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Comparison of Wood Preservatives in Stake Tests

2000 Progress Report



Research Contributors, 1922-2000

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, phenyl mercury oleate, 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 give excellent service. In addition, this publication contains information regarding the future of the FPL treated-stake testing program.

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

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Caution

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.

Pesticides can be injurious to humans, domestic animals, desirable plants, and fish or other wildlife if they are not handled or applied properly. Use all pesticides selectively and carefully. Follow recommended practices for the disposal of surplus pesticides and pesticide containers.

This publication reports research-involving pesticides. It does not contain recommendations for their use, nor does it imply that the uses discussed have been registered. All uses of pesticides must be registered by appropriate State and/or Federal agencies before they can be recommended.

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 would like to express their appreciation to the Statistical Methods in Wood and Fiber Research and the Research Facilities Engineering staffs for their contributions to the success of this publication.

Cover photos—Researchers involved in 80+ years of independent evaluation of the durability of preservative in field plots. (Research period in parentheses): (Upper left) Roy Baechler (1922–1970), Oscar Blue (1941–1970), Douglas Crawford (1970–present), Harley Davidson (1942–1979), Rodney DeGroot (1976–1999), Lee Gjovik (1961–1990), David Gutzmer (1960–1994), George Hunt (1919–1946), Bruce Johnson (1965–1994), John Kulp (1947–1967), Stan Lebow (1993–present), Ed Panek (1941–1968), Ray Wirka (1919–1942) and Bessie Woodward (1980–present).

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Comparison of Wood Preservatives in Stake Tests

2000 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, 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.

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 1999 and 2000 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, and 1995 have been published (Hunt and Snyder 1930, Blew 1948). In addition, this publication contains information regarding the future of the FPL treated-stake testing program.

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. Complete 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, is sandy loam, and that at Jacksonville, Florida, is sandy. Both plots are partially shaded. The plot at Lake Charles, Louisiana, is located on an open area partially covered with broom sedge and marsh grass. The top 10 in. of soil are sandy with some streaks of clay; underneath is 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. After examination, the stakes are 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 trails
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

^a50% or more of cross section destroyed.

In 1985, field data were recorded using a portable computer. Until this time, the rating system was alpha-numeric. 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. ^a	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

^aThis description of the conditions for the different grade ratings is slightly different than that given in the 1995 edition of this Research Note. The above description is consistent with Standard E07-01 of the American Wood Preservers' Association (AWPA 2001).

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 as 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 it ignores those that may have been noted but have not seriously contributed to the destruction. In estimating service life prior to 100% removal of stakes, note that the average life is approximately at the time when 60% of the stakes in a group has been removed. The new rating system is considered well suited to the requirements of the stake tests rated on the basis of visual examination.

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

Results

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

Southern Pine and Plywood Stakes

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 service 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 pressure treated with various preservatives cannot be determined. Estimates on 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/ft³ CZA (oxide basis) had an average life of 9.2 years, and those with approximately 0.69 lb/ft³ (oxide basis) had an average life of 15.3 years. Stakes treated with CZA to retention levels of 0.22 to 0.70 lb/ft³ (oxide basis) have had 100% failures in Wisconsin after 51-1/2 years, and in Mississippi failures have been noted only with the lower retention levels (Table 4; similar comparison in Table 20). This may be attributed to the presence of arsenic-tolerant fungi at the Wisconsin test area.

Of the waterborne preservatives in tests that contain copper and arsenic (24 to 45 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 no failures using retention levels of 0.29 lb/ft³ (oxide basis) or greater for CCA. 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 and 0.22 lb/ft³ (oxide basis) have had 75% and 65% failure, respectively, in Mississippi after 25 years of service. In contrast, the ACA-treated stakes show 95% failure at the 0.17-lb/ft³ retention level and 30% failure at the 0.23-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-pentachlorophenolate (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 of service 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 gave service 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 similar retention, which could show a service 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-pentachlorophenol 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 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 (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. However, stakes dipped for 15 min in coal-tar creosote had a life of about 8 years in Mississippi.

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. 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.

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 49 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.

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.

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.

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 of service. Propylene oxide-modified stakes gave a service life of 2.2 to 6.2 years, depending on the chemical loading (Table 50). Stakes, 3/4 in., treated with butylene oxide to 33.2% weight gain had an average life of 3.5 years (Table 56).

Future Research Program

As we move into the 21st century, it is critical to develop a wood preservative research program that addresses the future demands for durable forest products in light of a heightened public environmental consciousness. One goal of wood preservative research is to improve methods to evaluate degradation and protection. In the past, FPL evaluated and analyzed, especially through stake tests, the performance of many preservative systems. This work contributed to this report. Although the importance of these evaluations is recognized, research direction necessitates focusing on accelerated methods to predict durability.

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 55 years of age, and 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.

The following listing summarizes the FPL recommendation for the 77 existing stake plots at the Harrison Experimental Forest. For plots that will be closed, the stakes will remain in the ground at the site, but inspections will be discontinued, and the database will be maintained in archival records.

Status of FPL-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	C	42	59	1961	2000
C	4	4	1940	2000	C	45	61	1963	1998
C	5	5	1941	1996	K	43	62	1963	2000
C	6	6	1941	1996	C	44	63	1963	2000
C	7	7	1942	1992	C	46	66	1967	1997
C	8	8	1942	1963	K	47	67	1967	2002
C	9	9	1942	1997	K	48	68	1971	2000
C	10	10	1946	1960	K	49	70	1973	1998
C	11	11	1942	1950	C	50	71	1974	1995
C	12	12	1943	1963	K	51	72	1975	2000
C	13	13	1943	1950	K	52	73	1975	2002
K	14	14	1944	1999	C	53	74	1976	1993
K	15	15	1945	2000	K	54	75	1976	1993
C	16	16	1945	1996	K	55	78	1978	1998
C	17	20	1948	1998	C	56	79	1979	1989
C	18	24	1948	1992	K	57	80	1980	2002
C	19	25	1948	1998	C	58	81	1980	2000
C	20	28	1949	1995	K	59	82	1980	2000
C	21	26	1949	1995	C	60	83	1981	2000
C	22	27	1949	1999	K	61	84	1981	2002
K	26	32	1952	2002	K	62	85	1981	2002
C	24	33	1952	1997	C	63	86	1982	1996
C	23	34	1952	1997	C	64	87	1982	1996
C	25	35	1952	1997	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	2002
K	34	47	1956	2000	C	71	96	1984	1996
C	35	48	1957	2000	K	72	97	1985	2002
C	36	53	1958	1967	K	73	98	1985	1999
C	37	55	1959	1989	K	74	99	1987	2000
K	38	54	1959	1968	K	75	100	1988	2002
K	41	56	1960	2000	C	76	101	1989	1998
K	39	57	1960	2000					

^aC indicates maintain archives, plot closed. K indicates keep plot open, study will continue.

For the 24 plots at Harrison Experimental Forest listed as open, the current plans are to report the results of future inspections in separate publications. Reporting of results for any similar field plots installed since 1989 will also be expected to be in separate publications. Thus, this publication is the last revision of FPL–RN–02. Future inspections will normally be conducted each year for the first 5 years after installation, every other year for the next 4 years, and every 3rd year for the next 6 years. After 15 years, stakes will be evaluated every 5th year.

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
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
pound per cubic foot (lb/ft ³)	16.02	kilogram per cubic meter (kg/m ³)
°F	(°F – 32)/1.8	°C

References

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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	Existing specification or AWWA ^a reference	Table number
Chemical		
Acid copper chromate	Fed. Spec. TT-W-546; AWWA P5	15, 16, 46, 47
Acrylonitrile	—	36
Aldrin	—	41
Ammoniacal copper arsenate	Fed. Spec. TT-W-549; AWWA P5	14, 47, 51, 52, 55, 72
Ammoniacal copper borate	—	52
Ammoniacal 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; AWWA P5; AWWA P5, Type A	15, 47
Chromated copper arsenate	Fed. Spec. TT-W-550 Type II; AWWA P5, Type B	20, 47
Chromated copper arsenate	Fed. Spec. TT-W-550 Type III; AWWA P5, Type C	48, 49, 51, 55, 57, 72, 73, 74
Chromated copper fluoride (CFK)	—	59
Chromated zinc arsenate	Formerly in Fed. Spec. TT-W-538; AWWA P5	4, 24
Chromated zinc chloride	Fed. Spec. TT-W-551; AWWA P5	2, 16, 25, 35, 47
Chromated zinc chloride, copperized	Formerly in Fed. Spec. TT-W-562; AWWA P5	31
Chromated zinc chloride (FR)	AWWA P10, Type B	25
Copper arsenate	AWWA Proc. 1941; pp. 23–31	9
Copper carbonate	—	74
Copper chromate	AWWA 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	AWWA P8	7, 12, 16, 17, 29
Copper oxide	—	74
Copper-8-quinolinolate	AWWA P8	38, 43, 54, 61
Creosote, coal–tar	Fed. Spec. TT-C-645; AWWA P1	4, 5, 6, 8, 16–20, 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; AWWA P2	18, 47, 70
Creosote, petroleum solution	Fed. Spec. TT-W-568	18, 47, 70
Creosote, low xylene insolubles	—	75
Creosote, toluene	—	6
Diamyl phenol	—	14
Dichloro-diphenyl-trichloroethane (DDT)	—	14
Dieldrin	—	41
Dodecyl amine	—	14
Drop-liquor concentrate	—	27
Fire retardants	—	53
Fire retardants	AWWA P10	25
Fluor chrome arsenate phenol	Fed. Spec. TT-W-535, Type A; AWWA P5	2, 33, 37, 47, 49
Fluor chrome arsenate phenol	Fed. Spec. TT-W-535, Type B; AWWA P5	47
Fuel oils	—	5, 17, 27

Table 1—Index to materials tested—concluded

Material	Existing specification or AWWPA reference	Table number
Chemical—continued		
Heptadecyltrimethyltetra- hydropyrimidine (HTP)	—	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; AWWPA 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 wood, particleboard, plywood, and paper plastic	—	14
Acetylated wood		
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

^aAmerican 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 of service. Stakes placed in test at Barro Colorado Island, Canal Zone, September 1938; Bogalusa, LA, December 1939; Jacksonville, FL, January 1939; Harrison Experimental Forest, Saucier, MS, December 1938; and Madison, WI, November 1939 (Plot 2)

Preservative	Location	Condition of stakes December 1966 ^c (%)												
		Retention of salts ^a (lb/ft ³)			Num-ber in test ^b	Serviceable but showing some--			Destroyed by--			Total removed	Average life (year)	
		Minimum	Maximum	Average		Termite attack	Decay attack	fungi attack	Termite attack	Decay attack	fungi attack			
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	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 of service. Stakes placed in test at Barro Colorado Island, Canal Zone, September 1938; Bogalusa, LA, December 1939; Jacksonsville, FL, January 1939; Harrison Experimental Forest, Saucier, MS, December 1938; and Madison, WI, November 1939 (Plot 2)--continued

Preservative	Location	Condition of stakes December 1966 ^c (%)												Average life (year)	
		Retention of salts ^a (lb/ft ³)			Num-ber in test ^b	Serviceable but showing some--			Destroyed by--			Total removed Number	Total removed %		
		Minimum	Maximum	Average		Good	Decay	Termite attack	Decay fungi and	Termite attack	Decay fungi and				Termite attack
Sodium tetrachlorophenate (continued)	Canal	0.70	0.83	0.76	10	--	--	--	--	--	100	100	10	100	13.1
	LA	0.71	0.83	0.77	10	--	--	--	30	--	70	100	10	100	11.9
	FL	0.68	0.83	0.76	9	--	--	--	--	11	89	100	9	100	16.8
	MS	0.68	0.82	0.75	10	--	--	--	--	--	100	100	10	100	19.7
	WI	0.67	0.81	0.75	9	--	--	--	100	--	--	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	100	10	100	9.6
	FL	0.18 (0.11)	0.21 (0.13)	0.20 (0.12)	10	--	--	--	50	--	50	100	10	100	13.9
	MS	0.18 (0.11)	0.21 (0.13)	0.20 (0.12)	10	--	--	--	10	50	40	100	10	100	10.2
	WI	0.13 (0.08)	0.22 (0.14)	0.20 (0.12)	10	--	--	--	100	--	--	100	10	100	13.8
	Canal	0.28 (0.17)	0.33 (0.20)	0.30 (0.19)	10	--	--	--	--	30	70	100	10	100	6.4
	LA	0.28 (0.17)	0.32 (0.20)	0.30 (0.19)	10	--	--	--	20	--	80	100	10	100	13.7
	FL	0.29 (0.18)	0.32 (0.20)	0.30 (0.19)	10	--	--	--	100	--	--	100	10	100	15.4
	MS	0.29 (0.18)	0.32 (0.20)	0.30 (0.19)	10	--	--	--	10	--	90	100	10	100	18.0
	WI	0.27 (0.17)	0.30 (0.19)	0.28 (0.17)	10	--	--	--	100	--	--	100	10	100	16.5
	Canal	0.53 (0.33)	0.66 (0.41)	0.60 (0.37)	10	--	--	--	40	--	60	100	10	100	14.2
	LA	0.56 (0.35)	0.64 (0.40)	0.60 (0.37)	10	--	--	--	50	--	50	100	10	100	15.6
	FL	0.57 (0.35)	0.65 (0.40)	0.61 (0.38)	10	--	--	--	100	--	--	100	10	100	17.3
	MS	0.57 (0.35)	0.65 (0.40)	0.61 (0.38)	10	--	--	--	60	--	40	100	10	100	24.1
	WI	0.59 (0.36)	0.68 (0.42)	0.65 (0.40)	10	--	--	--	100	--	--	100	10	100	16.0
Sodium pentachlorophenate and sodium chloride ^e	Canal	0.52	0.55	0.54	10	--	--	--	--	30	70	100	10	100	8.7
	LA	0.46	0.53	0.49	10	--	--	--	--	--	100	100	10	100	13.3
	FL	0.48	0.54	0.50	10	--	--	50	10	--	40	50	5	50	--
	MS	0.46	0.53	0.49	10	--	--	--	--	--	100	100	10	100	16.3
	WI	0.46	0.53	0.50	10	--	--	--	100	--	--	100	10	100	16.8
Zinc chloride	Canal	0.44 (0.26)	0.53 (0.32)	0.47 (0.28)	10	--	--	--	--	30	70	100	10	100	3.9
	LA	0.45 (0.27)	0.55 (0.33)	0.50 (0.30)	10	--	--	--	30	--	70	100	10	100	8.2
	FL	0.45 (0.27)	0.53 (0.32)	0.49 (0.29)	10	--	--	--	20	--	80	100	10	100	12.9
	MS	0.45 (0.27)	0.54 (0.32)	0.50 (0.30)	10	--	--	--	40	--	60	100	10	100	15.4
	WI	0.45 (0.27)	0.53 (0.32)	0.49 (0.29)	10	--	--	--	100	--	--	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 of service. Stakes placed in test at Barro Colorado Island, Canal Zone, September 1938; Bogalusa, LA, December 1939; Jacksonville, FL, January 1939; Harrison Experimental Forest, Saucier, MS, December 1938; and Madison, WI, November 1939 (Plot 2)--continued

Preservative	Location	Condition of stakes December 1966 ^c (%)										Average life (year)				
		Retention of salts ^a (lb/ft ³)					Destroyed by--									
		Minimum	Maximum	Average	Num-ber in test ^b	Good	Decay	Termite attack	Decay fungi attack	Termite attack	Decay fungi and termites attack		Total removed Number	%		
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 of service. Stakes placed in test at Barro Colorado Island, Canal Zone, September 1938; Bogalusa, LA, December 1939; Jacksonville, FL, January 1939; Harrison Experimental Forest, Saucier, MS, December 1938; and Madison, WI, November 1939 (Plot 2)--concluded

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

^aRetention values in parentheses are based on preservative oxides.

^bTen 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.

^cFinal inspection at Canal Zone, January 1956; at Louisiana, December 1958; at Florida, December 1960; at Wisconsin, October 1964; and at Mississippi, December 1966.

^dEstimate based on percentage of stakes remaining after final inspection.

^eRetention values based on sodium pentachlorophenolate only. Sodium chloride added was equal to 20% of weight of sodium pentachlorophenolate 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, MS, after about 27 years of service (Plot 3)

Group	Stake number	Treatment	Approximate average retention (lb/ft ³)	Num-ber in test	Condition of stakes January 1967 (%)						Average life (year)		
					Good	Decay	Termite attack	Serviceable but showing some--	Destroyed by--	Decay and fungi		Total removed	
									fungi attack	fungi attack	Number	%	
Plywood ^a													
1	1-1-40 to 1-10-40	Each ply impregnated with a 50% aqueous solution 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 bonded 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 bonded 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 protected 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 film	--	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, MS, after about 27 years of service (Plot 3)--concluded

Group	Stake number	Treatment	Condition of stakes January 1967 (%)															
			Approximate average retention in test (lb/ft ³)	Num-ber in	Serviceable but showing some--			Destroyed by--			Total removed Number	Average life (year)						
					Good	Decay	Termite attack	Decay	Termite	fungi and								
											fungi attack	fungi attack	fungi attack	fungi attack	fungi attack	fungi attack	fungi attack	fungi attack
											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				

^aSpecimens 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.

^bIncrease based on treated faces.

^cDeterioration principally in cores.

^dSome separation of plies had also occurred.

^eSpecimens are Southern Pine sapwood, 2 by 4 nominal by 18 in.

^fBased on estimated life of 2 remaining stakes.

^gDouglas-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 of service. Stakes placed in test at Madison, WI, September 1940; Harrison Experimental arro Colorado Island, Canal Zone, September 1940 (Plot 4)

Preservative	Location	Oil	Average retention (lb/ft ³)	Dry salt ^b in test	Num- ber in test	Good Decay	Serviceable but showing some--			Destroyed by--			Average life (year)
							Termite attack	Decay attack	fungi attack	Termite attack	Decay attack	fungi attack	
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 arsenate (Boliden salts) ^c	WI	--	0.33 (0.22)	10	--	--	--	100	--	--	10	100	19.6
	MS	--	0.33 (0.22)	10	--	--	--	30	--	70	10	100	33.0
	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	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	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 of service. Stakes placed in test at Madison, WI, September 1940; Harrison Experimental Forest, Saucier, MS, June 1940; and Barro Colorado Island, Canal Zone, September 1940 (Plot 4)--concluded

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

^aFinal inspection at Canal Zone, January 1956.

^bRetention values in parentheses are based on preservative oxides.

^cRetention based upon total anhydrous salts: ZnSO₄ + H₃AsO₄ + Na₂HAsO₄ + Na₂Cr₂O₇.

^dEstimate based upon percentage of stakes remaining after final inspection.

^e15-min dip at room temperature.

^fBrush 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 of service. Stakes placed in test at Barro Colorado Island, Canal Zone, February 1941; Bogalusa, LA, March 1941; Jacksonville, FL, March 1941; and Harrison Experimental Forest, Saucier, MS, February 1941 (Plot 5)

Preservative	Location	Condition of stakes January 1996 ^c (%)												
		Retention of preservative ^a (lb/ft ³)		Number in test ^b	Serviceable but showing some--				Destroyed by--				Average life (year)	
		Minimum	Maximum		Termite attack	Decay	and fungi	Termite attack	Decay	fungi	Termite attack	Decay		fungi
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	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														
	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
3.24:1 chemical ratio														
	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														
	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
1.0:76 chemical ratio														
	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 of service. Stakes placed in test at Barro Colorado Island, Canal Zone, February 1941; Bogalusa, LA, March 1941; Jacksonville, FL, March 1941; and Harrison Experimental Forest, Saucier, MS, February 1941 (Plot 5)--continued

Preservative	Loca- tion	Condition of stakes January 1996 ^c (%)										Average life (year)		
		Retention of preservative ^a (lb/ft ³)		Num- ber in test ^b	Serviceable but showing some--		Destroyed by--		Termites attack	Decay fungi attack	Termites and fungi attack		Total removed Number	
		Mini- mum	Maxi- mum		Aver- age	Decay	and decay	Decay						fungi attack
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	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	100	20.9
5% pentachlorophenol in fuel oil ^e	Canal	4.0	5.4	4.7	10	--	--	--	--	40	--	60	100	13.0
	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	Canal	8.6	10.5	9.6	10	--	--	--	--	30	--	70	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	100	27.2
Canal	Canal	14.0	16.5	15.3	10	--	--	--	40	10	--	50	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	50	--
Canal	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	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 of service. Stakes placed in test at Barro Colorado Island, Canal Zone, February 1941; Bogalusa, LA, March 1941; Jacksonville, FL, March 1941; and Harrison Experimental Forest, Saucier, MS, February 1941 (Plot 5)--continued

Preservative	Loca- tion	Retention of preservative ^a (lb/ft ³)		Num- ber in test ^b	Condition of stakes January 1996 ^c (%)				Average life (year)						
		Mini- mum	Maxi- mum		Serviceable but showing some--		Destroyed by--								
					Good	Decay	Decay	fungi and termite attack							
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	20.0 ^b		
	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	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	--	--	--	--	--	--	
	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 of service. Stakes placed in test at Barro Colorado Island, Canal Zone, February 1941; Bogalusa, LA, March 1941; Jacksonville, FL, March 1941; and Harrison Experimental Forest, Saucier, MS, February 1941 (Plot 5)--continued

Preservative	Location	Retention of preservative ^a (lb/ft ³)		Number in test ^b	Condition of stakes January 1996 ^c (%)										Average life (year)
		Mini- mum	Maxi- mum		Serviceable but showing some--					Destroyed by--					
					Good	Decay	Termite attack	Decay	fungi	Decay	fungi	and	Termite	Total removed	
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	5.0	
	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	7.0	
	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 ^e 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	5.0	
	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	9.0	
	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 of service. Stakes placed in test at Barro Colorado Island, Canal Zone, February 1941; Bogalusa, LA, March 1941; Jacksonville, FL, March 1941; and Harrison Experimental Forest, Saucier, MS, February 1941 (Plot 5)--concluded

Preservative	Loca- tion	Retention of preservative ^a (lb/ft ³)		Num- ber in test ^b	Condition of stakes January 1996 ^c (%)						Average life (year)		
		Mini- num	Maxi- num		Serviceable but showing some--			Destroyed by--					
					Good	Decay	Termite attack	Decay fungi and termite attack	Decay fungi and termite attack	Total removed Number		Total removed %	
3% pentachlorophenol + 2% chloro-2-phenylphenol in solvent of 80% mineral spirits and 20% moisture repellent 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

^aBased upon weight of dry chemical for sodium pentachlorophenolate alone or mixed with other chemicals and on weight of solution for other treatments. Values for stakes originally installed.

^bTen 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.

^cFinal inspection at Canal Zone, January 1956; at Jacksonville, FL, November 1960; and at Bogalusa, LA, December 1962.

^dEstimate based upon percentage of stakes remaining after final inspection.

^ePurchased 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.

^fSolvent contained 1 part soybean oil and 9 parts each of fuel and naphtha by volume.

^gSpecimens 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 of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, May 1951 (Plot 6)

Preservative	Stake size (in.)	Average retention in (lb/ft ³)	Num- ber in test	Condition of stakes January 1996 (%)						Average life (year)	
				Serviceable but showing some--		Destroyed by--		Total removed	%		
				Termite attack	Decay attack	Termite attack	Decay attack				fungi and termite attack
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	--	50	7	70	--
		13.2	10	--	--	80	--	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	--	--	--	--	--

^aCreosote 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 of service. Stakes placed in test at Madison, WI, October 1941, and on the Harrison Experimental Forest, Saucier, MS, February 1942 (Plot 7)

Preservative	Treatment	Location	Average retention ^b (lb/ft ³)	Num-ber in test ^c	Condition of stakes October 1992 ^d (%)						Average life (year)		
					Serviceable but showing some--			Destroyed by--					
					Good	Decay	Termite	Decay	fungi	and			
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
1% (0.12% zinc metal)	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
2.5% (0.29% 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
5.0% (0.59% 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
7.5% (0.88% 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
Copper naphthenate solution 17.5% (2% copper metal)	Brush, one coat	MS	10.4 (0.092)	10	--	--	--	60	--	40	10	100	19.7
		WI	10.0 (0.088)	9 ^d	--	--	--	100	--	--	9	100	30.8
1% (0.11% copper metal)	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
2.5% (0.29% 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
5.0% (0.57% 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
7.5% (0.86% 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	--
Untreated controls	--	MS	9.6 (0.082)	10	20	--	--	60	--	20	8	80	29.6
		WI	9.8 (0.084)	3	--	--	--	100	--	--	3	100	35.4
		MS	--	10	--	--	--	30	70	10	100	1.8	
		WI	--	10	--	--	--	100	--	--	10	4.9	

^aLast inspection in Mississippi was 1985.

^bNumber in parentheses is the retention based on zinc or copper metal.

^cTen stakes were originally installed. This number has been reduced for causes other than decay or insect attack.

^dAverage retention based on nine stakes.

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, MS, February 1942 (Plot 8)

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

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

^bEstimate based on condition of stakes at final inspection.

^cSolvent contained 1 part pine oil and 12 parts Stoddard-type solvent by volume.

^dTwo stakes showed some delamination.

^eOne stake showed some delamination.

^fStoddard-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 stakes (2 by 4 in. nominal by 18 in.) treated with copper arsenate and copper chromate by the double-diffusion process after about 55 years of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, February 1942 (Plot 9)

Treatment	Condition of stakes January 1997 (%)										Average life (year)	
	Calculated retention of chemical ^a (lb/ft ³)			Number in test ^b	Serviceable but showing some--			Destroyed by--				
	Copper as CuSO ₄	Chromium as Na ₂ CrO ₄	Arsenic as Na ₂ AsO ₄		Total	Good	Decay	Termite attack	Decay	Termite attack	fungi and termites	Total removed
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	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	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	67
Untreated controls	--	--	--	--	10	--	--	--	--	20	80	100

^aRetention values in parentheses are oxides (CuO - CrO₃ - As₂O₅)

^bTen 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 of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, February 1942 and December 1946, and at Madison, WI, April 1942 (Plot 10)

Treatment	Location	Total retention of urea or solids ^a (lb)	Average retention of urea or solids ^a (lb/ft ³)	Condition of stakes late in 1960 (%)										Average life (year)			
				Serviceable but showing some--					Destroyed by--								
				Good	Decay	Termite attack	fungi attack	Decay	Termite attack	fungi attack	Decay	Termite attack	fungi attack		Total removed		
test	in	Num-ber	in	test	Good	Decay	Termite attack	fungi attack	Decay	Termite attack	fungi attack	Decay	Termite attack	fungi attack	Number	%	
Installed 1942																	
2-day soak ^b	MS	4.7	3.4	10	--	--	--	--	10	90	10	100	10	100	3.4		
	WI	4.7	3.4	10	--	--	100	--	--	--	10	100	10	100	8.1		
4-day soak ^b	MS	6.9	5.0	10	--	--	--	20	80	10	100	10	100	3.3			
	WI	6.9	5.0	10	--	--	100	--	--	10	100	10	100	8.0			
6-day soak ^b	MS	10.2	7.4	10	--	--	--	20	80	10	100	10	100	2.9			
	WI	10.2	7.4	10	--	--	100	--	--	10	100	10	100	6.0			
B ₁ ^c (thermosetting) 2-day soak	MS	9.9	7.1	10	--	--	--	20	80	10	100	10	100	4.5			
	WI	9.9	7.1	10	--	--	100	--	--	10	100	10	100	12.5			
B ₁ ^c (thermosetting) 4-day soak	MS	11.2	8.1	10	--	--	--	--	100	10	100	10	100	5.1			
	WI	11.2	8.1	10	--	--	100	--	--	10	100	10	100	13.2			
B ₁ ^c (thermosetting) 6-day soak	MS	11.7	8.4	10	--	--	--	10	90	10	100	10	100	5.6			
	WI	11.7	8.4	10	--	--	100	--	--	10	100	10	100	15.2			
Untreated controls	MS	--	--	10	--	--	--	20	80	10	100	10	100	1.8			
	WI	--	--	10	--	--	100	--	--	10	100	10	100	4.8			
Installed 1946																	
Urea resin, pressure ^d	MS	--	5.8	10	--	--	10	--	90	10	100	10	100	9.1			

^aCalculated total retention of urea or solids for 22 stakes.

^bTreating solution made up to 1.15 parts of urea to 1.00 part of water by weight.

^cSolution 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.

^dTreated 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 of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS (Plot 11)

Stake number	Composition	Num-ber in test	December 1950 stakes destroyed by--						Average life (year)
			Decay fungi		Termite attack		Decay fungi and termite attack		
			Number	%	Number	%	Number	%	
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

^aAlcohol-soluble.

^bSingle surface sheet on each side, coated side out.

^cHeavy 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 of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, December 1943 (Plot 12)

Preservative	Treatment	Average retention of solution (lb/ft ³)	Num-ber in test	Condition of stakes December 1963 (%)								Average life (year)	
				Serviceable but showing some--				Destroyed by--					
				Good	Decay	Termite attack	Decay and fungi	Termite attack	Decay and fungi	Termite attack	Total removed		
								Number	%				
Phenyl mercury oleate (percentage in naphtha solvent)													
0.4	3-min dip	1.4	10	--	--	--	--	--	20	80	10	100	3.7
0.4	18-hr soak	3.2	10	--	--	--	10	30	60	60	10	100	4.9
0.4	Pressure	5.9	10	--	--	--	--	10	90	90	10	100	6.7
0.4	Pressure	12.1	10	--	--	--	30	--	70	70	10	100	8.8
0.2	18-hr soak	3.1	10	--	--	--	10	30	60	60	10	100	4.4
0.2	Pressure	6.0	10	--	--	--	--	30	70	70	10	100	5.6
0.2	Pressure	11.8	10	--	--	--	--	30	70	70	10	100	6.2
0.1	18-hr soak	3.6	10	--	--	--	--	40	60	60	10	100	4.4
0.1	Pressure	5.9	10	--	--	--	--	30	70	70	10	100	4.6
0.1	Pressure	11.6	10	--	--	--	--	40	60	60	10	100	5.1
0.4 ^a	3-min dip	1.2	10	--	--	--	--	60	40	40	10	100	3.9
0.1 ^a	18-hr soak	6.0	10	--	--	--	--	20	80	80	10	100	5.5
0.1 ^a	Pressure	6.1	10	--	--	--	10	40	50	50	10	100	6.2
0.1 ^a	Pressure	12.0	10	--	--	--	--	10	90	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

^aSolution contained 16% solids as a water repellent.

^bEstimate based on percentage of stakes remaining after final inspection.

^cRetention 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 of service. Stakes placed in test December 1943 on the Harrison Experimental Forest, Saucier, MS, and inspected December 1950 (Plot 13)

Treating chemicals	Retention of dry salt (lb/ft ³)	Num- ber in test	December 1950 stakes destroyed by--				Average life (year)
			Decay fungi		Decay fungi and termite attack		
			Number	%	Number	%	
Ammonium sulfate, 78 parts; ammonium phosphate, 19 parts; sodium dichromate, 3 parts (by weight)	3.01 6.17	10 10	5 6	50 60	5 4	50 40	2.4 3.4
Ammonium phosphate, 10 parts; ammonium sulfate, 60 parts; borax, 10 parts; boric acid, 20 parts (by weight)	2.98 6.19	10 10	4 2	40 20	6 8	60 80	3.9 4.3
Borax, 60 parts; boric acid, 40 parts (by weight)	3.01 6.29	10 10	3 6	30 60	7 4	70 40	6.0 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 laminated acetylated yellow birch sapwood stakes (0.4 by 3-1/2 by 15-3/4 in.) after 55 years of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, December 1944 (Plot 14)

Preservative ^a	Average retention of or dry salt ^b (lb/ft ³)	Number in test	Condition of stakes January 1999 (%)								Total removed		Average life (year)
			Serviceable but showing some--				Destroyed by--						
			Good	Decay	Termite attack	termite attack	Decay fungi	Termite attack	termite attack	Decay fungi	Number	%	
Pine stakes													
Ammoniacal copper arsenate (Fed. Spec. TT-W-549) (percentage in solution)													
0.612 (0.59) ^b	0.25 (0.24)	9	--	11	--	--	67	--	22	8	89	--	
1.29 (1.24)	0.53 (0.51)	10	--	80	--	10	10	--	--	1	10	--	
2.57 (2.48)	1.01 (0.97)	10	70	30	--	--	--	--	--	--	--	--	
3.21 (3.10)	1.29 (1.25)	10	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) ^c													
Acetylated	--	10	--	--	--	--	90	--	10	10	100	17.5	
Untreated controls	--	10	--	--	--	--	10	10	80	10	100	2.7	

^aAll stakes except laminated yellow birch were pressure treated.

^bAmmoniacal copper arsenate solution and retention figures in parentheses are oxides (CuO and As₂O₅).

^cPrepared from six-ply, parallel-laminated, acetylated 1/16-in. veneer glued with hot-press phenolic resin.

Average acetyl content 19.2% based upon oven-dry 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 55 years of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, December 1945 (Plot 15)

Preservative	Average retention ^a (lb/ft ³)	Number in test	Condition of stakes January 2000 (%)								Total removed Number	Total removed %	Average life (year)
			Serviceable but showing some--		Destroyed by--		Decay fungi and		Termite attack	Termiticide attack			
			Good	Decay	Termite attack	Decay	fungi attack	fungi attack					
Acid copper chromate (Fed. Spec. TT-W-546)	0.25 (0.13) 0.51 (0.26) 0.75 (0.37)	10 10 10	-- -- --	-- -- 10	-- -- 10	-- 30 30	10 50 50	30 -- --	60 20 --	10 7 5	100 70 50	11.6 -- --	
Chromated copper arsenate type I (Fed. Spec. TT-W-550)	0.26 (0.15) 0.50 (0.29) 0.78 (0.44)	10 10 10	-- -- 10	-- 20 10	-- -- 40	-- 50 20	20 30 20	10 -- --	70 -- --	10 3 2	100 30 20	28.7 -- --	
Nickel-arsenic-chromium salts ^b	0.26 (0.16) 0.50 (0.32) 0.77 (0.50)	10 10 10	-- -- --	-- -- --	-- -- --	-- -- 50	10 20 50	30 10 --	60 70 --	10 10 5	100 100 50	17.4 41.2 --	
Untreated controls	--	10	--	--	--	--	10	30	60	10	100	3.2	

^a Retention values in parentheses based on preservative oxides.

^b Nickel sulfate (NiSO₄ · 6H₂O), 5.5 parts; sodium arsenate (NaHAsO₄ · 12H₂O), 4.0 parts; arsenic acid (H₃AsO₄), 1.5 parts; and sodium dichromate (Na₂Cr₂O₇ · 2H₂O), 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 of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, December 1945 (Plot 16)

Preservative	Treatment	Plywood ^a Num- ber of plies	Veneer thick- ness (in.)	Average retention ^{b,c} (lb/ft ³)	Num- ber in test	Condition of stakes January 1996 (%)			Decay fungi and termite attack	Total removed Number	Average life (year)	
						Serviceable but		Destroyed by--				
						showing some-- decay and termite attack	Decay fungi and termite attack					
						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	100	
	24-hour cold soak	13	1/16	12.9	10	30	40	10	20	--	10.2	
	24-hour cold soak	7	1/8	8.4	9	--	11	--	89	--	--	
	10-second dipping	7	1/16	5.1	9 ^g	--	56	11	22	--	--	
	10-second dipping	7	1/8	4.6	9	--	22	--	67	--	--	
	Pressure	13	1/16	15.5 (0.31)	9	67	22	--	11	--	--	
	Pressure	7	1/8	10.2 (0.20)	10	30	30	--	40	--	--	
	Heating and 1-hour cold bath ^d	7	1/8	6.7 (0.13)	9	11	11	--	67	11	11	
Copper naphthenate, 2% copper metal in coal-tar naphtha	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	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	--	100	
Pentachlorophenol, 5% in No. 2 fuel oil	Pressure	13	1/16	21.4	9	--	22	11	67	--	--	
	Pressure	7	1/8	18.2	10	--	--	50	30	--	50	
	Heating and 1-hour cold bath ^d	7	1/8	10.3	10	--	--	30	10	--	60	
	24-hour cold soak	13	1/16	7.4	9	--	--	33	44	--	67	
	24-hour cold soak	7	1/8	4.8	10	--	--	--	10	10	100	
	10-second dipping	13	1/16	4.9	10	--	--	--	10	30	90	
	10-second dipping	7	1/8	1.0	10	--	--	--	10	--	100	
	Pressure	13	1/16	1.02 ^g (0.62)	6	--	--	--	50	17	33	
	Pressure	7	1/8	1.06 ^e (0.65)	10	--	--	--	--	40	60	
	Heating and 1-hour cold bath ^d	7	1/8	0.98 (0.60)	10	--	--	--	--	50	100	
Chromated zinc chloride	24-hour steeping	13	1/16 ^f	1.07 (0.65)	8	--	--	--	88	--	12	
	24-hour steeping	13	1/16	1.84 (1.12)	8 ^g	--	--	13	50	25	27	
	24-hour steeping	7	1/8 ^f	0.59 (0.36)	10	--	--	--	--	10	90	
	24-hour steeping	7	1/8	1.30 (0.79)	10	--	--	--	--	10	20	
	10-second dipping	13	1/16 ^f	0.61 (0.37)	10	--	--	--	--	30	100	
	10-second dipping	7	1/8	0.66 (0.40)	10	--	--	--	--	10	100	
	10-second dipping	7	1/8	0.35 (0.21)	10	--	--	--	--	20	100	
	Pressure	13	1/16	0.76 (0.38)	9 ^g	--	--	22	67	11	11	
	Pressure	7	1/8	0.79 (0.39)	9	11	--	--	67	22	22	
	Heating and 1-hour cold bath ^d	7	1/8	1.07 (0.53)	10	--	--	--	60	30	40	
Acid copper chromate	24-hour steeping	13	1/16 ^f	0.88 (0.44)	9	44	11	33	11	--	--	
	24-hour steeping	7	1/8	1.89 (0.94)	10	40	--	40	20	--	--	
	24-hour steeping	7	1/8	0.54 (0.27)	9	22	11	22	33	11	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	30	
	10-second dipping	13	1/16	0.61 (0.30)	9	--	11	--	44	44	44	
	10-second dipping	7	1/8	0.27 (0.13)	10	--	--	--	20	80	100	
	10-second dipping	7	1/8	0.38 (0.19)	10	--	--	--	30	10	100	
												18.4
												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 of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, December 1945 (Plot 16)--concluded

Preservative	Treatment	Plywood ^a Num- ber of plies	Veneer thick- ness (in.)	Average retention ^{b,c} (lb/ft ³)	Num- ber in test	Condition of stakes January 1996 (%)						Average life (year)
						Serviceable but showing some--			Destroyed by--			
						Good	Decay	Termite	Decay	Termite	and	
						Plywood Treated After Gluing						
						100	0	0	0	0	0	0
Coal-tar creosote	Pressure Hot bath, 1-hour, and cold bath, 1-hour	5	1/8	19.6	10	70	10	10	--	--	--	--
	24-hour cold soak	5	1/8	2.0	10	20	--	80	--	--	--	--
	10-second dipping	5	1/8	5.3	10	--	--	--	20	30	50	100
		5	1/8	1.0 ^e	8 ^g	--	--	--	--	50	50	8
Copper naphthenate, (2% copper metal) in coal-tar naphtha	Pressure Hot bath, 1-hour, and cold bath, 1-hour	5	1/8	2.9 (0.058)	10	--	--	--	50	10	40	100
	24-hour cold soak	5	1/8	1.2 (0.024)	10	--	--	--	60	--	40	100
	10-second dipping	5	1/8	1.1 (0.022)	10	--	--	--	50	--	50	100
		5	1/8	0.4 (0.008)	10	--	--	--	60	--	40	100
Pentachlorophenol, 5% in No. 2 fuel oil	Pressure Hot bath, 1-hour, and cold bath, 1-hour	5	1/8	12.5	10	--	--	--	20	30	--	80
	24-hour cold soak	5	1/8	2.1	10	--	--	--	--	40	60	100
	10-second dipping	5	1/8	2.0	10	--	--	--	20	10	70	100
		5	1/8	0.7	10	--	--	--	10	20	70	100
Chromated zinc chloride	Pressure 24-hour steeping	5	1/8	0.62 ^e (0.038)	10	--	--	--	40	--	60	100
	10-second dipping	5	1/8	0.35 (0.021)	10	--	--	--	10	30	60	100
		5	1/8	0.03 (0.002)	10	--	--	--	--	50	50	100
Acid copper chromate	Pressure 24-hour steeping	5	1/8	0.46 (0.023)	10	10	--	--	10	50	--	80
	10-second dipping	5	1/8	0.28 (0.14)	10	--	--	--	10	40	50	100
		5	1/8	0.06 (0.003)	10	--	--	--	10	60	30	100
None	Untreated	13	1/16	--	10	--	--	--	--	50	50	100
	Untreated	7	1/8	--	10	--	--	--	--	60	40	100

^aPlywood glued with hot-press phenolic-resin adhesive.
^bOils 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.
^cRetention values in parentheses based on preservative oxides or copper metal.
^dVeneer heated in dryer and then submerged for 1 hour in unheated preservative.
^eApproximate values.
^fVeneer treated prior to drying.
^gSpecimens 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 of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, and at Bogalusa, LA, April 1948 (Plot 20)

Oil or preservative	Location	Average retention (lb/ft ³)	Num-ber in test ^a	Condition of stakes January 1998 ^b (%)										Average life (year)
				Serviceable but showing some--					Destroyed by--					
				Termite attack	Decay	fungi	and termites	Decay	fungi	and termites	Total removed	Number	%	
Unfortified petroleum oil														
Commercial aromatic solvent (Mid-United States)	MS	4	10	--	--	--	--	10	--	--	90	10	100	2.3
	LA	4	10	--	--	--	--	--	20	80	10	100	2.9	
Stoddard solvent (Mid-United States)	MS	4	10	--	--	--	--	10	20	70	10	100	2.1	
	LA	4	10	--	--	--	--	10	20	70	10	100	2.8	
No. 2 fuel oil (Mid-United States)	MS	4	10	--	--	--	--	10	10	80	10	100	4.4	
	LA	4	10	--	--	--	--	70	--	30	10	100	4.1	
Heavy thermal side cut (Mid-United States)	MS	4	10	--	--	--	--	--	10	90	10	100	3.4	
	LA	4	10	--	--	--	--	30	--	70	10	100	4.6	
No. 200 diesel oil (West Coast)	MS	4	10	--	--	--	--	20	10	70	10	100	4.8	
	LA	4	10	--	--	--	--	70	--	30	10	100	4.6	
Catalytic gas-base oil (West Coast)	MS	4	10	--	--	--	--	40	--	60	10	100	7.6	
	LA	4	10	--	--	--	--	40	--	60	10	100	7.6	
	MS	8	10	--	--	--	--	30	--	70	10	100	14.6	
	LA	8	10	--	10	--	50	20	--	20	4	40	--	
	MS	12	10	--	--	--	--	40	--	60	10	100	17.1	
	LA	12	10	--	25	--	63	12	--	--	1	12	--	
No. 300 fuel oil (West Coast)	MS	4	10	--	--	--	--	90	--	10	10	100	7.1	
	LA	4	10	--	--	--	20	80	--	--	8	80	6.5 ^c	
No. 400 fuel oil (West Coast)	MS	4	10	--	--	--	--	80	--	20	10	100	5.8	
	LA	4	10	--	--	--	--	90	--	10	10	100	5.5	
Light gas oil (Mid-United States)	MS	4	10	--	--	--	--	50	--	50	10	100	6.7	
	LA	4	10	--	--	--	--	60	--	40	10	100	6.0	
Denver No. 3 blend (50-50 topped crude residual and recycled overhead gas oil)	MS	4	10	--	--	--	--	60	--	40	10	100	6.4	
	LA	4	10	--	--	--	--	80	--	20	10	100	5.9	
Heavy gas oil (Mid-United States)	MS	4	10	--	--	--	--	100	--	--	10	100	12.9	
	LA	4	10	--	--	--	60	40	--	--	4	40	--	
	MS	8	10	--	--	--	10	90	--	--	9	90	--	
	LA	8	9	--	33	--	67	--	--	--	--	--	--	
	MS	12	10	--	--	--	20	80	--	--	8	80	--	
	LA	12	5	60	40	--	--	--	--	--	--	--	--	
Lube oil extract (Texas)	MS	4	10	--	--	--	--	100	--	--	10	100	12.0	
	LA	4	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 of service. Stakes placed in test on the Harrison Experimental Forest, Sauter, MS, and at Bogalusa, LA, April 1948 (Plot 20)--continued

Oil or preservative	Location	Average retention (lb/ft ³)	Num-ber in test ^a	Condition of stakes January 1998 ^b (%)										Average life (year)	
				Serviceable but showing some--					Destroyed by--						
				Good	Decay	Termite attack	and fungi	Decay	Termite attack	and fungi	Decay	Termite attack	Total removed		
Fortified petroleum oils and mixtures															
Commercial aromatic solvent (Mid-United States with 5% pentachlorophenol)	MS	4.2	10	--	--	--	--	--	--	--	--	100	10	100	10.9
	LA	4.2	10	--	--	--	--	10	--	10	--	90	10	100	8.6
Stoddard solvent (Mid-United States) with 5% pentachlorophenol	MS	4.0	10	--	--	--	--	10	--	10	--	90	10	100	13.7
	LA	4.0	10	--	--	--	--	20	--	20	--	80	10	100	8.8
No 2 fuel oil (Mid-United States) with 5% pentachlorophenol	MS	4.0	10	--	--	--	--	10	10	10	--	80	10	100	14.9
	LA	3.8	10	--	--	--	20	--	--	--	--	80	8	80	12.5 ^c
Heavy thermal side cut (Mid-United States) with 5% pentachlorophenol	MS	4.0	10	--	--	--	--	20	--	20	--	80	10	100	14.0
	LA	4.0	10	--	--	--	--	10	--	10	--	90	10	100	10.6
No. 200 diesel oil (West Coast) with 5% pentachlorophenol	MS	4.1	10	--	--	--	--	10	--	10	--	90	10	100	17.0
	LA	4.1	10	--	--	--	50	--	--	--	--	50	5	50	--
Catalytic gas-base oil (West Coast) with 5% pentachlorophenol	MS	4.2	10	--	--	--	--	--	--	--	--	100	10	100	16.3
	LA	4.1	8	--	--	--	88	12	--	12	--	--	1	12	--
	MS	8.0	10	--	--	--	--	10	--	10	--	90	10	100	20.7
	LA	7.9	8	--	12	--	88	--	--	--	--	--	--	--	--
	MS	12.0	10	--	--	--	--	30	--	30	--	70	10	100	30.2
	LA	12.0	9	--	56	--	44	--	--	--	--	--	--	--	--
No. 300 fuel oil (West Coast) with 5% pentachlorophenol	MS	4.0	10	--	--	--	--	80	--	80	--	20	10	100	14.6
	LA	4.1	8	--	12	--	50	12	--	12	--	25	3	37	--
No. 400 fuel oil (West Coast) with 5% pentachlorophenol	MS	4.2	10	--	--	--	--	40	--	40	--	60	10	100	13.9
	LA	4.2	9	--	--	--	22	22	--	22	--	56	7	78	12.5 ^c
Light gas oil (Mid-United States) with 5% pentachlorophenol	MS	4.0	10	--	--	--	--	--	--	--	--	100	10	100	15.6
	LA	4.2	10	--	--	--	50	--	--	50	--	50	5	50	--
Denver No. 3 blend (50-50 topped crude residual and recycled overhead gas oil) with 5% pentachlorophenol	MS	4.0	10	--	--	--	--	70	--	70	--	30	10	100	19.5
	LA	4.0	7	--	--	--	86	14	--	14	--	--	1	14	--
Heavy gas oil (Mid-United States) with 5% pentachlorophenol	MS	4.1	9	--	--	--	11	44	--	44	--	44	8	89	--
	LA	4.1	8	--	12	--	88	--	--	--	--	--	--	--	--
	MS	7.9	10	--	--	10	60	60	--	60	--	20	8	80	--
	LA	7.9	6	--	33	--	67	--	--	--	--	--	--	--	--
	MS	12.0	10	--	--	--	80	20	--	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 of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, and at Bogalusa, LA, April 1948 (Plot 20)--concluded

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

^aTen 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.

^bFinal inspection at Bogalusa, November 1962.

^cEstimate 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 of service. Stakes placed in test at Madison, WI, October 1948, and on the Harrison Experimental Forest, Saucier, MS, December 1948 (Plot 24)

Preservative	Location	Average retention (lb/ft ³)	Num-ber in test	Condition of stakes October 1992 ^a (%)										Average life (year)
				Serviceable but showing some--					Destroyed by--					
				Good	Decay	Termite attack	fungi attack	Decay	Termite attack	fungi attack	Decay	Termite attack	fungi attack	
Coal-tar creosote														
Low residue, straight run	MS	8.0	10	--	--	--	60	--	--	10	7	70	17.8 ^b	
	WI	8.0	10	--	40	--	60	--	--	--	6	60	--	
Medium residue, straight run	MS	8.0	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	--	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	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 year of service. Stakes placed in test at Madison, WI, October 1948, and on the Harrison Experimental Forest, Saucier, MS, December 1948 (Plot 24)--conclud

Preservative	Location	Average retention (lb/ft ³)	Num-ber in test	Condition of stakes October 1992 ^a (%)										Average life (year)
				Serviceable but showing some--					Destroyed by--					
				Good	Decay	Termite attack	Decay and termite attack	fungi	Decay	Termite attack	fungi	and termite attack	Total removed	
											Number	%		
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	100	3.4
	WI	8.1	9	--	--	--	--	100	--	--	9	100	100	14.8
Untreated controls	MS	--	10	--	--	--	--	10	10	80	10	100	100	1.9
	WI	--	10	--	--	--	--	100	--	--	10	100	100	5.6

^aFinal inspection in Mississippi, November 1968.

^bEstimate 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 of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, December 1948 (Plot 25)

Preservative	Average retention (lb/ft ³)	Num-ber in test	Condition of stakes February 1998 (%)										Average life (year)
			Serviceable but showing some--					Destroyed by--					
			Good	Decay	Termite attack	Decay and termite attack	fungi	Decay	Termite attack	fungi	Decay and termite attack	Total removed	
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 46 years of service. Stakes placed in test at Madison, WI, November 1949 and on the Harrison Experimental Forest, Saucier, MS, December 1949 (Plot 28)

Preservative	Condition of stakes January 1995 (MS) and October 1992 (WI) (%)													
	Location	Average retention ^a (lb/ft ³)	Num-ber in test	Serviceable but showing some--				Destroyed by--				Total removed	Average life (year)	
				Good	Decay	Termite attack	Decay and termite attack	Termite attack	Decay fungi and termite attack	fungi attack	fungi and termite attack			Number
Zinc-arsenic-chromium salt (S-32) ^b	WI	(0.96)	10	90	--	--	--	10	--	--	--	1	10	--
	MS	(0.96)	10	--	--	--	100	--	--	--	--	--	--	--
	WI	(0.74)	10	40	--	--	--	60	--	--	--	6	60	--
	MS	(0.72)	10	--	--	--	100	--	--	--	--	--	--	--
	WI	(0.50)	10	--	--	--	--	100	--	--	--	10	100	21.8
	MS	(0.50)	10	--	--	--	100	--	--	--	--	--	--	--
	WI	(0.35)	10	--	--	--	--	100	--	--	--	10	100	18.5
	MS	(0.35)	10	10	--	--	--	80	--	--	--	1	10	--
	WI	(0.22)	10	--	--	--	--	100	--	--	--	10	100	18.6
	MS	(0.22)	10	--	--	--	20	--	--	--	60	8	80	--
Chromated copper arsenate, type II (Fed. Spec. TT-W-550)	WI	(1.03)	10	90	10	--	--	--	--	--	--	--	--	--
	MS	(1.04)	10	10	20	10	60	--	--	--	--	--	--	--
	WI	(0.78)	10	90	10	--	--	--	--	--	--	--	--	--
	MS	(0.79)	9	11	--	--	89	--	--	--	--	--	--	--
	WI	(0.52)	9	--	100	--	--	--	--	--	--	--	--	--
	MS	(0.52)	10	--	--	--	100	--	--	--	--	--	--	--
	WI	(0.37)	10	--	100	--	--	--	--	--	--	--	--	--
	MS	(0.37)	10	--	--	--	100	--	--	--	--	--	--	--
	WI	(0.26)	10	--	80	--	--	20	--	--	--	2	20	--
	MS	(0.26)	10	--	--	--	100	--	--	--	--	--	--	--
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	--	--	--	50	30	--	20	5	50	--	
Untreated controls	WI	--	10	--	--	--	--	100	--	--	10	100	7.0	
	MS	--	10	--	--	--	--	10	30	60	10	100	2.8	

^aRetention figures in parentheses are based on preservative oxides.

^bZnO, 97 parts; CrO₃, 170 parts; and As₂O₅, 213 parts.

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 of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, December 1949 (Plot 26)

Preservative	Condition of stakes January 1995 (%)										
	Average retention (lb/ft ³)	Num-ber in test	Serviceable but showing some--			Destroyed by--			Total removed	Average life (year)	
			Good	Decay	Termite attack	Decay	fungi and termites	attack			Number
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

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

^bReported 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 pentachlorophenolate and pentachlorophenol after about 50 years of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, December 1949 (Plot 27)

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

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 pentachlorophenol and pentachlorophenol in petroleum oil (Wyoming residual) after about 45 years of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, March 1952 (Plot 34)

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

This study was initiated by J. Oscar Blew.

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 of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, March 1952 (Plot 33)

Preservative	Average retention, anhydrous salts ^a (lb/ft ³)	Number in test	Condition of stakes January 1997 (%)						Average life (year)	
			Good	Decay	Destroyed by--		Total removed	%		
					showing some--	Decay and				Termites
Boliden salts AWPA P5-55										
Chromated zinc arsenate (H ₃ AsO ₄ , 20 parts; Na ₂ HAsO ₄ , 21 parts; Na ₂ Cr ₂ O ₇ · H ₂ O, 16 parts; and ZnSO ₄ , 43 parts) ^b	0.22 (0.11) 0.38 (0.20) 0.77 (0.40) 1.01 (0.53)	10 10 10 10 ^c	-- -- -- --	-- -- -- --	-- 60 100 100	10 -- -- --	90 40 -- --	10 4 -- --	100 40 -- --	22.1 -- -- --
Boliden salts S-25 (CrO ₃ , 32 parts; CuO, 5 parts; ZnO, 14 parts; and As ₂ O ₅ , 49 parts)	(0.30) (0.50) (0.75) (1.01)	10 10 10 9	-- -- 20 44	-- -- 10 12	-- 100 100 70 44	-- -- -- --	-- -- -- --	-- -- -- --	-- -- -- --	-- -- -- --
Untreated controls	--	10	--	--	--	20	80	10	100	1.9

^aRetention values in parentheses are based on preservative oxides.

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

^cThis 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 of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, March 1952^a (Plot 35)

Preservative	Average retention ^b (lb/ft ³)	Num-ber in test	Condition of stakes January 1997 (%)										Average life (year)
			Serviceable but showing some--					Destroyed by--					
			Good	Decay	Termite attack	fungi attack	Decay	Termite attack	fungi attack	Decay	Termite attack	fungi attack	
Chromated zinc chloride (ZnCl ₂ , 80.4 parts; Na ₂ Cr ₂ O ₇ · 2H ₂ O, 19.6 parts)	1.50 (0.92) 2.91 (1.78) 6.00 (3.67)	10 10 10	--	--	--	30	--	70	30	10	100	23.4	
Chromated zinc chloride (FR) (Chromated zinc chloride, 80 parts; H ₃ BO ₃ , 10 parts; and (NH ₄) ₂ SO ₄ , 10 parts)	1.53 3.00 6.08	10 10 10	--	--	--	10	20	50	30	10	100	16.5	
Minalith ((NH ₄) ₂ HPO ₄ , 10 parts; (NH ₄) ₂ SO ₄ , 60 parts; Na ₂ B ₄ O ₇ , 10 parts; and H ₃ BO ₃ , 20 parts)	1.50 3.00 6.13	10 10 10	--	--	--	--	10	90	10	10	100	3.7	
Pyresote (ZnCl ₂ , 35 parts; (NH ₄) ₂ SO ₄ , Na ₂ Cr ₂ O ₇ 2H ₂ O, 5 parts)	1.50 3.01 6.26	10 10 10	--	--	--	--	20	80	20	10	100	11.2	
Untreated controls	--	10	--	--	--	--	20	80	20	10	100	2.6	

^aIn cooperation with Bureau of Ships, Department of the Navy.

^bRetention 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 of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, March 1952 (Plot 32)

Preservative	Average retention of (lb/ft ³)	Number in test	Condition of stakes January 2002 (%)						Average life (year)			
			Serviceable but showing some--			Destroyed by--						
			Good	Decay	Termite	Decay	Termite	Decay				
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

^aPershall process. Compound intended as fire retardant with retentions of 3-1/2 to 4 lb/ft³. Retentions of basic zinc chloride are expressed as weight of zinc oxide.

^bRetention 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 40 years of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, March 1952 (Plot 36)

Preservative ^a	Condition of stakes December 1991 (%)										Average life (year)	
	Serviceable but showing some--					Destroyed by--						Total removed
	Average retention (lb/ft ³)	Number in test	Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay and termite attack	Number		
Rosin oil and No. 2 fuel oil (2:7)	4.1	10	—	—	—	—	30	—	70	100	6.8	
	8.0	10	—	—	—	—	60	—	40	100	5.8	
	12.3	10	—	—	—	—	20	—	80	100	9.3	
Rosin oil and No. 2 fuel oil (1:7)	4.0	10	—	—	—	—	10	—	90	100	5.6	
	8.0	10	—	—	—	—	50	—	50	100	5.8	
	12.1	10	—	—	—	—	40	—	60	100	8.6	
Rosin oil and No. 2 fuel oil (1:7) with 2.98% pentachlorophenol	4.0	10	—	—	—	—	20	—	80	100	11.4	
	8.0	10	—	—	—	—	20	—	80	100	14.8	
	12.1	10	—	—	—	20	20	—	60	80	—	
No. 2 fuel oil	4.1	10	—	—	—	—	30	10	60	100	6.1	
No. 2 fuel oil with 2.92% pentachlorophenol	4.0	10	—	—	—	—	10	—	90	100	11.1	
	8.0	10	—	—	—	—	20	—	80	100	12.8	
	12.3	10	—	—	—	—	—	—	100	100	25.8	
No. 2 fuel oil with 4.94% pentachlorophenol	4.1	10	—	—	—	—	50	—	50	100	12.4	
	8.0	10	—	—	—	—	40	—	60	100	13.2	
	12.0	9 ^b	—	—	—	—	33	—	33	66	—	
Rosin oil and Stoddard solvent (1:7) with 3.21% pentachlorophenol	8.0	10	—	—	—	—	50	—	50	100	12.5	
Oleo resin and No. 2 fuel oil (2:7)	4.0	9 ^b	—	—	—	—	—	—	100	100	6.1	
	8.1	10	—	—	—	—	40	10	50	100	6.8	
	12.2	10	—	—	—	—	30	—	70	100	10.7	
Oleo resin and Stoddard solvent (1:7) with 3.11% pentachlorophenol	8.2	10	—	—	—	—	40	10	50	100	10.4	
Drop liquor concentrate and Stoddard solvent (1:7) with 2.99% pentachlorophenol	7.9	10	—	—	—	—	20	—	80	100	8.7	

Table 27--Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with naval stores products after about 40 years of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, March 1952 (Plot 36)--concluded

Preservative	Condition of stakes December 1991 (%)											
	Average retention (lb/ft ³)	Number in test	Serviceable but showing some--				Destroyed by--			Total removed		
			Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay and termite attack	Number	%	Average life (year)
Oleo resin and No. 2 fuel oil (1:7) with 2.94% pentachlorophenol	4.1	10	—	—	—	—	50	—	—	50	100	10.0
	8.0	10	—	—	—	—	30	—	—	70	100	13.5
	12.0	10	—	—	—	—	20	—	—	80	100	16.3
Drop liquor concentrate and No. 2 fuel oil (2:7)	4.0	10	—	—	—	—	10	—	—	90	100	6.8
	8.0	10	—	—	—	—	20	—	—	80	100	7.8
	12.0	10	—	—	—	—	—	—	—	100	100	10.2
Drop liquor concentrate and No. 2 fuel oil (1:7) with 3.03% pentachlorophenol	4.0	10	—	—	—	—	—	—	—	100	100	12.2
	8.0	10	—	—	—	—	30	—	—	70	100	16.2
	12.0	10	—	—	—	—	20	—	—	80	100	20.2
No. 2 fuel oil with 5% rosin amine D copper acetate complex	4.1	10	—	—	—	—	—	—	—	50	100	8.0
	8.0	10	—	—	—	—	50	—	—	50	100	9.6
	12.1	10	—	—	—	—	60	—	—	40	100	15.9
Untreated controls	—	10	—	—	—	—	—	—	30	70	100	2.8

^aRatios and percentages on weight basis.

^bOne 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 service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, December 1952 (Plot 37)

Preservative	Average retention (lb/ft ³)	Num-ber in test ^a	Condition of stakes June 2000 (%)										Average life (year)
			Serviceable but showing some--		Destroyed by--		Decay fungi and		Termite attack		Total removed		
			Good	Decay	Termite attack	Decay fungi	Termite attack	Decay fungi	Number	%	Number	%	
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		

^aTen 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 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 of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, April 1953^a (Plot 38)

Preservative	Conditioning after treatment ^d	Number in test	Average preservative retention (lb/ft ³)		Condition of stakes October 1992 (%)										Average life (year)
			By	analysis ^c	Serviceable but showing some--					Destroyed by--					
					Penta-chlorophenol or copper metal	Penta-chlorophenol or copper metal	Solu- tion	Good	Decay	Termite attack	Decay	fungi attack	Termite attack	fungi attack	
Pentachlorophenol, 2.5% in light aromatic solvent ^e	None	10	4.2	0.105	0.082	--	--	--	20	10	70	10	100	11.6	
Pentachlorophenol, 2.5% in light aromatic solvent	Steaming	10	4.2	0.105	0.091	--	--	--	10	--	90	10	100	12.4	
Pentachlorophenol, 4.5% in light aromatic solvent ^e	Vapor cleaning	10	4.1	0.102	0.069	--	--	--	10	10	80	10	100	11.3	
Pentachlorophenol, 4.5% in light aromatic solvent ^e	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, 5% in light aromatic solvent	None	10	4.6	0.230	0.186	--	--	--	10	--	90	10	100	14.1	
Pentachlorophenol, 5% in light aromatic solvent ^e	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 ^e	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, 5% in No. 2 fuel oil	None	10	6.2	0.310	0.121	--	--	--	--	--	100	10	100	16.5	
	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 of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, April 1953^a (Plot 38)--concluded

Preservative	Conditioning after treatment ^d	Num-ber in test	Average preservative retention (lb/ft ³)		Solution	Condition of stakes October 1992 (%)				Total removed Number	Total removed %	Average life (year)
			From weight ^b	By analysis ^c		Serviceable but showing some--		Destroyed by--				
						Penta-chloro-phenol or copper metal	Penta-chloro-phenol or copper metal	Decay and	Decay fungi and			
Copper naphthenate, 0.5% copper in light aromatic solvent	None Steaming	10 10	4.6 4.5	0.023 0.022	-- --	-- --	-- --	50 40	50 60	10 10	100 100	11.0 12.0
Copper naphthenate, 0.59% copper in light aromatic solvent	Vapor cleaning Steaming	10 10	4.6 4.4	0.023 0.026	-- --	-- --	-- --	40 30	60 70	10 10	100 100	11.8 14.3
Copper naphthenate, 0.7% copper in light aromatic solvent	Vapor cleaning	10	4.2	0.029	--	--	--	30	70	10	100	13.7
Untreated controls	--	10	--	--	--	--	--	--	60	40	100	2.4

^aIn cooperation with the Bureau of Ships, Department of the Navy.

^bWeights determined before and after treatment, prior to conditioning.

^cAnalysis performed 2 months after treatment.

^dOne-hour steaming with maximum temperature 259°F and 1-h vacuum, following which steaming and vacuum periods were repeated. 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.

^eSolution confined 5% ester gum (by weight) as a bloom preventative.

^fEstimate 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 UA^a after about 41 years of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, December 1954 (Plot 40)

Preservative	Average retention ^b (lb/ft ³)	Num-ber in test	Condition of stakes January 1995 (%)						Total removed Number	Average life (year)	
			Good Decay	Termite attack	Decay fungi attack	Termite attack	Decay fungi and	Destroyed by--			
											Termite attack
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

^aContains sodium fluoride, sodium dichromate, and sodium arsenate.

^bRetention 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, treated with coal-tar creosote, pentachlorophenol solution, and copper chromated zinc chloride, after about 41 years of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, December 1954 (Plot 41)

Preservative	Average retention ^a (lb/ft ³)	Num- ber in test ^b	Condition of stakes January 1995 (%)									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	Total removed		
								Number	%			
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 <i>Trichoderma</i> 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

^aRetention values in parentheses are based on preservative oxides.

^bTen 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 of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, December 1954 (Plot 42)

Preservative	Average retention (lb/ft ³)	Number in test	Condition of stakes January 1995 (%)							Total removed		Average life (year)
			Serviceable but showing some--			Destroyed by--				Number	%	
			Good	Decay and		Decay fungi	Termite attack		Decay fungi			
				Decay	Termite attack		Termite attack	Termite attack				
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 tangle plywood stakes treated with pentachlorophenol and with fluor chrome arsenate phenol type A after about 26 years of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, January 1956 (Plot 44)^a

Plywood	Preservative ^b	Treatment ^c	Average retention ^d (lb/ft ³)	Num-ber in test	Condition of stakes December 1981 (%)				Average life (year)
					Good	Serviceable but showing some--	Decayed and	Destroyed by--	
					Termit	Decay	fungi	Total removed	
					attack	fungi	attack	Number	%
Plywood Treated Before Gluing									
Douglas-fir	Pentachlorophenol	Hot and cold	10.0	9	--	--	22	77	9
	Pentachlorophenol Fluor chrome	Cold soaked	6.3	10	--	--	30	70	10
	arsenate phenol type A	Hot and cold	0.52 (0.32)	10	--	--	50	50	10
Sweetgum	Pentachlorophenol Fluor chrome	Hot and cold	15.1	10	--	--	30	70	10
	arsenate phenol type A	Hot and cold	0.62 (0.39)	10	--	--	60	40	10
Tangle	Pentachlorophenol Fluor chrome	Hot and cold	9.4	10	--	--	60	40	10
	arsenate phenol type A	Hot and cold	0.59 (0.37)	10	--	--	100	--	10
Plywood Treated After Gluing									
Douglas-fir	Pentachlorophenol	Pressure	9.6	10	--	--	20	80	10
	Pentachlorophenol	Cold soaked	0.9	10	--	--	20	70	10
	Pentachlorophenol Fluor chrome	Cold soaked	1.4 ^e	10	--	--	--	80	10
	arsenate phenol type A	Pressure	0.61 (0.38)	9	--	--	22	22	56
Sweetgum	Pentachlorophenol Fluor chrome	Pressure	10.6	10	--	--	70	30	10
	arsenate phenol type A	Pressure	0.55 (0.34)	10	--	--	50 ^f	10	40
Tangle	Pentachlorophenol Fluor chrome	Pressure	10.4	10	--	--	70	30	10
	arsenate phenol type A	Pressure	0.60 (0.37)	10	--	--	90	10	10

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 of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, January 1956 (Plot 44)--concluded

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

^aIn cooperation with the Bureau of Ships, Department of the Navy.

^bFor pentachlorophenol, 5% solution conforming to MIL-W-18142 (SHIPS) specification, 27 August 1954.

^cHot and cold treatment consisted of heating in a veneer dryer and immersion in unheated preservative solution until desired retention was obtained.

^dRetention values in parentheses are based on preservative oxides.

^eStakes were cut from the panels and then treated.

^fOne 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 44 years of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, December 1956 (Plot 47)

Preservative	Average retention (copper) (lb/ft ³)	Number in test	Condition of stakes January 2000 (%)								Total removed		Average life (year)
			Serviceable but showing some--				Destroyed by--						
			Good	Decay	Decay and		Decay fungi	Termite attack	Termite attack	Decay fungi	Termite attack		
					Termite attack	termite attack							
Copper formate	0.03	10	--	--	--	--	30	--	70	10	100	7.4	
	0.06	10	--	--	--	--	90	--	10	10	100	25.9	
	0.09	10	--	--	--	40	50	--	10	6	60	--	
	0.12	10	--	10	--	60	30	--	--	3	30	--	
Untreated controls	--	10	--	--	--	--	--	--	100	10	100	3.4	

This study was initiated by J. Oscar Blew.

Table 35--Condition of Southern Pine stakes treated with KP^a preservative after 34 and 43 years of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, December 1957 and Madison, WI, May 1958 (Plot 48)

Preservative	Location	Average retention ^b (lb/ft ³)	Number in test ^c	Condition of stakes October 1992 (WI) and December 2000 (MS) (%)										Average life (year)	
				Serviceable but showing some--				Destroyed by--							Total removed Number %
				Good	Decay	Termite attack	Termite attack	Decay fungi	Termite attack	Termite attack	Decay fungi				
												Decay and	Decay and		
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		

^aCopper oxide and chlorophenols.

^bRetention values in parentheses are based on preservative oxides.

^cWhen 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 of service in Mississippi and 8 years in Madison, WI. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, December 1958 and in Wisconsin, May 1959 (Plot 53)

Preservative	Location	Average retention (lb/ft ³)	Number in test	Condition of stakes January 1967 (%)									Average life (year)	
				Serviceable but showing some--			Destroyed by--							
				Good	Decay	attack	Decay and		Decay fungi and					
							Termite	termite	Decay	Termite	termite	attack		attack
											Total removed			
											Number	%		
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

^aIn Stoddard solvent.

^bUsed with ammonium hydroxide for cyanoethylation.

^cFollowed 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 of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, December 1959 (Plot 55)

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

^aRetention values in parentheses are based on preservative oxides.

^bWhen the number of stakes is less than 10, stakes were damaged mechanically and eliminated from test.

^cSodium 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 of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, December 1959 (Plot 54)

Preservative	Average retention Solution (lb/ft ³)	Copper-8- quinolinolate (lb/ft ³)	Num- ber in test	Condition of stakes November 1968 (%)				Average life (year)				
				Good	Decay	Destroyed by-- Serviceable but showing some--	Destroyed by-- Decay fungi and termites		Total removed Number	Total removed %		
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	100	4.2	
0.1% in Stoddard solvent	10.0	0.060	10	--	--	10	40	--	50	90	5.6 ^a	
0.1% in Stoddard solvent	10.2	0.123	10	--	--	10	60	--	30	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	--	9	90	6.6 ^a
Untreated controls	--	--	10	--	--	--	--	--	20	80	100	2.2

^aEstimate 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 40 years of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, December 1960 (Plot 57)

Lignite-tar extracts	Average retention (lb/ft ³)	Num-ber in test	Condition of stakes January 2000 (%)										Average life (year)
			Serviceable but showing some--			Destroyed by--			Decay by--				
			Good	Decay	Termite attack	Decay	Termite attack	Decay	Termite attack	fungi	and	fungi	
Hexane-soluble residue, 25%; and hexane distillate, 75% (by weight)	5.1 10.0 14.1	10 10 10	--	--	--	--	20	--	80	10	100	16.2	
High-boiling methanol solubles, 25%; hexane distillate, 75% (by weight)	5.0 9.3 15.2	10 10 10	--	--	--	--	100	--	--	10	30	18.8	
High-boiling methanol solubles, 10%; hexane-soluble residue, 20%; and hexane distillate, 70% (by weight)	5.1 10.1 14.7	10 10 10	--	--	--	--	100	10	90	10	100	18.8	
High-boiling methanol solubles, 20%; hexane-soluble residue, 10%; and hexane distillate, 70% (by weight)	5.2 10.0 15.2	10 10 10	--	--	--	--	100	20	80	10	100	20.2	
High-boiling methanol solubles, 15%; and hexane distillate, 85% (by weight)	5.0 10.2 14.9	10 10 10	--	--	10	--	90	10	80	10	100	22.0	
High-boiling methanol solubles, 24.5%; hexane distillate, 74.5%; and petroleum sulfonate (Morpel X-914), 1% (by weight)	5.1 9.9 15.0	10 10 10	--	--	--	--	10	30	30	6	60	--	
Untreated controls	--	10	--	--	--	--	--	--	100	10	100	2.6	

This study was initiated by J. Oscar Blew.

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

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

^aWestern hemlock strands in portland cement.

^bStakes missing and eliminated from test.

^cFailures 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 40 years of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, December 1960 (Plot 56)

Preservative	Condition of stakes January 2000 (%)										Average life (year)
	Average retention (lb/ft ³)	Num-ber in test ^a	Serviceable but showing some--			Destroyed by--			Total removed	%	
			Good	Decay	Termite attack	Decay	fungi and	Termittermite attack			
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%; Pentachlorophenol, 5%; pine oil, 5%; and water repellent, 4.7%	8.0	10	--	--	--	90	--	10	10	100	4.0
Pentachlorophenol, 5%; pine oil, 5%; and water repellent, 4.7%	8.0	9	--	--	--	11	44	--	44	89	--
Pentachlorophenol, 5%; pine oil, 5%; Dieldrin 0.3%; and water repellent, 4.7%	8.0	10	--	--	--	10	40	--	50	90	--
Water repellent, 4.7%	8.0	10	--	--	--	--	80	--	20	100	4.3
Pentachlorophenol, 5%; pine oil, 5%; Dieldrin 0.3% stabilizer wax, 2%; and water repellent, 4.7%	8.0	9	--	--	--	67	33	--	--	33	--
Solutions with heavy petroleum solvent (AWPA P9)											
Tributyltin oxide, 0.3%; and Dieldrin, 0.3%	8	10	--	--	--	100	--	--	10	100	22.2
Tributyltin oxide, 0.6%; and Dieldrin, 0.3%	8	10	--	--	--	60	--	40	10	100	23.0
Tributyltin oxide 0.3%	8	10	--	--	--	40	--	60	10	100	20.8
0.6%	8	10	--	--	--	20	10	70	10	100	24.0
Pentachlorophenol, 5%	8	10	--	--	--	70	10	20	3	30	--
Pentachlorophenol, 5%; and stabilizer wax, 2%	8	10	--	--	--	80	--	20	2	20	--
Petroleum solvent controls	8	9	--	--	--	--	11	--	89	9	23.3
Untreated controls	--	10	--	--	--	--	70	--	30	10	3.1

^aTen 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 of service. Stakes installed at Valley View Test Plot, Madison, WI, and on Harrison Experimental Forest, Saucier, MS, July 1961 (Plot 59)

Preservative	Location	Average retention										Total removed Number	Total removed %	Average life (year)
		(lb/in ³)		By weight analysis		Num- ber in test	Condition of stakes January 2000 (%)		Destroyed by--					
		Solu- tion	Penta- chloro- phenol	By weight Penta- chloro- phenol	Anal- ysis Penta- chloro- phenol		Serviceable but showing some--	Decay fungi and termite attack	Decay fungi and termite attack	Decay fungi and termite attack				
		Good	Decay	Termite attack	Decay fungi and termite attack	Termite attack	Decay fungi and termite attack	Decay fungi and termite attack	Decay fungi and termite attack	Decay fungi and termite attack				
Stakes 2 by 4 nominal by 18 in.														
Pentachlorophenol in liquefied petroleum gas ^a	MS	--	0.14 ^b	10	--	--	--	10	--	90	10	100	18.9	
	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%; paraffin, 2%; and Pentalyln-H, 10% (by weight)	MS	3.6	0.14	0.14	10	--	--	--	10	--	10	100	13.7	
	MS	4.6	0.18	0.18	10	--	--	--	--	--	10	100	15.9	
Pentachlorophenol, 5%; paraffin, 2%; and Pentalyln-H, 10% (by weight)	MS	7.6	0.38	0.39	10	--	--	20	--	80	8	80	--	
	MS	13.5	0.67	0.70	10	--	--	100	--	--	--	--	--	
Untreated controls	MS	--	--	--	10	--	--	--	30	30	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 of service. Stakes installed at Valley View Test Plot, Madison, WI, and on Harrison Experimental Forest, Saucier, MS, July 1961 (Plot 59)--concluded

Preservative	Location	Average retention (lb/in ³)		By analysis--Pentachlorophenol	Number in test	Condition of stakes January 2000 (%)				Total removed	Average life (year)		
		By weight	Pentachlorophenol			Serviceable but showing some--		Destroyed by--					
						Solution	phenol	Termitte attack	Decay fungi			Termitte attack	Decay fungi and termitte attack
Stakes 3/4 by 3/4 by 17 in.													
Pentachlorophenol in liquefied petroleum gas ^a	MS	--	--	0.15 ^c	10	--	--	40	--	60	10	100	5.5
	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 (heavy petroleum solvent)	MS	3.2	0.14	--	9 ^d	--	--	11	--	89	9	100	14.5
	WI	3.3	0.14	--	5 ^d	--	--	100	--	--	5	100	16.4
	MS	3.8	0.16	--	10	--	--	10	10	80	10	100	14.5
	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	MS	3.5	0.14	--	9 ^d	--	--	44	11	44	9	100	5.6
	WI	3.0	0.12	--	11 ^d	--	--	100	--	--	11	100	10.8
	MS	3.9	0.16	--	10	--	--	30	--	70	10	100	4.9
	WI	4.0	0.16	--	13 ^d	--	--	100	--	--	13	100	10.8
	MS	6.4	0.32	--	9 ^d	--	--	22	--	78	9	100	14.4
	WI	6.6	0.33	--	14	--	--	100	--	--	14	100	14.4
	MS	14.4	0.72	--	4 ^d	--	--	50	--	50	4	100	24.9
	WI	14.6	0.73	--	5 ^d	--	--	100	--	--	4	100	21.0
Untreated controls	MS	--	--	--	10	--	--	40	30	30	10	100	1.5
	WI	--	--	--	15	--	--	100	--	--	15	100	4.0

^aIt has been reported that the formulation of treating solution in liquefied petroleum gas has been changed since the stakes were treated.

^bFrom 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.

^cBased on analysis by Bell Telephone Laboratories of 2-in. sections cut adjacent to the test stakes.

^dStakes 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 37 years of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, December 1963 (Plot 62)

Preservative	Average retention Copper-8- quinolinolate or penta- chlorophenol (lb/ft ³)	Num- ber in test	Good	Condition of stakes January 2000 (%)				Total removed Number	Average life (year)		
				Decay	Termite attack	Decay fungi attack	Termite attack			Decay fungi and termite attack	
0.15%	9.4	10	--	--	10	20	10	60	9	90	--
0.3%	10.1	10	--	--	--	20	--	80	10	100	27.3
0.6%	9.9	10	--	--	10	50	--	40	9	90	--
1.2%	10.3	9 ^a	--	--	100	--	--	--	--	--	--
Pentachlorophenol 4.98%	10.6	10	--	10	--	90	--	--	--	--	--
Petroleum solvent controls	8.5	10	--	--	--	30	10	60	10	100	20.9
Untreated controls	--	10	--	--	--	20	--	80	10	100	2.9

Solutions with heavy petroleum solvent (AWPA P9):Copper-8-quinolinolate

^aTen 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 of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, December 1963 (Plot 63)

Preservative	Average retention (lb/ft ³)		Num- ber in test	Condition of stakes June 2000 (%)									Total removed		Average life (year)
				Serviceable but showing some--			Destroyed by--								
	Solution	HTP		Good	Decay and		Decay fungi	Decay fungi and		Termite attack	Termite attack	Termite attack	Number	%	
					Termite attack	Termite attack		Termite attack	Termite attack						
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 of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, December 1963 (Plot 61)

Preservative	Average retention		Num- ber in test ^c	Condition of stakes February 1998 (%)									Average life (year)
	(lb/in ³)			Serviceable but showing some--				Destroyed by--					
	Solu- tion	Penta- chloro- phenol		Good	Decay	attack	Decay and termite attack	Decay			Total removed		
								fungi	Termite attack	termite attack		Number	
Stakes 2 by 4 in.													
Pentachlorophenol in	--	0.34 ^a	10	--	--	--	10	40	--	50	9	90	--
liquefied petroleum gas ^b	--	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	--	0.34 ^a	10	--	--	--	--	70	--	30	10	100	8.6
liquefied petroleum gas ^b	--	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

^aBy x-ray analysis of samples from pieces from which stakes were cut.

^bWith cosolvent of isopropyl ether.

^cWhen the number of stakes is less than 10, stakes were damaged mechanically and eliminated from test.

^dTreated in commercial charge with poles and crossarms.

^eComputed.

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 of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, January 1967 (Plot 66)

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

^aRetention values in parentheses are based on preservative oxides.

^bTen 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 35 years of service. Stakes placed in test in November 1967 at Lake Charles, LA, in an area infested by Formosan termites and on the Harrison Experimental Forest, Saucier, MS (Plot 67)

Preservative	AWPA Standard	Location	Average retention ^a in (lb/ft ³)	Number in test ^b	Condition of stakes January 2002 (MS) and January 1984 (LA) (%)										Average life (year)		
					Serviceable but showing some--					Destroyed by--							
					Good	Decay	Termite attack	Decay and termite attack	fungi	Decay	Termite attack	Decay and termite attack	fungi	fungi and termite attack		fungi and termite attack	Number
Creosote, coal-tar	P1-65	LA	4.9	10	10	--	--	--	50	40	--	--	--	4	40	--	
		LA	10.2	10	60	20	--	--	20	--	--	--	--	--	--	--	--
Creosote-coal-tar solution (70-30)	P2-68	MS	15.0	10	100	--	--	--	--	--	--	--	--	--	--	--	--
		MS	5.1	10	--	--	--	40	50	--	--	10	--	6	60	--	
		MS	9.7	10	--	10	--	--	90	--	--	--	--	--	--	--	--
		MS	15.4	10	--	40	--	--	60	--	--	--	--	--	--	--	--
Creosote-petroleum solution (50-50)	P3-67	LA	4.7	10	--	--	--	--	60	40	--	--	--	4	40	--	
		LA	9.9	10	90	10	--	--	--	--	--	--	--	--	--	--	--
		MS	14.9	10	100	--	--	--	--	--	--	--	--	--	--	--	--
		MS	3.9	10	--	--	--	20	50	--	--	30	--	8	80	--	
Pentachlorophenol, 5% in heavy petroleum	P8-64 and P9-67	LA	10.7	10	10	40	--	--	50	--	--	--	--	--	--	--	--
		LA	16.2	10	20	80	--	--	--	--	--	--	--	--	--	--	--
		LA	5.8	10	10	10	--	--	40	30	--	--	10	4	40	--	
		MS	12.1	10	70	10	--	--	20	--	--	--	--	--	--	--	--
Acid copper chromate	P5-68	MS	18.3	10	100	--	--	--	--	--	--	--	--	--	--	--	--
		MS	6.0	10	--	--	--	30	50	--	--	20	7	70	--		
		MS	12.1	10	10	30	--	--	60	--	--	--	--	--	--	--	--
		MS	18.5	10	10	60	--	--	20	--	--	--	--	--	--	--	--
Ammoniacal copper arsenate	P5-68	LA	7.0	10	--	--	--	--	100	--	--	--	--	--	--	--	--
		LA	9.5	10	--	--	--	78	--	--	--	--	--	--	--	--	--
		LA	14.6	9	--	22	--	--	--	--	--	--	--	--	--	--	--
		LA	0.50 (0.25)	10	--	--	--	--	--	--	30	60	10	10	100	8.5	
Ammoniacal copper arsenate	P5-68	MS	1.00 (0.50)	9	--	11	--	78	--	--	--	11	1	11	--		
		MS	1.49 (0.74)	9	20	10	--	60	--	--	--	--	--	--	--	--	
		MS	0.51 (0.25)	10	--	--	--	30	60	--	--	10	7	70	--		
		MS	1.01 (0.50)	10	40	20	--	40	--	--	--	--	4	40	--		
Ammoniacal copper arsenate	P5-68	LA	1.54 (0.76)	9	56	--	11	11	--	--	22	--	2	22	--		
		LA	0.25 (0.24)	10	--	--	--	10	70	--	--	20	9	90	--		
		LA	0.46 (0.44)	10	--	--	--	80	20	--	--	--	2	20	--		
		MS	0.67 (0.63)	10	10	10	--	70	10	--	--	--	1	10	--		
Ammoniacal copper arsenate	P5-68	MS	0.26 (0.25)	10	--	10	--	60	20	--	--	10	3	30	--		
		MS	0.48 (0.45)	10	--	60	--	30	10	--	--	1	10	--			
		MS	0.70 (0.66)	10	10	30	--	60	--	--	--	--	--	--			
		MS	0.70 (0.66)	10	10	30	--	60	--	--	--	--	--	--			

Table 47--Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with 11 standard wood preservatives after about 35 years of service. Stakes placed in test in November 1967 at Lake Charles, LA, in an area infested by Formosan termites and on the Harrison Experimental Forest, Saucier, MS (Plot 67)--concluded

Preservative	Standard	Location	Average retention (lb/ft ³)	Num-ber in test ^b	Condition of stakes January 2002 (MS) and January 1984 (LA) (%)									
					Serviceable but showing some--					Destroyed by--				
					Good	Decay	Termite attack	Decay termite attack	Decay fungi and termite attack	Decay fungi and termite attack	Termite attack	Decay fungi and termite attack	Termite attack	Decay fungi and termite attack
Chromated copper arsenate type A	P5-68	LA	0.40 (0.23)	10	--	--	--	70	10	10	10	3	30	--
		MS	0.76 (0.44)	10	50	10	--	40	--	--	--	--	--	--
Chromated copper arsenate type B	P5-68	LA	1.11 (0.64)	10	90	10	--	--	--	--	--	4	40	--
		MS	0.39 (0.22)	10	--	20	10	30	30	10	--	1	10	--
Chromated zinc chloride	P5-68	LA	0.76 (0.44)	10	50	--	--	--	--	--	--	--	--	--
		MS	1.14 (0.66)	8	100	--	--	--	--	--	--	--	--	--
Fluor chrome arsenate phenol type A	P5-68	LA	0.25 (0.23)	10	--	--	80	10	--	--	10	2	20	--
		MS	0.44 (0.40)	10	20	30	--	50	--	--	--	--	--	--
Fluor chrome arsenate phenol type B	P5-68	LA	0.65 (0.59)	10	80	10	--	10	--	--	--	--	--	--
		MS	0.25 (0.23)	10	--	20	30	50	30	10	10	2	20	--
Untreated controls		LA	0.42 (0.38)	10	--	20	--	60	10	--	--	--	--	--
		MS	0.61 (0.55)	10	30	50	20	--	--	--	--	--	--	--
Untreated controls		LA	0.76 (0.46)	10	--	--	--	--	--	80	20	10	100	6.0
		MS	1.02 (0.62)	10	--	--	--	--	10	60	30	10	100	7.2
Untreated controls		LA	1.50 (0.92)	9	--	--	--	--	--	11	67	9	100	8.3
		MS	0.76 (0.46)	10	--	--	--	--	30	30	--	70	100	13.8
Untreated controls		LA	1.02 (0.62)	10	--	--	--	--	--	30	--	70	100	14.9
		MS	1.57 (0.96)	10	--	--	--	--	--	70	--	30	100	17.8
Untreated controls		LA	0.35 (0.22)	10	--	--	10	50	20	20	9	90	--	
		MS	0.50 (0.31)	10	--	--	20	10	10	60	8	80	--	
Untreated controls		LA	1.11 (0.69)	10	--	--	30	70	--	--	7	70	--	
		MS	0.36 (0.22)	10	--	--	--	60	--	40	10	100	19.3	
Untreated controls		LA	0.51 (0.31)	10	--	--	10	60	--	30	9	90	--	
		MS	1.16 (0.72)	10	--	--	50	40	--	10	5	50	--	
Untreated controls		LA	0.35 (0.21)	10	--	--	10	20	10	60	9	90	--	
		MS	0.50 (0.30)	10	--	--	20	60	--	20	8	80	--	
Untreated controls		LA	1.12 (0.68)	10	10	10	--	50	30	--	--	3	30	--
		MS	0.35 (0.21)	9	--	--	--	44	11	44	9	100	19.2	
Untreated controls		LA	0.51 (0.30)	10	--	--	20	70	--	10	8	80	--	
		MS	1.19 (0.72)	9	--	11	--	56	33	--	3	33	--	

^aRetention values in parentheses are based on preservative oxides.

^bTen 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 29 and 20 years of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, December 1971, and Madison, WI, May 1972 (Plot 68)

Preservative	Location	Average retention (lb/ft ³)	Num-ber in test ^c	Condition of stakes January 2000 (MS) and October 1992 (WI) (%)				Destroyed by--				Average life (year)	
				Serviceable but showing some--		Decay		Decay		fungi and			Total removed
				Good	Decay	Termite attack	Decay and termite attack	fungi attack	termite attack	Number	%		
Copper chrome phosphorus	MS	0.26 ^a	10	--	--	40	60	--	--	6	60	--	
	WI	0.27 ^a	9	--	33	--	67	--	--	6	67	--	
	MS	0.46 ^a	10	10	10	20	50	--	--	5	50	--	
	MS	0.75 ^a	10	50	10	20	--	20	--	2	20	--	
	WI	0.74 ^a	10	70	30	--	--	--	--	--	--	--	
	MS	1.50 ^a	10	50	--	--	30	20	--	--	2	20	--
Chromated copper arsenate type III (Fed. Spec. TT-W-550)	MS	0.20 ^b	10	10	--	--	90	--	--	--	--	--	
	WI	0.20 ^b	10	20	80	--	--	--	--	--	--	--	
	MS	0.40 ^b	10	80	10	10	--	--	--	--	--	--	
	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	

^aRetention based on Osmose Company's analysis of preservative oxides.

^bRetention based on preservative oxides.

^cTen 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 25-1/2 years of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, May 1973 (Plot 70)

Preservative	Average retention based on preservative oxides (lb/ft ³)	Num-ber in test ^b	Condition of stakes February 1998 (%)										Average life (year)
			Serviceable but showing some--					Destroyed by--					
			Good	Decay	Termite attack	Decay and termite attack	fungi attack	Decay	Termite attack	fungi attack	Decay and termite attack	Total removed	
											Number	%	
Flakes treated before fabrication into particleboard ^c													
Chromated copper arsenate type III (Fed. Spec. TT-W-550)	0.25	9	--	22	--	11	67	--	--	--	6	67	--
	0.40	10	--	10	--	30	60	--	--	--	6	60	--
	0.80	10	10	80	--	--	10	--	--	--	1	10	--
Fluor chrome arsenate phenol type A (Fed. Spec. TT-W-535)	0.25	10	--	--	--	--	90	--	10	10	10	100	6.0
	0.50	10	--	--	--	--	90	--	10	10	10	100	8.8
Pentachlorophenol (Fed. Spec. TT-W-570) in ethanol	0.25	10	--	--	--	--	40	--	60	10	100	100	5.5
	0.40	10	--	--	--	--	50	--	50	10	100	100	7.5
	0.80	10	--	--	--	10	50	--	40	9	90	90	--
Pressure-treated particleboard													
Chromated copper arsenate type III (Fed. Spec. TT-W-550)	0.26	8	--	--	--	--	100	--	--	--	8	100	19.7
	0.41	9	--	11	--	67	22	--	--	2	22	--	--
	0.84	10	60	30	10	--	--	--	--	--	--	--	--
Fluor chrome arsenate phenol type A (Fed. Spec. TT-W-535)	0.26	10	--	--	--	--	70	--	30	10	100	100	7.5
	0.54	9	--	--	--	--	100	--	--	9	100	100	11.3
Pentachlorophenol (Fed. Spec. TT-W-570) 5% in mineral spirits and 4% pine oil	0.22	10	--	--	--	--	70	--	30	10	100	100	5.5
	0.40	10	--	--	--	--	80	--	20	10	100	100	8.5
	0.82	10	--	--	--	30	50	--	20	7	70	--	--
Untreated controls	--	10	--	--	--	--	10	10	80	10	100	100	2.4

^aDensity 40 lb/ft³.

^bTen stakes originally installed; eliminated stakes removed for causes other than decay or insect attack.

^cFlakes sprayed with predetermined amount of preservative solution while being tumbled in screen.

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 of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, October 31, 1974, and September 1978 (Plot 71)

Nontoxic preservatives	Average loading-- Weight add-on (%)	Num- ber in test	Condition of stakes August 1995 (%)								Total removed		Average life (year)
			Serviceable but showing some--			Destroyed by--							
			Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	termite attack	Decay fungi and termite attack	Number	%	
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	

^aFifteen 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 26 years of service. Stakes placed in test at Madison, WI, May 1976, and on the Harrison Experimental Forest, Saucier, MS, December 1975 (Plot 72)

Preservative	Location	Average retention (lb/ft ³)	Number in test	Condition of stakes January 2000 (%)									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	%			
				Southern Pine ^{a,b} nominal 2- by 4-in. by 18-in. unincised											
Chromated copper arsenate type III	MS	0.23	10	20	60	10	10	--	--	--	--	--	--		
	WI	0.14	10	70	30	--	--	--	--	--	--	--	--		
	MS	0.28	10	70	10	20	--	--	--	--	--	--	--		
	WI	0.19	9 ^d	100	--	--	--	--	--	--	--	--	--		
	MS	0.48	10	90	10	--	--	--	--	--	--	--	--		
	WI	0.29	10	100	--	--	--	--	--	--	--	--	--		
None	MS	--	10	--	--	--	10	20	10	60	9	90	--		
	WI	--	10	--	50	--	--	50	--	--	5	50	--		
Southern Pine ^{a,b} nominal 2- by 4-in. by 18-in. incised															
Chromated copper arsenate type III	MS	0.27	10	70	10	--	20	--	--	--	--	--	--		
	WI	0.19	10	90	10	--	--	--	--	--	--	--	--		
	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 arsenate type III ^c	MS	0.39	10	20	30	--	20	30	--	--	3	30	--		
	WI	0.38	10	60	40	--	--	--	--	--	--	--	--		
	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 arsenate type III ^e	MS	0.36 ^f	9 ^d	11	44	11	22	11	--	--	1	11	--		
	WI	0.36 ^f	9 ^d	22	78	--	--	--	--	--	--	--	--		
	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 arsenate type III ^g	MS	0.36 ^f	9 ^d	33	56	--	11	--	--	--	--	--	--		
	WI	0.36 ^f	9 ^d	67	33	--	--	--	--	--	--	--	--		
	MS	0.75 ^f	10	90	10	--	--	--	--	--	--	--	--		
	WI	0.75 ^f	10	100	--	--	--	--	--	--	--	--	--		
	MS	1.16 ^f	10	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 26 years of service. Stakes placed in test at Madison, WI, May 1976, and on the Harrison Experimental Forest, Saucier, MS, December 1975 (Plot 72)--continued

Preservative	Location	Average retention (lb/ft ³)	Number in test	Condition of stakes January 2000 (%)							Total removed		Average life (year)	
				Serviceable but showing some--			Destroyed by--				Decay fungi and termite attack	Number		%
				Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack					
Southern Pine ^{a,b} nominal 2- by 4-in. 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	--	10	10	10	--	2	20	--	
	WI	0.16	10	100	--	--	--	--	--	--	--	--	--	
	MS	0.42	10	60	40	--	--	--	--	--	--	--	--	
	WI	0.26	10	100	--	--	--	--	--	--	--	--	--	
Southern Pine ^{a,b} nominal 2- by 4-in. by 18-in. incised														
Ammoniacal copper arsenate	MS	0.14	10	--	40	--	10	50	--	--	5	50	--	
	WI	0.07	10	20	70	--	--	10	--	--	1	10	--	
	MS	0.30	9 ^d	56	33	--	11	--	--	--	--	--	--	
	WI	0.15	10	70	30	--	--	--	--	--	--	--	--	
	MS	0.65	10	60	40	--	--	--	--	--	--	--	--	
	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	10	--	40	--	--	60	--	--	6	60	--	
	WI	0.38	10	10	90	--	--	--	--	--	--	--	--	
	MS	0.81	10	20	80	--	--	--	--	--	--	--	--	
	WI	0.79	10	90	10	--	--	--	--	--	--	--	--	
	MS	1.19	10	20	80	--	--	--	--	--	--	--	--	
	WI	1.15	9 ^d	100	--	--	--	--	--	--	--	--	--	
Ammoniacal copper arsenate ^c	MS	0.38 ^f	10	--	20	--	10	70	--	--	7	70	--	
	WI	0.38 ^f	9 ^d	--	89	--	--	11	--	--	1	11	--	
	MS	0.77 ^f	10	30	70	--	--	--	--	--	--	--	--	
	WI	0.77 ^f	10	70	30	--	--	--	--	--	--	--	--	
	MS	1.08 ^f	10	30	70	--	--	--	--	--	--	--	--	
	WI	1.08 ^f	10	100	--	--	--	--	--	--	--	--	--	
Ammoniacal copper arsenate ^c	MS	0.38 ^f	10	--	10	--	10	70	--	10	8	80	--	
	WI	0.38 ^f	9 ^d	11	89	--	--	--	--	--	--	--	--	
	MS	0.77 ^f	10	20	70	--	--	10	--	--	1	10	--	
	WI	0.77 ^f	10	100	--	--	--	--	--	--	--	--	--	
	MS	1.08 ^f	10	20	80	--	--	--	--	--	--	--	--	
	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 26 years of service. Stakes placed in test at Madison, WI, May 1976, and on the Harrison Experimental Forest, Saucier, MS, December 1975 (Plot 72)--continued

Preservative	Location	Average retention (lb/ft ³)	Number in test	Condition of stakes January 2000 (%)									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	Total removed		
											Number	%	
Douglas-fir nominal 2- by 4-in. by 18-in. unincised													
Chromated copper arsenate type III	MS	0.66	10	100	--	--	--	--	--	--	--	--	--
	WI	0.55	10	100	--	--	--	--	--	--	--	--	--
	MS	1.24	10	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	4
	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	10	100	--	--	--	--	--	--	--	--	--
	WI	0.96	10	100	--	--	--	--	--	--	--	--	--
	MS	1.88	10	100	--	--	--	--	--	--	--	--	--
	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	90	10	--	--	--	--	--	--	--	--
	WI	0.62	10	90	10	--	--	--	--	--	--	--	--
	MS	1.25	10	100	--	--	--	--	--	--	--	--	--
	WI	1.22	10	90	10	--	--	--	--	--	--	--	--
	MS	1.88	10	90	10	--	--	--	--	--	--	--	--
	WI	1.83	10	100	--	--	--	--	--	--	--	--	--
None	MS	--	10	--	--	--	--	20	20	60	10	100	3
	WI	--	8 ^d	--	--	--	--	100	--	--	8	100	6
Chromated copper arsenate type III ^e	MS	0.60 ^f	9 ^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	10	100	--	--	--	--	--	--	--	--	--
	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	10	100	--	--	--	--	--	--	--	--	--
	WI	1.21 ^f	8 ^d	100	--	--	--	--	--	--	--	--	--
	MS	1.82 ^f	10	100	--	--	--	--	--	--	--	--	--
	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 26 years of service. Stakes placed in test at Madison, WI, May 1976, and on the Harrison Experimental Forest, Saucier, MS, December 1975 (Plot 72)--continued

Preservative	Location	Average retention (lb/ft ³)	Number in test	Condition of stakes January 2000 (%)								Total removed		Average life (year)
				Serviceable but showing some--			Destroyed by--							
				Good	Decay	attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Number	%		
Douglas-fir nominal 2- by 4-in. by 18-in. unincised														
Ammoniacal copper arsenate	MS	0.70	10	100	--	--	--	--	--	--	--	--	--	--
	WI	0.61	10	80	20	--	--	--	--	--	--	--	--	--
	MS	1.42	10	100	--	--	--	--	--	--	--	--	--	--
	WI	1.29	10	100	--	--	--	--	--	--	--	--	--	--
	MS	2.14	10	50	50	--	--	--	--	--	--	--	--	--
	WI	1.95	9 ^d	78	11	--	--	--	--	--	--	--	--	--
Douglas-fir 2- by 4-in. nominal by 18-in. incised														
Ammoniacal copper arsenate	MS	0.70	10	70	30	--	--	--	--	--	--	--	--	--
	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	60	30	--	10	--	--	--	--	--	--	--
	WI	0.62	10	40	60	--	--	--	--	--	--	--	--	--
	MS	1.30	10	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	20	80	--	--	--	--	--	--	--	--	--
	WI	0.64 ^f	9 ^d	33	67	--	--	--	--	--	--	--	--	--
	MS	1.30 ^f	10	100	--	--	--	--	--	--	--	--	--	--
	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	50	50	--	--	--	--	--	--	--	--	--
	WI	0.64 ^f	10	80	20	--	--	--	--	--	--	--	--	--
	MS	1.30 ^f	10	100	--	--	--	--	--	--	--	--	--	--
	WI	1.30 ^f	9 ^d	100	--	--	--	--	--	--	--	--	--	--
	MS	1.97 ^f	10	90	10	--	--	--	--	--	--	--	--	--
	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 26 years of service. Stakes placed in test at Madison, WI, May 1976, and on the Harrison Experimental Forest, Saucier, MS, December 1975 (Plot 72)--continued

Preservative	Location	Average retention (lb/ft ³)	Number in test	Condition of stakes January 2000 (%)							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	%	
Chromated copper arsenate type III	MS	0.31	10	80	--	--	10	--	--	10	1	10	--
	WI	0.21	8 ^d	88	12	--	--	--	--	--	--	--	--
	MS	0.50	10	50	10	10	10	10	10	--	2	20	--
	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 nominal 2- by 4-in. by 18-in. incised													
Chromated copper arsenate type III	MS	0.41	10	100	--	--	--	--	--	--	--	--	--
	WI	0.28	9 ^d	78	22	--	--	--	--	--	--	--	--
	MS	0.66	10	100	--	--	--	--	--	--	--	--	--
	WI	0.56	10	100	--	--	--	--	--	--	--	--	--
	MS	1.02	10	100	--	--	--	--	--	--	--	--	--
	WI	0.86	10	90	--	--	--	10	--	--	1	10	--
Engelmann spruce 3/4- by 3-1/2-in. by 18-in. plywood													
Chromated copper arsenate type III ^c	MS	0.71	10	100	--	--	--	--	--	--	--	--	--
	WI	0.70	9 ^d	89	11	--	--	--	--	--	--	--	--
	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 arsenate type III ^e	MS	0.67 ^f	10	90	10	--	--	--	--	--	--	--	--
	WI	0.67 ^f	10	80	20	--	--	--	--	--	--	--	--
	MS	1.25 ^f	10	100	--	--	--	--	--	--	--	--	--
	WI	1.26 ^f	9 ^d	100	--	--	--	--	--	--	--	--	--
	MS	1.76 ^f	9 ^d	100	--	--	--	--	--	--	--	--	--
	WI	1.76 ^f	9 ^d	100	--	--	--	--	--	--	--	--	--
Chromated copper arsenate type III ^g	MS	0.67 ^f	9 ^d	100	--	--	--	--	--	--	--	--	--
	WI	0.67 ^f	9 ^d	100	--	--	--	--	--	--	--	--	--
	MS	1.25 ^f	10	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 26 years of service. Stakes placed in test at Madison, WI, May 1976, and on the Harrison Experimental Forest, Saucier, MS, December 1975 (Plot 72)--concluded

Preservative	Location	Average retention (lb/ft ³)	Number in test	Condition of stakes January 2000 (%)								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	Total removed		
											Number		%
Engelmann spruce nominal 2- by 4-in. by 18-in. unincised													
Ammoniacal copper arsenate	MS	0.26	9 ^d	11	89	--	--	--	--	--	--	--	--
	WI	0.20	10	30	70	--	--	--	--	--	--	--	--
	MS	0.63	10	60	40	--	--	--	--	--	--	--	--
	WI	0.50	10	100	--	--	--	--	--	--	--	--	--
	MS	1.03	10	80	20	--	--	--	--	--	--	--	--
	WI	0.75	10	90	10	--	--	--	--	--	--	--	--
Engelmann spruce nominal 2- by 4-in. by 18-in. incised													
Ammoniacal copper arsenate	MS	0.42	10	40	60	--	--	--	--	--	--	--	--
	WI	0.30	10	60	40	--	--	--	--	--	--	--	--
	MS	0.97	10	80	20	--	--	--	--	--	--	--	--
	WI	0.81	10	80	20	--	--	--	--	--	--	--	--
	MS	1.41	10	80	20	--	--	--	--	--	--	--	--
	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	70	--	--	--	--	--	--	--	--
	WI	0.68	10	60	40	--	--	--	--	--	--	--	--
	MS	1.42	10	60	40	--	--	--	--	--	--	--	--
	WI	1.35	9 ^d	100	--	--	--	--	--	--	--	--	--
	MS	2.14	10	60	40	--	--	--	--	--	--	--	--
	WI	2.08	9 ^d	100	--	--	--	--	--	--	--	--	--
Ammoniacal copper arsenate ^e	MS	0.65 ^f	10	10	90	--	--	--	--	--	--	--	--
	WI	0.65 ^f	10	80	20	--	--	--	--	--	--	--	--
	MS	1.29 ^f	10	70	30	--	--	--	--	--	--	--	--
	WI	1.29 ^f	9 ^d	100	--	--	--	--	--	--	--	--	--
	MS	2.02 ^f	10	90	10	--	--	--	--	--	--	--	--
	WI	2.02 ^f	8 ^d	100	--	--	--	--	--	--	--	--	--
Ammoniacal copper arsenate ^g	MS	0.65 ^f	10	20	80	--	--	--	--	--	--	--	--
	WI	0.65 ^f	9 ^d	100	--	--	--	--	--	--	--	--	--
	MS	1.29 ^f	10	80	20	--	--	--	--	--	--	--	--
	WI	1.29 ^f	8 ^d	100	--	--	--	--	--	--	--	--	--
	MS	2.02 ^f	10	90	10	--	--	--	--	--	--	--	--
	WI	2.02 ^f	9 ^d	100	--	--	--	--	--	--	--	--	--

^aSome Southern Pine contained a small amount of sapwood, and the Southern Pine plywood was mixed heartwood and sap.

^bResin content of Southern Pine ranged from 0.87% to 27.4%.

^cTreated as 3/4- by 3-1/2 by 18-in. stakes.

^dTen stakes originally installed; eliminations were for causes other than decay or insect attack.

^eStakes cut from treated 2- by 4-ft panel.

^fRetention by weight of panels from which stakes were cut.

^gStakes 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 arsenate after approximately 25 years of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, December 1975 (Plot 73)

Preservative	Average retention ^a (lb/ft ³)	Number in test	Condition of stakes June 2002 (%)									Average life (year)	
			Serviceable but showing some--			Destroyed by--							
			Good	Decay	Termite attack	Decay and termite attack		Decay fungi and termite attack			Total removed		
						Termite attack	Decay	Termite attack	Decay	Termite attack	Number		%
Ammoniacal copper borate	1.33	20	85	10	--	5	--	--	--	--	--	--	
	0.66	20	50	25	--	--	25	--	--	5	25	--	
	0.45	20	25	60	--	15	--	--	--	--	--	--	
	0.33	20	20	40	--	10	30	--	--	6	30	--	
	0.22	20	5	25	--	--	70	--	--	14	70	--	
	0.17	20	--	25	--	--	70	--	5	15	75	--	
Ammoniacal copper arsenate	1.35	20	55	45	--	--	--	--	--	--	--	--	
	0.66	20	35	65	--	--	--	--	--	--	--	--	
	0.46	20	25	75	--	--	--	--	--	--	--	--	
	0.33	20	--	75	--	20	5	--	--	1	5	--	
	0.23	20	--	50	--	20	25	--	5	6	30	--	
	0.17	20	--	--	--	5	50	--	45	19	95	--	
Untreated controls	--	20	--	--	--	--	5	20	75	20	100	2.6	

^aRetention based on preservative oxides.

This study was initiated 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 of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, May 1976 (Plot 74)

Preservative	Average retention (lb/ft ³)	Number in test	Condition of stakes December 1993 (%)									Average life (year)		
			Serviceable but showing some--			Destroyed by--								
			Good	Decay	Termite attack	Decay and Termite			fungi and Termite				Total removed	
						fungi	attack	attack	attack	Number	%			
UDFP fire retardant ^a	2.8	9	--	--	--	--	--	100	--	9	100	4.8		
	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		

^aReported 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 of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, December 1976 (Plot 75)

Preservative	Average retention (lb/ft ³)	Number in test ^b	Condition of stakes December 1993 (%)							Total removed		Average life (year)
			Serviceable but showing some--			Destroyed by--						
			Good	Decay	Termite attack	Decay and termite attack	fungi	Termite attack	termite attack	Decay and fungi	Number	
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

^aWater-soluble form containing 1.07% copper metal (PQ-8).

^bTen 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 20 years of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, November 1978 (Plot 78)

Preservative	Average retention based on preservative oxides (lb/ft ³)	Number in test ^a	Condition of stakes February 1998 (%)							Total removed		Average life (year)
			Serviceable but showing some--			Destroyed by--						
			Good	Decay	Termite attack	Decay and termite	Decay fungi	Termite attack	Termite and	Number	%	
Southern Pine												
Chromated copper arsenate type III	0.25	10	10	80	10	--	--	--	--	--	--	--
	0.40	10	70	30	--	--	--	--	--	--	--	--
	0.77	10	100	--	--	--	--	--	--	--	--	--
Untreated controls	--	10	--	--	--	--	100	--	--	10	100	2.5
Douglas-fir												
Chromated copper arsenate type III	0.26	10	--	90	--	--	10	--	--	1	10	--
	0.60	10	70	30	--	--	--	--	--	--	--	--
Ammoniacal copper arsenate	0.25	10	--	30	--	10	60	--	--	6	60	--
	0.39	10	--	100	--	--	--	--	--	--	--	--
	0.62	9	30	60	--	--	--	--	--	--	--	--
Untreated controls	--	10	--	--	--	--	70	--	30	10	100	3.5

^aTen 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 of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, December 1979 (Plot 79)

Preservative	Average loading-- Weight add-on (%)	Num- ber in test	Condition of stakes December 1989 (%)								Average life (year)	
			Good	Serviceable but showing some--				Destroyed by--				
				Decay	Decay and		Decay fungi	Decay fungi and				
					Termite attack	Termite attack		Termite attack	Termite attack	Termite attack		
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 22 years of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, April 1980 (Plot 80)

Preservative	Average retention (lb/ft ³)	Number in test ^a	Condition of stakes January 2002 (%)								Total removed		Average life (year)
			Serviceable but showing some--			Destroyed by--							
			Good	Decay	Termite attack	Decay and termite attack		Decay fungi	Termite attack	Decay and termite attack	Number	%	
						Decay	Termite attack						
Chromated copper arsenate type C													
2- by 4- by 18-in. stakes													
Full cell	0.14	10	10	20	--	70	--	--	--	--	--	--	
	0.27	10	50	40	--	10	--	--	--	--	--	--	
	0.40	10	80	20	--	--	--	--	--	--	--	--	
	0.62	10	100	--	--	--	--	--	--	--	--	--	
	0.79	10	100	--	--	--	--	--	--	--	--	--	
3/4- by 3/4- by 18-in. stakes													
	0.14	9	--	--	10	40	20	20	--	4	44	--	
	0.27	10	10	30	--	50	10	--	--	1	10	--	
	0.40	9	55	22	11	11	--	--	--	--	--	--	
	0.61	10	70	10	10	10	--	--	--	--	--	--	
	0.80	10	100	--	--	--	--	--	--	--	--	--	
2- by 4- by 18-in. stakes													
Empty cell	0.15 ^b	10	10	10	--	80	--	--	--	--	--	--	
	0.26	10	10	80	--	10	--	--	--	--	--	--	
	0.33	10	80	20	--	--	--	--	--	--	--	--	
	0.59	10	100	--	--	--	--	--	--	--	--	--	
	0.78	10	90	10	--	--	--	--	--	--	--	--	
3/4- by 3/4- by 18-in. stakes													
	0.14 ^c	10	--	10	--	--	30	10	50	9	90	--	
	0.27	10	--	--	--	10	40	30	20	9	70	--	
	0.40	10	--	20	10	50	20	--	--	2	20	--	
	0.61	10	10	70	--	10	10	--	--	1	10	--	
	0.80	9	55	33	--	--	--	--	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	

^aTen stakes originally installed; eliminated stakes removed for causes other than decay or insect attack.

^bThe retentions are based on chemical analysis after treatment.

^cThe 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 of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, June 1980 (Plot 81)

Preservative	Average retention (lb/ft ³)	Number in test ^a	Condition of stakes June 2000 (%)								Total removed		Average life (year)
			Serviceable but showing some--				Destroyed by--						
			Good	Decay	attack	attack	Decay	fungi	Decay	fungi	attack	attack	
Water-dispersible pentachlorophenol	0.10	10	--	--	--	10	--	--	90	9	90	--	
	0.18	9	--	--	--	--	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 spirits	0.09	10	--	--	--	10	--	10	80	9	90	--	
	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	

^aTen stakes originally installed; eliminated stakes removed for causes other than decay or insect attack.

^bConcentrate 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 20 years of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, June 1980 (Plot 82)

Preservative	Average retention ^a (lb/ft ³)	Number in test ^b	Condition of stakes June 2000 (%)								Average life	
			Serviceable but showing some--				Destroyed by--					
			Good	Decay	Termite attack	Termite attack	Decay fungi	Termite attack	Termite attack	Decay fungi	Total removed	
											Number	%
2- by 4- by 18-in. stakes												
Chromated copper fluoride (CFK)	0.28	10	10	--	--	50	10	--	30	4	40	--
	0.58	9	--	22	22	56	--	--	--	--	--	--
	1.22	10	100	--	--	--	--	--	--	--	--	--
	1.57	10	100	--	--	--	--	--	--	--	--	--
Untreated controls	--	10	--	--	--	--	10	--	90	10	100	1.9
2.5- by 5.0- by 50-cm stakes												
Chromated copper fluoride (CFK)	0.30	10	--	--	--	30	30	--	40	7	70	--
	0.62	10	20	30	--	40	10	--	--	1	10	--
	1.26	10	90	--	10	--	--	--	--	--	--	--
	1.69	10	100	--	--	--	--	--	--	--	--	--
Untreated controls	--	10	--	--	--	--	--	20	80	10	100	1.6

^aRetention based on preservative oxides.

^bTen 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 of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, May 1981 (Plot 83)

Preservative	Average retention (lb/ft ³)	Number in test	Condition of stakes June 2000 (%)							Total removed		Average life (year)
			Serviceable but showing some--			Destroyed by--						
			Good	Decay	Termite attack	Termite attack	Decay and fungi	Termite attack	Termite attack	Number	%	
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 21 years of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, December 1981 (Plot 84)

Preservative	Condition of stakes January 2002 (%)												Average life (year)	
	Average retention (lb/ft ³)	Active ingredient (lb/ft ³)	Number in test ^a	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			%
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	10	--	--	--	50	--	--	50	5	50	--	
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	9	--	--	--	11	77	--	11	8	89	--	
Didecyl dimethyl ammonium chloride, 20%, + 6.3% copper as the metal	1.62	0.22	9	--	11	--	33	44	--	11	4	44	--	
	0.40	0.11	10	--	--	--	--	60	--	40	10	100	7.5	
	0.81	0.21	10	--	--	--	40	50	--	10	6	60	--	
Dimethyl cocoamine 2-ethyl hexoate, 20%; copper 2-ethyl hexoate, 21.0% (3.8% metallic copper)	1.21	0.32	10	--	10	--	60	30	--	--	3	30	--	
	1.60	0.42	8	--	25	--	75	--	--	--	--	--	--	
	0.30	0.08	10	--	--	--	--	30	10	60	10	100	3.2	
Copper 2-ethyl hexoate, 35.0% (6.3 metallic copper)	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	--	--	--	10	60	--	30	9	90	--	
Pentachlorophenol, 21.9%, and 2.4% other chlorophenols	0.40	0.17	10	--	--	--	--	90	--	10	10	100	5.5	
	0.80	0.33	10	--	--	--	20	80	--	--	8	80	--	
	1.20	0.50	10	--	--	--	10	80	--	10	9	90	--	
	1.61	0.66	10	--	--	--	10	70	--	10	8	80	--	
Pentachlorophenol, 27.6%, and 3.1% other chlorophenols	0.82	0.20	10	--	--	--	20	20	--	60	8	80	--	
	1.66	0.40	8	--	--	--	87	--	--	10	1	13	--	
	3.23	0.78	10	--	50	--	50	--	--	--	--	--	--	
	4.12	1.00	10	--	50	--	50	--	--	--	--	--	--	
Tri-n-butyl tin oxide, 9.5%, dimethyl benzyl ammonium chloride, 20%, and dimethyl ethyl benzyl ammonium chloride, 20%	0.65	0.20	10	--	--	--	--	10	--	90	10	100	--	
	1.30	0.40	10	--	20	--	80	--	--	--	--	--	--	
	2.60	0.80	10	--	20	--	80	--	--	--	--	--	--	
	3.27	1.00	10	--	60	--	40	--	--	--	--	--	--	
Diluted in toluene	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	22	--	44	6	67	--	
	1.63	0.81	9	--	11	--	78	11	--	--	1	11	--	
Copper-8-quinolinolate, 0.675% (0.12% metallic copper)	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	22	--	44	6	67	--	
	1.63	0.81	9	--	11	--	78	11	--	--	1	11	--	
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	10	--	30	--	70	--	--	--	--	--	--	
	17.50	0.12	8	37	25	10	37	--	--	--	--	--	--	
Pentachlorophenol, 6.3%, and other chlorophenols, 0.7%, in No. 2 diesel fuel	2.86	0.20	10	--	--	--	60	10	--	30	4	40	--	
	5.73	0.40	10	--	20	--	80	--	--	--	--	--	--	
	11.44	0.80	10	30	40	10	20	--	--	--	--	--	--	
	14.29	1.00	10	60	20	--	20	--	--	--	--	--	--	
Untreated controls	--	--	20	--	--	--	--	25	--	75	20	100	2.4	

^aTen stakes originally installed; eliminated stakes removed for causes other than decay or insect attack.

This study was initiated 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 21 years of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, December 1981 (Plot 85)

Preservative	Average retention (lb/ft ³)	Number in test	Condition of stakes January 2002 (%)								Total removed		Average life (year)
			Serviceable but showing some--				Destroyed by--						
			Good	Decay and Termite attack			Decay fungi	Decay and Termite attack			Number	%	
				Decay	Termite attack	Termite attack		Decay	Termite attack	Termite attack			
Ammoniacal copper zinc arsenate	0.10	10	--	--	--	--	--	80	--	20	10	100	16.0
	0.25	10	--	100	--	--	--	--	--	--	--	--	--
	0.40	10	20	60	10	--	--	--	--	10	1	10	--
	0.60	10	90	10	--	--	--	--	--	--	--	--	--
	1.22	10	100	--	--	--	--	--	--	--	--	--	--
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 of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, May 1982 (Plot 86)

Preservative	Average retention (lb/ft ³)			Number in test	Condition of stakes January 1996 (%)								Average life (year)	
	Solu- tion	Penta- chloro- phenol	Creo- sote		Serviceable but showing some--				Destroyed by--					
					Good	Decay	Termite attack	Termite attack	Decay fungi	Termite attack	Termite attack	Total removed		
													and	and
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

This study was initiated 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 of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, May 1982 (Plot 87)

Preservative	Average retention (lb/ft ³)	Number in test	Condition of stakes January 1996 (%)							Total removed		Average life (year)
			Serviceable but showing some--				Destroyed by--					
			Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay and termite attack	Number	%	
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

This study was initiated 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 of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, May 1982 (Plot 88)

Preservative	Average retention (lb/ft ³)	Number in test	Condition of stakes January 1996 (%)									Average life (year)
			Serviceable but showing some--			Destroyed by--						
			Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	termite attack	Total removed		
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 of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, May 1982 (Plot 89)

Preservative	Average retention (lb/ft ³)	Number in test	Condition of stakes January 1996 (%)							Total removed		Average life (year)
			Serviceable but showing some--			Destroyed by--						
			Good	Decay	attack	Decay and Termite		Decay Termite		fungi attack	fungi attack	
						termite attack	termite attack					
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 of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, December 1982 (Plot 90)

Preservative	Average retention (lb/ft ³)	Number in test ^a	Condition of stakes January 1999 (%)							Total removed		Average life (year)
			Good	Serviceable but showing some--			Destroyed by--			Number	%	
				Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay and termite attack			
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

^aTen 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 pentachlorophenol emulsion, pentachlorophenol-creosote emulsion, ammonium pentachlorophenol, and pentachlorophenol in P9 oil after 12 years of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, December 1983 (Plots 92 and 93)

Preservative	Average retention (lb/ft ³)	Number in test	Condition of stakes August 1995 (%)							Total removed		Average life (year)
			Serviceable but showing some--			Destroyed by--						
			Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay and termite attack	Number	%	
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 pentachlorophenol emulsion, pentachlorophenol-creosote emulsion, ammonium pentachlorophenol, and pentachlorophenol in P9 oil after 12 years of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, December 1983 (Plots 92 and 93)--concluded

Preservative	Average retention (lb/ft ³)	Number in test	Condition of stakes August 1995 (%)								Total removed Number	Average life (year)
			Good	Serviceable but showing some--			Destroyed by--			Total removed %		
				Decay	Termite attack	Termite attack	Decay fungi	Termite attack	Termite attack			
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

This study was initiated 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 of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, May 1984 (Plot 94)

Preservative	Average retention (lb/ft ³)	Number in test	Condition of stakes June 2000 (%)							Total removed		Average life (year)
			Serviceable but showing some--			Destroyed by--						
			Good	Decay and		Decay fungi and	Termite attack	Termite attack	Termite attack	Termite attack		
				Decay	Termite attack							
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 pentachlorophenol with inhibitor, after about 18 years of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, December 1984 (Plot 95)

Preservative	Average retention (lb/ft ³)	Number in test ^a	Condition of stakes January 2002 (%)							Total removed		Average life (year)
			Serviceable but showing some--			Destroyed by--						
			Good	Decay	attack	Decay and termite attack	fungi	Termite attack	termite attack	Number	%	
Creosote coal-tar	1.69	10	--	--	--	10	50	--	40	9	90	--
	3.31	8	--	--	--	13	87	--	--	7	87	--
	4.93	9	--	--	--	33	67	--	--	6	67	--
	6.59	10	--	20	--	60	20	--	--	2	20	--
Coal-tar creosote plus 2% sulfur	2.23	10	--	--	--	10	70	--	20	9	90	--
	3.48	10	--	--	--		70	--	30	10	100	13.6
	4.93	9	--	--	--	11	89	--	--	8	89	--
Coal-tar creosote and pentachlorophenol with inhibitor	6.58	10	--	--	--	10	80	--	10	9	90	--
	2.11	9	--	--	--		44	--	56	9	100	13.1
	3.57	9	--	--	--	44	56	--	--	5	56	--
	4.70	10	--	10	--	80	10	--	--	1	10	--
Untreated controls	6.83	10	--	10	--	70	20	--	--	2	20	--
	--	10	--	--	--	--	10	--	90	10	100	1.9

^aTen 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 of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, December 1984 (Plot 96)

Preservative	Average retention (lb/ft ³)	Number in test	Condition of stakes January 1996 (%)							Total removed		Average life (year)
			Serviceable but showing some--			Destroyed by--						
			Good	Decay	attack	Decay and termite attack	Decay fungi	Termite attack	termite attack	Number	%	
Penta amine in water	0.14	10	--	--	--	--	40	--	60	10	100	2.3
	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 in P9 oil and toluene	0.14	10	--	--	--	--	50	--	50	10	100	7.4
	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

This study was initiated 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 17 years. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, May 1985 and near Portland, ME, August 1985 (Plot 97)

Preservative	Loca- tion	Average retention (lb/ft ³)	Num- ber in test ^a	Condition of stakes September 1995 (ME) and January 2002 (MS) (%)									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	%	
White pine--unincised													
Ammoniacal copper arsenate	ME	0.32	10	90	10	--	--	--	--	--	--	--	--
	MS	0.26	10	--	40	--	10	40	--	10	5	50	--
	ME	0.38	10	90	10	--	--	--	--	--	--	--	--
	MS	0.42	9	33	56	--	11	--	--	--	--	--	--
	ME	0.71	10	100	--	--	--	--	--	--	--	--	--
	MS	0.72	10	100	--	--	--	--	--	--	--	--	--
Chromated copper arsenate III	ME	0.30	10	100	--	--	--	--	--	--	--	--	--
	MS	0.31	10	100	--	--	--	--	--	--	--	--	--
	ME	0.46	10	100	--	--	--	--	--	--	--	--	--
	MS	0.44	10	90	10	--	--	--	--	--	--	--	--
	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	70	20	--	--	10	--	--	1	10	--
	ME	0.44	10	100	--	--	--	--	--	--	--	--	--
	MS	0.42	10	80	10	--	--	10	--	--	1	10	--
	ME	0.80	10	100	--	--	--	--	--	--	--	--	--
	MS	0.73	10	100	--	--	--	--	--	--	--	--	--
Chromated copper arsenate III	ME	0.32	10	100	--	--	--	--	--	--	--	--	--
	MS	0.33	10	100	--	--	--	--	--	--	--	--	--
	ME	0.47	10	100	--	--	--	--	--	--	--	--	--
	MS	0.52	10	100	--	--	--	--	--	--	--	--	--
	ME	0.72	10	100	--	--	--	--	--	--	--	--	--
	MS	0.74	10	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	--	30	--	10	40	--	20	6	60	--
	ME	0.38	10	100	--	--	--	--	--	--	--	--	--
	MS	0.30	10	40	50	--	--	10	--	--	1	10	--
	ME	0.67	10	100	--	--	--	--	--	--	--	--	--
	MS	0.44	10	90	10	--	--	--	--	--	--	--	--

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 17 years. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, May 1985 and near Portland, ME, August 1985 (Plot 97)--continued

Condition of stakes September 1995 (ME) and January 2002 (MS) (%)													
Preservative	Loca- tion	Average retention (lb/ft ³)	Num- ber in test ^a	Serviceable but showing some--			Destroyed by--			Total removed		Average life (year)	
				Good	Decay	Termite attack	Decay and termite attack	Decay fungi and termite attack	Number	%			
Red pine--unincised--con.													
Chromated copper arsenate III	ME	0.18	10	90	10	--	--	--	--	--	--	--	--
	MS	0.23	10	60	30	10	--	--	--	--	--	--	--
	ME	0.33	10	100	--	--	--	--	--	--	--	--	--
	MS	0.32	9	78	11	11	--	--	--	--	--	--	--
	ME	0.70	10	100	--	--	--	--	--	--	--	--	--
	MS	0.46	10	90	--	--	10	--	--	--	--	--	--
Red pine--incised													
Ammoniacal copper arsenate	ME	0.26	10	70	30	--	--	--	--	--	--	--	--
	MS	0.31	10	30	50	--	--	20	--	--	2	20	--
	ME	0.45	10	100	--	--	--	--	--	--	--	--	--
	MS	0.40	10	90	--	--	10	--	--	--	--	--	--
	ME	0.53	10	100	--	--	--	--	--	--	--	--	--
	MS	0.64	10	100	--	--	--	--	--	--	--	--	--
Chromated copper arsenate III	ME	0.23	10	100	--	--	--	--	--	--	--	--	--
	MS	0.25	10	100	--	--	--	--	--	--	--	--	--
	ME	0.45	10	100	--	--	--	--	--	--	--	--	--
	MS	0.40	10	100	--	--	--	--	--	--	--	--	--
	ME	0.78	10	100	--	--	--	--	--	--	--	--	--
	MS	0.55	10	100	--	--	--	--	--	--	--	--	--
Untreated controls	ME	--	10	--	80	--	--	20	--	--	2	20	--
	MS	--	10	--	--	--	--	70	--	30	10	100	3.7
Eastern spruce--unincised--con.													
Ammoniacal copper arsenate	ME	0.13	10	30	70	--	--	--	--	--	--	--	--
	MS	0.16	10	--	--	--	10	30	--	60	9	90	--
	ME	0.21	10	20	80	--	--	--	--	--	--	--	--
	MS	0.25	10	--	10	--	--	40	20	30	9	90	--
	ME	0.26	10	50	50	--	--	--	--	--	--	--	--
	MS	0.39	10	70	30	--	--	--	--	--	--	--	--

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 17 years. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, May 1985 and near Portland, ME, August 1985 (Plot 97)--continued

Preservative	Loca- tion	Average retention (lb/ft ³)	Num- ber in test	Condition of stakes September 1995 (ME) and January 2002 (MS) (%)								Total removed		Average life (year)
				Good	Serviceable but showing some--		Destroyed by--			Termite attack	Termite attack			
					Decay	Decay and Termite attack	Decay fungi and Termite attack	Decay fungi and Termite attack						
				Decay	Decay and Termite attack	Decay fungi and Termite attack	Decay fungi and Termite attack	Number	%					
Eastern spruce--unincised--con.														
Chromated copper arsenate III	ME	0.10	10	80	20	--	--	--	--	--	--	--	--	
	MS	0.14	10	--	10	--	60	20	--	10	3	30	--	
	ME	0.13	10	90	10	--	--	--	--	--	--	--	--	
	MS	0.20	10	70	10	10	--	10	--	--	1	10	--	
	ME	0.53	10	100	--	--	--	--	--	--	--	--	--	
	MS	0.71	10	100	--	--	--	--	--	--	--	--	--	
Eastern spruce--incised														
Ammoniacal copper arsenate	ME	0.20	10	20	80	--	--	--	--	--	--	--	--	
	MS	0.24	10	10	70	--	10	10	--	--	1	10	--	
	ME	0.28	10	70	30	--	--	--	--	--	--	--	--	
	MS	0.28	10	50	20	--	10	20	--	--	2	20	--	
	ME	0.39	10	80	20	--	--	--	--	--	--	--	--	
	MS	0.48	10	100	--	--	--	--	--	--	--	--	--	
Chromated copper arsenate III	ME	0.20	10	100	--	--	--	--	--	--	--	--	--	
	MS	0.25	10	100	--	--	--	--	--	--	--	--	--	
	ME	0.28	10	100	--	--	--	--	--	--	--	--	--	
	MS	0.35	10	100	--	--	--	--	--	--	--	--	--	
	ME	0.54	10	100	--	--	--	--	--	--	--	--	--	
	MS	0.78	10	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	--	30	--	--	30	--	40	7	70	--	
	ME	0.25	10	70	30	--	--	--	--	--	--	--	--	
	MS	0.32	10	30	50	10	10	--	--	--	--	--	--	
	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 17 years. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, May 1985 and near Portland, ME, August 1985 (Plot 97)--continued

Preservative	Loca- tion	Average retention (lb/ft ³)	Num- ber in test	Condition of stakes September 1995 (ME) and January 2002 (MS) (%)									Average life (year)
				Good	Serviceable but showing some--			Destroyed by--			Total removed		
					Decay	Termite attack	Decay and Termite attack	Decay fungi and Termite attack	Decay fungi and Termite attack				
										Decay	Termite attack	Decay fungi and Termite attack	
Balsam fir--incised													
Ammoniacal copper arsenate	ME	0.31	10	80	20	--	--	--	--	--	--	--	--
	MS	0.29	10	60	30	--	--	10	--	--	1	10	--
	ME	0.35	10	100	--	--	--	--	--	--	--	--	--
	MS	0.40	10	100	--	--	--	--	--	--	--	--	--
	ME	0.47	10	100	--	--	--	--	--	--	--	--	--
	MS	0.73	10	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	50	40	--	10	--	--	--	--	--	--
	ME	0.38	10	80	20	--	--	--	--	--	--	--	--
	MS	0.32	10	10	60	--	--	30	--	--	3	30	--
	ME	0.36	10	100	--	--	--	--	--	--	--	--	--
	MS	0.37	10	100	--	--	--	--	--	--	--	--	--
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	10	60	30	--	--	10	--	--	1	10	--
	ME	0.41	10	100	--	--	--	--	--	--	--	--	--
	MS	0.38	10	100	--	--	--	--	--	--	--	--	--
	ME	0.56	10	100	--	--	--	--	--	--	--	--	--
	MS	0.68	10	100	--	--	--	--	--	--	--	--	--
Chromated copper arsenate III	ME	0.25	10	100	--	--	--	--	--	--	--	--	--
	ME	0.38	10	100	--	--	--	--	--	--	--	--	--
	ME	0.57	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 17 years. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, May 1985 and near Portland, ME, August 1985 (Plot 97)--concluded

Preservative	Loca- tion	Average retention (lb/ft ³)	Num- ber in test	Condition of stakes September 1995 (ME) and January 2002 (MS) (%)									Average life (year)
				Serviceable but showing some--			Destroyed by--			Total removed			
				Good	Decay and		Decay fungi	Decay and		Number	%		
					Termite attack	termite attack		Termite attack	termite attack				
Eastern hemlock--incised--con.													
Untreated controls	ME	--	10	10	40	--	--	50	--	--	5	50	--
	MS	--	10	--	--	--	--	50	--	50	10	100	3.7
Eastern larch--unincised													
Ammoniacal copper arsenate	ME	0.15	10	50	50	--	--	--	--	--	--	--	--
	MS	0.18	10	--	10	--	50	20	--	20	4	40	--
	ME	0.23	10	100	--	--	--	--	--	--	--	--	--
	MS	0.20	10	30	20	--	30	10	--	10	2	20	--
	ME	0.24	10	100	--	--	--	--	--	--	--	--	--
	MS	0.41	10	100	--	--	--	--	--	--	--	--	--
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	10	20	40	--	30	--	--	10	1	10	--
	ME	0.25	10	90	10	--	--	--	--	--	--	--	--
	MS	0.32	10	80	20	--	--	--	--	--	--	--	--
	ME	0.32	10	100	--	--	--	--	--	--	--	--	--
	MS	0.60	10	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

^aTen 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 16-1/2 years. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, November 1985 (Plot 98)

Preservative	Average retention (lb/ft ³)	Num-ber in test ^a	Condition of stakes January 1999 (%)							Total removed		Average life (year)
			Serviceable but showing some--			Destroyed by--						
			Good	Decay	attack	Decay and Termite	fungi	Termite	and termite	Number	%	
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	9	11	11	--	22	44	--	11	5	56	--
	0.40	10	--	40	30	--	--	30	--	3	30	--
	0.58	10	--	40	--	--	--	60	--	6	60	--
	1.18	10	--	20	--	--	--	80	--	8	80	--
Cut from 4 by 4 treated panels, cut edge dip treated												
	0.09	10	--	20	--	10	70	--	--	7	70	--
	0.20	10	50	10	--	20	--	20	--	2	20	--
	0.41	10	30	--	--	--	--	70	--	7	70	--
	0.58	10	20	--	--	--	--	80	--	8	80	--
	1.24	10	--	--	--	--	--	100	--	10	100	13.2
Treated as stakes												
	0.33	10	40	--	--	--	--	60	--	6	60	--
	0.52	10	10	--	--	--	--	90	--	9	90	--
Cut from 4 by 4 treated panel												
Chromated copper arsenate III	0.09	10	--	--	--	--	10	--	90	10	100	5.8
	0.19	10	10	40	10	20	--	20	--	2	20	--
	0.40	10	10	--	--	--	--	90	--	9	90	--
	0.59	10	30	--	--	--	--	70	--	7	70	--
	1.18	10	20	--	--	--	--	80	--	8	80	--
Cut from 4 by 4 treated panels, cut edge dip treated												
	0.10	10	10	20	--	20	10	--	40	5	50	--
	0.19	10	40	10	10	10	10	10	10	3	30	--
	0.40	10	30	--	--	--	--	70	--	7	70	--
	0.59	10	40	--	--	--	--	60	--	6	60	--
	1.18	10	20	--	--	--	--	80	--	8	80	--
Treated as stakes												
	0.41	10	40	--	--	--	--	60	--	6	60	--
	0.59	10	--	--	--	--	--	100	--	10	100	13.2
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 16-1/2 years. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, November 1985 (Plot 98)--continued

Preservative	Average retention (lb/ft ³)	Number in test ^a	Condition of stakes January 1999 (%)							Total removed		Average life (year)	
			Serviceable but showing some--			Destroyed by--							
			Good	Decay	attack	Decay and Termite	Termite	Decay	Termite	fungi	attack		attack
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	10	--	--	--	20	70	10	--	8	80	--	
	0.40	10	40	--	--	--	--	60	--	6	60	--	
	0.61	10	30	10	--	--	--	60	--	6	60	--	
	1.25	10	20	--	--	--	--	80	--	8	80	--	
Cut from 4 by 4 treated panels, cut edge dip treated													
	0.10	10	10	--	--	--	80	--	10	9	90	--	
	0.20	10	--	20	--	40	20	20	--	4	40	--	
	0.41	9	44	--	--	--	--	56	--	5	56	--	
	0.61	10	30	--	--	--	--	70	--	7	70	--	
	1.25	10	10	--	--	--	--	90	--	9	90	--	
Treated as stakes													
	0.42	10	30	--	--	--	--	70	--	7	70	--	
	0.62	10	30	--	--	--	--	70	--	7	70	--	
Cut from 4 by 4 treated panel													
Chromated copper arsenate III	0.10	10	--	--	--	--	60	--	40	10	100	6.1	
	0.20	10	--	20	--	50	20	--	10	3	30	--	
	0.41	10	70	--	--	--	--	30	--	3	30	--	
	0.61	10	30	--	--	--	--	70	--	7	70	--	
	1.22	10	--	--	--	--	--	100	--	10	100	13.2	
Cut from 4 by 4 treated panels, cut edge dip treated													
	0.10	9	--	--	--	11	44	--	44	8	89	--	
	0.20	10	20	30	--	20	--	20	10	3	30	--	
	0.40	10	10	10	--	--	--	80	--	8	80	--	
	0.61	10	30	--	--	--	--	70	--	7	70	--	
	1.22	10	10	--	--	--	--	90	--	9	90	--	
Treated as stakes													
	0.41	10	40	10	--	--	--	50	--	5	50	--	
	0.58	10	20	--	--	--	10	70	--	8	80	--	
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 16-1/2 years. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, November 1985 (Plot 98)--continued

Preservative	Average retention (lb/ft ³)	Number in test ^a	Condition of stakes January 1999 (%)							Total removed		Average life (year)
			Serviceable but showing some--			Destroyed by--				Number	%	
			Good	Decay	attack	Decay and Termitetermite	Decay fungi	Termitetermite	Decay fungi			
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	10	--	10	--	10	50	--	30	8	80	--
	0.40	10	40	10	--	--	10	30	10	5	50	--
	0.61	10	10	--	--	--	--	90	--	9	90	--
	1.24	10	--	--	--	--	--	100	--	10	100	13.2
Cut from 4 by 4 treated panels, cut edge dip treated												
	0.10	10	--	--	--	--	100	--	--	10	100	7.9
	0.19	10	--	20	--	40	30	10	--	4	40	--
	0.40	10	30	30	--	--	10	30	--	4	40	--
	0.62	10	20	--	--	--	--	80	--	8	80	--
	1.24	10	20	--	--	--	--	80	--	8	80	--
Treated as stakes												
	0.39	10	60	--	--	--	--	40	--	4	40	--
	0.61	10	40	--	--	--	--	60	--	6	60	--
Cut from 4 by 4 treated panel												
Chromated copper arsenate III	0.10	10	--	--	--	--	40	--	60	10	100	6.2
	0.19	10	30	--	10	30	20	10	--	3	30	--
	0.40	10	30	10	10	--	--	50	--	5	50	--
	0.63	10	--	--	--	--	--	100	--	10	100	13.2
	1.22	10	10	--	--	--	--	90	--	9	90	--
Cut from 4 by 4 treated panels, cut edge dip treated												
	0.10	10	--	--	--	--	20	20	60	10	100	5.8
	0.19	10	30	--	--	20	30	20	--	5	50	--
	0.40	10	70	--	--	--	--	30	--	3	30	--
	0.62	10	10	--	--	--	--	90	--	9	90	--
	1.20	10	10	--	10	--	--	80	--	8	80	--
Treated as stakes												
	0.41	10	30	--	--	--	--	70	--	7	70	--
	0.59	10	20	--	--	--	--	80	--	8	80	--
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 16-1/2 years. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, November 1985 (Plot 98)--continued

Preservative	Average retention (lb/ft ³)	Number in test ^a	Condition of stakes January 1999 (%)							Total removed		Average life (year)
			Serviceable but showing some--			Destroyed by--						
			Good	Decay	attack	Decay and Termitetermite attack	fungi attack	Termitetermite attack	Decay fungi and termitetermite attack	Number	%	
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	10	--	50	--	20	10	20	--	3	30	--
	0.40	10	10	20	--	10	--	50	10	6	60	--
	0.62	10	30	--	--	10	--	60	--	6	60	--
	1.27	10	10	--	--	--	--	90	--	9	90	--
Cut from 4 by 4 treated panels, cut edge dip treated												
	0.10	10	--	--	--	20	70	--	10	8	80	--
	0.20	10	10	40	--	10	20	20	--	4	40	--
	0.40	10	30	20	--	--	--	50	--	5	50	--
	0.62	10	30	--	--	--	--	70	--	7	70	--
	1.27	10	20	--	--	--	--	80	--	8	80	--
Treated as stakes												
	0.40	10	40	10	--	10	--	40	--	4	40	--
	0.64	10	30	--	--	--	--	70	--	7	70	--
Cut from 4 by 4 treated panel												
Chromated copper arsenate III	0.10	8	--	--	--	--	25	--	75	8	100	7.2
	0.20	10	--	50	10	30	10	--	--	1	10	--
	0.40	10	30	--	--	--	--	70	--	7	70	--
	0.62	10	20	--	--	--	--	80	--	8	80	--
	1.23	10	20	--	--	--	--	80	--	8	80	--
Cut from 4 by 4 treated panels, cut edge dip treated												
	0.10	9	--	--	--	--	56	44	5	9	100	8.1
	0.20	10	10	--	10	60	10	10	--	2	20	--
	0.40	10	30	20	--	--	--	50	--	5	50	--
	0.62	10	20	--	--	--	--	80	--	8	80	--
	1.23	10	--	--	--	--	--	100	--	10	100	13.2
Treated as stakes												
	0.43	10	60	--	--	--	--	40	--	4	40	--
	0.63	10	--	--	--	--	--	100	--	10	100	13.2
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 16-1/2 years. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, November 1985 (Plot 98)--concluded

Preservative	Average retention (lb/ft ³)	Number in test ^a	Condition of stakes January 1999 (%)							Total removed		Average life (year)
			Serviceable but showing some--			Destroyed by--						
			Good	Decay	attack	Decay and Termite attack	Termite Decay	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	10	--	--	--	60	40	--	--	4	40	--
	0.41	10	40	--	--	--	--	50	10	6	60	--
	0.62	10	30	20	--	--	--	50	--	5	50	--
	1.25	10	--	--	--	--	--	100	--	10	100	13.2
Cut from 4 by 4 treated panels, cut edge dip treated												
	0.10	10	--	--	--	--	60	--	40	10	100	8.0
	0.20	10	10	30	--	--	30	10	20	6	60	--
	0.41	10	30	--	--	--	--	70	--	7	70	--
	0.62	10	--	--	--	--	--	100	--	10	100	13.2
	1.24	10	--	--	--	--	--	100	--	10	100	13.2
Treated as stakes												
	0.38	10	40	--	--	--	--	50	10	6	60	--
	0.59	10	20	--	--	--	--	80	--	8	80	--
Cut from 4 by 4 treated panel												
Chromated copper arsenate III	0.10	9	--	--	--	--	22	--	78	9	100	6.2
	0.20	10	10	--	--	50	30	10	--	4	40	--
	0.41	10	30	--	20	--	--	50	--	5	50	--
	0.62	10	10	--	--	--	--	90	--	9	90	--
	1.20	10	--	--	--	--	--	100	--	10	100	13.2
Cut from 4 by 4 treated panels, cut edge dip treated												
	0.10	9	--	--	--	--	44	--	56	9	100	6.9
	0.20	10	50	--	10	20	20	--	--	2	20	--
	0.41	10	40	--	--	--	--	60	--	6	60	--
	0.62	10	10	--	--	--	--	90	--	9	90	--
	1.21	10	10	--	--	--	--	90	--	9	90	--
Treated as stakes												
	0.45	10	40	--	--	--	--	60	--	6	60	--
	0.63	10	20	--	--	--	--	80	--	8	80	--
Untreated controls	--	10	--	--	--	--	50	--	50	10	100	1.4

^aTen stakes were originally installed. This number has been reduced for causes other than decay or insect attack.

This study was initiated 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 combination with pelargonic acid and octanoic acid after about 13 years of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, April 1987 (Plot 99)

Preservative	Average retention (lb/ft ³)	Number in test ^a	Condition of stakes June 2000 (%)									Average life (year)
			Good	Serviceable but showing some--			Destroyed by--			Total removed		
				Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay and termite attack			
										Number	%	
Copper carbonate/ pelargonic acid	0.10	9	11	11	--	33	44	--	--	4	40	--
	0.25	10	30	20	--	--	50	--	--	5	50	--
	0.40	10	60	20	--	--	20	--	--	2	20	--
	0.60	10	60	10	--	--	20	--	10	3	30	--
	1.00	9	89	--	--	--	11	--	--	1	11	--
Copper carbonate/ octanoic acid	0.10	9	--	22	11	44	22	--	--	2	22	--
	0.25	10	20	30	--	10	40	--	--	4	40	--
	0.41	9	56	11	--	--	33	--	--	3	30	--
	0.59	9	78	--	--	--	22	--	--	2	22	--
	1.00	10	70	--	--	--	30	--	--	3	30	--
Copper oxide/ pelargonic acid	0.10	10	20	40	--	10	30	--	--	3	30	--
	0.25	10	40	20	--	--	40	--	--	4	40	--
	0.40	10	100	--	--	--	--	--	--	--	--	--
	0.60	10	50	--	--	--	50	--	--	5	50	--
	1.00	10	50	20	--	--	30	--	--	3	30	--
Copper oxide/ octanoic acid	0.10	10	--	30	10	40	10	--	10	2	20	--
	0.25	10	30	10	--	10	30	--	20	5	50	--
	0.41	10	80	10	--	--	10	--	--	1	10	--
	0.59	8	63	--	--	--	37	--	--	3	37	--
	1.01	9	67	11	--	--	22	--	--	2	22	--
Chromated copper arsenate	0.10	9	--	22	--	56	11	--	11	2	22	--
	0.25	9	100	--	--	--	--	--	--	--	--	--
	0.40	10	100	--	--	--	--	--	--	--	--	--
	0.60	10	100	--	--	--	--	--	--	--	--	--
Untreated controls	--	10	--	--	--	--	30	10	60	10	100	2.3

^aTen 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 14 years of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, April 1988 (Plot 100)

Preservative	Average retention (lb/ft ³)	Number in test ^a	Condition of stakes January 2002 (%)								Average life (year)	
			Serviceable but showing some--				Destroyed by--					
			Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	termite attack	Total removed		
										Number		%
AWPA P1-13 creosote with xylene insolubles less than 0.1%	1.0	9	--	--	--	--	67	--	33	9	100	8.7
	2.0	10	--	--	--	--	80	--	20	10	100	11.7
	4.0	10	--	30	40	--	30	--	--	3	30	--
	6.2	10	10	60	--	10	20	--	--	2	20	--
	8.5	10	10	70	--	20	--	--	--	--	--	--
+0.5% chlorpyrifos	1.0	10	--	--	--	--	80	--	20	10	100	9.1
	2.0	10	--	--	--	10	90	--	--	9	90	--
	3.9	10	--	40	--	30	30	--	--	3	30	--
	6.0	10	--	90	--	10	--	--	--	--	--	--
	8.3	10	--	70	--	30	--	--	--	--	--	--
+0.78% chlorpyrifos	1.0	10	--	--	--	--	90	--	10	10	100	8.4
	2.0	10	--	--	--	--	100	--	--	10	100	12.6
	4.0	10	--	20	--	20	60	--	--	6	60	--
	6.0	10	--	60	--	40	--	--	--	--	--	--
	8.2	10	--	70	--	30	--	--	--	--	--	--
+2% chlorothalonil	1.0	10	--	--	--	--	60	10	30	10	100	9.7
	2.0	10	--	10	--	--	90	--	--	9	90	--
	4.0	10	--	60	--	30	10	--	--	1	10	--
	6.0	10	--	90	--	10	--	--	--	--	--	--
	8.2	10	40	50	--	10	--	--	--	--	--	--
Untreated controls	--	10	--	--	--	--	10	80	10	10	100	1.7

^aTen 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 of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, April 1989 (Plot 101)

Preservative	Average retention (lb/ft ³)	Number in test	Condition of stakes February 1998 (%)								Total removed		Average life (year)
			Serviceable but showing some--				Destroyed by--						
			Decay and		Termite attack		Decay fungi		Termite attack		Number	%	
			Good	Decay	Termite	attack	Decay	fungi	Termite	attack			
Pentachlorophenol (1965 manufacture date) in 20% P9 oil and toluene	0.1	10	40	40	10	10	--	--	--	--	--	--	--
	0.2	10	50	50	--	--	--	--	--	--	--	--	--
	0.4	10	60	40	--	--	--	--	--	--	--	--	--
	0.6	10	80	20	--	--	--	--	--	--	--	--	--
Pentachlorophenol (1989 manufacture date) in 20% P9 oil and toluene	0.1	10	100	--	--	--	--	--	--	--	--	--	--
	0.2	10	90	--	10	--	--	--	--	--	--	--	--
	0.4	10	100	--	--	--	--	--	--	--	--	--	--
	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 (Fed. Spec. TT-W-546)	0.25 (0.13)	15	11.6	--	
	0.30 (0.14)	46	6.1	--	
	0.51 (0.25)	47	--	70% failed after 35 years	
	0.51 (0.26)	15	--	70% failed after 55 years	
	0.60 (0.29)	46	4.6	--	
	0.75 (0.37)	15	--	50% failed after 55 years	
	1.01 (0.50)	47	--	40% failed after 35 years	
	1.54 (0.76)	47	--	22% failed after 35 years	
Ammoniacal copper borate	(0.17)	52	--	75% failed after 25 years	
	(0.22)	52	--	65% failed after 25 years	
	(0.33)	52	--	25% failed after 25 years	
	(0.45)	52	--	No failures after 25 years	
	(0.66)	52	--	15% failed after 25 years	
	(1.33)	52	--	No failures after 25 years	
Ammoniacal copper arsenate (Fed. Spec. TT-W-549)	0.17	52	--	95% failed after 25 years	
	0.23	52	--	30% failed after 25 years	
	0.25 (0.24)	14	--	89% failed after 55 years	
	0.26 (0.25)	47	--	30% failed after 35 years	
	0.48 (0.45)	47	--	10% failed after 35 years	
	0.53 (0.51)	14	--	10% failed after 55 years	
	1.01 (0.97)	14	--	No failures after 55 years	
	1.29 (1.25)	14	--	No failures after 55 years	
Chromated copper arsenate Type I (Fed. Spec. TT-W-550)	0.26 (0.15)	15	28.7	--	
	0.39 (0.22)	47	--	40% failed after 35 years	
	0.50 (0.29)	15	--	30% failed after 55 years	
	0.76 (0.44)	47	--	10% failed after 35 years	
	0.78 (0.44)	15	--	20% failed after 55 years	
	Type II (Fed. Spec. TT-W-550)	0.25 (0.23)	47	--	30% failed after 35 years
		(0.26)	20	--	No failures after 46 years
		(0.37)	20	--	No failures after 46 years
		(0.52)	20	--	No failures after 46 years
		(0.79)	20	--	No failures after 46 years
Type III (Fed. Spec. TT-W-550)	(1.04)	20	--	No failures after 46 years	
	(0.14)	57	--	No failures after 22 years	
	(0.20)	48	--	No failures after 29 years	
	(0.25)	55	--	No failures after 20 years	
	(0.27)	57	--	No failures after 22 years	
	(0.40)	48	--	No failures after 29 years	
	(0.40)	55	--	No failures after 20 years	
	(0.40)	57	--	No failures after 22 years	
	(0.60)	48	--	No failures after 29 years	
	(0.62)	57	--	No failures after 22 years	
(0.77)	55	--	No failures after 20 years		
(0.79)	57	--	No failures after 22 years		

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

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 (Fed. Spec. TT-W-551)	0.49 (0.30)	2	14.2	--	
	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 Stoddard solvent	0.01	38	5.3	--	
	0.02	38	4.2	--	
	0.06	38	5.6	--	
	0.12	38	7.8	--	
Copper-8-quinolinolate AWPA P9 heavy petroleum	0.01	43	--	90% failed after 37 years	
	0.03	43	27.3	--	
	0.06	43	--	90% failed after 37 years	
	0.12	43	--	No failures after 37 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	--	50% failed after 46 years	
	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--continued

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	18.4	--
	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--concluded

Preservative	Average retention ^a (lb/ft ³)	Data from table number	Average life (year)	Remarks
Heavy gas oil (Mid-United States)	4.10	17	--	89% failed after 50 years
	7.90	17	--	80% failed after 50 years
	12.00	17	--	20% failed after 50 years
No. 4 aromatic oil (West Coast)	4.20	22	21.0	--
	8.20	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%	8.00	41	20.8	--
6%	8.00	41	24.0	--
Petroleum solvent controls	4.00	17	7.6	--
	4.10	17	4.4	--
	4.00	17	12.9	--
	7.70	23	14.6	--
	7.90	17	--	90% failed after 50 years
	8.00	45	19.7	--
	8.00	41	23.3	--
	8.00	17	14.6	--
	8.10	18	3.4	--
	8.50	43	20.9	--
	9.80	5	6.3	--
	12.00	17	17.1	--
	12.10	17	--	80% failed after 50 years
	19.40	5	9.1	--
Untreated stakes	--	Misc.	1.8 to 3.6	--

^aRetention values in parentheses are based on preservative oxides or copper metal.

^bSee Tables 5 and 17 for pentachlorophenol in other solvents.