Coast) with copper naphthenate (0.5% copper metal), 50% by volume	LA	4.2	9	–	–	–	100	–	–	–	–	–	–
Untreated controls	MS	–	10	–	–	–	–	20	20	60	10	100	2.2
	LA	–	10	–	–	–	–	–	–	100	10	100	2.8

[a]Ten stakes were originally installed at each test station; this number has since been reduced because of failure to locate the stakes at the time of inspection.

[b]Final inspection at Bogalusa, November 1962.

[c]Estimate based on percentage of stakes remaining after final inspection.

This study was initiated by J. Oscar Blew.

Table 18–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with various coal-tar creosotes and creosote solutions after about 44 years in test. Stakes placed in test at Madison, Wisconsin, October 1948, and on the Harrison Experimental Forest, Saucier, Mississippi, December 1948 (Plot 24)

				Condition of stakes October 1992[a] (%)									
					Serviceable but showing some–			Destroyed by–					
Preservative	Location	Average retention (lb/ft^3)	Number in test	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
Coal-tar creosote													
Low residue, straight run	MS	8.0	10	–	–	–	30	60	–	10	7	70	17.8[b]
	WI	8.0	10	–	40	–	–	60	–	–	6	60	–
Medium residue, straight run	MS	8.0	10	–	10	–	10	80	–	–	8	80	18.8[b]
	WI	8.0	10	–	70	–	–	30	–	–	3	30	–
High residue, straight run	MS	7.8	10	–	20	–	20	60	–	–	6	60	20.3[b]
	WI	7.8	10	–	10	–	–	–	–	–	–	–	–
Medium residue													
Low in tar acids	MS	8.1	10	–	10	–	20	70	–	–	7	70	19.4[b]
	WI	8.1	10	–	100	–	–	–	–	–	–	–	–
Low in naphthalene	MS	8.2	10	–	10	–	50	40	–	–	4	40	21.3[b]
	WI	8.2	10	–	90	–	–	10	–	–	1	10	–
Low in tar acids and naphthalene	MS	8.0	10	–	–	–	30	60	–	10	7	70	18.9[b]
	WI	8.0	10	–	100	–	–	–	–	–	–	–	–
Low residue, low in tar acids and naphthalene	MS	8.0	10	–	10	–	20	50	–	20	7	70	19.2[b]
	WI	8.0	10	–	40	–	–	60	–	–	6	60	–
High residue, low in tar acids and naphthalene	MS	8.2	10	–	10	–	10	70	–	10	8	80	20.0[b]
	WI	8.1	9	33	67	–	–	–	–	–	–	–	–
English vertical retort	MS	8.0	10	–	–	–	30	60	–	10	7	70	18.9[b]
	WI	8.0	10	10	90	–	–	–	–	–	–	–	–
English coke oven	MS	7.9	10	–	–	–	–	70	–	30	10	100	13.6
	WI	7.9	10	–	30	–	–	70	–	–	7	70	–
English coke oven, 50%, and English vertical retort, 50% by volume	MS	8.1	10	–	–	–	10	40	–	50	9	90	16.9[b]
	WI	8.1	10	10	70	–	–	20	–	–	2	20	–

Table 18–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with various coal-tar creosotes and creosote solutions after about 44 years in test. Stakes placed in test at Madison, Wiisconsin, October 1948, and on the Harrison Experimental Forest, Saucier, Mississippi, December 1948 (Plot 24)–cont.

				Condition of stakes October 1992[a] (%)									
					Serviceable but showing some–			Destroyed by–					
Preservative	Location	Average retention (lb/ft^3)	Number in test	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
Medium residue, low in tar acids and naphthalene, 70%, and coal tar, 30% by volume	MS	8.1	10	–	20	–	10	70	–	–	7	70	20.4[b]
	WI	8.1	10	–	70	–	–	30	–	–	3	30	–
Medium residue, low in tar acids and naphthalene, 70%, and petroleum oil (Wyoming residual), 30% by volume	MS	8.1	10	–	10	–	20	70	–	–	7	70	19.6[b]
	WI	8.1	10	–	70	–	–	30	–	–	3	30	–
Petroleum oil (Wyoming residual)	MS	8.1	10	–	–	–	–	90	–	10	10	100	3.4
	WI	8.1	9	–	–	–	–	100	–	–	9	100	14.8
Untreated controls	MS	–	10	–	–	–	–	10	10	80	10	100	1.9
	WI	–	10	–	–	–	–	100	–	–	10	100	5.6

[a]Final inspection in Mississippi, November 1968.

[b]Estimate based on percentage of stakes remaining after final inspection.

This study was initiated by J. Oscar Blew.

Table 19–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with English coke oven and verticle retort coal-tar creosotes after about 50 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, December 1948 (Plot 25)

			Condition of stakes February 1998 (%)									
				Serviceable but showing some–			Destroyed by–					
Preservative	Average retention (lb/ft^3)	Number in test	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
Coal-tar creosote English vertical retort	5.3	10	–	–	–	10	70	–	20	9	90	–
	10.1	10	–	–	–	20	70	–	10	8	80	–
	15.0	10	–	10	–	90	–	–	–	–	–	–
English coke oven	4.7	10	–	–	–	–	80	–	20	10	100	16.3
	10.1	10	–	–	–	30	60	10	–	7	70	–
	14.8	10	–	–	–	20	60	–	20	8	80	–
Untreated controls	–	10	–	–	–	–	–	–	100	10	100	1.9

Table 20–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with zinc-arsenic chromium and chromated copper arsenate salts after about 43 and 61 years in test. Stakes placed in test at Madison, Wisconsin, November 1949 and on the Harrison Experimental Forest, Saucier, Mississippi, December 1949 (Plot 28)

				Condition of stakes March 2010 (MS) and October 1992 (WI) (%)										
					Serviceable but showing some–			Destroyed by–						
Preservative	Location	Average retention[b] (lb/ft^3)	Number in test[c]	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
Zinc-arsenic-chromium salt (S-32)[a]	WI	(0.96)	10	90	–	–	–	10	–	–	1	10	–
	MS	(0.96)	10	–	80	–	10	10	–	–	1	10	–
	WI	(0.74)	10	40	–	–	–	60	–	–	6	60	–
	MS	(0.72)	9	–	89	–	–	11	–	–	1	11	–
	WI	(0.50)	10	–	–	–	–	100	–	–	10	100	21.8
	MS	(0.50)	10	–	70	–	20	10	–	–	1	10	–
	WI	(0.35)	10	–	–	–	–	100	–	–	10	100	18.5
	MS	(0.35)	10	10	20	–	10	50	–	10	6	60	–
	WI	(0.22)	10	–	–	–	–	100	–	–	10	100	18.6
	MS	(0.22)	10	–	–	–	–	40	–	60	10	100	41.8
Chromated copper arsenate, type II (Fed. Spec. TT-W-550)	WI	(1.03)	10	90	10	–	–	–	–	–	–	–	–
	MS	(1.04)	9	89	11	–	–	–	–	–	–	–	–
	WI	(0.78)	10	90	10	–	–	–	–	–	–	–	–
	MS	(0.79)	9	67	33	–	–	–	–	–	–	–	–
	WI	(0.52)	9	–	100	–	–	–	–	–	–	–	–
	MS	(0.52)	9	33	67	–	–	–	–	–	–	–	–
	WI	(0.37)	10	–	100	–	–	–	–	–	–	–	–
	MS	(0.37)	10	–	70	–	20	10	–	–	1	10	–
	WI	(0.26)	10	–	80	–	–	20	–	–	2	20	–
	MS	(0.26)	10	–	60	–	40	–	–	–	–	–	–
Zinc chloride	WI	1.04 (0.61)	10	–	–	–	–	100	–	–	10	100	12.8
	MS	1.04 (0.62)	10	–	–	–	–	20	–	80	10	100	17.0
Coal-tar creosote	WI	8.36	10	–	90	–	–	10	–	–	1	10	–
	MS	8.30	10	–	–	–	–	70	–	30	10	100	47.1
Untreated controls	WI	–	10	–	–	–	–	100	–	–	10	100	7.0
	MS	–	10	–	–	–	–	10	30	60	10	100	2.8

[a]ZnO, 97 parts; CrO_3, 170 parts; and As_2O_5, 213 parts.

[b]Retention figures in parentheses are based on preservative oxides.

[c]Ten stakes originally installed; eliminations were for mechanical damage or causes other than decay or insect attack.

Table 21–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with two fortified aromatic petroleum oils after about 47 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, December 1949 (Plot 26)

			Condition of stakes January 1995 (%)									
				Serviceable but showing some–			Destroyed by–					
Preservative	Average retention (lb/ft^3)	Number in test	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
Standard wood preservative[a]	3.7	10	–	–	–	–	20	10	70	10	100	7.3
	8.2	10	–	–	–	10	20	10	60	9	90	–
	11.7	10	–	–	–	30	40	–	30	7	70	–
Wood preservative No. 51746-R[b]	4.0	10	–	–	–	–	20	–	80	10	100	11.6
	8.0	10	–	–	–	10	20	–	70	9	90	–
	12.1	10	–	–	–	30	10	–	60	7	70	–
Untreated controls	–	10	–	–	–	–	–	30	70	10	100	2.2

[a]Reported to be a mixture of heavy petroleum cresylic acids, an aromatic solvent, and copper naphthenate equivalent to 0.3% copper metal.

[b]Reported to be a mixture of petroleum cresylic acids, aromatic oils, and 1.0% pentachlorophenol.

This study was initiated by J. Oscar Blew.

Table 22–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with oil solutions of rosin amine D pentachlorophenate and pentachlorophenol after about 50 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, December 1949 (Plot 27)

			Condition of stakes January 1999 (%)									
				Serviceable but showing some–			Destroyed by–					
Preservative	Average retention (lb/ft^3)	Number in test	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
Rosin amine D pentachlorophenate, 5%, in Stoddard solvent	4.0	10	–	–	–	–	–	20	80	10	100	3.8
	7.9	10	–	–	–	–	–		100	10	100	5.1
	11.9	10	–	–	–	–	–	–	100	10	100	9.5
Rosin amine D pentachlorophenate, 5%, and paraffin wax, 2%, in Stoddard solvent	4.2	10	–	–	–	–	–	20	80	10	100	4.5
	8.0	10	–	–	–	–	10	–	90	10	100	7.8
Rosin amine D pentachlorophenate, 5%, paraffin wax, 2%, and pentalyn H, 10%, in Stoddard solvent	4.0	10	–	–	–	–	–	30	70	10	100	8.0
	8.0	10	–	–	–	–	30	30	40	10	100	8.7
Rosin amine D pentachlorophenate, 5%, in No. 4 aromatic oil	4.0	10	–	–	–	–	60	–	40	10	100	12.8
	7.6	10	–	–	–	–	50	–	50	10	100	16.1
	12.3	10	–	20	–	10	70	–	–	7	70	–
Pentachlorophenol, 5%, and pine oil, 5%, in Stoddard solvent	4.1	10	–	–	–	–	–	–	100	10	100	9.5
	8.0	9	–	–	–	–	–	–	100	9	100	15.5
Pentachlorophenol, 5%, and pine oil, 5%; paraffin wax, 2%; and pentalyn H, 10%, in Stoddard solvent	4.1	10	–	–	–	–	–	10	90	10	100	12.8
	7.8	10	–	–	–	–	20	–	80	10	100	15.7
Pentachlorophenol, 5%, in No. 4 aromatic oil	4.2	10	–	–	–	–	60	–	40	10	100	21.0
	8.2	10	–	10	–	20	30	–	40	7	70	–
Untreated controls	–	10	–	–	–	–	–	30	70	10	100	2.3

This study was initiated by J. Oscar Blew.

Table 23–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with rosin amine D pentachlorophenate and pentachlorophenol in petroleum oil (Wyoming residual) after about 45 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississipi, March 1952 (Plot 34)

			Condition of stakes January 1997 (%)									
				Serviceable but showing some–			Destroyed by–					
Preservative	Average retention (lb/ft^3)	Number in test	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
Rosin amine D pentachlorophenate	4.0	10	–	–	–	–	70	–	30	10	100	22.4
5% in petroleum oil	8.0	10	–	–	–	–	60	–	40	10	100	25.7
(Wyoming residual)	12.7	10	–	–	–	20	50	–	30	8	80	–
Pentachlorophenol 5% in	4.0	10	–	–	–	–	50	–	50	10	100	18.6
petroleum oil	8.0	10	–	–	–	40	30	–	30	6	60	–
(Wyoming residual)	11.7	10	–	20	–	80	–	–	–	–	–	–
Petroleum oil	7.7	10	–	–	–	–	70	–	30	10	100	14.6
(Wyoming residual)	12.2	10	–	–	–	–	100	–	–	10	100	17.4
Untreated controls	–	10	–	–	–	–	–	20	80	10	100	2.1

Table 24–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with two Boliden salt formulations after about 45 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, March 1952 (Plot 33)

Preservative	Average retention, anhydrous salts[a] (lb/ft^3)	Num-ber in test	Condition of stakes January 1997 (%)									Average life (year)
				Serviceable but showing some–			Destroyed by–			Total removed		
			Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Number	%	
Boliden salts AWPA P5-55												
Chromated zinc arsenate (H_3ASO_4,	0.22 (0.11)	10	–	–	–	–	–	10	90	10	100	22.1
20 parts; Na_2HAsO_4, 21 parts;	0.38 (0.20)	10	–	–	–	60	–	–	40	4	40	–
$Na_2Cr_2O_7$ ◊ H_2O, 16 parts; and	0.77 (0.40)	10	–	–	–	100	–	–	–	–	–	–
$ZnSO_4$, 43 parts)[b]	1.01 (0.53)	10[c]	–	–	–	100	–	–	–	–	–	–
Boliden salts S-25 (CrO_3, 32 parts;	(0.30)	10	–	–	–	100	–	–	–	–	–	–
CuO, 5 parts; ZnO, 14 parts; and	(0.50)	10	–	–	–	100	–	–	–	–	–	–
As_2O_5, 49 parts)	(0.75)	10	20	10	–	70	–	–	–	–	–	–
	(1.01)	9	44	12	–	44	–	–	–	–	–	–
Untreated controls	–	10	–	–	–	–	–	20	80	10	100	1.9

[a]Retention values in parentheses are based on preservative oxides.

[b]Retentions are shown on an anhydrous basis, and figures should be increased approximately 26% to obtain values as computed in AWPA Standard P5-55.

[c]This stake group placed in test in August 1952.

This study was initiated by J. Oscar Blew.

Table 25–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with four fire-retardant formulations (AWPA P10-51) after about 45 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, March 1952[a] (Plot 35)

			Condition of stakes January 1997[a] (%)									
				Serviceable but showing some–			Destroyed by–					
Preservative	Average retention[b] (lb/ft^3)	Number in test	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
Chromated zinc chloride	1.50 (0.92)	10	–	–	–	–	30	–	70	10	100	23.4
($ZnCl_2$, 80.4 parts;	2.91 (1.78)	10	–	–	–	–	60	10	30	10	100	32.7
$Na_2Cr_2O_7 \cdot 2H_2O$, 19.6 parts)	6.00 (3.67)	10	60	–	30	10	–	–	–	–	–	–
Chromated zinc chloride (FR)	1.53	10	–	–	–	–	30	20	50	10	100	16.5
(Chromated zinc chloride, 80 parts;	3.00	10	–	–	–	10	30	10	50	9	90	–
H_3BO_3,10 parts; and $(NH_4)_2SO_4$, 10 parts)	6.08	10	20	–	10	20	20	10	20	5	50	–
Minalith	1.50	10	–	–	–	–	–	10	90	10	100	3.7
($(NH_4)_2HPO_4$, 10 parts; $(NH_4)_2SO_4$,	3.00	10	–	–	–	–	–	10	90	10	100	4.9
60 parts; $Na_2B_4O_7$, 10 parts;	6.13	10	–	–	–	–	–	30	70	10	100	5.1
and H_3BO, 20 parts)												
Pyresote	1.50	10	–	–	–	–	–	10	90	10	100	11.2
($ZnCl_2$, 35 parts; $(NH_4)SO_4$,	3.01	10	–	–	–	–	–	20	80	10	100	13.1
$Na_2Cr_2O_7$ $2H_2O$, 5 parts)	6.26	10	–	–	–	–	20	20	60	10	100	18.3
Untreated controls	–	10	–	–	–	–	–	20	80	10	100	2.6

[a]In cooperation with Bureau of Ships, Department of the Navy.

[b]Retention values in parentheses based on preservative oxides.

This study was initiated by J. Oscar Blew.

Table 26–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with basic zinc chloride and zinc chloride after about 50 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, March 1952 (Plot 32)

			Condition of stakes January 2002 (%)									
				Serviceable but showing some–			Destroyed by–					
Preservative	Average retention of (lb/ft^3)	Number in test	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
Basic zinc chloride[a]												
	1.00	10	–	20	–	70	10	–	–	1	10	–
	2.11	10	–	40	10	50	–	–	–	–	–	–
	4.13	10	–	70	20	10	–	–	–	–	–	–
Zinc chloride	1.02 (0.61)[b]	10	–	–	–	–	10	–	90	10	100	24.2
Untreated controls	–	10	–	–	–	–	10	20	70	10	100	2.3

[a]Pershall process. Compound intended as fire retardant with retentions of 3-1/2 to 4 lb/ft^3. Retentions of basic zinc chloride are expressed as weight of zinc oxide.

[b]Retention value in parentheses based on preservative oxide ZnO.

This study was initiated by J. Oscar Blew.

Table 27–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with naval-stores products after about 42 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, March 1952 (Plot 36)

			Condition of stakes November 1993 (%)									
				Serviceable but showing some–			Destroyed by–					
Preservative[a]	Average retention (lb/ft^3)	Number in test	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
Rosin oil and No. 2 fuel oil (2:7)	4.1	10	–	–	–	–	30	–	70	10	100	6.9
	8.0	10	–	–	–	–	60	–	40	10	100	5.8
	12.3	10	–	–	–	–	20	–	80	10	100	9.3
Rosin oil and No. 2 fuel oil (1:7)	4.0	10	–	–	–	–	10	–	90	10	100	5.7
	8.0	10	–	–	–	–	50	–	50	10	100	5.8
	12.1	10	–	–	–	–	40	–	60	10	100	8.6
Rosin oil and No. 2 fuel oil (1:7) with 2.98% pentachlorophenol	4.0	10	–	–	–	–	20	–	80	10	100	11.4
	8.0	10	–	–	–	–	20	–	80	10	100	14.8
	12.1	10	–	–	–	20	20	–	60	8	80	–
No. 2 fuel oil	4.1	10	–	–	–	–	30	10	60	10	100	6.1
No. 2 fuel oil with 2.92% pentachlorophenol	4.0	10	–	–	–	–	10	–	90	10	100	11.1
	8.0	10	–	–	–	–	20	–	80	10	100	12.8
	12.3	10	–	–	–	–	–	–	100	10	100	25.9
No. 2 fuel oil with 4.94% pentachlorophenol	4.1	10	–	–	–	–	50	–	50	10	100	12.4
	8.0	10	–	–	–	–	40	–	60	10	100	13.2
	12.0	9[b]	–	–	–	33	33	–	33	6	67	–
Rosin oil and Stoddard solvent (1:7) with 3.21% pentachlorophenol	8.0	10	–	–	–	–	50	–	50	10	100	12.5
Oleo resin and No. 2 fuel oil (2:7)	4.0	9[b]	–	–	–	–	–	–	100	9	100	6.1
	8.1	10	–	–	–	–	40	10	50	10	100	6.8
	12.2	10	–	–	–	–	30	–	70	10	100	10.7
Oleo resin and Stoddard solvent (1:7) with 3.11% pentachlorophenol	8.2	10	–	–	–	–	40	10	50	10	100	10.4
Drop liquor concentrate and Stoddard solvent (1:7) with 2.99% pentachlorophenol	7.9	10	–	–	–	–	20	–	80	10	100	8.7
Oleo resin and No. 2 fuel oil (1:7) with 2.94% pentachlorophenol	4.1	10	–	–	–	–	50	–	50	10	100	10.0
	8.0	10	–	–	–	–	30	–	70	10	100	13.5
	12.0	10	–	–	–	–	20	–	80	10	100	16.3

Table 27–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with naval-stores products after about 42 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, March 1952 (Plot 36)–cont.

			Condition of stakes November 1993 (%)									
				Serviceable but showing some–			Destroyed by–					
Preservative[a]	Average retention (lb/ft^3)	Number in test	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
Drop liquor concentrate and No. 2 fuel oil (2:7)	4.0	10	–	–	–	–	10	–	90	10	100	6.8
	8.0	10	–	–	–	–	20	–	80	10	100	7.9
	12.0	10	–	–	–	–	–	–	100	10	100	10.2
Drop liquor concentrate and No. 2 fuel oil (1:7)	4.0	10	–	–	–	–	–	–	100	10	100	12.2
with 3.03% pentachlorophenol	8.0	10	–	–	–	–	30	–	70	10	100	16.2
	12.0	10	–	–	–	–	20	–	80	10	100	20.2
No. 2 fuel oil with 5% rosin amine D copper	4.1	10	–	–	–	–	50	–	50	10	100	8.1
acetate complex	8.0	10	–	–	–	–	50	–	50	10	100	9.6
	12.1	10	–	–	–	–	60	–	40	10	100	15.9
Untreated controls	–	10	–	–	–	–	–	30	70	10	100	2.8

[a]Ratios and percentages on a weight basis.

[b]One stake missing; eliminated from test.

This study was initiated by J. Oscar Blew.

Table 28–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with coal-tar creosotes from tars produced by low-temperature carbonization (Disco process) after 48 years of in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, December 1952 (Plot 37)

			Condition of stakes June 2000 (%)									
				Serviceable but showing some–			Destroyed by–					
Preservative	Average retention (lb/ft^3)	Number in test[a]	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
Low-temperature coal-tar creosote, type 1 (tar acids present)	5.0	8	–	–	–	12	63	–	25	7	88	–
	10.2	9	–	11	–	22	33	–	33	6	67	–
	15.4	9	–	44	–	56	–	–	–	–	–	–
Low-temperature coal-tar creosote, type 2 (high percentage of tar acids removed)	5.0	9	–	–	–	–	44	–	56	9	100	27.2
	9.8	10	–	20	–	20	50	–	10	6	60	–
	15.2	10	–	30	–	60	10	–	–	1	10	–
Untreated controls	–	10	–	–	–	–	–	40	60	10	100	2.3

[a]Ten stakes were originally installed at each test station; this number has since been reduced because of failure to locate the stakes at the time of inspection.

Table 29–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with preservative oils and conditioned by vapor cleaning and steaming to remove residual solvents after about 28-1/2 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, April 1953[a] (Plot 38)—cont.

Preservative	Conditioning after treatment[e]	Number in test	Average preservative retention (lb/ft^3) From weights[b] Solution	From weights[b] Penta-chloro-phenol or copper metal	By analysis[c] Penta-chloro-phenol or copper metal	Condition of stakes October 1992 (%) Good	Serviceable but showing some– Decay	Termite attack	Decay and termite attack	Destroyed by– Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
Pentachlorophenol,	None	10	4.2	0.105	0.082	–	–	–	–	20	10	70	10	100	11.6
2.5% in light aromatic solvent[d]	Steaming	10	4.2	0.105	0.091	–	–	–	–	10	–	90	10	100	12.4
Pentachlorophenol, 2.5% in light aromatic solvent	Vapor cleaning	10	4.1	0.102	0.069	–	–	–	–	10	10	80	10	100	11.3
Pentachlorophenol, 4.5% in light aromatic solvent[d]	Steaming	10	4.4	0.200	0.139	–	–	–	–	30	–	70	10	100	10.8
Pentachlorophenol, 5% in light aromatic solvent	Vapor cleaning	10	4.5	0.225	0.136	–	–	–	–	20	–	80	10	100	14.2
Pentachlorophenol,	None	10	4.6	0.230	0.186	–	–	–	–	10	–	90	10	100	14.1
5% in light aromatic solvent[d]	Steaming	10	4.8	0.240	0.222	–	–	–	–	10	–	90	10	100	12.9
Pentachlorophenol, 5% in light aromatic solvent	Vapor cleaning	10	6.0	0.300	0.173	–	–	–	–	–	–	100	10	100	12.3
Pentachlorophenol, 9.1% in light aromatic solvent[d]	Steaming	10	4.4	0.400	0.319	–	–	–	20	10	–	70	8	80	18.0[f]
Pentachlorophenol, 10% in light aromatic solvent	Vapor cleaning	10	6.0	0.600	0.397	–	–	–	30	–	–	70	7	70	18.5[f]
Pentachlorophenol,	None	10	6.2	0.310	0.121	–	–	–	–	–	–	100	10	100	16.5
5% in No. 2 fuel oil	Steaming	10	6.6	0.330	0.146	–	–	–	10	20	–	70	9	90	15.0[f]
	Vapor cleaning	10	7.2	0.360	0.111	–	–	–	–	20	–	80	10	100	13.1

Table 29–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with preservative oils and conditioned by vapor cleaning and steaming to remove residual solvents after about 28-1/2 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, April 1953[a] (Plot 38)—cont.

Preservative	Conditioning after treatment[e]	Number in test	Average preservative retention (lb/ft^3) From weights[b] Solution	From weights[b] Pentachlorophenol or copper metal	By analysis[c] Pentachlorophenol or copper metal	Condition of stakes October 1992 (%) Good	Serviceable but showing some– Decay	Termite attack	Decay and termite attack	Destroyed by– Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
Copper naphthenate, 0.5% copper in light aromatic solvent	None	10	4.6	0.023	0.020	–	–	–	–	50	–	50	10	100	11.0
	Steaming	10	4.5	0.022	0.020	–	–	–	–	40	–	60	10	100	12.0
	Vapor cleaning	10	4.6	0.023	0.018	–	–	–	–	40	–	60	10	100	11.8
Copper naphthenate, 0.59% copper in light aromatic solvent	Steaming	10	4.4	0.026	0.023	–	–	–	–	30	–	70	10	100	14.3
Copper naphthenate, 0.7% copper in light aromatic solvent	Vapor cleaning	10	4.2	0.029	0.021	–	–	–	–	30	–	70	10	100	13.7
Untreated controls	–	10	–	–	–	–	–	–	–	–	60	40	10	100	2.4

[a]In cooperation with the Bureau of Ships, Department of the Navy.

[b]Weights determined before and after treatment, prior to conditioning.

[c]Analysis performed 2 months after treatment.

[d]Solution contined 5% ester gum (by weight) as a bloom preventative.

[e]One-hour steaming with maximum temperature 259°F and 1-h vacuum, following which steaming and vacuum periods were repeated.

[e]One-hour heating in vapor of aromatic solvent with maximum temperature of 280°F and 1-h vacuum, following which vapor heating and vacuum periods were repeated.

[f]Estimate based on percentage of stakes remaining after final inspection.

This study was initiated by J. Oscar Blew.

Table 30–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with Basilit UAa after about 41 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, December 1954 (Plot 40)

			Condition of stakes January 1995 (%)									
				Serviceable but showing some–			Destroyed by–					
Preservative	Average retention[b] (lb/ft^3)	Number in test	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
Basilit UA	0.25 (0.19)	10	–	–	–	–	–	50	50	10	100	21.6
Basilit UA	0.53 (0.39)	10	–	–	–	70	30	–	–	3	30	–
Basilit UA	0.75 (0.56)	9	–	–	–	100	–	–	–	–	–	–
Untreated controls	–	10	–	–	–	–	–	20	80	10	100	1.8

[a]Contains sodium fluoride, sodium dichromate, and sodium arsenate.

[b]Retention values in parentheses based on preservative oxides.

This study was initiated by J. Oscar Blew.

Table 31–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) of uninfected and Trichoderma mold-infected wood, reated with coal-tar creosote, pentachlorophenol solution, and copper chromated zinc chloride, after about 41 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, December 1954 (Plot 41)

Preservative	Average retention[a] (lb/ft^3)	Number in test[b]	Condition of stakes January 1995 (%)									
				Serviceable but showing some–			Destroyed by–					
			Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
Without Mold Infection												
Coal-tar creosote (high residue, straight run)	3.9	10	–	–	–	–	70	–	30	10	100	25.2
	7.8	9	–	–	–	22	78	–	–	7	78	–
	12.2	10	–	10	–	70	20	–	–	2	20	–
Coal-tar creosote (low residue, low in tar acids and naphthalenes)	4.0	10	–	–	–	10	20	–	70	9	90	–
	8.0	10	–	–	–	40	30	–	30	6	60	–
	12.4	8	–	–	–	100	–	–	–	–	–	–
Pentachlorophenol (4.7% in No. 2 fuel oil)	4.2	10	–	–	–	–	10	20	70	10	100	16.7
	8.1	9	–	–	–	–	33	–	67	9	100	21.6
	12.1	9	–	–	–	89	–	–	11	1	11	–
Copperized chromated zinc chloride	0.34 (0.20)	10	–	–	–	–	–	20	80	10	100	16.6
	0.73 (0.45)	10	–	–	–	10	60	–	30	9	90	–
	1.15 (0.71)	9	–	–	–	44	44	–	11	5	56	–
Untreated controls	–	10	–	–	–	–	–	60	40	10	100	2.1
Infected with *Trichoderma* Mold												
Coal-tar creosote (high residue, straight run)	4.0	10	–	–	–	10	40	–	50	9	90	–
	8.0	10	–	–	–	40	60	–	–	6	60	–
	12.0	9	–	–	–	78	22	–	–	2	22	–
Coal-tar creosote (low residue, low in tar acids and naphthalenes)	4.1	10	–	–	–	–	60	–	40	10	100	16.6
	8.0	10	–	–	–	20	40	–	40	8	80	–
	12.0	10	–	–	–	90	–	–	10	1	10	–
Pentachlorophenol (4.7% in No. 2 fuel oil)	4.2	10	–	–	–	–	20	20	60	10	100	17.6
	7.8	9	–	–	–	–	11	–	89	9	100	19.2
	11.9	10	–	–	–	50	10	–	40	5	50	–
Copperized chromated zinc chloride	0.34 (0.20)	10	–	–	–	–	–	20	80	10	100	20.2
	0.74 (0.45)	9	–	–	–	56	22	–	22	4	44	–
	1.17 (0.71)	10	–	–	–	60	30	–	10	4	40	–
Untreated controls	–	10	–	–	–	–	10	30	60	10	100	2.5

[a]Retention values in parentheses are based on preservative oxides.

[b]Ten stakes were originally installed at each test station; this number has since been reduced because of failure to locate the stakes at the time of inspection.

This study was initiated by Edward Panek.

Table 32–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with Texas lignite coal-tar creosote and with paraffin alone and fortified with pentachlorophenol after 41 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, December 1954 (Plot 42)

			Condition of stakes January 1995 (%)									
				Serviceable but showing some–			Destroyed by–					
Preservative	Average retention (lb/ft^3)	Number in test	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
Texas lignite coal-tar creosote	5.0	9	–	–	–	–	11	–	89	9	100	17.2
	9.8	10	–	–	–	10	–	–	90	9	90	–
	15.2	10	–	–	–	100	–	–	–	–	–	–
25% paraffin in aromatic volatile solvent (by weight)	25.9	10	–	–	–	–	1	1	8	10	100	18.4
5% pentachlorophenol plus 28.5% paraffin in aromatic volatile solvent (by weight)	26.3	10	–	–	–	100	–	–	–	–	–	–
Untreated controls	–	10	–	–	–	–	–	30	70	10	100	2.3

This study was initiated by J. Oscar Blew.

Table 33–Condition of Douglas-fir, sweetgum, and tangile plywood stakes treated with pentachlorophenol and with fluor chrome arsenate phenol type A after about 26 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, January 1956 (Plot 44)[a]

					Condition of stakes December 1981 (%)									
						Serviceable but showing some–			Destroyed by–					
Plywood	Preservative[b]	Treatment[c]	Average retention[d] (lb/ft^3)	Number in test	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
					Plywood Treated Before Gluing									
Douglas-fir	Pentachlorophenol	Hot and cold	10.0	9	–	–	–	–	22	–	77	9	100	14.0
	Pentachlorophenol	Cold soaked	6.3	10	–	–	–	–	30	–	70	10	100	8.2
	Fluor chrome arsenate phenol type A	Hot and cold	0.52 (0.32)	10	–	–	–	–	50	–	50	10	100	12.3
Sweetgum	Pentachlorophenol	Hot and cold	15.1	10	–	–	–	–	30	–	70	10	100	7.4
	Fluor chrome arsenate phenol type A	Hot and cold	0.62 (0.39)	10	–	–	–	–	60	–	40	10	100	8.5
Tangile	Pentachlorophenol	Hot and cold	9.4	10	–	–	–	–	60	–	40	10	100	6.8
	Fluor chrome arsenate phenol type A	Hot and cold	0.59 (0.37)	10	–	–	–	–	100	–	–	10	100	10.4
					Plywood Treated After Gluing									
Douglas-fir	Pentachlorophenol	Pressure	9.6	10	–	–	–	–	20	–	80	10	100	15.4
	Pentachlorophenol	Cold soaked	0.9	10	–	–	–	–	20	10	70	10	100	5.3
	Pentachlorophenol	Cold soaked	1.4[e]	10	–	–	–	–	–	20	80	10	100	7.1
	Fluor chrome arsenate phenol type A	Pressure	0.61 (0.38)	9	–	–	–	–	22	22	56	9	100	18.3
Sweetgum	Pentachlorophenol	Pressure	10.6	10	–	–	–	–	70	–	30	10	100	6.3
	Fluor chrome arsenate phenol type A	Pressure	0.55 (0.34)	10	–	–	–	–	50[f]	10	40	10	100	7.6
Tangile	Pentachlorophenol	Pressure	10.4	10	–	–	–	–	70	–	30	10	100	13.4
	Fluor chrome arsenate phenol type A	Pressure	0.60 (0.37)	10	–	–	–	–	90	–	10	10	100	14.9

Table 33–Condition of Douglas-fir, sweeetgum, and tangile plywood stakes treated with pentachlorophenol and with fluor chrome arsenate phenol type A after about 26 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, January 1956 (Plot 44)–cont.

					Condition of stakes December 1981 (%)									
						Serviceable but showing some–			Destroyed by–					
Plywood	Preservative	Treatment	Average retention (lb/ft^3)	Number in test	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
					Untreated controls									
Douglas-fir	–	–	–	10	–	–	–	–	–	–	100	10	100	3.6
Sweetgum	–	–	–	10	–	–	–	–	10	10	80	10	100	1.4
Tangile	–	–	–	10	–	–	–	–	40	–	60	10	100	1.9

[a]In cooperation with the Bureau of Ships, Department of the Navy.

[b]For pentachlorophenol, 5% solution conforming to MIL-W-18142 (SHIPS) specification, 27 August 1954.

[c]Hot and cold treatment consisted of heating in a veneer dryer and immersion in unheated preservative solution until desired retention was obtained.

[d]Retention values in parentheses are based on preservative oxides.

[e]Stakes were cut from the panels and then treated.

[f]One stake decayed by soft-rot fungus.

NOTE: The stakes were five-ply veneer, 5/8 by 4 by 18 in., cut from panels 24 by 48 in. For other treated items, the stakes were cut after treatment and the edges exposed in sawing were brush coated with the preservative.

This study was initiated by Edward Panek.

Table 34–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with copper formate, after about 55 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, December 1956 (Plot 47)

			Condition of stakes March 2011 (%)									
				Serviceable but showing some–			Destroyed by–					
Preservative	Average retention (copper) (lb/ft^3)	Number in test[a]	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
Copper formate	0.03	10	–	–	–	–	30	–	70	10	100	7.4
	0.06	10	–	–	–	–	90	–	10	10	100	25.9
	0.09	10	–	–	–	–	90	–	10	10	100	38.2
	0.12	9	–	44	–	–	56	–	–	5	56	–
Untreated controls	–	10	–	–	–	–	–	–	100	10	100	3.4

[a]Ten stakes were originally installed at each test station; this number has since been reduced because of failure to locate the stakes at the time of inspection.

This study was initiated by J. Oscar Blew.

Table 35–Condition of Southern Pine stakes treated with KPa preservative after 34 and 43 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, December 1957 and Madison, Wisconsin, May 1958 (Plot 48)

				Condition of stakes October 1992 (WI) and December 2000 (MS) (%)									
					Serviceable but showing some–			Destroyed by–					
Preservative	Location	Average retention[b] (lb/ft^3)	Number in test[c]	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
						Stakes 3/4 by 3/4 by 18 in.							
KP preservative	MS	0.09	9	–	–	–	–	56	11	33	9	100	9.9
	MS	0.18	7	–	–	–	–	86	–	14	7	100	16.4
	MS	0.28	8	–	29	–	–	57	–	14	5	71	–
	MS	0.37	4	–	–	–	–	100	–	–	4	100	25.6
Chromated zinc chloride	MS	1.20 (0.73)	9	–	–	–	–	11	67	22	9	100	13.7
Coal-tar creosote	MS	11.70	8	–	–	–	25	50		25	6	75	–
Untreated controls	MS	–	10	–	–	–	–	40	–	60	10	100	2.1
						Stakes 2 by 4 by 18 in.							
KP preservative	MS	0.09	10	–	–	–	–	70	–	30	10	100	13.5
	WI	0.09	8	–	–	–	–	100	–	–	8	100	19.8
	MS	0.19	9	–	11	–	44	44	–	–	4	44	–
	WI	0.18	10	–	30	–	–	70	–	–	7	70	–
	MS	0.27	10	10	10	10	50	20	–	–	2	20	–
	WI	0.27	8	–	63	–	–	37	–	–	3	37	–
	MS	0.37	9	11	22	22	22	22	–	–	2	22	–
	WI	0.35	7	–	100	–	–	–	–	–	–	–	–
Chromated zinc chloride	MS	1.16 (0.71)	10	–	–	–	–	20	–	80	10	100	22.9
	WI	1.21 (0.74)	8	–	25	–	–	75	–	–	–	–	–
Coal-tar creosote	MS	10.20	9	–	22	–	78	–	–	–	–	–	–
	WI	10.20	10	10	90	–	–	–	–	–	–	–	–
Untreated controls	MS	–	10	–	–	–	–	20	–	80	10	100	2.5
	WI	–	10	–	–	–	–	100	–	–	–	–	3.6

[a]Copper oxide and chlorophenols.

[b]Retention values in parentheses are based on preservative oxides.

[c]When the number of stakes is less than 10, specimens were found broken and eliminated from test.

This study was initiated by J. Oscar Blew.

Table 36–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with tributyltin oxide, cyanoethylated stakes and stakes treated for destruction of thiamine, after approximately 9-1/2 years in test in Mississippi and 8 years in Madison, WI. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, December 1958 and in Wisconsin, May 1959 (Plot 53)

				Condition of stakes January 1967 (%)									
					Serviceable but showing some–			Destroyed by–					
Preservative	Location	Average retention (lb/ft^3)	Number in test	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
Tributyltin oxide[a]	MS	0.015	10	–	–	–	–	–	10	90	10	100	6.4
	MS	0.030	10	–	–	–	–	10	–	90	10	100	7.2
	MS	0.045	10	–	–	–	–	10	–	90	10	100	7.4
Stoddard solvent (controls)	MS	7.1	10	–	–	–	–	–	20	80	10	100	4.0
Acrylonitrile[b]	MS	1.23	10	–	–	–	–	–	10	90	10	100	3.9
	WI	1.22	10	–	–	–	–	100	–	–	10	100	6.3
	MS	2.46	10	–	–	–	–	–	10	90	10	100	5.3
	WI	2.48	10	–	–	–	–	100	–	–	10	100	7.8
Ammonium hydroxide[c]	MS	–	10	–	–	–	–	–	10	90	10	100	3.5
Untreated controls	MS	–	10	–	–	–	–	–	–	100	10	100	3.6
	WI	–	10	–	–	–	–	100	–	–	10	100	4.0

[a]In Stoddard solvent.

[b]Used with ammonium hydroxide for cyanoethylation.

[c]Followed by steaming for thiamine destruction.

This study was initiated by J. Oscar Blew.

Table 37–Condition of Southern Pine stakes (2 by 4 in. nominal and 3/4 by 3/4 in. by 18 in.) treated with fluor chrome arsenate phenol type A (AWPA-P5 and modification) after about 30 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, December 1959 (Plot 55)

			Condition of stakes December 1989 (%)									
				Serviceable but showing some–			Destroyed by–					
Preservative	Average retention[a] (lb/ft^3)	Number in test[b]	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
						Stakes 2 by 4 Nominal by 18 in.						
Fluor chrome arsenate	0.35 (0.22)	8	–	–	–	–	63	–	37	9	100	18.3
phenol (Federal Spec.	0.50 (0.31)	10	–	–	–	–	80	–	20	10	100	18.5
TT-W-535) (Type A)	0.75 (0.47)	10	–	–	–	–	80	–	20	10	100	25.1
Fluor chrome arsenate	0.35 (0.22)	9	–	–	–	–	33	11	56	9	100	16.7
phenol (Type A)	0.50 (0.31)	10	–	–	–	–	80	–	20	10	100	17.5
(Modified)[c]	0.76 (0.47)	10	–	–	–	–	90	–	10	10	100	21.4
Untreated controls	–	10	–	–	–	–	40	20	40	10	100	2.1
						Stakes 3/4 by 3/4 by 18 in.						
Fluor chrome arsenate	0.36 (0.22)	9	–	–	–	–	33	33	33	9	100	7.4
phenol (Federal Spec.	0.51 (0.32)	9	–	–	–	–	56	33	11	9	100	11.9
TT-W-535) (Type A)	0.77 (0.48)	8	–	–	–	–	50	13	37	8	100	16.5
Fluor chrome arsenate	0.37 (0.23)	10	–	–	–	–	20	30	50	10	100	8.3
phenol (Type A)	0.52 (0.32)	10	–	–	–	–	20	40	40	10	100	11.6
(Modified)[c]	0.80 (0.38)	9	–	–	–	–	56	11	33	9	100	15.3
Untreated controls	–	10	–	–	–	–	30	20	50	10	100	1.4

[a]Retention values in parentheses are based on preservative oxides.

[b]When the number of stakes is less than 10, stakes were damaged mechanically and eliminated from test.

[c]Sodium pentachlorophenate substituted for dinitrophenol.

This study was initiated by J. Oscar Blew.

Table 38–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with copper-8-quinolinolate after approximately 9 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, December 1959 (Plot 54)

Preservative	Average retention: Solution (lb/ft³)	Average retention: Copper-8-quinolinolate (lb/ft³)	Number in test[a]	Condition of stakes November 1968 (%): Good	Serviceable but showing some–: Decay	Termite attack	Decay and termite attack	Destroyed by–: Decay fungi	Termite attack	Decay fungi and termite attack	Total removed: Number	Total removed: %	Average life (year)
Copper-8-quinolinolate													
0.1% in Stoddard solvent	9.9	0.010	10	–	–	–	–	10	–	90	10	100	5.3
0.1% in Stoddard solvent	9.9	0.020	10	–	–	–	–	20	10	70	10	100	4.2
0.1% in Stoddard solvent	10.0	0.060	10	–	–	–	10	40	–	50	9	90	5.6[a]
0.1% in Stoddard solvent	10.2	0.123	10	–	–	–	10	60	–	30	9	90	7.8[a]
0.6% paraffin, 2%; and Pentalyn-H, 10% in Stoddard solvent	10.1	0.061	10	–	10	–	20	70	–	–	7	70	8.8[a]
0.6%; Dieldrin, 0.5% in Stoddard solvent	10.1	0.060	10	–	–	–	10	70	–	20	9	90	6.6[a]
Untreated controls	–	–	10	–	–	–	–	–	20	80	10	100	2.2

[a]Estimate based on percentage of stakes remaining after final inspection.

This study was initiated by J. Oscar Blew.

Table 39–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with blends of extracts from Texas lignite tar after about 49 in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, December 1960 (Plot 57)

			Condition of stakes November 2009 (%)									
				Serviceable but showing some–			Destroyed by–					
Lignite-tar extracts	Average retention (lb/ft^3)	Number in test[a]	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
Hexane-soluble residue, 25%; and hexane	5.1	10	–	–	–	–	20	–	80	10	100	16.2
distillate, 75% (by weight)	10.0	10	–	–	–	–	30	–	70	10	100	35.5
	14.1	10	–	10	–	10	80	–	–	8	80	–
High-boiling methanol solubles, 25%; hexane	5.0	10	–	–	–	–	–	–	100	10	100	18.8
distillate, 75% (by weight)	9.3	9	–	33	–	–	22	–	45	6	67	–
	15.2	10	–	80	–	20	–	–	–	–	–	–
High-boiling methanol solubles, 10%; hexane-	5.1	10	–	–	–	–	10	–	90	10	100	18.8
soluble residue, 20%; and hexane distillate,	10.1	10	–	–	–	–	40	–	60	10	100	35.8
70% (by weight)	14.7	8	–	50	–	13	37	–	–	3	37	–
High-boiling methanol solubles, 20%; and hexane-	5.2	10	–	–	–	–	20	–	80	10	100	20.2
soluble residue, 10%; and hexane distillate,	10.0	8	–	13	–	13	37	–	37	6	75	–
70% (by weight)	15.2	10	30	20	–	20	30	–	–	3	30	–
High-boiling methanol solubles, 15%; and hexane	5.0	10	–	–	–	–	10	10	80	10	100	22.0
distillate, 85% (by weight)	10.2	7	–	13	–	29	29	–	29	4	58	–
	14.9	9	–	89	–	11	–	–	–	–	–	–
High-boiling methanol solubles, 24,5%; hexane	5.1	10	–	–	–	–	30	–	70	10	100	24.2
distillate, 74.5%; and petroleum sulfonate	9.9	10	–	10	–	20	50	–	20	7	70	–
(Morpel X-914), 1% (by weight)	15.0	10	–	70	–	10	20	–	–	2	20	–
Untreated controls	–	10	–	–	–	–	–	–	100	10	100	2.6

[a]Ten stakes were originally installed at each test station; this number has since been reduced because of failure to locate the stakes at the time of inspection.

This study was initiated by J. Oscar Blew.

Table 40–Condition of 1- by 4- by 18-in. stakes of embedded fiberboarda and untreated Douglas-fir heartwood after 18 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, December 1960 (Plot 58)

		Condition of stakes December 1978 (%)									
			Serviceable but showing some–			Destroyed by–					
Material	Number in test	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
Embedded fiberboard[a]	6[b]	–	–	–	–	100[c]	–	–	6	100	11.3
Douglas-fir heartwood	10	–	–	–	–	70	10	20	10	100	3.0

[a]Western hemlock strands in portland cement.

[b]Stakes missing and eliminated from test.

[c]Failures attributed mainly to the effect of moisture.

Table 41–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with tributyltin oxide and pentachlorophenol solutions with heavy and light petroleum solvents, with and without the addition of Dieldrin and Aldrin, after about 49 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, December 1960 (Plot 56)

			Condition of stakes November 2009 (%)									
				Serviceable but showing some–			Destroyed by–					
Preservative	Average retention (lb/ft^3)	Number in test[a]	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
						Solutions with Stoddard Solvent						
Tributyltin oxide, 0.3%; and Dieldrin, 0.3%	8.0	10	–	–	–	–	90	–	10	10	100	4.9
Tributyltin oxide, 0.6%; and Dieldrin, 0.3%	8.0	10	–	–	–	–	90	–	10	10	100	6.9
Tributyltin oxide, 0.3%; and Aldrin, 0.3%	8.0	10	–	–	–	–	90	–	10	10	100	4.6
Tributyltin oxide												
0.3%	8.2	10	–	–	–	–	80	–	20	10	100	4.5
0.6%	7.9	10	–	–	–	–	50	–	50	10	100	7.0
Tributyltin oxide, 0.6%; Dieldrin, 0.3%; and water repellent, 4.7%	8.0	10	–	–	–	–	100	–	–	10	100	6.9
Tributyltin oxide, 0.6%; Aldrin, 0.3%; and water repellent, 4.7%	8.0	10	–	–	–	–	70	–	30	10	100	5.3
Dieldrin, 0.6%;	8.0	10	–	–	–	–	90	–	10	10	100	4.0
Pentachlorophenol, 5%; pine oil, 5%; and water repellent, 4.7%	8.0	9	–	–	–	–	44	–	56	9	100	32.3
Pentachlorophenol, 5%; pine oil, 5%; Dieldrin 0.3%; and water repellent, 4.7%	8.0	10	–	–	–	–	50	–	50	10	100	33.7
Water repellent, 4.7%	8.0	10	–	–	–	–	80	–	20	10	100	4.3
Pentachlorophenol, 5%; pine oil, 5%; Dieldrin 0.3% stabilizer wax, 2%; and water repellent, 4.7%	8.0	9	–	33	–	–	67	–	–	6	67	–
						Solutions with Heavy Petroleum Solvent (AWPA P9)						
Tributyltin oxide, 0.3%; and Dieldrin, 0.3%	8.0	10	–	–	–	–	100	–	–	10	100	22.2
Tributyltin oxide, 0.6%; and Dieldrin, 0.3%	8.0	10	–	–	–	–	60	–	40	10	100	23.0
Tributyltin oxide												
0.3%	8.0	10	–	–	–	–	40	–	60	10	100	20.8
0.6%	8.0	10	–	–	–	–	20	10	70	10	100	24.0
Pentachlorophenol, 5%	8.0	10	–	10	–	10	40	–	40	8	80	–
Pentachlorophenol, 5%; and stabilizer wax, 2%	7.7	10	–	–	–	40	10	–	50	6	60	–
Petroleum solvent contols	8.0	9	–	–	–	–	11	–	89	9	100	23.3
Untreated controls	–	10	–	–	–	–	70	–	30	10	100	3.1

[a]Ten stakes were originally installed at each test station; this number has since been reduced because of failure to locate the stakes at the time of inspection.

This study was initiated by Edward Panek.

Table 42–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in. and 3/4 by 3/4 in. by 17 in.) treated with pentachlorophenol in liquefied petroleum gas and in heavy and light petroleum solvents after about 38-1/2 years in test. Stakes installed at Valley View Test Plot, Madison, Wisconsin, and on Harrison Experimental Forest, Saucier, Mississippi, July 1961 (Plot 59)

Preservative	Location	Average retention (lb/in^3) By weight: Solution	By weight: Pentachlorophenol	By analysis, Pentachlorophenol	Number in test	Condition of stakes January 2000 (%): Good	Serviceable but showing some–: Decay	Termite attack	Decay and termite attack	Destroyed by–: Decay fungi	Termite attack	Decay fungi and termite attack	Total removed: Number	Total removed: %	Average life (year)
						Stakes 2 by 4 nominal by 18 in.									
Pentachlorophenol in	MS	–	–	0.14[b]	10	–	–	–	–	10	–	90	10	100	18.9
liquefied petroleum gas[a]	MS	–	–	0.19[b]	10	–	–	–	–	10	–	90	10	100	15.9
	MS	–	–	0.34[b]	10	–	–	–	90	–	–	10	1	10	–
	MS	–	–	0.58[b]	10	–	–	–	100	–	–	–	–	–	–
Solutions with AWPA P9 (heavy petroleum solvent)															
Pentachlorophenol															
3.5% (by weight)	MS	3.0	0.11	0.14	10	–	–	–	10	–	–	90	9	90	–
	MS	4.5	0.19	0.22	10	–	–	–	40	–	–	60	6	60	–
4.2% (by weight)	MS	6.8	0.29	0.32	10	–	–	–	100	–	–	–	–	–	–
	MS	16.0	0.67	0.69	10	2	1	–	70	–	–	–	–	–	–
Solutions with Stoddard solvent															
Pentachlorophenol, 4.0%;	MS	3.6	0.14	0.14	10	–	–	–	–	10	–	90	10	100	13.7
paraffin, 2%; and Pentalyn-H, 10% (by weight)	MS	4.6	0.18	0.18	10	–	–	–	–	–	–	100	10	100	15.9
Pentachlorophenol, 5%;	MS	7.6	0.38	0.39	10	–	–	–	20	–	–	80	8	80	–
paraffin, 2%; and Pentalyn-H, 10% (by weight)	MS	13.5	0.67	0.70	10	–	–	–	100	–	–	–	–	–	–
Untreated controls	MS	–	–	–	10	–	–	–	–	30	30	40	10	100	2.1

Table 42–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in. and 3/4 by 3/4 in. by 17 in.) treated with pentachlorophenol in liquefied petroleum gas and in heavy and light petroleum solvents after about 38-1/2 years in test. Stakes installed at Valley View Test Plot, Madison, Wisconsin, and on Harrison Experimental Forest, Saucier, Mississippi, July 1961 (Plot 59)–cont.

		Average retention (lb/in^3)				Condition of stakes January 2000 (%)									
		By weight		By analysis,			Serviceable but showing some–			Destroyed by–					
Preservative	Location	Solution	Pentachlorophenol	Pentachlorophenol	Number in test	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
						Stakes 3/4 by 3/4 by 17 in.									
Pentachlorophenol in	MS	–	–	0.15[c]	10	–	–	–	–	40	–	60	10	100	5.5
liquefied petroleum gas[a]	WI	–	–	0.15[c]	15	–	–	–	–	100	–	–	15	100	10.0
	MS	–	–	0.19[c]	8[d]	–	–	–	–	50	–	50	8	100	4.6
	WI	–	–	0.19[c]	14[d]	–	–	–	–	100	–	–	14	100	12.4
	MS	–	–	0.31[c]	9[d]	–	–	–	–	22	11	67	9	100	11.9
	WI	–	–	0.31[c]	13[d]	–	–	–	–	100	–	–	13	100	13.7
	MS	–	–	0.48[c]	8[d]	–	–	–	–	38	12	50	8	100	14.9
	WI	–	–	0.48[c]	7[d]	–	–	–	–	100	–	–	7	100	17.5
Solutions with AWPA P9	MS	3.2	0.14	–	9[d]	–	–	–	–	11	–	89	9	100	14.5
(heavy petroleum solvent)	WI	3.3	0.14	–	5[d]	–	–	–	–	100	–	–	5	100	16.4
Pentachlorophenol	MS	3.8	0.16	–	10	–	–	–	–	10	10	80	10	100	14.5
4.2% (by weight)	WI	3.9	0.16	–	7[d]	–	–	–	–	100	–	–	7	100	15.8
	MS	5.7	0.24	–	4[d]	–	–	–	–	25	–	75	4	100	18.4
	WI	5.5	0.23	–	5[d]	–	–	–	–	100	–	–	5	100	17.8
	MS	16.7	0.70	–	4[d]	–	–	–	–		–	100	4	100	30.4
	WI	17.2	0.73	–	4[d]	–	–	–	–	100	–	–	4	100	22.4
Solutions in Stoddard solvent															
Pentachlorophenol, 4.0%;	MS	3.5	0.14	–	9[d]	–	–	–	–	44	11	44	9	100	5.6
paraffin, 2%; and	WI	3.0	0.12	–	11[d]	–	–	–	–	100	–	–	11	100	10.8
Pentalyn-H, 10% (by weight)	MS	3.9	0.16	–	10	–	–	–	–	30	–	70	10	100	4.9
	WI	4.0	0.16	–	13[d]	–	–	–	–	100	–	–	13	100	10.8
Pentachlorophenol, 5.0%;	MS	6.4	0.32	–	9[d]	–	–	–	–	22	–	78	9	100	14.4
paraffin, 2.0%; and	WI	6.6	0.33	–	14	–	–	–	–	100	–	–	14	100	14.4
Pentalyn-H, 10% (by weight)	MS	14.4	0.72	–	4[d]	–	–	–	–	50	–	50	4	100	24.9
	WI	14.6	0.73	–	5[d]	–	–	–	–	100	–	–		100	21.0
Untreated controls	MS	–	–	–	10	–	–	–	–	40	30	30	10	100	1.5
	WI	–	–	–	15	–	–	–	–	100	–	–	15	100	4.0

[a]It has been reported that the formulation of treating solution in liquefied petroleum gas has been changed since the stakes were treated.

[b]From the analysis of composite sample of cross-section wafers taken at midpoint from ten 2- by 4- by 18-in. stakes and matched to the 10 stakes treated for installation. Because retentions were not determined for individual test stakes, extra stakes were not treated to provide a selection, according to retentions, for the test installation.

[c]Based on analysis by Bell Telephone Laboratories of 2-in. sections cut adjacent to the test stakes.

[d]Stakes injured mechanically and eliminated from test.

This study was initiated by J. Oscar Blew.

Table 43–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with copper-8-quinolinolate and pentachlorophenol in heavy petroleum solvent after 45 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, December 1963 (Plot 62)

	Average retention			Condition of stakes March 2008 (%)									
					Serviceable but showing some–			Destroyed by–					
Preservative	Solution (lb/ft^3)	Copper-8-quinolinolate or pentachlorophenol (lb/ft^3)	Number in test[a]	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
Solutions with heavy petroleum solvent (AWPA P9):Copper-8-quinolinolate													
0.15%	9.35	0.014	10	–	–	–	–	30	10	60	10	100	26.9
0.3%	10.14	0.030	10	–	–	–	–	20	–	80	10	100	27.3
0.6%	9.89	0.059	10	–	–	–	–	60	–	40	10	100	31.3
1.2%	10.31	0.124	9	–	44	–	44	–	–	12	1	12	–
Pentachlorophenol 4.98%	10.64	0.540	9	–	44	–	56	–	–	–	–	–	–
Petroleum solvent controls	8.49	–	10	–	–	–	–	30	10	60	10	100	20.9
Untreated controls	–	–	10	–	–	–	–	20	–	80	10	100	2.9

[a]Ten stakes originally installed; eliminated stakes removed for causes other than decay or insect attack.

This study was initiated by L. R. Gjovik.

Table 44–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with heptadecyltrimethyl-tetrahydropyrimidine (HTP) in No. 2 fuel oil after about 37 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, December 1963 (Plot 63)

				Condition of stakes June 2000 (%)									
					Serviceable but showing some–			Destroyed by–					
	Average retention (lb/ft^3)		Number in test	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed		Average life (year)
Preservative	Solution	HTP									Number	%	
HTP, 2.5%, No. 2 fuel oil	6.0	0.150	10	–	–	–	–	–	–	100	10	100	12.5
HTP, 5%, No. 2 fuel oil	8.1	0.406	10	–	–	–	30	–	–	70	7	70	–
HTP, 5%, No. 2 fuel oil	10.0	0.498	10	–	–	–	60	20	–	20	4	40	–
Untreated controls	–	–	10	–	–	–	–	–	–	100	10	100	2.3

This study was initiated by H. L. Davidson.

Table 45–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in. and 3/4 by 3/4 by 16 in.) treated with pentachlorophenol in liquefied petroleum gas and in heavy and light petroleum solvents after about 35 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, December 1963 (Plot 61)

	Average retention (lb/in^3)			Condition of stakes February 1998 (%)									
					Serviceable but showing some–			Destroyed by–					
Preservative	Solution	Pentachlorophenol	Number in test[c]	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
							Stakes 2 by 4 in.						
Pentachlorophenol in liquefied petroleum gas[b]	–	0.34[a]	10	–	–	–	10	40	–	50	9	90	–
	–	0.49[a]	10	–	–	–	90	10	–	–	1	10	–
	–	0.65[a]	10	–	–	–	100	–	–	–	–	–	–
	–	0.39[a,d]	10	–	–	–	100	–	–	–	–	–	–
Pentachlorophenol, 5% in heavy petroleum oil	10.6	0.53[a]	10	10	10	80	–	–	–	–	–	–	–
Heavy petroleum oil	8.0	–	10	–	–	–	–	20	–	80	10	100	19.7
Untreated controls	–	–	10	–	–	–	–	20	–	80	10	100	2.5
							Stakes 3/4 by 3/4 in.						
Pentachlorophenol in liquefied petroleum gas[b]	–	0.34[a]	10	–	–	–	–	70	–	30	10	100	8.6
	–	0.40[a]	8	–	–	–	–	75	–	25	8	100	7.2
	–	0.59[a]	6	–	–	–	–	67	–	33	6	100	9.1
	–	0.70[a]	8	–	–	–	–	50	–	50	8	100	16.5
Pentachlorophenol, 5% in heavy petroleum oil	10.8	0.54[e]	4	–	–	–	–	50	–	50	4	100	20.7
Heavy petroleum oil	8.3	–	8	–	–	–	–	75	25	–	8	100	6.6
Untreated controls	–	–	10	–	–	–	–	40	10	50	10	100	1.4

[a]By x-ray analysis of samples from pieces from which stakes were cut.

[b]With cosolvent of isopropyl ether.

[c]When the number of stakes is less than 10, stakes were damaged mechanically and eliminated from test.

[d]Treated in commercial charge with poles and crossarms.

[e]Computed.

This study was initiated by J. Oscar Blew.

Table 46–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with copper-chrome-boron and acid copper chromate preservatives after 30 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, January 1967 (Plot 66)

			Condition of stakes January 1997 (%)									
				Serviceable but showing some–			Destroyed by–					
Preservative	Average retention[a] (lb/ft^3)	Number in test[b]	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
Copper-chrome-boron	0.25 (0.13)	10	–	–	–	–	60	–	40	10	100	3.9
(a product of	0.30 (0.16)	10	–	–	–	–	60	–	40	10	100	4.9
Dr. Wolman, GmbH,	0.60 (0.31)	10	–	–	–	–	100	–	–	10	100	5.5
Sinzheim, Germany,	1.11 (0.58)	10	–	–	–	10	90	–	–	9	90	–
covered by U.S. patent	1.24 (0.65)	9	11	22	–	11	44	–	11	5	56	–
No. 3,007,844)	1.64 (0.86)	10	20	20	–	20	40	–	–	4	40	–
Acid copper chromate	0.30 (0.14)	10	–	–	–	–	100	–	–	10	100	6.1
(AWPA P5-68)	0.60 (0.29)	10	–	–	–	–	100	–	–	10	100	4.6
Untreated controls	–	10	–	–	–	–	10	90	–	10	100	2.6

[a]Retention values in parentheses are based on preservative oxides.

[b]Ten stakes originally installed; eliminated stakes removed for causes other than decay or insect attack.

This study was initiated by J. Oscar Blew.

Table 47–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with 11 standard wood preservatives after about 40 years in test. Stakes placed in test in November 1967 at Lake Charles, Louisiana, in an area infested by Formosan termites and on the Harrison Experimental Forest, Saucier, Mississippi (Plot 67)

					Condition of stakes February 2007 (MS) and January 1984 (LA) (%)									
						Serviceable but showing some–			Destroyed by–					
Preservative	AWPA Standard	Location	Average retention[a] (lb/ft^3)	Number in test[b]	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
Creosote, coal-tar	P1-65	LA	4.9	10	10	–	–	50	40	–	–	4	40	–
			10.2	10	60	20	–	20	–	–	–	–	–	–
			15.0	10	100	–	–	–	–	–	–	–	–	–
		MS	5.1	10	–	–	–	20	70	–	10	8	80	–
			9.7	10	–	80	–	–	20	–	–	2	20	–
			15.4	10	–	30	–	70	–	–	–	–	–	–
Creosote-coal-tar solution (70-30)	P2-68	LA	4.7	10	–	–	–	60	40	–	–	4	40	–
			9.9	10	90	10	–	–	–	–	–	–	–	–
			14.9	10	100	–	–	–	–	–	–	–	–	–
		MS	3.9	10	–	10	–	–	60	–	30	9	90	–
			10.7	10	50	50	–	–	–	–	–	–	–	–
			16.2	10	80	20	–	–	–	–	–	–	–	–
Creosote-petroleum solution (50-50)	P3-67	LA	5.8	10	10	10	–	40	30	–	10	4	40	–
			12.1	10	70	10	–	20	–	–	–	–	–	–
			18.3	10	100	–	–	–	–	–	–	–	–	–
		MS	6.0	10	–	30	–	–	50	–	20	7	70	–
			12.1	10	50	50	–	–	–	–	–	–	–	–
			18.5	8	62	38	–	–	–	–	–	–	–	–
Pentachlorophenol, 5% in heavy petroleum	P8-64 and P9-67	LA	5.8	10	40	–	–	60	–	–	–	–	–	–
			9.9	10	70	10	–	20	–	–	–	–	–	–
			15.1	10	80	20	–	–	–	–	–	–	–	–
		MS	7.0	10	–	10	–	50	30	–	10	4	40	–
			9.5	9	–	67	–	–	11	–	22	3	33	–
			14.6	9	–	78	–	11	–	–	11	1	11	–
Acid copper chromate	P5-68	LA	0.50 (0.25)	10	–	–	–	–	30	60	10	10	100	8.5
			1.00 (0.50)	9	–	11	–	78	–	–	11	1	11	–
			1.49 (0.74)	9	20	10	–	60	–	–	–	–	–	–
		MS	0.51 (0.25)	10	–	10	–	10	70	–	10	8	80	–
			1.01 (0.50)	10	50	–	–	–	50	–	–	5	50	–
			1.54 (0.76)	9	67	–	–	11	22	–	–	2	22	–
Ammoniacal copper arsenate	P5-68	LA	0.25 (0.24)	10	–	–	–	10	70	–	20	9	90	–
			0.46 (0.44)	10	–	–	–	80	20	–	–	2	20	–
			0.67 (0.63)	10	10	10		70	10	–	–	1	10	–
		MS	0.26 (0.25)	9	–	33	–	–	56	–	11	6	67	–
			0.48 (0.45)	10	10	70	–	–	20	–	–	2	20	–
			0.70 (0.66)	10	20	70	–	–	10	–	–	1	10	–

Table 47–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with 11 standard wood preservatives after about 40 years in test. Stakes placed in test in November 1967 at Lake Charles, Louisiana, in an area infested by Formosan termites and on the Harrison Experimental Forest, Saucier, Mississippi (Plot 67)–cont.

					Condition of stakes February 2007 (MS) and January 1984 (LA) (%)									
						Serviceable but showing some–			Destroyed by–					
Preservative	AWPA Standard	Location	Average retention[a] (lb/ft^3)	Number in test[b]	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
Chromated copper arsenate type A	P5-68	LA	0.40 (0.23)	10	–	–	–	70	10	10	10	3	30	–
			0.76 (0.44)	10	50	10	–	40	–	–	–	–	–	–
			1.11 (0.64)	10	90	10	–	–	–	–	–	–	–	–
		MS	0.39 (0.22)	9	11	33	–	–	45	–	11	5	56	–
			0.76 (0.44)	10	90	–	–	–	10	–	–	1	10	–
			1.14 (0.66)	8	100	–	–	–	–	–	–	–	–	–
Chromated copper arsenate type B	P5-68	LA	0.25 (0.23)	10	–	–	–	80	10	–	10	2	20	–
			0.44 (0.40)	10	20	30	–	50	–	–	–	–	–	–
			0.65 (0.59)	10	80	10	–	10	–	–	–	–	–	–
		MS	0.25 (0.23)	10	10	50	–	10	30	–	–	3	30	–
			0.42 (0.38)	10	30	50	–	–	10	10	–	2	20	–
			0.61 (0.55)	10	100	–	–	–	–	–	–	–	–	–
Chromated zinc chloride	P5-68	LA	0.76 (0.46)	10	–	–	–	–	–	80	20	10	100	6.0
			1.02 (0.62)	10	–	–	–	–	10	60	30	10	100	7.2
			1.50 (0.92)	9	–	–	–	–	11	67	22	9	100	8.3
		MS	0.76 (0.46)	10	–	–	–	–	30	–	70	10	100	13.8
			1.02 (0.62)	10	–	–	–	–	30	–	70	10	100	14.9
			1.57 (0.96)	10	–	–	–	–	70	–	30	10	100	17.8
Fluor chrome arsenate phenol type A	P5-68	LA	0.35 (0.22)	10	–	–	–	10	50	20	20	9	90	–
			0.50 (0.31)	10	–	–	–	20	10	10	60	8	80	–
			1.11 (0.69)	10	–	–	–	30	70	–	–	7	70	–
		MS	0.36 (0.22)	10	–	–	–	–	60	–	40	10	100	19.3
			0.51 (0.31)	10	–	–	–	–	70	–	30	10	100	22.5
			1.16 (0.72)	10	–	10	–	20	60	–	10	7	70	–
Fluor chrome arsenate phenol type B	P5-68	LA	0.35 (0.21)	10	–	–	–	10	20	10	60	9	90	–
			0.50 (0.30)	10	–	–	–	20	60	–	20	8	80	–
			1.12 (0.68)	10	10	10	–	50	30	–	–	3	30	–
		MS	0.35 (0.21)	9	–	–	–	–	44	11	44	9	100	19.2
			0.51 (0.30)	10	–	–	–	–	90	–	10	10	100	27.3
			1.19 (0.72)	8	–	–	–	13	87	–	–	7	87	–
Untreated controls		LA	–	10	–	–	–	–	10	90	–	10	100	2.3
		MS	–	10	–	–	–	–	30	20	50	10	100	2.3

[a]Retention values in parentheses are based on preservative oxides.

[b]Ten stakes originally installed; eliminated stakes removed for causes other than decay or insect attack.

This study was initiated by J. Oscar Blew.

Table 48–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with copper chrome phosphorus and chromated copper arsenate type III preservatives after about 40 and 20 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, December 1971, and Madison, Wisconsin, May 1972 (Plot 68)

				Condition of stakes March 2011 (MS) and October 1992 (WI) (%)									
					Serviceable but showing some–			Destroyed by–					
Preservative	Location	Average retention (lb/ft^3)	Number in test[c]	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
Copper chrome phosphorus	MS	0.26[a]	10	–	–	–	10	80	–	10	9	90	–
	WI	0.27[a]	9	–	33	–	–	67	–	–	6	67	–
	MS	0.46[a]	10	20	30	–	–	50	–	–	5	50	–
	MS	0.75[a]	10	40	40	–	–	20	–	–	2	20	–
	WI	0.74[a]	10	70	30	–	–	–	–	–	–	–	–
	MS	1.50[a]	10	50	10.0	–	20	20	–	–	2	20	–
Chromated copper arsenate type III	MS	0.20[b]	9	–	67.0	–	22	11	–	–	1	11	–
(Fed. Spec. TT-W-550)	WI	0.20[b]	10	20	80	–	–	–	–	–	–	–	–
	MS	0.40[b]	10	40	60	–	–	–	–	–	–	–	–
	WI	0.40[b]	10	100	–	–	–	–	–	–	–	–	–
	MS	0.60[b]	10	90	10	–	–	–	–	–	–	–	–
	WI	0.60[b]	10	90	10	–	–	–	–	–	–	–	–
Untreated controls	MS	–	10	–	–	–	–	10	–	90	10	100	2.9
	WI	–	9	–	–	–	–	100	–	–	9	100	7.4

[a]Retention based on Osmose Company's analysis of preservative oxides.

[b]Retention based on preservative oxides.

[c]Ten stakes originally installed; eliminated stakes removed for causes other than decay or insect attack.
This study was initiated by L. R. Gjovik.

Table 49–Condition of aspen particleboard[a] stakes (3/4 by 4 by 18 in.) treated with chromated copper arsenate type III, fluor chrome arsenate phenol type A, and pentachlorophenol in ethanol or mineral spirits after about 35-1/2 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, May 1973 (Plot 70)

Preservative	Average retention based on preservative oxides (lb/ft^3)	Number in test[c]	Condition of stakes March 2008 (%)									
				Serviceable but showing some–			Destroyed by–			Total removed		Average life
			Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Number	%	(year)
Flakes Treated Before Fabrication into Particleboard[b]												
Chromated copper arsentate type III	0.25	9	–	–	–	–	100	–	–	9	100	25.7
(Fed. Spec. TT-W-550)	0.40	10	–	–	–	–	100	–	–	10	100	27.8
	0.80	6	17	50	–	–	33	–	–	2	33	–
Fluor chrome arsenate phenol type A	0.25	10	–	–	–	–	90	–	10	10	100	6.0
(Fed. Spec. TT-W-535)	0.50	10	–	–	–	–	90	–	10	10	100	8.8
Pentachlorophenol (Fed. Spec. TT-W-570)	0.25	10	–	–	–	–	40	–	60	10	100	5.5
in ethanol	0.40	10	–	–	–	–	50	–	50	10	100	7.5
	0.80	10	–	–	–	–	60	–	40	10	100	13.4
Pressure-Treated Particleboard												
Chromated copper arsentate type III	0.26	8	–	–	–	–	100	–	–	8	100	19.7
(Fed. Spec. TT-W-550)	0.41	9	–	–	–	–	100	–	–	9	100	29.7
	0.84	8	12	63	–	–	25	–	–	2	25	–
Fluor chrome arsenate phenol type A	0.26	10	–	–	–	–	70	–	30	10	100	7.5
(Fed. Spec. TT-W-535)	0.54	9	–	–	–	–	100	–	–	9	100	11.3
Pentachlorophenol (Fed. Spec. TT-W-570)	0.22	10	–	–	–	–	70	–	30	10	100	5.5
5% in mineral spirits and 4% pine oil	0.40	10	–	–	–	–	80	–	20	10	100	8.5
	0.82	10	–	–	–	–	80	–	20	10	100	21.6
Untreated controls	–	10	–	–	–	–	10	10	80	10	100	2.4

[a]Density 40 lb/ft^3.

[b]Flakes sprayed with predetermined amount of preservative solution while being tumbled in screen.

[c]Ten stakes originally installed; eliminated stakes removed for causes other than decay or insect attack.

This study was initiated by L. R. Gjovik.

Table 50–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with propylene oxide, butylene oxide, and epichlorohydrin/propylene oxide combinations after 17 and 21 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, October 31, 1974, and September 1978 (Plot 71)

			Condition of stakes August 1995 (%)									
				Serviceable but showing some–			Destroyed by–					
Nontoxic preservatives	Average loading–Weight add-on (%)	Number in test	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
Propylene oxide	15-27	2	–	–	–	–	–	–	100	2	100	2.2
	29-33	3	–	–	–	–	33	–	67	3	100	6.2
Butylene oxide	17-22	2	–	–	–	–	–	–	100	2	100	4.7
	37-40	3	–	–	–	–	100	–	–	3	100	12.2
	31[a]	15	–	7	–	53	33	–	–	5	33	–
Epichlorohydrin, 1 part; propylene oxide, 2 parts	10	1	–	–	–	–	–	–	100	1	100	9.2
	26	1	–	–	–	–	–	–	100	1	100	5.2
Controls	–	16	–	–	–	–	56	–	44	16	100	3.0

[a]Fifteen butylene-oxide-treated stakes installed in Mississippi, September 1978.

Data presented in this table are part of a larger study under the guidance of R. M. Rowell.

Table 51–Condition of Southern Pine, Douglas-fir, and Engelmann spruce heartwood stakes treated with ammoniacal copper arsenate and chromated copper arsenate after approximately 34 years in test. Stakes placed in test at Madison, Wisconsin, May 1976, and on the Harrison Experimental Forest, Saucier, Mississippi, December 1975 (Plot 72)

				Condition of stakes November 2009 (MS) and May 1994 (WI) (%)									
					Serviceable but showing some–			Destroyed by–					
Preservative	Location	Average retention (lb/ft^3)	Number in test	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
				Southern Pine[a,b] 2- by 4-in. nominal by 18-in. unincised									
Chromated copper	MS	0.23	10	40	50	–	–	10	–	–	1	10	–
arsenate	WI	0.14	10	70	30	–	–	–	–	–	–	–	–
type III	MS	0.28	10	40	40	–	–	20	–	–	2	20	–
	WI	0.19	9[d]	100	–	–	–	–	–	–	–	–	–
	MS	0.47	10	100	–	–	–	–	–	–	–	–	–
	WI	0.29	10	100	–	–	–	–	–	–	–	–	–
None	MS	–	10	–	–	–	10	20	10	60	9	90	–
	WI	–	10	–	50	–	–	50	–	–	5	50	–
				Southern Pine[a,b] 2- by 4-in. nominal by 18-in. incised									
Chromated copper	MS	0.27	10	50	50	–	–	–	–	–	–	–	–
arsenate	WI	0.19	10	90	10	–	–	–	–	–	–	–	–
type III	MS	0.47	10	100	–	–	–	–	–	–	–	–	–
	WI	3.30	10	100	–	–	–	–	–	–	–	–	–
	MS	0.62	10	100	–	–	–	–	–	–	–	–	–
	WI	0.37	10	100	–	–	–	–	–	–	–	–	–
				Southern Pine[a] 3/4- by 3-1/2 by 18-in. plywood									
Chromated copper	MS	0.39	10	10	20	–	–	70	–	–	7	70	–
arsenate	WI	0.38	10	60	40	–	–	–	–	–	–	–	–
type III[c]	MS	0.80	10	100	–	–	–	–	–	–	–	–	–
	WI	0.78	9[d]	100	–	–	–	–	–	–	–	–	–
	MS	1.22	10	100	–	–	–	–	–	–	–	–	–
	WI	1.17	9[d]	100	–	–	–	–	–	–	–	–	–
None	MS	–	10	–	–	–	–	–	10	90	10	100	2.8
	WI	–	9[d]	–	–	–	–	100	–	–	10	100	5.8
Chromated copper	MS	0.36[f]	9[d]	–	11	–	–	89	–	–	8	89	–
arsenate	WI	0.36[f]	9[d]	22	78	–	–	–	–	–	–	–	–
type III[e]	MS	0.75[f]	10	100	–	–	–	–	–	–	–	–	–
	WI	0.75[f]	10	100	–	–	–	–	–	–	–	–	–
	MS	1.16[f]	10	100	–	–	–	–	–	–	–	–	–
	WI	1.16[f]	9[d]	100	–	–	–	–	–	–	–	–	–
Chromated copper	MS	0.36[f]	9[d]	11	78	–	–	11	–	–	1	11	–
arsenate	WI	0.36[f]	9[d]	67	33	–	–	–	–	–	–	–	–
type III[g]	MS	0.75[f]	10	80	20	–	–	–	–	–	–	–	–
	WI	0.75[f]	10	100	–	–	–	–	–	–	–	–	–
	MS	1.16[f]	9[d]	100	–	–	–	–	–	–	–	–	–
	WI	1.16[f]	9[d]	100	–	–	–	–	–	–	–	–	–

Table 51–Condition of Southern Pine, Douglas-fir, and Engelmann spruce heartwood stakes treated with ammoniacal copper arsenate and chromated copper arsenate after approximately 34 years in test. Stakes placed in test at Madison, Wisconsin, May 1976, and on the Harrison Experimental Forest, Saucier, Mississippi, December 1975 (Plot 72)–cont.

				Condition of stakes November 2009 (MS) and May 1994 (WI) (%)									
					Serviceable but showing some–			Destroyed by–					
Preservative	Location	Average retention (lb/ft^3)	Number in test	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
				Southern Pine[a,b] 2- by 4-in. nominal by 18-in. Unincised									
Ammoniacal copper arsenate	MS	0.11	10	–	10	–	–	20	10	60	9	90	–
	WI	0.07	10	10	90	–	–	–	–	–	–	–	–
	MS	0.30	10	–	70	–	–	20	10	–	3	30	–
	WI	0.16	10	100	–	–	–	–	–	–	–	–	–
	MS	0.42	10	70	20	–	–	10	–	–	1	10	–
	WI	0.26	10	100	–	–	–	–	–	–	–	–	–
				Southern Pine[a,b] 2- by 4-in. nominal by 18-in. incised									
Ammoniacal copper arsenate	MS	0.14	10	–	10	–	10	70	–	10	8	80	–
	WI	0.07	10	20	70	–	–	10	–	–	1	10	–
	MS	0.30	9[d]	45	33	–	–	22	–	–	2	22	–
	WI	0.15	10	70	30	–	–	–	–	–	–	–	–
	MS	0.65	10	70	30	–	–	–	–	–	–	–	–
	WI	0.39	10	100	–	–	–	–	–	–	–	–	–
				Southern Pine[a] 3/4- by 3-1/2- by 18-in. plywood									
Ammoniacal copper arsenate[c]	MS	0.39	9[d]	–	–	–	–	100	–	–	9	100	26.3
	WI	0.38	10	10	90	–	–	–	–	–	–	–	–
	MS	0.81	9[d]	11	67	–	–	22	–	–	2	22	–
	WI	0.79	10	90	10	–	–	–	–	–	–	–	–
	MS	1.19	10	20	70	–	–	10	–	–	1	10	–
	WI	1.15	9[d]	100	–	–	–	–	–	–	–	–	–
Ammoniacal copper arsenate[c]	MS	0.38[f]	10	–	–	–	–	100	–	–	10	100	24.2
	WI	0.38[f]	9[d]	–	89	–	–	11	–	–	1	11	–
	MS	0.77[f]	10	10	50	–	–	40	–	–	4	40	–
	WI	0.77[f]	10	70	30	–	–	–	–	–	–	–	–
	MS	1.08[f]	10	–	70	–	–	30	–	–	3	30	–
	WI	1.08[f]	10	100	–	–	–	–	–	–	–	–	–
Ammoniacal copper arsenate[c]	MS	0.38[f]	10	10	–	–	10	80	–	10	9	90	–
	WI	0.38[f]	9[d]	11	89	–	–	–	–	–	–	–	–
	MS	0.77[f]	10	10	50	–	–	40	–	–	4	40	–
	WI	0.77[f]	10	100	–	–	–	–	–	–	–	–	–
	MS	1.08[f]	9[d]	–	89	–	–	11	–	–	1	11	–
	WI	1.08[f]	9[d]	90	10	–	–	–	–	–	–	–	–

Table 51–Condition of Southern Pine, Douglas-fir, and Engelmann spruce heartwood stakes treated with ammoniacal copper arsenate and chromated copper arsenate after approximately 34 years in test. Stakes placed in test at Madison, Wisconsin, May 1976, and on the Harrison Experimental Forest, Saucier, Mississippi, December 1975 (Plot 72)–cont.

				Condition of stakes November 2009 (MS) and May 1994 (WI) (%)									
					Serviceable but showing some–			Destroyed by–					
Preservative	Location	Average retention (lb/ft^3)	Number in test	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
				Douglas-fir 2- by 4-in. nominal by 18-in. unincised									
Chromated copper arsenate type III	MS	0.66	8[d]	100	–	–	–	–	–	–	–	–	–
	WI	0.55	10	100	–	–	–	–	–	–	–	–	–
	MS	1.24	9[d]	100	–	–	–	–	–	–	–	–	–
	WI	0.82	9[d]	89	11	–	–	–	–	–	–	–	–
	MS	1.62	10	100	–	–	–	–	–	–	–	–	–
	WI	1.11	10	100	–	–	–	–	–	–	–	–	–
None	MS	–	10	–	–	–	–	10	10	80	10	100	3.7
	WI	–	10	–	20	–	–	80	–	–	8	80	–
Chromated copper arsenate type III	MS	0.66	10	100	–	–	–	–	–	–	–	–	–
	WI	0.56	10	90	10	–	–	–	–	–	–	–	–
	MS	1.28	9[d]	100	–	–	–	–	–	–	–	–	–
	WI	0.96	10	100	–	–	–	–	–	–	–	–	–
	MS	1.88	9[d]	89	–	–	–	11	–	–	1	11	–
	WI	1.28	10	100	–	–	–	–	–	–	–	–	–
				Douglas-fir 3/4- by 3-1/2- by 18-in. plywood									
Chromated copper arsenate type III[c]	MS	0.62	10	100	–	–	–	–	–	–	–	–	–
	WI	0.62	10	90	10	–	–	–	–	–	–	–	–
	MS	1.25	10	100	–	–	–	–	–	–	–	–	–
	WI	1.22	10	90	10	–	–	–	–	–	–	–	–
	MS	1.88	10	100	–	–	–	–	–	–	–	–	–
	WI	1.83	10	100	–	–	–	–	–	–	–	–	–
None	MS	–	10	–	–	–	–	20	20	60	10	100	3.2
	WI	–	8[d]	–	–	–	–	100	–	–	8	100	5.5
Chromated copper arsenate type III[c]	MS	0.60[f]	8[d]	100	–	–	–	–	–	–	–	–	–
	WI	0.60[f]	8[d]	100	–	–	–	–	–	–	–	–	–
	MS	1.21[f]	9[d]	100	–	–	–	–	–	–	–	–	–
	WI	1.21[f]	9[d]	100	–	–	–	–	–	–	–	–	–
	MS	1.82[f]	9[d]	89	–	–	–	11	–	–	1	11	–
	WI	1.82[f]	10	100	–	–	–	–	–	–	–	–	–
Chromated copper arsenate type III[g]	MS	0.60[f]	10	100	–	–	–	–	–	–	–	–	–
	WI	0.60	10	100	–	–	–	–	–	–	–	–	–
	MS	1.21[f]	9[d]	89	–	–	–	11	–	–	1	11	–
	WI	1.21[f]	8[d]	100	–	–	–	–	–	–	–	–	–
	MS	1.82[f]	10	90	–	–	–	10	–	–	1	10	–
	WI	1.82[f]	9[d]	100	–	–	–	–	–	–	–	–	–

Table 51–Condition of Southern Pine, Douglas-fir, and Engelmann spruce heartwood stakes treated with ammoniacal copper arsenate and chromated copper arsenate after approximately 34 years in test. Stakes placed in test at Madison, Wisconsin, May 1976, and on the Harrison Experimental Forest, Saucier, Mississippi, December 1975 (Plot 72)–cont.

				Condition of stakes November 2009 (MS) and May 1994 (WI) (%)									
					Serviceable but showing some–			Destroyed by–					
Preservative	Location	Average retention (lb/ft^3)	Number in test	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
				Douglas-fir 2- by 4-in. nominal by 18-in. unincised									
Ammoniacal copper arsenate	MS	0.70	9[d]	100	–	–	–	–	–	–	–	–	–
	WI	0.61	10	80	20	–	–	–	–	–	–	–	–
	MS	1.42	10	90	10	–	–	–	–	–	–	–	–
	WI	1.29	10	100	–	–	–	–	–	–	–	–	–
	MS	2.14	10	80	20	–	–	–	–	–	–	–	–
	WI	1.95	9[d]	78	22	–	–	–	–	–	–	–	–
				Douglas-fir 2- by 4-in. nominal by 18-in. incised									
Ammoniacal copper arsenate	MS	0.70	10	50	40	–	–	10	–	–	1	10	–
	WI	0.62	10	90	10	–	–	–	–	–	–	–	–
	MS	1.41	10	100	–	–	–	–	–	–	–	–	–
	WI	1.26	10	100	–	–	–	–	–	–	–	–	–
	MS	2.17	10	100	–	–	–	–	–	–	–	–	–
	WI	2.00	10	100	–	–	–	–	–	–	–	–	–
				Douglas-fir 3/4- by 3-1/2- by 18-in. plywood									
Ammoniacal copper arsenate[c]	MS	0.63	10	20	40	–	–	40	–	–	4	40	–
	WI	0.62	10	40	60	–	–	–	–	–	–	–	–
	MS	1.30	7[d]	100	–	–	–	–	–	–	–	–	–
	WI	1.27	10	100	–	–	–	–	–	–	–	–	–
	MS	1.97	10	100	–	–	–	–	–	–	–	–	–
	WI	1.93	10	100	–	–	–	–	–	–	–	–	–
Ammoniacal copper arsenate[e]	MS	0.64[f]	10	10	80	–	–	10	–	–	1	10	–
	WI	0.64[f]	9[d]	33	67	–	–	–	–	–	–	–	–
	MS	1.30[f]	9[d]	78	11	–	–	11	–	–	1	11	–
	WI	1.30[f]	9[d]	100	–	–	–	–	–	–	–	–	–
	MS	1.97[f]	10	100	–	–	–	–	–	–	–	–	–
	WI	1.97[f]	9[d]	100	–	–	–	–	–	–	–	–	–
Ammoniacal copper arsenate[g]	MS	0.64[f]	10	10	60	–	–	30	–	–	3	30	–
	WI	0.64[f]	10	80	20	–	–	–	–	–	–	–	–
	MS	1.30[f]	10	90	10	–	–	–	–	–	–	–	–
	WI	1.30[f]	9[d]	100	–	–	–	–	–	–	–	–	–
	MS	1.97[f]	8[d]	100	–	–	–	–	–	–	–	–	–
	WI	1.97[f]	10	100	–	–	–	–	–	–	–	–	–

Table 51–Condition of Southern Pine, Douglas-fir, and Engelmann spruce heartwood stakes treated with ammoniacal copper arsenate and chromated copper arsenate after approximately 34 years in test. Stakes placed in test at Madison, Wisconsin, May 1976, and on the Harrison Experimental Forest, Saucier, Mississippi, December 1975 (Plot 72)–continued

				Condition of stakes November 2009 (MS) and May 1994 (WI) (%)									
					Serviceable but showing some–			Destroyed by–					
Preservative	Location	Average retention (lb/ft^3)	Number in test	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
				Engelmann spruce 2- by 4-in. nominal by 18-in. unincised									
Chromated copper	MS	0.31	10	70	–	–	10	10	–	20	3	30	–
arsenate	WI	0.21	8[d]	88	12	–	–	–	–	–	–	–	–
type III	MS	0.50	10	60	–	–	–	10	10	20	4	40	–
	WI	0.40	10	100	–	–	–	–	–	–	–	–	–
	MS	0.65	10	100	–	–	–	–	–	–	–	–	–
	WI	0.48	10	100	–	–	–	–	–	–	–	–	–
None	MS	–	10	–	–	–	–	10	10	80	10	100	3.3
	WI	–	10	–	–	–	–	10	–	–	1	10	7.5
				Engelmann spruce 2- by 4-in. nominal by 18-in. incised									
Chromated copper	MS	0.41	10	100	–	–	–	–	–	–	–	–	–
arsenate	WI	0.28	9[d]	78	22	–	–	–	–	–	–	–	–
type III	MS	0.66	10	90	10	–	–	–	–	–	–	–	–
	WI	0.56	10	100	–	–	–	–	–	–	–	–	–
	MS	1.02	9[d]	100	–	–	–	–	–	–	–	–	–
	WI	0.86	10	90	–	–	–	10	–	–	1	10	–
				Engelmann spruce 3/4- by 3-1/2-in. by 18-in. plywood									
Chromated copper	MS	0.71	9[d]	100	–	–	–	–	–	–	–	–	–
arsenate	WI	0.70	9[d]	89	11	–	–	–	–	–	–	–	–
type III[c]	MS	1.38	10	100	–	–	–	–	–	–	–	–	–
	WI	1.34	9[d]	100	–	–	–	–	–	–	–	–	–
	MS	2.03	10	100	–	–	–	–	–	–	–	–	–
	WI	1.82	9[d]	100	–	–	–	–	–	–	–	–	–
None	MS	–	10	–	–	–	–	10	20	70	10	100	2.6
	WI	–	8[d]	–	–	–	–	100	–	–	8	100	3.1
Chromated copper	MS	0.67[f]	9[d]	89	–	–	–	11	–	–	1	11	–
arsenate	WI	0.67[f]	10	80	20	–	–	–	–	–	–	–	–
type III[e]	MS	1.25[f]	10	100	–	–	–	–	–	–	–	–	–
	WI	1.26[f]	9[d]	100	–	–	–	–	–	–	–	–	–
	MS	1.76[f]	9[d]	89	–	–	–	11	–	–	1	11	–
	WI	1.76[f]	9[d]	100	–	–	–	–	–	–	–	–	–
Chromated copper	MS	0.67[f]	9[d]	78	22	–	–	–	–	–	–	–	–
arsenate	WI	0.67[f]	9[d]	100	–	–	–	–	–	–	–	–	–
type III[g]	MS	1.25[f]	9[d]	100	–	–	–	–	–	–	–	–	–
	WI	1.25[f]	9[d]	100	–	–	–	–	–	–	–	–	–
	MS	1.76[f]	9[d]	100	–	–	–	–	–	–	–	–	–
	WI	1.76[f]	9[d]	100	–	–	–	–	–	–	–	–	–

Table 51–Condition of Southern Pine, Douglas-fir, and Engelmann spruce heartwood stakes treated with ammoniacal copper arsenate and chromated copper arsenate after approximately 34 years in test. Stakes placed in test at Madison, Wisconsin, May 1976, and on the Harrison Experimental Forest, Saucier, Mississippi, December 1975 (Plot 72)–cont.

				Condition of stakes November 2009 (MS) and May 1994 (WI) (%)										
					Serviceable but showing some–			Destroyed by–						
Preservative	Location	Average retention (lb/ft^3)	Number in test	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
				Engelmann spruce 2- by 4-in. nominal by 18-in. unincised									
Ammoniacal copper arsenate	MS	0.26	8[d]	–	75	–	–	25	–	–	2	25	–
	WI	0.20	10	30	70	–	–	–	–	–	–	–	–
	MS	0.63	10	50	30	–	–	20	–	–	2	20	–
	WI	0.50	10	100	–	–	–	–	–	–	–	–	–
	MS	1.03	9[d]	78	22	–	–	–	–	–	–	–	–
	WI	0.75	10	90	10	–	–	–	–	–	–	–	–
				Engelmann spruce 2- by 4-in. nominal by 18-in. incised									
Ammoniacal copper arsenate	MS	0.42	9[d]	11	78	–	–	11	–	–	1	11	–
	WI	0.30	10	60	40	–	–	–	–	–	–	–	–
	MS	0.97	10	100	–	–	–	–	–	–	–	–	–
	WI	0.81	10	80	20	–	–	–	–	–	–	–	–
	MS	1.41	10	100	–	–	–	–	–	–	–	–	–
	WI	1.16	10	100	–	–	–	–	–	–	–	–	–
				Engelmann spruce 3/4- by 3-1/2-in. by 18-in. plywood									
Ammoniacal copper arsenate[c]	MS	0.70	10	20	50	–	–	30	–	–	3	30	–
	WI	0.68	10	60	40	–	–	–	–	–	–	–	–
	MS	1.42	9[d]	67	22	–	–	11	–	–	1	11	–
	WI	1.35	9[d]	100	–	–	–	–	–	–	–	–	–
	MS	2.14	9[d]	56	33	–	–	11	–	–	1	11	–
	WI	2.08	9[d]	100	–	–	–	–	–	–	–	–	–
Ammoniacal copper arsenate[e]	MS	0.65[f]	9[d]	22	67	–	–	11	–	–	1	11	–
	WI	0.65[f]	10	80	20	–	–	–	–	–	–	–	–
	MS	1.29[f]	10	80	20	–	–	–	–	–	–	–	–
	WI	1.29[f]	9[d]	100	–	–	–	–	–	–	–	–	–
	MS	2.02[f]	10	100	–	–	–	–	–	–	–	–	–
	WI	2.02[f]	8[d]	100	–	–	–	–	–	–	–	–	–
Ammoniacal copper arsenate[g]	MS	0.65[f]	10	10	70	–	–	20	–	–	2	20	–
	WI	0.65[f]	9[d]	100	–	–	–	–	–	–	–	–	–
	MS	1.29[f]	10	60	40	–	–	–	–	–	–	–	–
	WI	1.29[f]	8[d]	100	–	–	–	–	–	–	–	–	–
	MS	2.02[f]	10	80	20	–	–	–	–	–	–	–	–
	WI	2.02[f]	9[d]	100	–	–	–	–	–	–	–	–	–

[a]Some Southern Pine contained a small amount of sapwood, and the Southern Pine plywood was mixed heartwood and sap.

[b]Resin content of the Southern Pine ranged from 0.87% to 27.4%.

[c]Treated as 3/4- by 3-1/2 by 18-in. stakes.

[d]Ten stakes originally installed; eliminations were for causes other than decay or insect attack.

[e]Stakes cut from treated 2- by 4-ft panel.

[f]Retention by weight of panels from which stakes were cut.

[g]Stakes cut from treated 2- by 4-ft panel; all cut surfaces given a liberal brush coat of a 4.5% solution of the preservative in which the panels were treated.

This study was initiated by L. R. Gjovik.

Table 52–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with ammoniacal copper borate and ammoniacal copper asrsenate after approximately 34 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, December 1975 (Plot 73)

			Condition of stakes November 2009 (%)									
				Serviceable but showing some–			Destroyed by–					
Preservative	Average retention[a] (lb/ft^3)	Number in test[b]	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
Ammoniacal copper borate	1.33	17	82	–	–	–	18	–	–	3	18	–
	0.66	18	56	–	–	–	44	–	–	8	44	–
	0.45	16	50	38	–	–	12	–	–	2	12	–
	0.33	16	19	25	–	–	56	–	–	9	56	–
	0.22	17	–	6	–	–	94	–	–	16	94	–
	0.17	17	–	6	–	–	88	–	6	16	94	–
Ammoniacal copper arsenate	1.35	18	89	11	–	–	–	–	–	–	–	–
	0.66	19	42	58	–	–	–	–	–	–	–	–
	0.46	18	11	72	–	–	17	–	–	3	17	–
	0.33	20	5	60	–	–	35	–	–	7	35	–
	0.23	20	–	5	–	–	90	–	5	19	95	–
	0.17	20	–	–	–	–	55	–	45	20	100	8.11
Untreated controls	–	20	–	–	–	–	5	20	75	20	100	2.6

[a]Retention based on preservative oxides.

[b]Twenty stakes originally installed; eliminations were for causes other than decay or insect attack.

Data presented in this table are part of a study under investigation by B. R. Johnson.

Table 53–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with fire-retardant chemicals after about 17-1/2 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, May 1976 (Plot 74)

			Condition of stakes December 1993 (%)									
				Serviceable but showing some–			Destroyed by–					
Preservative	Average retention (lb/ft^3)	Number in test	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
UDFP fire	2.8	9	–	–	–	–	–	100	–	9	100	4.8
retardant[a]	6.0	10	–	–	–	–	–	90	10	10	100	9.7
	9.5	10	–	–	–	–	30	40	30	10	100	15.4
Untreated controls	–	10	–	–	–	–	10	–	90	10	100	2.5

[a]Reported to contain urea, dicyandiamide, formaldehyde, and phosphoric acid.

This study was initiated by L. R. Gjovik.

Table 54–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in. and 3/4 by 3/4 in.) treated with pentachlorophenol in light cycle oil and copper-8-quinolinolate after 17 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, December 1976 (Plot 75)

			Condition of stakes December 1993 (%)									
				Serviceable but showing some–			Destroyed by–					
Preservative	Average retention (lb/ft^3)	Number in test[b]	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
						Stakes 2 by 4 by 18 in.						
Pentachlorophenol	0.48	10	–	10	–	90	–	–	–	–	–	–
Copper-8-quinolinolate[a]	1.12	10	–	–	–	60	10	–	30	4	40	–
Untreated controls	–	10	–	–	–	–	30	20	50	10	100	2.5
						Stakes 3/4 by 3/4 by 18 in.						
Pentachlorophenol	0.21	8	–	–	–	–	25	–	75	8	100	13.2
	0.31	10	–	–	–	30	40	10	20	7	70	–
	0.38	10	–	–	–	30	30	–	10	4	40	–
	0.47	10	–	–	–	70	20	–	10	3	30	–
	0.67	10	–	10	–	90	–	–	–	–	–	–
Copper-8-quinolinolate[a]	0.34	9	–	–	–	–	11	44	44	9	100	3.3
	0.38	10	–	–	–	–	30	30	40	10	100	3.8
	0.50	10	–	–	–	–	20	10	70	10	100	4.6
	0.94	10	–	–	–	–	30	20	50	10	100	6.2
	1.16	7	–	–	–	–	43	–	5	7	100	8.0
	1.30	9	–	–	–	–	44	11	44	9	100	7.3
	1.84	8	–	–	–	–	25	–	75	8	100	8.6
Untreated controls	–	8	–	–	–	–	38	12	50	8	100	2.3

[a]Water-soluble form containing 1.07% copper metal (PQ-8).

[b]Ten stakes originally installed; eliminations were for mechanical damage or causes other than decay or insect attack.

This study was initiated by L. R. Gjovik.

Table 55–Condition of Southern Pine and Douglas-fir Comply stakes (2 by 4 in. nominal by 18 in.) treated with chromated copper arsenate and ammoniacal copper arsenate after about 30 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, November 1978 (Plot 78)

			Condition of stakes March 2008 (%)									
				Serviceable but showing some–			Destroyed by–					
Preservative	Average retention based on preservative oxides (lb/ft^3)	Number in test[a]	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
						Southern Pine						
Chromated copper arsenate type III	0.25	10	–	20	–	–	80	–	–	8	80	–
	0.40	10	10	90	–	–	–	–	–	–	–	–
	0.77	10	100	–	–	–	–	–	–	–	–	–
Untreated controls	–	10	–	–	–	–	100	–	–	10	100	2.5
						Douglas-fir						
Chromated copper arsenate type III	0.26	9	–	56	–	–	44	–	–	4	44	–
	0.60	10	20	80	–	–	–	–	–	–	–	–
Ammoniacal copper arsenate	0.25	10	–	20	–	–	80	–	–	8	80	–
	0.39	10	–	90	–	–	10	–	–	1	10	–
	0.62	9	11	78	–	–	11	–	–	1	11	–
Untreated controls	–	10	–	–	–	–	70	–	30	10	100	3.5

[a]Ten stakes originally installed; eliminated stakes removed for causes other than decay or insect attack.

This study was initiated by L. R. Gjovik.

Table 56–Condition of Southern Pine stakes (3/4 by 3/4 in. nominal by 18 in.) treated with butylene oxide after 10 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, December 1979 (Plot 79)

			Condition of stakes December 1989 (%)									
				Serviceable but showing some–			Destroyed by–					
Preservative	Average loading–Weight add-on (%)	Number in test	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
Butylene oxide	33.2	20	–	–	–	–	100	–	–	20	100	3.5
Untreated controls	–	10	–	–	–	–	80	–	20	10	100	1.9

Data presented in this table are part of a larger study under the guidance of R. M. Rowell.

Table 57–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in. and 3/4 by 3/4 by 18 in.) treated with chromated copper arsenate type C using conventional full-cell (FC) process and Mississippi State University (MSU process–empty cell) after about 29 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, MississippiS, April 1980 (Plot 80)

			Condition of stakes November 2009 (%)									
				Serviceable but showing some–			Destroyed by–					
Preservative	Average retention (lb/ft^3)	Number in test[a]	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
Chromated copper arsenate type C					2- by 4- by 18-in. Stakes							
Full cell	0.14	10	–	90	–	10	–	–	–	–	–	–
	0.27	10	30	60	–	–	–	10	–	1	10	–
	0.40	9	56	44	–	–	–	–	–	–	–	–
	0.62	10	100	–	–	–	–	–	–	–	–	–
	0.79	9	100	–	–	–	–	–	–	–	–	–
					3/4- by 3/4- by 18-in. Stakes							
	0.14	9	–	–	–	11	34	44	11	8	89	–
	0.27	10	–	10	–	–	70	10	10	9	90	–
	0.40	9	38	62	–	–	–	–	–	–	–	–
	0.61	10	40	60	–	–	–	–	–	–	–	–
	0.80	10	90	10	–	–	–	–	–	–	–	–
					2- by 4- by 18-in. Stakes							
Empty cell	0.15[b]	10	–	60	–	10	30	–	–	3	30	–
	0.26	9	–	100	–	–	–	–	–	–	–	–
	0.33	10	20	80	–	–	–	–	–	–	–	–
	0.59	10	100	–	–	–	–	–	–	–	–	–
	0.78	10	100	–	–	–	–	–	–	–	–	–
					3/4- by 3/4- by 18-in. Stakes							
	0.14[c]	10	–	–	–	–	30	10	60	10	100	18.7
	0.27	10	–	–	–	–	40	30	30	10	100	17.7
	0.40	9	–	11	–	11	44	22	11	7	78	–
	0.61	10	–	50	–	–	40	–	10	5	50	–
	0.80	9	22	67	–	–	–	–	11	1	11	–
					2- by 4- by 18-in. Stakes							
Untreated controls	–	10	–	–	–	–	20	–	80	10	100	2.3
					3/4- by 3/4- by 18-in. Stakes							
	–	10	–	–	–	–	50	–	50	10	100	1.9

[a]Ten stakes originally installed; eliminated stakes removed for causes other than decay or insect attack.

[b]The retentions are based on chemical analysis after treatment.

[c]The retentions are estimates based on the full-cell treatments.

This study was initiated by L. R. Gjovik.

Table 58–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with pentachlorophenol in P9 oil diluted with mineral spirits and water-dispersible pentachlorophenol after 20 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, June 1980 (Plot 81)

			Condition of stakes June 2000 (%)									
				Serviceable but showing some–			Destroyed by–					
Preservative	Average retention (lb/ft^3)	Number in test	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
Water-dispersible	0.10	10	–	–	–	10	–	–	90	9	90	–
pentachlorophenol	0.18	9[a]	–	–	–	–	33	–	67	9	100	11.9
	0.35	10	–	–	–	100	–	–	–	–	–	–
	0.37	10	–	–	–	70	–	–	30	3	30	–
	0.74[b]	10	–	10	–	90	–	–	–	–	–	–
Penta P9 in mineral	0.09	10	–	–	–	10	–	10	80	9	90	–
spirits	0.18	10	–	–	–	80	–	–	20	2	20	–
	0.33	10	–	20	–	80	–	–	–	–	–	–
	0.78	10	20	40	10	30	–	–	–	–	–	–
Untreated controls	–	10	–	–	–	–	30	20	50	10	100	2.1

[a]Ten stakes originally installed; eliminated stakes removed for causes other than decay or insect attack.

[b]Concentrate diluted in tap water. At all other retentions of water-dispersible pentachlorophenol, concentrate was diluted in a 50/50 dionized tap-water solution.

This study was initiated by L. R. Gjovik.

Table 59–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in. and 2.5 by 5.0 cm by 50 cm) treated with chromated copper fluoride (CFK) after approximately 29 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, June 1980 (Plot 82)

			Condition of stakes November 2009 (%)									
				Serviceable but showing some–			Destroyed by–					
Preservative	Average retention[a] (lb/ft^3)	Number in test[b]	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
						Stakes 2- by 4- by 18-in.						
Chromated copper fluoride (CFK)	0.28	10	10	–	–	–	20	–	70	9	90	–
	0.58	9	11	44	–	22	11	–	11	2	22	–
	1.22	10	100	–	–	–	–	–	–	–	–	–
	1.57	10	90	10	–	–	–	–	–	–	–	–
Untreated controls	–	10	–	–	–	–	10	–	90	10	100	1.9
						Stakes 2.5- by 5.0- by 50-cm.						
Chromated copper fluoride (CFK)	0.30	10	–	–	–	–	40	–	60	10	100	19.4
	0.62	10	–	30	10	10	30	–	10	4	40	–
	1.26	9	89		11	–	–	–	–	–	–	–
	1.69	10	100	–	–	–	–	–	–	–	–	–
Untreated controls	–	10	–	–	–	–	–	20	80	10	100	1.6

[a]Retention based on preservative oxides.

[b]Ten stakes were originally installed at each test station; this number has since been reduced because of failure to locate the stakes at the time of inspection.

Table 60–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with water-dispersible pentachlorophenol after 19 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, May 1981 (Plot 83)

			Condition of stakes June 2000 (%)									
				Serviceable but showing some–			Destroyed by–					
Preservative	Average retention (lb/ft^3)	Number in test	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
Water-dispersible pentachlorophenol	0.10	10	–	–	–	–	40	10	50	10	100	11.9
	0.18	10	–	–	–	20	10	–	70	8	80	–
	0.43	10	–	–	–	100	–	–	–	–	–	–
	0.84	10	10	10	–	80	–	–	–	–	–	–
	1.75	10	70	30	–	–	–	–	–	–	–	–
Untreated controls	–	10	–	–	–	–	30	20	50	10	100	2.4

Table 61–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with eight water-based formulations of wood preservatives and with Cu-8-quinolinolate and pentachlorophenol in toluene after about 30 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, December 1981 (Plot 84)

				Condition of stakes March 2011 (%)									
					Serviceable but showing some–			Destroyed by–					
Preservative	Average retention (lb/ft^3)	Active ingredient (lb/ft^3)	Number in test[a]	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	%	Average life (year)
Didecyl dimethyl ammonium chloride, 50.0%	0.19	0.10	10	–	–	–	–	20	–	80	10	100	4.8
	0.41	0.21	10	–	–	–	–	–	20	80	10	100	9.8
	0.60	0.30	10	–	–	–	–	30	–	70	10	100	14.9
	0.78	0.39	9	–	–	–	–	33	–	67	9	100	22.2
Coco dimethyl benzyl ammonium chlorides, 9.8% + 3.8% copper as the metal	0.45	0.06	10	–	–	–	–	60	–	40	10	100	4.3
	0.81	0.11	10	–	–	–	–	100	–	–	10	100	8.8
	1.19	0.16	8	–	–	–	–	87	–	13	8	100	14.1
	1.62	0.22	9	–	11	–	–	78	–	11	8	89	–
Didecyl dimethyl ammonium chloride, 20%, + 6.3% copper as the metal	0.40	0.11	10	–	–	–	–	60	–	40	10	100	7.5
	0.81	0.21	10	–	–	–	–	90	–	10	10	100	19.7
	1.21	0.32	8	–	13	–	–	87	–	–	7	87	–
	1.60	0.42	8	–	75	–	–	25	–	–	2	25	–
Dimethyl cocoamine 2-ethyl hexoate, 20%; copper 2-ethyl hexoate, 21.0% (3.8% metallic copper)	0.30	0.08	10	–	–	–	–	30	10	60	10	100	3.2
	0.61	0.16	10	–	–	–	–	100	–	–	10	100	6.3
	0.90	0.24	10	–	–	–	–	80	–	20	10	100	10.1
	1.20	0.32	10	–	–	–	–	70	–	30	10	100	15.2
Copper 2-ethyl hexoate, 35.0% (6.3 metallic copper)	0.40	0.17	10	–	–	–	–	90	–	10	10	100	5.5
	0.80	0.33	10	–	–	–	–	100	–	–	10	100	14.0
	1.20	0.50	10	–	10	–	–	80	–	10	9	90	–
	1.61	0.66	10	–	20	–	–	70	–	10	8	80	–
Pentachlorophenol, 21.9%, and 2.4% other chlorophenols	0.82	0.20	10	–	–	–	–	20	–	80	10	100	18.6
	1.66	0.40	6	–	50	–	–	33	–	17	3	50	–
	3.23	0.78	10	–	90	–	10	–	–	–	–	–	–
	4.12	1.00	9	–	100	–	–	–	–	–	–	–	–
Pentachlorophenol, 27.6%, and 3.1% other chlorophenols	0.65	0.20	10	–	–	–	–	10	–	90	10	100	16.0
	1.30	0.40	7	–	43	–	–	43	–	14	4	57	–
	2.60	0.80	9	–	89	–	11	–	–	–	–	–	–
	3.27	1.00	8	–	100	–	–	–	–	–	–	–	–
Tri-n-butyl tin oxide, 9.5%, dimethyl benzyl ammonium chloride, 20%, and dimethyl ethyl benzyl ammonium chloride, 20%	0.40	0.20	10	–	–	–	–	20	10	70	10	100	4.8
	0.81	0.40	10	–	–	–	–	30	10	60	10	100	10.1
	1.21	0.60	9	–	–	–	–	33	–	67	9	100	20.3
	1.63	0.81	9	–	33	–	–	67	–	–	6	67	–
Diluted in toluene													
Copper-8-quinolinolate, 0.675% (0.12% metallic copper)	1.50	0.01	10	–	–	–	–	20	10	70	10	100	5.9
	2.96	0.02	10	–	–	–	–	50	–	50	10	100	12.1
	8.75	0.06	9	–	56	–	–	33	–	11	4	44	–
	17.50	0.12	7	14	86	–	–	–	–	–	–	–	–
Pentachlorophenol, 6.3%, and other chlorophenols, 0.7%, in No. 2 diesel fuel	2.86	0.20	10	–	–	–	10	20	–	70	9	90	–
	5.73	0.40	9	–	78	–	–	22	–	–	2	22	–
	11.44	0.80	10	20	70	–	10	–	–	–	–	–	–
	14.29	1.00	9	33	67	–	–	–	–	–	–	–	–
Untreated controls	–	–	20	–	–	–	–	25	–	75	20	100	2.4

[a]Ten stakes originally installed; eliminated stakes removed for causes other than decay or insect attack.

Data presented in this table are part of a study under investigation by R. C. DeGroot.

Table 62–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with ammoniacal copper zinc arsenate (ACZA) after 30 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, December 1981 (Plot 85)

			Condition of stakes March 2011 (%)									
				Serviceable but showing some–			Destroyed by–					
Preservative	Average retention (lb/ft^3)	Number in test	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
Ammoniacal copper zinc arsenate	0.10	10	–	–	–	–	80	–	20	10	100	16.0
	0.25	10	–	100	–	–	–	–	–	–	–	–
	0.40	10	20	80	–	–	–	–	–	–	–	–
	0.60	10	70	30	–	–	–	–	–	–	–	–
	1.22	10	90	10	–	–	–	–	–	–	–	–
Untreated controls	–	10	–	–	–	–	–	10	90	10	100	2.0

This study was initiated by L. R. Gjovik.

Table 63–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with water-based emulsions of pentachlorophenol and creosote after 14-1/2 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, May 1982 (Plot 86)

Preservative	Average retention (lb/ft^3)			Number in test	Condition of stakes January 1996 (%)									
					Serviceable but showing some–				Destroyed by–					
	Solution	Penta-chlorophenol	Creosote		Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
Emulsified pentachlorophenol-creosote														
Pentachlorophenol 17.90%	0.50	0.10	0.10	10	–	–	–	–	30	–	70	10	100	6.0
Other chlorophenols 2.10%	1.02	0.20	0.20	10	–	–	–	50	10	–	40	5	50	–
P-1 creosote 20.0%	2.00	0.40	0.40	10	–	–	–	100	–	–	–	–	–	–
	2.98	0.60	0.60	10	–	–	–	100	–	–	–	–	–	–
	4.00	0.80	0.80	10	10	10	–	80	–	–	–	–	–	–
Pentachlorophenol 21.76%	0.40	0.10	0.04	10	–	–	–	–	–	–	100	10	100	6.9
Other chlorophenols 2.56%	0.84	0.21	0.08	10	–	–	–	80	20	–	–	2	20	–
P-1 creosote 20.0%	1.65	0.41	0.16	10	–	–	–	100	–	–	–	–	–	–
	2.49	0.62	0.25	10	–	–	–	100	–	–	–	–	–	–
	3.29	0.82	0.33	10	–	10	–	90	–	–	–	–	–	–
Untreated controls	–	–	–	10	–	–	–	–	20	10	70	10	100	2.0

Data presented in this table are part of a study under investigation by R. C. Degroot.

Table 64–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with pentachlorophenol emulsion and pentachlorophenol in P9 type A oil diluted with mineral spirits after 14-1/2 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, May 1982 (Plot 87)

			Condition of stakes January 1996 (%)									
				Serviceable but showing some–			Destroyed by–					
Preservative	Average retention (lb/ft^3)	Number in test	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
Emulsified pentachlorophenol	0.10	10	–	–	–	–	–	10	90	10	100	7.7
	0.20	10	–	–	–	80	–	–	20	2	20	–
	0.40	10	–	–	–	100	–	–	–	–	–	–
	0.60	10	–	–	–	100	–	–	–	–	–	–
	0.80	10	–	–	–	100	–	–	–	–	–	–
Pentachlorophenol in P9 oil and mineral spirits	0.10	10	–	–	–	70	10	–	20	3	30	–
	0.20	10	–	–	–	100	–	–	–	–	–	–
Untreated controls	–	10	–	–	–	–	50	–	50	10	100	1.6

Data presented in this table are part of a study under investigation by R. C. Degroot.

Table 65–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with pentachlorophenol, tetrachlorophenol, and tetrachlorophenol plus copper oxide in water and ammonia after 14-1/2 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, May 1982 (Plot 88)

			Condition of stakes January 1996 (%)									
				Serviceable but showing some–			Destroyed by–					
Preservative	Average retention (lb/ft^3)	Number in test	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
Pentachlorophenol in water and ammonia	0.13	10	–	–	–	–	–	20	80	10	100	4.2
	0.26	10	–	–	–	–	60	10	30	10	100	7.6
	0.40	10	–	–	–	–	50	–	50	10	100	9.7
	0.62	10	–	–	–	90	10	–	–	1	10	–
	1.03	10	–	–	–	100	–	–	–	–	–	–
	1.49	10	–	20	–	80	–	–	–	–	–	–
Tetrachlorophenol and copper oxide in water and ammonia	0.12	10	–	–	–	–	40	–	60	10	100	5.7
	0.25	10	–	–	–	–	90	–	10	10	100	9.6
	0.41	10	–	10	–	50	20	–	–	2	20	–
	0.62	10	40	20	30	10	–	–	–	–	–	–
	0.98	10	80	–	–	20	–	–	–	–	–	–
Tetrachlorophenol	0.25	10	–	–	–	–	20	–	80	10	100	6.9
	0.40	10	–	–	–	10	20	–	70	9	90	–
	0.60	10	–	–	–	30	10	–	60	7	70	–
	1.02	10	–	–	–	100	–	–	–	–	–	–
	1.52	10	–	–	–	100	–	–	–	–	–	–
Untreated controls	–	10	–	–	–	–	50	10	40	10	100	2.3

This study was initiated by L. R. Gjovik.

Table 66–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with 2% sulfur in creosote after 14-1/2 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, May 1982 (Plot 89)

			Condition of stakes January 1996 (%)									
				Serviceable but showing some–			Destroyed by–					
Preservative	Average retention (lb/ft^3)	Number in test	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
Coal-tar creosote with 5% sulfur in toluene	2.01	10	–	–	–	–	40	–	60	10	100	9.5
	3.19	8	–	–	–	100	–	–	–	–	–	–
	4.43	10	–	–	–	100	–	–	–	–	–	–
	6.28	9	–	–	33	67	–	–	–	–	–	–
	9.20	10	40	10	–	50	–	–	–	–	–	–
Untreated controls	–	10	–	–	–	–	10	10	80	10	100	2.8

This study was initiated by L. R. Gjovik.

Table 67–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with phenol-formaldehyde resin after about 17 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, December 1982 (Plot 90)

			Condition of stakes January 1999 (%)									
				Serviceable but showing some–			Destroyed by–					
Preservative	Average retention (lb/ft^3)	Number in test[a]	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
Phenol-formaldehyde resin	1.00	10	–	–	–	–	10	–	90	10	100	3.2
	1.90	10	–	–	–	–	50	–	50	10	100	3.2
	3.01	10	–	–	–	–	10	–	90	10	100	5.0
	6.15	10	–	–	–	10	40	10	40	9	90	–
	10.22	9	–	–	–	22	56	–	22	7	78	–
Phenol-formaldehyde resin and pentachlorophenol	0.08	10	–	–	–	–	40	–	60	10	100	2.5
	0.14	10	–	–	–	–	50	10	40	10	100	3.7
	0.30	10	–	–	–	–	20	–	80	10	100	4.8
	0.49	10	–	–	–	–	10	10	80	10	100	7.4
	0.79	10	–	–	–	10	20	–	60	8	80	–
Untreated controls	–	10	–	–	–	–	10	20	70	10	100	3.4

[a]Ten stakes originally installed; eliminated stakes removed for causes other than decay or insect attack.

This study was initiated by L. R. Gjovik.

Table 68–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with pentalchlorophenol emulsion, pentachlorophenol-creosote emulsion, ammonium pentachlorophenol, and pentachlorophenol in P9 oil after 12 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, December 1983 (Plots 92 and 93)

			Condition of stakes August 1995 (%)									
				Serviceable but showing some–			Destroyed by–					
Preservative	Average retention (lb/ft^3)	Number in test	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
						2- by 4- by 18-in. Stakes						
Pentachlorophenol emulsion	0.14	10	–	–	–	–	40	–	60	10	100	7.0
	0.20	10	–	–	–	100	–	–	–	–	–	–
	0.28	10	–	–	–	100	–	–	–	–	–	–
	0.40	10	–	–	–	100	–	–	–	–	–	–
	0.56	10	10	–	–	90	–	–	–	–	–	–
	0.81	10	10	10	–	80	–	–	–	–	–	–
Pentachlorophenol-creosote emulsion diluted with 3% ammonia	0.14	10	–	–	–	–	50	–	50	10	100	6.5
	0.20	10	–	–	–	10	10	–	80	9	90	–
	0.28	10	–	–	–	70	–	–	30	3	30	–
	0.40	10	–	–	–	100	–	–	–	–	–	–
	0.55	10	–	–	–	100	–	–	–	–	–	–
	0.85	10	–	–	–	100	–	–	–	–	–	–
Ammonium pentachlorophenol	0.16	10	–	–	–	–	40	–	60	10	100	6.6
	0.20	10	–	–	–	–	30	–	70	10	100	6.1
	0.27	10	–	–	–	10	30	–	60	9	90	–
	0.38	10	–	–	–	90	–	–	10	1	10	–
	0.55	10	–	–	–	100	–	–	–	–	–	–
	0.77	10	–	–	–	100	–	–	–	–	–	–
Pentachlorophenol in P9 oil and toluene	0.14	10	–	–	–	100	–	–	–	–	–	–
	0.20	10	–	–	–	100	–	–	–	–	–	–
	0.28	10	–	–	–	100	–	–	–	–	–	–
	0.40	10	30	10	10	50	–	–	–	–	–	–
	0.56	10	60	10	10	20	–	–	–	–	–	–
	0.80	10	90	10	–	–	–	–	–	–	–	–
Toluene only	30.70	10	–	–	–	–	10	10	80	10	100	2.7
Mineral spirits only	26.00	10	–	–	–	–	10	20	70	10	100	3.3
Untreated controls	–	10	–	–	–	–	–	10	90	10	100	1.7

Table 68–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with pentalchlorophenol emulsion, pentachlorophenol-creosote emulsion, ammonium pentachlorophenol, and pentachlorophenol in P9 oil after 12 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, December 1983 (Plots 92 and 93)–cont.

Preservative	Average retention (lb/ft^3)	Number in test	Condition of stakes August 1995 (%)									
				Serviceable but showing some–			Destroyed by–					
			Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
3/4- by 3/4- by 18-in. Stakes												
Pentachlorophenol emulsion	0.14	25	–	–	–	–	24	–	76	25	100	3.4
	0.21	25	–	–	–	4	52	–	44	24	96	–
	0.28	25	–	–	–	–	40	4	56	25	100	6.6
	0.40	25	–	–	–	28	16	4	52	18	72	–
	0.56	24	–	–	–	72	8	–	16	6	25	–
	0.81	25	–	–	–	92	8	–	–	2	8	–
Pentachlorophenol-creosote emulsion diluted with 3% ammonia	0.14	25	–	–	–	–	24	–	76	25	100	2.7
	0.21	25	–	–	–	–	36	–	64	25	100	3.5
	0.30	25	–	–	–	–	40	4	56	25	100	5.1
	0.46	25	–	–	–	4	32	–	64	24	96	–
	0.58	24	–	–	–	47	33	–	21	13	54	–
	0.87	23	–	–	–	96	–	4	–	1	4	–
Ammonium pentachlorophenol	0.16	24	–	–	–	–	4	8	88	24	100	2.7
	0.22	24	–	–	–	–	21	4	75	24	100	3.5
	0.28	25	–	–	–	–	48	4	48	25	100	4.3
	0.42	25	–	–	–	4	32	8	56	24	96	–
	0.63	25	–	–	–	40	28	–	32	15	60	–
	0.89	23	–	–	4	83	4	–	9	3	13	–
Pentachlorophenol in P9 oil and toluene	0.16	24	–	–	–	8	32	–	60	22	92	–
	0.20	25	–	–	–	36	20	8	36	16	64	–
	0.27	25	–	–	–	84	4	–	12	4	16	–
	0.40	24	–	–	4	88	8	–	–	2	8	–
	0.56	25	20	4	8	60	8	–	–	2	8	–
	0.80	25	40	20	40	–	–	–	–	–	–	–
Untreated controls	–	25	–	–	–	–	32	8	60	25	100	1.1

Data presented in this table are part of a study under investigation by R. C. DeGroot.

Table 69–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with pentachlorophenol in P9 oil and toluene, tetrachlorophenol in P9 oil and toluene, and P9 oil and toluene after about 16 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, May 1984 (Plot 94)

			Condition of stakes June 2000 (%)									
				Serviceable but showing some–			Destroyed by–					
Preservative	Average retention (lb/ft^3)	Number in test	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
Pentachlorophenol in P9 oil and toluene	0.10	10	–	20	–	10	30	–	40	7	70	–
	0.24	10	–	30	–	60	–	–	–	–	–	–
	0.40	10	40	60	–	–	–	–	–	–	–	–
	0.60	10	100	–	–	–	–	–	–	–	–	–
	1.24	10	100	–	–	–	–	–	–	–	–	–
Tetrachlorophenol and P9 oil and toluene	0.10	10	–	–	–	10	30	–	60	9	90	–
	0.25	10	–	40	–	50	10	–	–	1	10	–
	0.40	10	–	40	–	60	–	–	–	–	–	–
	0.60	10	70	30	–	–	–	–	–	–	–	–
	1.25	10	100	–	–	–	–	–	–	–	–	–
P9 oil and toluene	1.34	10	–	–	–	–	20	–	80	10	100	8.4
	3.50	10	–	20	–	30	30	–	20	5	50	–
	5.83	10	–	20	–	50	30	–	–	3	30	–
	8.70	10	50	30	10	10	–	–	–	–	–	–
	18.03	10	100	–	–	–	–	–	–	–	–	–
Untreated controls	–	10	–	–	–	–	10	40	50	10	100	1.6

This study was initiated by L. R. Gjovik.

Table 70–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with creosote coal-tar, coal-tar creosote and 2% sulfur, coal-tar creosote and phentachlorophenol with inhibitor, after about 25 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, December 1984 (Plot 95)

			Condition of stakes November 2009 (%)									
				Serviceable but showing some–			Destroyed by–					
Preservative	Average retention (lb/ft^3)	Number in test[a]	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
Creosote coal-tar	1.69	10	–	10	–	–	50	–	40	9	90	–
	3.31	8	–	–	–	–	100	–	–	8	100	17.0
	4.93	9	–	33	–	–	67	–	–	6	67	–
	6.59	10	–	40	–	–	60	–	–	6	60	–
Coal-tar creosote	2.23	10	–	–	–	–	80	–	20	10	100	12.7
plus 2% sulfur	3.48	10	–	–	–	–	70	–	30	10	100	13.6
	4.93	9	–	–	–	–	100	–	–	9	100	15.0
	6.58	10	–	–	–	–	90	–	10	10	100	16.8
Coal-tar creosote	2.11	9	–	–	–	–	44	–	56	9	100	13.1
and pentachlorophenol	3.57	9	–	11	–	–	89	–	–	8	89	–
with inhibitor	4.70	10	–	20	–	–	80	–	–	8	80	–
	6.83	10	–	20	–	–	80	–	–	8	80	–
Untreated controls	–	10	–	–	–	–	10	–	90	10	100	1.9

[a]Ten stakes originally installed; this number has since been reduced because of failure to locate the stakes at the time of inspection.

This study was initiated by L. R. Gjovik.

Table 71–Condition of Southern Pine stakes (3/4 by 3/4 by 18 in.) treated with penta amine in water and pentachlorophenol in P9 oil and toluene after approximately 12 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, December 1984 (Plot 96)

			Condition of stakes January 1996 (%)									
				Serviceable but showing some–			Destroyed by–					
Preservative	Average retention (lb/ft^3)	Number in test	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
Penta amine	0.14	10	–	–	–	–	40	–	60	10	100	2.3
in water	0.21	10	–	–	–	–	–	–	100	10	100	3.4
	0.28	10	–	–	–	–	20	–	80	10	100	4.2
	0.39	10	–	–	–	10	50	–	40	9	90	–
	0.57	9	–	–	–	–	33	–	67	9	100	5.4
	0.80	10	–	–	–	–	50	10	40	10	100	7.0
Pentachlorophenol	0.14	10	–	–	–	–	50	–	50	10	100	7.4
in P9 oil and toluene	0.21	10	–	–	–	30	10	10	50	7	70	–
	0.28	10	–	–	–	70	10	–	20	3	30	–
	0.44	10	–	–	–	90	10	–	–	1	10	–
	0.55	10	–	10	50	40	–	–	–	–	–	–
	0.80	10	30	10	–	50	10	–	–	1	10	–
Untreated controls	–	10	–	–	–	–	50	20	30	10	100	1.1

Data presented in this table are part of a study under investigation by R. C. DeGroot.

Table 72–Condition of balsam fir, eastern hemlock, eastern larch, eastern spruce, red pine and white pine stakes (2 by 4 in. nominal by 18 in.) incised and unincised, treated with ammoniacal copper arsenate and chromated copper arsenate III after 10 and 24 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, May 1985 and near Portland, Maine, August 1985 (Plot 97)

				Condition of stakes September 1995 (ME) and November 2009 (MS) (%)									
					Serviceable but showing some–			Destroyed by–					
Preservative	Location	Average retention (lb/ft^3)	Number in test[a]	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
						White Pine–Unincised							
Ammoniacal copper arsenate	ME	0.32	10	90	10	–	–	–	–	–	–	–	–
	MS	0.26	10	–	–	–	–	80	–	20	10	100	17.1
	ME	0.38	10	90	10	–	–	–	–	–	–	–	–
	MS	0.42	9	–	56	–	–	44	–	–	4	44	–
	ME	0.71	10	100	–	–	–	–	–	–	–	–	–
	MS	0.72	10	90	–	–	–	10	–	–	1	10	–
Chromated copper arsenate III	ME	0.30	10	100	–	–	–	–	–	–	–	–	–
	MS	0.31	10	70	30	–	–	–	–	–	–	–	–
	ME	0.46	10	100	–	–	–	–	–	–	–	–	–
	MS	0.44	10	100	–	–	–	–	–	–	–	–	–
	ME	0.66	10	100	–	–	–	–	–	–	–	–	–
	MS	0.65	10	100	–	–	–	–	–	–	–	–	–
						White Pine–Incised							
Ammoniacal copper arsenate	ME	0.32	10	90	10	–	–	–	–	–	–	–	–
	MS	0.26	10	–	50	–	–	50	–	–	5	50	–
	ME	0.44	10	100	–	–	–	–	–	–	–	–	–
	MS	0.42	9	11	67	–	–	22	–	–	2	22	–
	ME	0.80	10	100	–	–	–	–	–	–	–	–	–
	MS	0.73	10	100	–	–	–	–	–	–	–	–	–
Chromated copper arsenate III	ME	0.32	10	100	–	–	–	–	–	–	–	–	–
	MS	0.33	9	78	22	–	–	–	–	–	–	–	–
	ME	0.47	10	100	–	–	–	–	–	–	–	–	–
	MS	0.52	8	100	–	–	–	–	–	–	–	–	–
	ME	0.72	10	100	–	–	–	–	–	–	–	–	–
	MS	0.74	9	100	–	–	–	–	–	–	–	–	–
Untreated controls	ME	–	10	10	50	–	–	40	–	–	4	40	–
	MS	–	10	–	–	–	–	60	–	40	10	100	2.4
						Red Pine–Unincised							
Ammoniacal copper arsenate	ME	0.29	10	60	40	–	–	–	–	–	–	–	–
	MS	0.29	10	–	–	–	–	60	–	40	10	100	17.5
	ME	0.38	10	100	–	–	–	–	–	–	–	–	–
	MS	0.30	9	–	33	–	–	44	11	11	6	67	–
	ME	0.67	10	100	–	–	–	–	–	–	–	–	–
	MS	0.44	9	89	11	–	–	–	–	–	–	–	–

Table 72–Condition of balsam fir, eastern hemlock, eastern larch, eastern spruce, red pine and white pine stakes (2 by 4 in. nominal by 18 in.) incised and unincised, treated with ammoniacal copper arsenate and chromated copper arsenate III after 10 and 24 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, May 1985 and near Portland, Maine, August 1985 (Plot 97)–cont.

				Condition of stakes September 1995 (ME) and November 2009 (MS) (%)									
					Serviceable but showing some–			Destroyed by–					
Preservative	Location	Average retention (lb/ft^3)	Number in test[a]	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
						Red Pine–Unincised–con.							
Chromated copper arsenate III	ME	0.18	10	90	10	–	–	–	–	–	–	–	–
	MS	0.23	10	10	50	–	–	40	–	–	4	40	–
	ME	0.33	10	100	–	–	–	–	–	–	–	–	–
	MS	0.32	9	56	22	–	–	22	–	–	2	22	–
	ME	0.70	10	100	–	–	–	–	–	–	–	–	–
	MS	0.46	9	89	11	–	–	–	–	–	–	–	–
						Red Pine–Incised							
Ammoniacal copper arsenate	ME	0.26	10	70	30	–	–	–	–	–	–	–	–
	MS	0.31	10	10	20	–	–	70	–	–	7	70	–
	ME	0.45	10	100	–	–	–	–	–	–	–	–	–
	MS	0.40	9	33	56	–	–	11	–	–	1	11	–
	ME	0.53	10	100	–	–	–	–	–	–	–	–	–
	MS	0.64	9	78	22	–	–	–	–	–	–	–	–
Chromated copper arsenate III	ME	0.23	10	100	–	–	–	–	–	–	–	–	–
	MS	0.25	10	40	60	–	–	–	–	–	–	–	–
	ME	0.45	10	100	–	–	–	–	–	–	–	–	–
	MS	0.40	10	100	–	–	–	–	–	–	–	–	–
	ME	0.78	10	100	–	–	–	–	–	–	–	–	–
	MS	0.55	9	100	–	–	–	–	–	–	–	–	–
Untreated controls	ME	–	10	–	80	–	–	20	–	–	2	20	–
	MS	–	10	–	–	–	–	70	–	30	10	100	3.7
						Eastern Spruce–Unincised							
Ammoniacal copper arsenate	ME	0.13	10	30	70	–	–	–	–	–	–	–	–
	MS	0.16	10	–	–	–	–	40	–	60	10	100	12.3
	ME	0.21	10	20	80	–	–	–	–	–	–	–	–
	MS	0.25	10	–	–	–	–	40	20	40	10	100	13.0
	ME	0.26	10	50	50	–	–	–	–	–	–	–	–
	MS	0.39	10	–	50	–	–	50	–	–	5	50	–

Table 72–Condition of balsam fir, eastern hemlock, eastern larch, eastern spruce, red pine, and white pine stakes (2 by 4 in. nominal by 18 in.) incised and unincised, treated with ammoniacal copper arsenate and chromated copper arsenate III after 10 and 24 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, May 1985 and near Portland, Maine, August 1985 (Plot 97)–cont.

				Condition of stakes September 1995 (ME) and November 2009 (MS) (%)									
					Serviceable but showing some–			Destroyed by–					
Preservative	Location	Average retention (lb/ft^3)	Number in test	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
						Eastern Spruce–Unincised–con.							
Chromated copper arsenate III	ME	0.10	10	80	20	–	–	–	–	–	–	–	–
	MS	0.14	10	–	20	–	–	50	10	20	8	80	–
	ME	0.13	10	90	10	–	–	–	–	–	–	–	–
	MS	0.20	10	20	20	–	10	30	20	–	5	50	–
	ME	0.53	10	100	–	–	–	–	–	–	–	–	–
	MS	0.71	9	100	–	–	–	–	–	–	–	–	–
						Eastern Spruce–Incised							
Ammoniacal copper arsenate	ME	0.20	10	20	80	–	–	–	–	–	–	–	–
	MS	0.24	10	–	10	–	–	80	–	–	8	80	–
	ME	0.28	10	70	30	–	–	–	–	–	–	–	–
	MS	0.28	10	–	30	–	–	70	–	–	7	70	–
	ME	0.39	10	80	20	–	–	–	–	–	–	–	–
	MS	0.48	10	80	20	–	–	–	–	–	–	–	–
Chromated copper arsenate III	ME	0.20	10	100	–	–	–	–	–	–	–	–	–
	MS	0.25	9	56	44	–	–	–	–	–	–	–	–
	ME	0.28	10	100	–	–	–	–	–	–	–	–	–
	MS	0.35	9	100	–	–	–	–	–	–	–	–	–
	ME	0.54	10	100	–	–	–	–	–	–	–	–	–
	MS	0.78	8	100	–	–	–	–	–	–	–	–	–
Untreated controls	ME	–	10	–	40	–	–	60	–	–	6	60	–
	MS	–	10	–	–	–	–	40	30	30	10	100	2.2
						Balsam Fir–Unincised							
Ammoniacal copper arsenate	ME	0.20	10	50	50	–	–	–	–	–	–	–	–
	MS	0.26	10	–	–	–	–	40	–	60	10	100	16.9
	ME	0.25	10	70	30	–	–	–	–	–	–	–	–
	MS	0.32	9	–	33	–	–	67	–	–	6	67	–
	ME	0.42	10	100	–	–	–	–	–	–	–	–	–
	MS	0.59	10	100	–	–	–	–	–	–	–	–	–
Chromated copper arsenate III	ME	0.19	10	100	–	–	–	–	–	–	–	–	–
	ME	0.40	10	100	–	–	–	–	–	–	–	–	–
	ME	0.59	10	100	–	–	–	–	–	–	–	–	–

Table 72–Condition of balsam fir, eastern hemlock, eastern larch, eastern spruce, red pine and white pine stakes (2 by 4 in. nominal by 18 in.) incised and unincised, treated with ammoniacal copper arsenate and chromated copper arsenate III after 10 and 24 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, May 1985 and near Portland, Maine, August 1985 (Plot 97)–cont.

				Condition of stakes September 1995 (ME) and November 2009 (MS) (%)									
					Serviceable but showing some–			Destroyed by–					
Preservative	Location	Average retention (lb/ft^3)	Number in test	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
						Balsam Fir–Incised							
Ammoniacal copper arsenate	ME	0.31	10	80	20	–	–	–	–	–	–	–	–
	MS	0.29	9	–	67	–	–	33	–	–	3	33	–
	ME	0.35	10	100	–	–	–	–	–	–	–	–	–
	MS	0.40	10	60	20	–	–	20	–	–	2	20	–
	ME	0.47	10	100	–	–	–	–	–	–	–	–	–
	MS	0.73	9	100	–	–	–	–	–	–	–	–	–
Chromated copper arsenate III	ME	0.29	10	100	–	–	–	–	–	–	–	–	–
	ME	0.53	10	100	–	–	–	–	–	–	–	–	–
	ME	0.73	10	100	–	–	–	–	–	–	–	–	–
Untreated controls	ME	–	10	–	60	–	–	40	–	–	4	40	–
	MS	–	10	–	–	–	–	50	–	50	10	100	3.8
						Eastern Hemlock–Unincised							
Ammoniacal copper arsenate	ME	0.22	10	90	10	–	–	–	–	–	–	–	–
	MS	0.20	10	–	40	–	–	50	10	–	6	60	–
	ME	0.38	10	80	20	–	–	–	–	–	–	–	–
	MS	0.32	10	–	–	–	–	100	–	–	10	100	20.7
	ME	0.36	10	100	–	–	–	–	–	–	–	–	–
	MS	0.37	10	70	30	–	–	–	–	–	–	–	–
Chromated copper arsenate III	ME	0.20	10	100	–	–	–	–	–	–	–	–	–
	ME	0.30	10	100	–	–	–	–	–	–	–	–	–
	ME	0.41	10	100	–	–	–	–	–	–	–	–	–
						Eastern Hemlock–Incised							
Ammoniacal copper arsenate	ME	0.28	10	90	10	–	–	–	–	–	–	–	–
	MS	0.34	8	–	38	–	–	62	–	–	5	62	–
	ME	0.41	10	100	–	–	–	–	–	–	–	–	–
	MS	0.38	10	90	10	–	–	–	–	–	–	–	–
	ME	0.56	10	100	–	–	–	–	–	–	–	–	–
	MS	0.68	9	100	–	–	–	–	–	–	–	–	–
Chromated copper arsenate III	ME	0.25	10	100	–	–	–	–	–	–	–	–	–
	ME	0.38	10	100	–	–	–	–	–	–	–	–	–
	ME	0.57	10	100	–	–	–	–	–	–	–	–	–
Untreated controls	ME	–	10	10	40	–	–	50	–	–	5	50	–
	MS	–	10	–	–	–	–	50	–	50	10	100	3.7

Table 72–Condition of balsam fir, eastern hemlock, eastern larch, eastern spruce, red pine and white pine stakes (2 by 4 in. nominal by 18 in.) incised and unincised, treated with ammoniacal copper arsenate and chromated copper arsenate III after 10 and 24 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, May 1985 and near Portland, Maine, August 1985 (Plot 97)–cont.

				Condition of stakes September 1995 (ME) and November 2009 (MS) (%)									
					Serviceable but showing some–			Destroyed by–					
Preservative	Location	Average retention (lb/ft^3)	Number in test	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
						Eastern Larch–Unincised							
Ammoniacal copper arsenate	ME	0.15	10	50	50	–	–	–	–	–	–	–	–
	MS	0.18	10	–	–	–	–	50	–	50	10	100	18.1
	ME	0.23	10	100	–	–	–	–	–	–	–	–	–
	MS	0.20	9	–	11	–	–	44	11	33	8	89	–
	ME	0.24	10	100	–	–	–	–	–	–	–	–	–
	MS	0.41	9	78	22	–	–	–	–	–	–	–	–
Chromated copper arsenate III	ME	0.10	10	100	–	–	–	–	–	–	–	–	–
	ME	0.18	10	100	–	–	–	–	–	–	–	–	–
	ME	0.33	10	100	–	–	–	–	–	–	–	–	–
						Eastern Larch–Incised							
Ammoniacal copper arsenate	ME	0.16	10	90	10	–	–	–	–	–	–	–	–
	MS	0.25	9	–	11	–	–	78	–	11	8	89	–
	ME	0.25	10	90	10	–	–	–	–	–	–	–	–
	MS	0.32	9	11	67	–	–	22	–	–	2	22	–
	ME	0.32	10	100	–	–	–	–	–	–	–	–	–
	MS	0.60	9	100	–	–	–	–	–	–	–	–	–
Chromated copper arsenate III	ME	0.14	10	100	–	–	–	–	–	–	–	–	–
	ME	0.28	10	100	–	–	–	–	–	–	–	–	–
	ME	0.49	10	100	–	–	–	–	–	–	–	–	–
Untreated controls	ME	–	10	10	70	–	–	20	–	–	2	20	–
	MS	–	10	–	–	–	–	30	–	70	10	100	3.9

[a]Ten stakes originally installed; eliminations were for causes other than decay or insect attack.

This study was initiated by L. R. Gjovik.

Table 73–Condition of three-ply plywood, layed up in combinations of Southern Pine, sweetgum, and yellow poplar, treated with ammoniacal copper arsenate and chromated copper arsenate after about 24-1/2 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, November 1985 (Plot 98)

			Condition of stakes January 2010 (%)									
				Serviceable but showing some–			Destroyed by–					
Preservative	Average retention (lb/ft^3)	Number in test[a]	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)[b]
Southern Pine–Southern Pine–Southern Pine												
Cut from 4 by 4 Treated Panel												
Ammoniacal copper arsenate	0.09	10	–	–	–	–	90	–	10	10	100	5.3
	0.20	6	–	–	–	–	83	–	17	6	100	12.1*
	0.40	3	–	33	–	–	67	–	–	2	67	–
	0.58	8	–	25	–	–	75	–	–	6	75	–
	1.18	9	56	22	–	–	22	–	–	2	22	–
Cut from 4 by 4 Treated Panels, Cut Edge Dip Treated												
	0.09	9	–	–	–	–	90	–	–	9	100	14.1*
	0.20	2	–	–	–	–	100	–	–	2	100	24.2*
	0.41	7	14	–	–	–	86	–	–	6	86	–
	0.58	6	–	33	–	–	67	–	–	4	67	–
	1.24	9	78	22	–	–	–	–	–	–	–	–
Treated as Stakes												
	0.33	7	–	71	–	–	29	–	–	2	29	–
	0.52	8	25	50	–	–	25	–	–	2	25	–
Cut from 4 by 4 Treated Panel												
Chromated copper arsenate III	0.09	9	–	–	–	–	11	–	89	9	100	5.0
	0.19	2	–	50	–	–	50	–	–	1	50	–
	0.40	5	–	20	–	–	80	–	–	4	80	–
	0.59	7	86	–	–	–	14	–	–	1	14	–
	1.18	9	100	–	–	–	–	–	–	–	–	–
Cut from 4 by 4 Treated Panels, Cut Edge Dip Treated												
	0.10	7	–	–	–	–	43	–	57	7	100	13.8*
	0.19	6	–	–	–	–	83	–	17	6	100	19.3*
	0.40	5	20	40	–	–	40	–	–	2	40	–
	0.59	8	75	25	–	–	–	–	–	–	–	–
	1.18	8	87	–	–	–	13	–	–	1	13	–
Treated as Stakes												
	0.41	5	20	20	–	–	60	–	–	3	60	–
	0.59	8	87	–	–	–	13	–	–	1	13	–
Untreated controls	–	10	–	–	–	–	50	–	50	10	100	1.7

Table 73–Condition of three-ply plywood, layed up in combinations of Southern Pine, sweetgum, and yellow poplar, treated with ammoniacal copper arsenate and chromated copper arsenate after about 24-1/2 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, November 1985 (Plot 98)–cont.

Preservative	Average retention (lb/ft^3)	Number in test[a]	Condition of stakes January 2010 (%)							Total removed		Average life (year)[b]
			Good	Serviceable but showing some– Decay	Termite attack	Decay and termite attack	Destroyed by– Decay fungi	Termite attack	Decay fungi and termite attack	Number	%	
Southern Pine–Southern Pine–Sweetgum												
Cut from 4 by 4 Treated Panel												
Ammoniacal copper arsenate	0.10	10	–	–	–	–	80	–	20	10	100	4.4
	0.20	7	–	–	–	–	100	–	–	7	100	8.1*
	0.40	3	–	–	–	–	100	–	–	3	100	24.2*
	0.61	3	–	–	–	–	100	–	–	3	100	24.2*
	1.25	10	10	70	–	–	20	–	–	2	20	–
Cut from 4 by 4 Treated Panels, Cut Edge Dip Treated												
	0.10	9	–	–	–	–	89	–	10	9	100	9.2*
	0.20	5	–	–	–	–	100	–	–	5	100	18.1*
	0.41	4	–	25	–	–	75	–	–	3	75	–
	0.61	5	–	40	–	–	60	–	–	3	60	–
	1.25	9	33	56	–	–	11	–	–	1	11	–
Treated as Stakes												
	0.42	6	–	–	–	–	100	–	–	6	100	24.2*
	0.62	9	–	44	–	–	56	–	–	5	56	–
Cut from 4 by 4 Treated Panel												
Chromated copper arsenate III	0.10	10	–	–	–	–	60	–	40	10	100	6.1
	0.20	5	–	–	–	–	60	–	40	5	100	16.2*
	0.41	4	25	–	–	–	75	–	–	3	75	–
	0.61	6	–	83	–	–	17	–	–	1	17	–
	1.22	9	100	–	–	–	–	–	–	–	–	–
Cut from 4 by 4 Treated Panels, Cut Edge Dip Treated												
	0.10	9	–	–	–	–	56	–	44	9	100	9.4*
	0.20	2	–	–	–	–	50	–	50	2	100	16.1*
	0.40	6	–	17	–	–	83	–	–	5	83	–
	0.61	4	–	50	–	–	50	–	–	2	50	–
	1.22	9	78	22	–	–	–	–	–	–	–	–
Treated as Stakes												
	0.41	4	–	25	–	–	75	–	–	3	75	–
	0.58	7	29	57	–	–	14	–	–	1	14	–
Untreated controls	–	10	–	–	–	–	30	–	70	10	100	1.4

Table 73–Condition of three-ply plywood, layed up in combinations of Southern Pine, sweetgum, and yellow poplar, treated with ammoniacal copper arsenate and chromated copper arsenate after about 24-1/2 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, November 1985 (Plot 98)–cont.

			Condition of stakes January 2010 (%)									
				Serviceable but showing some–			Destroyed by–					
Preservative	Average retention (lb/ft^3)	Number in test[a]	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)[b]
						Southern Pine–Sweetgum–Southern Pine						
						Cut from 4 by 4 Treated Panel						
Ammoniacal copper arsenate	0.10	10	–	–	–	–	100	–	–	10	100	5.0
	0.19	8	–	–	–	–	87	–	13	8	100	12.5*
	0.40	5	–	–	–	–	100	–	–	5	100	20.4*
	0.61	4	–	–	–	–	100	–	–	4	100	24.2*
	1.24	8	13	75	–	–	13	–	–	1	13	–
						Cut from 4 by 4 Treated Panels, Cut Edge Dip Treated						
	0.10	10	–	–	–	–	100	–	–	10	100	7.9
	0.19	6	–	–	–	–	100	–	–	6	100	17.0*
	0.40	7	–	–	–	–	100	–	–	7	100	22.6*
	0.62	9	11	11	–	–	78	–	–	7	78	–
	1.24	9	33	44	–	–	22	–	–	2	22	–
						Treated as Stakes						
	0.39	5	–	20	–	–	80	–	–	4	80	–
	0.61	7	–	–	–	–	100	–	–	7	100	24.2*
						Cut from 4 by 4 Treated Panel						
Chromated copper arsenate III	0.10	10	–	–	–	–	40	–	60	10	100	6.2
	0.19	6	–	–	–	–	83	–	17	6	100	20.5*
	0.40	7	14	29	–	–	57	–	–	4	57	–
	0.63	5	40	40	–	–	20	–	–	1	20	–
	1.22	6	100	–	–	–	–	–	–	–	–	–
						Cut from 4 by 4 Treated Panels, Cut Edge Dip Treated						
	0.10	10	–	–	–	–	20	20	60	10	100	5.8
	0.19	6	–	–	–	–	100	–	–	6	100	17.8*
	0.40	3	–	–	–	–	100	–	–	3	100	24.2*
	0.62	6	50	17	–	–	33	–	–	2	33	–
	1.20	6	100	–	–	–	–	–	–	–	–	–
						Treated as Stakes						
	0.41	5	40	40	–	–	20	–	–	1	20	–
	0.59	9	56	44	–	–	–	–	–	–	–	–
Untreated controls	–	10	–	–	–	–	50	–	50	10	100	1.2

Table 73–Condition of three-ply plywood, layed up in combinations of Southern Pine, sweetgum, and yellow poplar, treated with ammoniacal copper arsenate and chromated copper arsenate after about 24-1/2 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, November 1985 (Plot 98)–cont.

			Condition of stakes January 2010 (%)									
				Serviceable but showing some–			Destroyed by–					
Preservative	Average retention (lb/ft^3)	Number in test[a]	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)[b]
Southern Pine–Southern Pine-Yellow Poplar												
Cut from 4 by 4 Treated Panel												
Ammoniacal copper arsenate	0.10	10	–	–	–	–	60	–	40	10	100	5.4
	0.20	4	–	–	–	–	100	–	–	4	100	21.4*
	0.40	4	–	25	–	–	75	–	–	3	75	–
	0.62	4	–	–	–	–	100	–	–	4	100	24.2*
	1.27	9	33	44	–	–	22	–	–	2	22	–
Cut from 4 by 4 Treated Panels, Cut Edge Dip Treated												
	0.10	9	–	–	–	–	89	–	11	9	100	10.1*
	0.20	4	–	–	–	–	100	–	–	4	100	17.4*
	0.40	2	–	–	–	–	100	–	–	2	100	24.2*
	0.62	7	–	–	–	–	100	–	–	7	100	24.2*
	1.27	7	43	43	–	–	14	–	–	1	14	–
Treated as Stakes												
	0.40	7	–	–	–	–	100	–	–	7	100	24.2*
	0.64	6	17	17	–	–	66	–	–	4	66	–
Cut from 4 by 4 Treated Panel												
Chromated copper arsenate III	0.10	8	–	–	–	–	38	–	62	8	100	8.6
	0.20	3	–	–	–	–	100	–	–	3	100	18.8*
	0.40	4	–	25	–	–	75	–	–	3	75	–
	0.62	8	62	38	–	–	–	–	–	–	–	–
	1.23	7	100	–	–	–	–	–	–	–	–	–
Cut from 4 by 4 Treated Panels, Cut Edge Dip Treated												
	0.10	9	–	–	–	–	56	–	44	9	100	8.1
	0.20	4	–	–	–	–	100	–	–	4	100	21.4*
	0.40	5	–	–	–	–	100	–	–	5	100	24.2*
	0.62	6	–	50	–	–	50	–	–	3	50	–
	1.23	7	86	14	–	–	–	–	–	–	–	–
Treated as Stakes												
	0.43	7	–	29	–	–	71	–	–	5	71	–
	0.63	6	17	66	–	–	–	17	–	1	17	–
Untreated controls	–	10	–	–	–	–	70	–	30	10	100	1.1

Table 73–Condition of three-ply plywood, layed up in combinations of Southern Pine, sweetgum, and yellow poplar, treated with ammoniacal copper arsenate and chromated copper arsenate after about 24-1/2 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, November 1985 (Plot 98)–cont.

Preservative	Average retention (lb/ft^3)	Number in test[a]	Condition of stakes January 2010 (%)							Total removed		Average life (year)[b]
			Good	Serviceable but showing some– Decay	Termite attack	Decay and termite attack	Destroyed by– Decay fungi	Termite attack	Decay fungi and termite attack	Number	%	
Southern Pine–Yellow Poplar–Southern Pine												
Cut from 4 by 4 Treated Panel												
Ammoniacal copper arsenate	0.10	10	–	–	–	–	90	–	10	10	100	4.2
	0.20	7	–	–	–	–	86	–	14	7	100	17.2*
	0.41	4	–	–	–	–	100	–	–	4	100	24.2*
	0.62	5	–	–	–	–	100	–	–	5	100	24.2*
	1.25	8	25	62	–	–	13	–	–	1	13	–
Cut from 4 by 4 Treated Panels, Cut Edge Dip Treated												
	0.10	10	–	–	–	–	60	–	40	10	100	8.0
	0.20	7	–	–	–	–	86	–	14	7	100	15.7*
	0.41	8	–	–	–	–	100	–	–	8	100	24.2*
	0.62	8	–	38	–	–	62	–	–	5	62	–
	1.24	9	44	44	–	–	11	–	–	1	11	–
Treated as Stakes												
	0.38	7	14	58	–	–	14	–	14	2	28	–
	0.59	9	–	56	–	–	44	–	–	4	44	–
Cut from 4 by 4 Treated Panel												
Chromated copper arsenate III	0.10	9	–	–	–	–	22	–	78	9	100	6.2
	0.20	6	–	–	–	–	100	–	–	6	100	18.7*
	0.41	5	–	20	–	–	80	–	–	4	80	–
	0.62	5	40	60	–	–	–	–	–	–	–	–
	1.20	10	100	–	–	–	–	–	–	–	–	–
Cut from 4 by 4 Treated Panels, Cut Edge Dip Treated												
	0.10	9	–	–	–	–	56	–	44	9	100	8.1
	0.20	6	–	–	–	–	100	–	–	4	100	19.7*
	0.41	8	25	38	–	–	38	–	–	3	38	–
	0.62	8	38	12	–	–	50	–	–	4	50	–
	1.21	10	100	–	–	–	–	–	–	–	–	–
Treated as Stakes												
	0.45	5	40	–	–	–	100	–	–	5	100	24.2*
	0.63	7	86	14	–	–	–	–	–	–	–	–
Untreated controls	–	10	–	–	–	–	50	–	50	10	100	1.4

[a]Ten stakes were originally installed. Eliminations were for causes other than decay or insect attack, or failure to locate the stakes at time of inspection.

[b]Average life denoted by a '*' had multiple stakes which could not be located after a hurricane. Average life is based only on those stakes that were rated until failure.

Data presented in this table are part of a study under investigation by R. C. DeGroot and L. R. Gjovik.

Table 74–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with copper carbonate and copper oxide in com with pelargonic acid and octanoic acid after about 20 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, April 1987 (Plot 99)

			Condition of stakes February 2007 (%)									
				Serviceable but showing some–			Destroyed by–					
Preservative	Average retention (lb/ft^3)	Number in test[a]	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
Copper carbonate/ pelargonic acid	0.10	9	–	–	–	–	100	–	–	9	100	14.5
	0.25	10	–	–	–	–	100	–	–	10	100	13.7
	0.40	10	–	–	–	–	100	–	–	10	100	16.1
	0.60	10	10	10	–	–	70	–	10	8	80	–
	1.00	9	11	–	–	–	89	–	–	8	89	–
Copper carbonate/ octanoic acid	0.10	9	–	–	–	–	89	–	11	9	100	16.7
	0.25	10	–	–	–	–	100	–	–	10	100	14.5
	0.41	9	11	–	–	–	89	–	–	8	89	–
	0.59	9	11	–	–	–	89	–	–	8	89	–
	1.00	10	30	–	–	–	70	–	–	7	70	–
Copper oxide/ pelargonic acid	0.10	10	–	–	–	–	100	–	–	10	100	14.0
	0.25	10	–	–	–	–	100	–	–	10	100	14.0
	0.40	10	10	–	–	–	80	–	10	9	90	–
	0.60	10	–	–	–	–	100	–	–	10	100	14.5
	1.00	10	–	10	–	–	90	–	–	9	90	–
Copper oxide/ octanoic acid	0.10	10	–	–	–	–	80	–	20	10	100	15.1
	0.25	10	10	–	–	–	70	–	20	9	90	–
	0.41	10	10	20	–	–	70	–	–	7	70	–
	0.59	8	25	–	–	–	75	–	–	6	75	–
	1.01	9	33	–	–	–	67	–	–	6	67	–
Chromated copper arsenate	0.10	9	–	–	–	–	33	–	67	9	100	16.7
	0.25	9	56	22	–	–	22	–	–	2	22	–
	0.40	10	100	–	–	–	–	–	–	–	–	–
	0.60	10	100	–	–	–	–	–	–	–	–	–
Untreated controls	–	10		–	–	–	30	10	60	10	100	2.3

[a]Ten stakes originally installed; eliminated stakes removed for causes other than decay or insect attack.

Table 75–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with toluene-diluted AWPA P1-13 creosote with xylene insolubles less than 0.1% (clean creosote) plus additives of chlorpyrifos and chlorothalonil after about 20 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, April 1988 (Plot 100)

			Condition of stakes March 2008 (%)									
			Serviceable but showing some–				Destroyed by–					
Preservative	Average retention (lb/ft^3)	Number in test[a]	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
AWPA P1-13 creosote	1.00	9	–	–	–	–	67	–	33	9	100	8.7
with xylene insolubles	1.96	10	–	–	–	–	80	–	20	10	100	11.7
less than 0.1%	4.03	10	–	10	–	–	90	–	–	9	90	–
	6.20	10	–	40	–	–	60	–	–	6	60	–
	8.53	9	–	89	–	–	11	–	–	1	11	–
+0.5% chlorpyrifos	1.01	10	–	–	–	–	80	–	20	10	100	9.1
	1.98	10	–	–	–	–	100	–	–	10	100	12.7
	3.92	10	–	20	–	–	80	–	–	8	80	–
	5.97	10	–	50	–	–	50	–	–	5	50	–
	8.30	10	–	50	–	–	50	–	–	5	50	–
+0.78% chlorpyrifos	1.00	10	–	–	–	–	90	–	10	10	100	8.4
	2.04	10	–	–	–	–	100	–	–	10	100	12.6
	3.97	10	–	–	–	–	100	–	–	10	100	14.9
	6.00	10	–	20	–	–	80	–	–	8	80	–
	8.18	10	10	80	–	–	10	–	–	1	10	–
+2% chlorothalonil	1.04	10	–	–	–	–	60	10	30	10	100	9.7
	2.02	10	–	–	–	–	100	–	–	10	100	12.7
	4.00	9	–	33	–	–	67	–	–	6	67	–
	6.00	10	10	60	–	–	30	–	–	3	30	–
	8.20	10	40	60	–	–	–	–	–	–	–	–
Untreated controls	–	10	–	–	–	–	10	80	10	10	100	1.7

[a]Ten stakes were originally installed; this number has since been reduced because of failure to locate the stakes at the time of inspection.

Table 76–Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with pentachlorophenol (manufactured 24 years apart) after 9 years in test. Stakes placed in test on the Harrison Experimental Forest, Saucier, Mississippi, April 1989 (Plot 101)

			Condition of stakes February 1998 (%)									
				Serviceable but showing some–			Destroyed by–					
Preservative	Average retention (lb/ft^3)	Number in test	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Total removed Number	Total removed %	Average life (year)
Pentachlorophenol	0.1	10	40	40	10	10	–	–	–	–	–	–
(1965 manufacture	0.2	10	50	50	–	–	–	–	–	–	–	–
date) in 20% P9 oil	0.4	10	60	40	–	–	–	–	–	–	–	–
and toluene	0.6	10	80	20	–	–	–	–	–	–	–	–
Pentachlorophenol	0.1	10	100	–	–	–	–	–	–	–	–	–
(1989 manufacture	0.2	10	90	–	10	–	–	–	–	–	–	–
date) in 20% P9 oil	0.4	10	100	–	–	–	–	–	–	–	–	–
and toluene	0.6	10	80	20	–	–	–	–	–	–	–	–
20% P9 oil and toluene	0.6	10	100	–	–	–	–	–	–	–	–	–
Untreated controls	–	10	–	–	–	–	60	–	40	10	100	2.0

This study was initiated by L. R. Gjovik.

Table 77--Summary of 2- by 4-in. stake selected results obtained in Mississippi with wood preservatives in general use.

Preservative	Average retention[a] (lb/ft^3)	Data from table number	Average life (year)	Remarks
Acid copper chromate	0.25 (0.13)	15	11.6	--
(Fed. Spec. TT-W-546)	0.30 (0.14)	46	6.1	--
	0.51 (0.25)	47	--	80% failed after 40 years
	0.51 (0.26)	15	--	80% failed after 60 years
	0.60 (0.29)	46	4.6	--
	0.75 (0.37)	15	--	60% failed after 60 years
	1.01 (0.50)	47	--	50% failed after 40 years
	1.54 (0.76)	47	--	22% failed after 40 years
Ammoniacal copper borate	(0.17)	52	--	94% failed after 34 years
	(0.22)	52	--	94% failed after 34 years
	(0.33)	52	--	56% failed after 34 years
	(0.45)	52	--	12% failed after 34 years
	(0.66)	52	--	44% failed after 34 years
	(1.33)	52	--	18% failed after 34 years
Ammoniacal copper arsenate	0.17	52	8.11	--
(Fed. Spec. TT-W-549)	0.23	52	--	95% failed after 34 years
	0.25 (0.24)	14	38.7	--
	0.26 (0.25)	47	--	67% failed after 40 years
	0.48 (0.45)	47	--	20% failed after 40 years
	0.53 (0.51)	14	--	12% failed after 60 years
	1.01 (0.97)	14	--	No failures after 60 years
	1.29 (1.25)	14	--	No failures after 60 years
Ammoniacal copper zinc arsenate	(0.10)	62	16.0	--
	(0.25)	62	--	No failures after 30 years
	(0.40)	62	--	No failures after 30 years
	(0.60)	62	--	No failures after 30 years
	(1.22)	62	--	No failures after 30 years
Chromated copper arsenate	0.26 (0.15)	15	28.7	--
Type I (Fed. Spec. TT-W-550)	0.39 (0.22)	47	--	56% failed after 40 years
	0.50 (0.29)	15	--	30% failed after 60 years
	0.76 (0.44)	47	--	10% failed after 40 years
	0.78 (0.44)	15	--	20% failed after 60 years
Type II (Fed. Spec. TT-W-550)	0.25 (0.23)	47	--	30% failed after 40 years
	(0.26)	20	--	No failures after 61 years
	(0.37)	20	--	10% failed after 61 years
	(0.52)	20	--	No failures after 61 years
	(0.79)	20	--	No failures after 61 years
	(1.04)	20	--	No failures after 61 years
Type III (Fed. Spec. TT-W-550)	(0.14)	57	--	No failures after 29 years
	(0.20)	48	--	11% failed after 40 years
	(0.25)	55	--	80% failed after 30 years
	(0.27)	57	--	10% failed after 29 years
	(0.40)	48	--	No failures after 40 years
	(0.40)	55	--	No failures after 30 years
	(0.40)	57	--	No failures after 29 years
	(0.60)	48	--	No failures after 40 years
	(0.62)	57	--	No failures after 29 years
	(0.77)	55	--	No failures after 30 years
	(0.79)	57	--	No failures after 29 years

Table 77–Summary of 2- by 4-in. stake selected results obtained in Mississippi with wood preservatives in general use–cont.

Preservative	Average retention[a] (lb/ft^3)	Data from table number	Average life (year)	Remarks
Chromated zinc arsenate				
(former Fed. Spec. TT-W-538)	0.22 (0.11)	24	22.1	–
	0.33 (0.22)	4	33.0	–
	0.44 (0.29)	4	39.3	–
	0.38 (0.20)	24	–	40% failed after 45 years
	0.77 (0.40)	24	–	No failures after 45 years
	1.01 (0.53)	24	–	No failures after 45 years
	0.58 (0.38)	4	51.7	–
	0.78 (0.52)	4	–	30% failed after 60 years
	1.06 (0.70)	4	–	No failures after 60 years
Chromated zinc chloride	0.49 (0.30)	2	14.2	–
(Fed. Spec. TT-W-551)	0.76 (0.47)	2	20.2	–
	0.76 (0.46)	47	13.8	–
	1.03 (0.63)	2	20.1	–
	1.02 (0.62)	47	14.9	–
	1.50 (0.92)	25	23.4	–
	1.57 (0.96)	47	17.8	–
	2.91 (1.78)	25	32.7	–
	6.00 (3.67)	25	–	No failures after 45 years
Copper-8-quinolinolate	0.010	38	5.3	–
Stoddard solvent	0.020	38	4.2	–
	0.060	38	5.6	–
	0.123	38	7.8	–
Copper-8-quinolinolate	0.014	43	26.9	–
AWPA P9 heavy petroleum	0.030	43	27.3	–
	0.059	43	31.3	–
	0.124	43	–	12% failed after 45 years
Copper naphthenate				
0.11% copper in No. 2 fuel oil	10.3 (0.012)	7	15.9	–
0.29% copper in No. 2 fuel oil	10.2 (0.029)	7	21.8	–
0.57% copper in No. 2 fuel oil	10.6 (0.061)	7	27.1	–
0.86% copper in No. 2 fuel oil	9.6 (0.082)	7	29.6	–
Creosote, coal-tar	3.3	6	24.9	–
	4.1	17	14.2	–
	4.2	4	17.8	–
	4.6	5	21.3	–
	7.8	6	–	70% failed after 54-1/2 years
	8.0	4	–	90% failed after 60 years
	8.3	20	47.1	–
	10.0	5	–	90% failed after 55 years
	11.8	4	–	50% failed after 60 years
	13.2	6	–	20% failed after 54-1/2 years
	14.5	5	–	No failures after 55 years
	16.5	4	–	10% failed after 60 years

Table 77–Summary of 2- by 4-in. stake selected results obtained in Mississippi with wood preservatives in general use–cont.

Preservative	Average retention[a] (lb/ft^3)	Data from table number	Average life (year)	Remarks
Creosote, coal-tar–continued				
Low residue, straight run	8.0	18	17.8	–
Medium residue, straight run	8.0	18	18.8	–
High residue, straight run	7.8	18	20.3	–
Medium residue				
Low in tar acids	8.1	18	19.4	–
Low in naphthalene	8.2	18	21.3	–
Low in tar acids and naphthalene	8.0	18	18.9	–
Low residue				
Low in tar acids and naphthalene	8.0	18	19.2	–
High residue				
Low in tar acids and naphthalene	8.2	18	20.0	–
English vertical retort	5.3	19	–	90% failed after 50 years
	8.0	18	18.9	–
	10.1	19	–	80% failed after 50 years
	15.0	19	–	No failures after 50 years
English coke oven	4.7	19	16.3	–
	7.9	18	13.6	–
	10.1	19	–	70% failed after 50 years
	14.8	19	–	80% failed after 50 years
Fluor chrome arsenate phenol type A (Fed. Spec. TT-W-535)	0.20 (0.12)	2	10.2	–
	0.30 (0.19)	2	18.0	–
	0.35 (0.22)	37	18.3	–
	0.50 (0.31)	37	18.5	–
	0.61 (0.38)	2	24.1	–
Pentachlorophenol (various solvents)[b]				
Liquified petroleum gas	0.14	42	18.9	–
	0.19	42	15.9	–
	0.34	42	–	10% failed after 38-1/2 years
	0.34	45	–	90% failed after 35 years
	0.49	45	–	10% failed after 35 years
	0.58	42	–	No failures after 38-1/2 years
	0.65	45	–	No failures after 35 years
Stoddard solvent (mineral spirits)	0.14	42	13.7	–
	0.18	42	15.9	–
	0.38	42	–	80% failed after 38-1/2 years
	0.67	42	–	No failures after 38-1/2 years
	4.00	17	13.7	–
	4.10	22	9.5	–
	8.00	22	15.5	–

Table 77–Summary of 2- by 4-in. stake selected results obtained in Mississippi with wood preservatives in general use.

Preservative		Average retention[a] (lb/ft^3)	Data from table number	Average life (year)	Remarks
Heavy gas oil (Mid-United States)		4.1	17	--	89% failed after 50 years
		7.9	17	--	80% failed after 50 years
		12.0	17	--	20% failed after 50 years
No. 4 aromatic oil (West Coast)		4.2	22	21.0	--
		8.2	22	--	70% failed after 50 years
AWPA P9 (heavy petroleum)		0.11	42	--	90% failed after 38-1/2 years
		0.19	42	--	60% failed after 38-1/2 years
		0.29	42	--	No failures after 38-1/2 years
		0.53	45	--	No failures after 35 years
		0.67	42	--	No failures after 38-1/2 years
Tributyltin oxide		0.015	36	6.4	--
Stoddard solvent		0.030	36	7.2	--
		0.045	36	7.4	--
		7.900	41	7.0	--
		8.200	41	4.5	--
AWPA P9 (heavy petroleum)	3%	8.0	41	20.8	--
	6%	8.0	41	24.0	--
Petroleum solvent controls		4.0	17	7.6	--
		4.1	17	4.4	--
		4.0	17	12.9	--
		7.7	23	14.6	--
		7.9	17	--	90% failed after 50 years
		8.0	45	19.7	--
		8.0	41	23.3	--
		8.0	17	14.6	--
		8.1	18	3.4	--
		8.5	43	20.9	--
		9.8	5	6.3	--
		12.0	17	17.1	--
		12.1	17	--	80% failed after 50 years
		19.4	5	9.1	--
Untreated stakes		--	Misc.	1.8 to 3.6	--

[a]Retention values in parentheses are based on preservative oxides or copper metal.

[b]See Tables 5 and 17 for pentachlorophenol in other solvents.