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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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The Forest Products Laboratory is maintained in cooperation with the University of Wisconsin.




# 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 31in. 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] |

[a]50% 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:

| | Description of condition | |
|---|---|---|
| Grade no.[a] | 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 |

[a]This 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/ft$^3$ CZA (oxide basis) had an average life of 9.2 years, and those with approximately 0.69 lb/ft$^3$ (oxide basis) had an average life of 15.3 years. Stakes treated with CZA to retention levels of 0.22 to 0.70 lb/ft$^3$ (oxide basis) have had 100% failures in Wisconsin after 51-1/2 years, and in Mississippi 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/ft$^3$ (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/ft$^3$ (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/ft$^3$ retention level and 30% failure at the 0.23-lb/ft$^3$ retention level for the same exposure (Table 52).

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

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

Pentachlorophenol retention levels of 0.47 lb/ft$^3$ 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/ft$^3$ 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/ft$^3$ 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/ft$^3$, 6.0 lb/ft$^3$ and 9.5-lb/ft$^3$ had an average life of 4.8, 9.7 and 15.4 years, respectively. Termites caused failures at lower retentions (Table 53).

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

Rosin amine-D-pentachlorophenate in Stoddard solvent performed less satisfactorily than pentachlorophenol with that solvent and similar retention levels. Products from naval stores such as rosin oil, oleo resin, and drop liquor concentrate with petroleum solvents appear to have limited value as preservatives but are improved by the addition of pentachlorophenol. Urea (Table 10) has also shown limited protection. Stakes pressure treated with 5.8 lb/ft$^3$ 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/ft$^3$, 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/ft$^3$ of pentachlorophenol showed failures of 100, 100, and 70% respectively, and only the low retention level (0.26 lb/ft$^3$) 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 | | | | | |

[a]C 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 ($kg/m^3$) |
| $^oF$ | ($^oF$ – 32)/1.8 | $^oC$ |

## References


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**Baechler, R.H.; Gjovik, L.R.; Davidson, H.L.** 1978. 1948 cooperative creosote project: review and results of field tests on costs and 2 × 4 stakes. In: Proceedings of the American Wood-Preservers' Association; 1978 April 26–28. 74: 173–180.

**Blew, J.O.** 1948. Comparison of wood preservatives in stake tests. In: Proceedings of the American Wood-Preservers' Association; April 27–29. 88–119.

**Fisher, R.A.; Yates, F**. 1938. Statistical tables for agricultural and medical research. London: Oliver and Boyd. 99 p.

**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 AWPA[a] reference | Table number |
|---|---|---|
| Chemical | | |
| Acid copper chromate | Fed. Spec. TT-W-546; AWPA P5 | 15, 16, 46, 47 |
| Acrylonitrile | — | 36 |
| Aldrin | — | 41 |
| Ammoniacal copper arsenate | Fed. Spec. TT-W-549; AWPA 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; AWPA P5; AWPA P5, Type A | 15, 47 |
| Chromated copper arsenate | Fed. Spec. TT-W-550 Type II; AWPA P5, Type B | 20, 47 |
| Chromated copper arsenate | Fed. Spec. TT-W-550 Type III; AWPA P5, Type C | 48, 49, 51, 55, 57, 72, 73, 74 |
| Chromated copper fluoride (CFK) | — | 59 |
| Chromated zinc arsenate | Formerly in Fed. Spec. TT-W-538; AWPA P5 | 4, 24 |
| Chromated zinc chloride | Fed. Spec. TT-W-551; AWPA P5 | 2, 16, 25, 35, 47 |
| Chromated zinc chloride, copperized | Formerly in Fed. Spec. TT-W-562; AWPA P5 | 31 |
| Chromated zinc chloride (FR) | AWPA P10, Type B | 25 |
| Copper arsenate | AWPA Proc. 1941; pp. 23–31 | 9 |
| Copper carbonate | — | 74 |
| Copper chromate | AWPA Proc. 1941; pp. 23–31 | 9 |
| Copper–chrome–boron (CB) | U.S. Patent No. 3,007,844 | 46 |
| Copper–chrome–phosphorus | — | 48 |
| Copper formate | — | 34 |
| Copper naphthenate | AWPA P8 | 7, 12, 16, 17, 29 |
| Copper oxide | — | 74 |
| Copper-8-quinolinolate | AWPA P8 | 38, 43, 54, 61 |
| Creosote, coal–tar | Fed. Spec. TT-C-645; AWPA P1 | 4, 5, 6, 8, 16–20, 31, 35, 47, 63, 66 |
| Creosote, coal–tar (English) | — | 18, 19 |
| Creosote, coal–tar (low temperature) | — | 28 |
| Creosote, coal–tar (Texas lignite) | — | 32 |
| Creosote, coal–tar solution | Fed. Spec. TT-C-650; AWPA P2 | 18, 47, 70 |
| Creosote, petroleum solution | Fed. Spec. TT-W-568 | 18, 47, 70 |
| Creosote, low xylene insolubles | — | 75 |
| Creosote, toluene | — | 6 |
| Diamyl phenol | — | 14 |
| Dichloro-diphenyl-trichloroethane (DDT) | — | 14 |
| Dieldrin | — | 41 |
| Dodecyl amine | — | 14 |
| Drop-liquor concentrate | — | 27 |
| Fire retardants | — | 53 |
| Fire retardants | AWPA P10 | 25 |
| Fluor chrome arsenate phenol | Fed. Spec. TT-W-535, Type A; AWPA P5 | 2, 33, 37, 47, 49 |
| Fluor chrome arsenate phenol | Fed. Spec. TT-W-535, Type B; AWPA P5 | 47 |
| Fuel oils | — | 5, 17, 27 |

Table 1—Index to materials tested--concluded

| Material | Existing specification or AWPA 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; AWPA P8 | 5, 8, 12, 16, 17, 22, 23, 27, 29, 31, 32, 33, 41, 42, 43, 45, 47, 49, 54, 58, 60, 61, 63, 64, 65, 68, 69, 71, 76 |
| Petroleum oils (various types) | — | 17, 18, 21, 23, 45, 69, 76 |
| Phenyl mercury oleate | — | 12 |
| Phenol-formaldehyde | — | 67 |
| Pyresote | AWPA P10, Type D | 25 |
| Rosin amine D copper acetate complex | — | 27 |
| Rosin amine D pentachlorophenate | — | 22, 23 |
| Rosin oil | — | 27 |
| Sodium pentachlorophenate | — | 2, 5 |
| Sodium tetrachlorophenate | — | 2 |
| Tetrachlorophenol | — | 65, 69 |
| Toluene | — | 6 |
| Tributyltin oxide | — | 36, 41, 61 |
| Urea | — | 10 |
| Zinc–arsenate–chromium salts | — | 20 |
| Zinc chloride | — | 2, 4, 20, 26 |
| Zinc naphthenate | — | 7, 8 |
| Modified 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 |

[a]American Wood Preservers Association.

Table 2--Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with chlorinated phenols and with fluor chrome arsenate phenol--Type A, zinc chloride, and chromated zinc chloride after 15 to 28 years 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)

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

Table 2--Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with chlorinated phenols and with fluor chrome arsenate phenol--Type A, zinc chloride, and chromated zinc chloride after 15 to 28 years 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

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

Table 2--Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with chlorinated phenols and with fluor chrome arsenate phenol--Type A, zinc chloride, and chromated zinc chloride after 15 to 28 years 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

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

Table 2--Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with chlorinated phenols and with fluor chrome arsenate phenol--Type A, zinc chloride, and chromated zinc chloride after 15 to 28 years 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

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

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

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

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

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

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

This study was initiated by R. M. Wirka.

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

| Group | Stake number | Treatment | Approximate average retention (lb/ft$^3$) | Number in test | Condition of stakes January 1967 (%) | | | | | | | | | Average life (year) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Serviceable | Serviceable but showing some-- | | | Destroyed by-- | | | Total removed | | |
| | | | | | | | Termite attack | Decay and termite attack | Decay fungi | Termite attack | Decay fungi and termite attack | Number | % | |
| | | | | | | | Plywood[a] | | | | | | | |
| 1 | 1-1-40 to 1-10-40 | Each ply impregnated with a 50% aqueous 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 flim | -- | 10 | -- | -- | -- | -- | 10 | 30 | 60 | 10 | 100 | 1.9 |
| 11 | 11-1-40 to 11-10-40 | Untreated controls--solid wood (1/4 by 4 by 18 in.) | -- | 10 | -- | -- | -- | -- | -- | 80 | 20 | 10 | 100 | 2.4 |

Table 3--Condition of plywood stakes and resin-impregnated stakes set January 1940 on Harrison Experimental Forest, Saucier, MS, after about 27 years of service (Plot 3)--concluded

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

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

[b]Increase based on treated faces.

[c]Deterioration principally in cores.

[d]Some separation of plies had also occurred.

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

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

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

NOTE--Stakes remaining after the 1952 inspection were takien 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)

| | | | | | Condition of stakes January 2000[a] (%) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Serviceable but showing some-- | | | Destroyed by-- | | | | | |
| | | Average retention ($lb/ft^3$) | | Num-ber in | | | | Decay and | | | Decay fungi and | | | Average life |
| Preservative | Location | Oil | Dry salt[b] | test | Good | Decay | Termite attack | termite attack | Decay fungi | Termite attack | termite attack | Total removed Number | % | (year) |
| Zinc chloride | WI | -- | 0.50 (0.30) | 10 | -- | -- | -- | -- | 100 | -- | -- | 10 | 100 | 14.8 |
| | MS | -- | 0.50 (0.30) | 10 | -- | -- | -- | -- | 60 | -- | 40 | 10 | 100 | 14.2 |
| | Canal | -- | 0.49 (0.29) | 10 | -- | -- | -- | -- | -- | -- | 100 | 10 | 100 | 3.0 |
| | WI | -- | 1.03 (0.61) | 10 | -- | -- | -- | -- | 100 | -- | -- | 10 | 100 | 19.8 |
| | MS | -- | 1.02 (0.61) | 10 | -- | -- | -- | -- | 60 | 10 | 30 | 10 | 100 | 14.4 |
| | Canal | -- | 1.01 (0.60) | 10 | -- | -- | -- | -- | -- | -- | 100 | 10 | 100 | 3.6 |
| | WI | -- | 1.51 (0.90) | 10 | -- | -- | -- | -- | 100 | -- | -- | 10 | 100 | 22.3 |
| | MS | -- | 1.51 (0.90) | 10 | -- | -- | -- | -- | 60 | -- | 40 | 10 | 100 | 18.1 |
| | Canal | -- | 1.49 (0.89) | 10 | -- | -- | -- | -- | -- | -- | 100 | 10 | 100 | 4.5 |
| Chromated zinc 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 | -- | 0.78 (0.52) | 10 | -- | -- | -- | -- | 100 | -- | -- | 10 | 100 | 34.6 |
| | MS | -- | 0.78 (0.52) | 10 | -- | -- | -- | 70 | 10 | -- | 20 | 3 | 30 | -- |
| | Canal | -- | 0.78 (0.52) | 10 | -- | -- | -- | -- | 100 | -- | -- | 10 | 100 | 15.1 |
| | WI | -- | 1.06 (0.70) | 9 | -- | -- | -- | -- | 100 | -- | -- | 10 | 100 | 36.2 |
| | MS | -- | 1.06 (0.70) | 10 | -- | -- | -- | 10 | -- | -- | -- | -- | -- | -- |
| | Canal | -- | 1.05 (0.69) | 10 | -- | -- | -- | -- | 100 | -- | -- | 10 | 100 | 15.3 |

Table 4--Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with chromated zinc arsenate (Boliden salts), zinc chloride and coal-tar creosote after 15 to 60 years 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

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

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

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

[c]Retention based upon total anhydrous salts: $ZnSO_4 + H_3AsO_4 + Na_2HAsO_4 + Na_2Cr_2O_7$.

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

[e]15-min dip at room temperature.

[f]Brush treatment, two coats.

This study was initiated by R. M. Wirka.

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

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

Table 5--Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with chlorinated phenols and coal-tar creosote after 15 to 55 years of service. Stakes placed in test at Barro Colorado Island, Canal Zone, Feburary 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$^3$) Minimum | Maximum | Average | Number in test[b] | Condition of stakes January 1996[c] (%) Good | Serviceable but showing some-- Decay | Termite attack | Decay and termite attack | Destroyed by-- Decay fungi | Termite attack | Decay fungi and termite attack | Total removed Number | % | Average life (year) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1:1.52 chemical ratio | Canal | 0.78 | 0.88 | 0.83 | 10 | -- | -- | -- | -- | 50 | -- | 50 | 10 | 100 | 13.0 |
| | LA | 0.77 | 0.88 | 0.82 | 10 | -- | -- | -- | -- | 30 | -- | 70 | 10 | 100 | 10.0 |
| | FL | 0.79 | 0.86 | 0.82 | 9 | -- | -- | -- | -- | -- | -- | 100 | 10 | 100 | 16.7 |
| | MS | 0.79 | 0.87 | 0.83 | 10 | -- | -- | -- | -- | -- | -- | 100 | 10 | 100 | 18.9 |
| 1:3 chemical ratio | Canal | 0.91 | 1.06 | 0.98 | 10 | -- | -- | -- | -- | -- | -- | 100 | 10 | 100 | 11.5 |
| | LA | 0.90 | 1.07 | 0.98 | 10 | -- | -- | -- | -- | 10 | -- | 90 | 10 | 100 | 8.9 |
| | FL | 0.92 | 1.05 | 0.98 | 10 | -- | -- | -- | -- | -- | -- | 100 | 10 | 100 | 13.2 |
| | MS | 0.92 | 1.06 | 0.98 | 10 | -- | -- | -- | -- | 10 | -- | 90 | 10 | 100 | 16.1 |
| 1:2.27 chemical ratio | Canal | 1.00 | 1.19 | 1.09 | 10 | -- | -- | -- | -- | -- | -- | 100 | 10 | 100 | 12.7 |
| | LA | 1.01 | 1.16 | 1.09 | 10 | -- | -- | -- | -- | 20 | -- | 80 | 10 | 100 | 9.9 |
| | FL | 1.01 | 1.18 | 1.09 | 10 | -- | -- | -- | -- | -- | -- | 100 | 10 | 100 | 18.6 |
| | MS | 1.01 | 1.18 | 1.09 | 10 | -- | -- | -- | -- | -- | -- | 100 | 10 | 100 | 18.6 |
| 1:1.50 chemical ratio | Canal | 1.17 | 1.32 | 1.25 | 10 | -- | -- | -- | -- | 10 | -- | 90 | 10 | 100 | 12.8 |
| | LA | 1.17 | 1.32 | 1.25 | 10 | -- | -- | -- | -- | -- | -- | 100 | 10 | 100 | 14.6 |
| | FL | 1.17 | 1.32 | 1.25 | 10 | -- | -- | -- | 20 | 10 | -- | 70 | 8 | 80 | 16.5[d] |
| | MS | 1.17 | 1.33 | 1.25 | 10 | -- | -- | -- | -- | 10 | 10 | 80 | 10 | 100 | 20.9 |
| 5% pentachlorophenol | Canal | 4.0 | 5.4 | 4.7 | 10 | -- | -- | -- | -- | 40 | -- | 60 | 10 | 100 | 13.0 |
| in fuel oil[e] | LA | 4.0 | 5.4 | 4.8 | 10 | -- | -- | -- | -- | -- | -- | 100 | 10 | 100 | 16.6 |
| | FL | 4.0 | 5.6 | 4.8 | 10 | -- | -- | -- | 40 | -- | -- | 60 | 6 | 60 | 20.0[d] |
| | MS | 4.2 | 5.4 | 4.7 | 10 | -- | -- | -- | -- | -- | -- | 100 | 10 | 100 | 21.0 |
| | Canal | 8.6 | 10.5 | 9.6 | 10 | -- | -- | -- | -- | 30 | -- | 70 | 10 | 100 | 14.4 |
| | LA | 8.4 | 10.9 | 9.6 | 7 | -- | -- | -- | 57 | -- | -- | 43 | 3 | 43 | 23.0[d] |
| | FL | 8.8 | 10.5 | 9.6 | 9 | -- | -- | -- | 67 | -- | -- | 33 | 3 | 33 | 24.0[d] |
| | MS | 8.6 | 10.5 | 9.6 | 10 | -- | -- | -- | -- | 10 | -- | 90 | 10 | 100 | 27.2 |
| | Canal | 14.0 | 16.5 | 15.3 | 10 | -- | -- | -- | 40 | 10 | -- | 50 | 6 | 60 | 15.0[d] |
| | LA | 14.2 | 16.3 | 15.3 | 7 | -- | -- | -- | 100 | -- | -- | -- | -- | -- | -- |
| | FL | 14.2 | 16.3 | 15.3 | 10 | -- | -- | -- | 100 | -- | -- | -- | -- | -- | -- |
| | MS | 14.0 | 16.3 | 15.3 | 10 | -- | -- | -- | 50 | 10 | -- | 40 | 5 | 50 | -- |
| | Canal | 18.6 | 21.5 | 20.1 | 10 | -- | -- | -- | 100 | -- | -- | -- | -- | -- | -- |
| | LA | 18.2 | 21.7 | 20.1 | 7 | -- | -- | -- | 100 | -- | -- | -- | -- | -- | -- |
| | FL | 18.2 | 21.7 | 20.1 | 9 | -- | 22 | -- | 78 | -- | -- | -- | -- | -- | -- |
| | MS | 18.2 | 21.9 | 20.0 | 9 | -- | -- | -- | 89 | -- | -- | 11 | 1 | 11 | -- |

Table 5--Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with chlorinated phenols and coal-tar creosote after 15 to 55 years of service. Stakes placed in test at Barro Colorado Island, Canal Zone, Feburary 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$^3$) Minimum | Maximum | Average | Number in test[b] | Condition of stakes January 1996[c] (%) Serviceable but showing some-- Good | Decay | Termite attack | Decay and termite attack | Destroyed by-- Decay fungi | Termite attack | Decay fungi and termite attack | Total removed Number | % | Average life (year) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3% pentachlorophenol + 2% chloro-2-phenylphenol in fuel oil[e] | Canal | 4.2 | 5.8 | 4.9 | 10 | -- | -- | -- | -- | 20 | -- | 80 | 10 | 100 | 12.6 |
| | LA | 4.4 | 5.8 | 4.9 | 10 | -- | -- | -- | -- | -- | -- | 100 | 10 | 100 | 14.2 |
| | FL | 4.4 | 5.8 | 4.9 | 9 | -- | -- | -- | 22 | -- | -- | 78 | 7 | 78 | 20.0[a] |
| | MS | 4.2 | 5.8 | 4.9 | 10 | -- | -- | -- | -- | -- | -- | 100 | 10 | 100 | 19.2 |
| | Canal | 9.1 | 10.9 | 10.0 | 10 | -- | -- | -- | -- | 50 | -- | 50 | 10 | 100 | 13.7 |
| | LA | 9.1 | 10.9 | 10.0 | 6 | -- | -- | -- | 67 | -- | -- | 33 | 2 | 33 | 24.7[d] |
| | FL | 8.9 | 11.0 | 10.0 | 8 | -- | -- | -- | 75 | -- | -- | 25 | 2 | 25 | 25.3[d] |
| | MS | 8.9 | 11.0 | 10.0 | 10 | -- | -- | -- | -- | 10 | -- | 90 | 10 | 100 | 24.4 |
| | Canal | 14.2 | 16.3 | 15.4 | 10 | -- | -- | -- | 10 | 10 | -- | 80 | 9 | 90 | 12.0[d] |
| | LA | 13.8 | 16.3 | 15.3 | 6 | -- | -- | -- | 100 | -- | -- | -- | -- | -- | -- |
| | FL | 13.8 | 16.3 | 15.3 | 9 | -- | -- | -- | 100 | -- | -- | -- | -- | -- | -- |
| | MS | 14.4 | 16.1 | 15.3 | 10 | -- | -- | -- | -- | 40 | -- | 60 | 10 | 100 | 31.9 |
| Coal-tar creosote, grade 1 | Canal | 3.5 | 6.7 | 4.7 | 10 | -- | -- | -- | 10 | 90 | -- | -- | 9 | 90 | 12.0[d] |
| | LA | 3.3 | 6.7 | 4.6 | 6 | -- | -- | -- | 33 | -- | -- | 67 | 4 | 67 | 22.0[d] |
| | FL | 3.3 | 6.5 | 4.7 | 9 | -- | -- | -- | 33 | 33 | -- | 33 | 6 | 67 | 19.0[d] |
| | MS | 3.5 | 6.5 | 4.6 | 10 | -- | -- | -- | -- | 40 | -- | 60 | 10 | 100 | 21.3 |
| | Canal | 8.4 | 11.6 | 10.0 | 10 | -- | 60 | -- | 20 | 10 | -- | 10 | 2 | 20 | 20.0[d] |
| | LA | 8.6 | 11.2 | 10.0 | 4 | -- | -- | -- | 75 | -- | -- | 25 | 1 | 25 | 26.6[d] |
| | FL | 8.6 | 11.4 | 10.0 | 10 | -- | -- | -- | 90 | 10 | -- | -- | 1 | 10 | -- |
| | MS | 8.4 | 11.4 | 10.0 | 10 | -- | -- | -- | 10 | 60 | -- | 30 | 9 | 90 | -- |
| | Canal | 13.5 | 15.4 | 14.4 | 10 | 10 | 90 | -- | -- | -- | -- | -- | -- | -- | -- |
| | LA | 13.5 | 15.9 | 14.5 | 6 | 50 | 17 | 17 | 17 | -- | -- | -- | -- | -- | -- |
| | FL | 13.5 | 15.9 | 14.4 | 9 | 22 | 56 | -- | 22 | -- | -- | -- | -- | -- | -- |
| | MS | 13.3 | 16.1 | 14.5 | 10 | -- | -- | -- | 100 | -- | -- | -- | -- | -- | -- |
| Fuel oil[e] | Canal | 8.2 | 11.9 | 9.9 | 10 | -- | -- | -- | -- | -- | 60 | 40 | 10 | 100 | 5.9 |
| | LA | 8.4 | 11.7 | 9.8 | 10 | -- | -- | -- | -- | 40 | -- | 60 | 10 | 100 | 8.4 |
| | FL | 8.2 | 11.7 | 9.8 | 8 | -- | -- | -- | -- | 12 | -- | 88 | 8 | 100 | 9.7 |
| | MS | 8.2 | 11.7 | 9.8 | 10 | -- | -- | -- | -- | 20 | 10 | 70 | 10 | 100 | 6.3 |
| | Canal | 18.2 | 21.0 | 19.4 | 10 | -- | -- | -- | -- | -- | 30 | 70 | 10 | 100 | 7.8 |
| | LA | 18.2 | 21.4 | 19.4 | 10 | -- | -- | -- | -- | 50 | -- | 50 | 10 | 100 | 11.9 |
| | FL | 18.2 | 21.4 | 19.4 | 9 | -- | -- | -- | -- | -- | -- | 100 | 10 | 100 | 12.4 |
| | MS | 18.0 | 21.9 | 19.4 | 10 | -- | -- | -- | -- | 30 | 10 | 60 | 10 | 100 | 9.1 |

Table 5--Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with chlorinated phenols and coal-tar creosote after 15 to 55 years of service. Stakes placed in test at Barro Colorado Island, Canal Zone, Feburary 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$^3$) Minimum | Maximum | Average | Number in test[b] | Condition of stakes January 1996[c] (%) Good | Serviceable but showing some-- Decay | Termite attack | Decay and termite attack | Destroyed by-- Decay fungi | Termite attack | Decay fungi and termite attack | Total removed Number | % | Average life (year) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5% pentachlorophenol in | Canal | 0.5 | 1.4 | 0.8 | 10 | -- | -- | -- | -- | -- | 90 | 10 | 10 | 100 | 2.7 |
| fuel oil[e] and naphtha | LA | 0.5 | 1.2 | 0.8 | 10 | -- | -- | -- | -- | 30 | -- | 70 | 10 | 100 | 4.2 |
| 3-min dip | 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 | Canal | 0.7 | 1.2 | 0.9 | 10 | -- | -- | -- | -- | -- | 100 | -- | 10 | 100 | 3.3 |
| soybean oil, naphtha and | LA | 0.5 | 1.2 | 0.9 | 10 | -- | -- | -- | -- | 50 | -- | 50 | 10 | 100 | 3.9 |
| fuel oil [e,f] | FL | 0.5 | 1.6 | 0.9 | 7 | -- | -- | -- | -- | -- | 14 | 86 | 7 | 100 | 5.4 |
| 3-min dip | 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% | Canal | 0.9 | 1.6 | 1.2 | 10 | -- | -- | -- | -- | -- | 100 | -- | 10 | 100 | 2.3 |
| chloro-2-phenylphenol in | LA | 0.9 | 1.6 | 1.2 | 10 | -- | -- | -- | -- | 40 | -- | 60 | 10 | 100 | 4.1 |
| naphtha and fuel oil[e] | FL | 0.7 | 1.6 | 1.2 | 10 | -- | -- | -- | -- | 10 | 10 | 80 | 10 | 100 | 5.0 |
| 3-min dip | 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, Feburary 1941; Bogalusa, LA, March 1941; Jacksonville, FL, March 1941; and Harrison Experimental Forest, Saucier, MS, February 1941 (Plot 5)--concluded

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

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

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

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

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

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

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

[g]Specimens contained some heartwood.

This study was initiated by R. M. Wirka.

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

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

[a]Creosote only.

This study was initiated by R. M. Wirka.

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

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

[a]Last inspection in Mississippi was 1985.

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

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

[d]Average retention based on nine stakes.

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

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

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

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

[d]Two stakes showed some delamination.

[e]One stake showed some delamination.

[f]Stoddard-type solvent used.

NOTE: The stakes remaining in test after the 1950 inspection were taken up and reset in the same general area.

This study was initiated by J. Oscar Blew and R. M. Wirka.

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

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

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

This study was initiated by R. H. Baechler.

Table 10.--Condition of urea-treated Southern Pine stakes (2 by 4 in. nominal by 18 in.) after about 14 to 19 years 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)

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

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

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

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

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

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

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

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

[a]Alcohol-soluble.

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

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

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

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

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

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

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

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

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

This study was initiated by J. Oscar Blew.

Table 13--Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with fire-retardant chemicals after 7 years 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 ($lb/ft^3$) | Number in test | December 1950 stakes destroyed by-- Decay fungi Number | Decay fungi % | Decay fungi and termite attack Number | Decay fungi and termite attack % | Average life (year) |
|---|---|---|---|---|---|---|---|
| Ammonium sulfate, 78 parts; ammonium phosphate, 19 parts; sodium dichromate, 3 parts (by weight) | 3.01 | 10 | 5 | 50 | 5 | 50 | 2.4 |
| | 6.17 | 10 | 6 | 60 | 4 | 40 | 3.4 |
| Ammonium phosphate, 10 parts; ammonium sulfate, 60 parts; borax, 10 parts; boric acid, 20 parts (by weight) | 2.98 | 10 | 4 | 40 | 6 | 60 | 3.9 |
| | 6.19 | 10 | 2 | 20 | 8 | 80 | 4.3 |
| Borax, 60 parts; boric acid, 40 parts (by weight) | 3.01 | 10 | 3 | 30 | 7 | 70 | 6.0 |
| | 6.29 | 10 | 6 | 60 | 4 | 40 | 6.5 |
| Untreated controls | -- | 10 | 2 | 20 | 8 | 80 | 2.2 |

This study was initiated by J. Oscar Blew.

Table 14--Condition of Southern Pine sapwood stakes (2 by 4 in. nominal by 18 in.) treated with various chemicals and of 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 preservative or dry salt[b] (lb/ft$^3$) | Number in test | Condition of stakes January 1999 (%) | | | | | | | | | Average life (year) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Serviceable but showing some-- | | | Destroyed by-- | | | Total removed | | |
| | | | Good | Decay | Termite attack | Decay and termite attack | Decay fungi | Termite attack | Decay fungi and termite attack | Number | % | |
| **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 |

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

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

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

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

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

Table 15--Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with acid copper chromate, chromated copper arsenate type I, and nickel-arsenic-chromium salts after 55 years of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, December 1945 (Plot 15)

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

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

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

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

| | | | | | | Condition of stakes January 1996 (%) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Plywood[a] | | | | | Serviceable but showing some-- | | | Destroyed by-- | | | | | |
| Preservative | Treatment | Number of plies | Veneer thickness (in.) | Average retention[b,c] (lb/ft$^3$) | Number in test | Good | Decay | Termite attack | Decay and termite attack | Decay fungi | Termite attack | Decay fungi and termite attack | Total removed Number | Total removed % | Average life (year) |
| | | | | | Plywood from Veneer Treated Before Gluing | | | | | | | | | | |
| Coal-tar creosote | Pressure | 13 | 1/16 | 40.9 | 10 | 80 | -- | -- | 20 | -- | -- | -- | -- | -- | -- |
| | Pressure | 7 | 1/8 | 30.9 | 9 | 56 | 11 | 11 | 22 | -- | -- | -- | -- | -- | -- |
| | Heating and 1-hour cold bath[d] | 7 | 1/8 | 12.6 | 10 | -- | -- | -- | -- | 10 | 20 | 70 | 10 | 100 | 10.2 |
| | 24-hour cold soak | 13 | 1/16 | 12.9 | 10 | 30 | 40 | 10 | 20 | -- | -- | -- | -- | -- | -- |
| | 24-hour cold soak | 7 | 1/8 | 8.4 | 9 | -- | 11 | -- | 89 | -- | -- | -- | -- | -- | -- |
| | 10-second dipping | 13 | 1/16 | 5.1 | 9[g] | -- | 56 | 11 | 22 | -- | -- | -- | -- | -- | -- |
| | 10-second dipping | 7 | 1/8 | 4.6 | 9 | -- | 22 | -- | 67 | -- | -- | -- | -- | -- | -- |
| Copper naphthenate, 2% copper metal in coal-tar naphtha | 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 | -- | -- | 1 | 11 | -- |
| | 24-hour cold soak | 13 | 1/16 | 10.1 (0.20) | 10 | -- | 40 | -- | 60 | -- | -- | -- | -- | -- | -- |
| | 24-hour cold soak | 7 | 1/8 | 6.2 (0.12) | 10 | -- | -- | -- | 70 | 20 | -- | 10 | 3 | 30 | -- |
| | 10-second dipping | 13 | 1/16 | 4.2 (0.084) | 10 | -- | 20 | -- | 80 | -- | -- | -- | -- | -- | -- |
| | 10-second dipping | 7 | 1/8 | 2.8 (0.056) | 10 | -- | -- | -- | -- | 50 | -- | 50 | 10 | 100 | 32.5 |
| Pentachlorophenol, 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 | -- | 20 | 5 | 50 | -- |
| | Heating and 1-hour cold bath[d] | 7 | 1/8 | 10.3 | 10 | -- | -- | -- | 30 | 10 | -- | 60 | 7 | 70 | -- |
| | 24-hour cold soak | 13 | 1/16 | 7.4 | 9 | -- | -- | -- | 33 | 44 | -- | 22 | 6 | 67 | -- |
| | 24-hour cold soak | 7 | 1/8 | 4.8 | 10 | -- | -- | -- | -- | 10 | 10 | 80 | 10 | 100 | 23.1 |
| | 10-second dipping | 13 | 1/16 | 4.9 | 10 | -- | -- | -- | 10 | 30 | -- | 60 | 9 | 90 | -- |
| | 10-second dipping | 7 | 1/8 | 1.0 | 10 | -- | -- | -- | -- | 10 | -- | 90 | 10 | 100 | 15.8 |
| Chromated zinc chloride | Pressure | 13 | 1/16 | 1.02[e] (0.62) | 6 | -- | -- | -- | 50 | 17 | -- | 33 | 3 | 50 | -- |
| | Pressure | 7 | 1/8 | 1.06[e] (0.65) | 10 | -- | -- | -- | -- | -- | 40 | 60 | 10 | 100 | 25.8 |
| | Heating and 1-hour cold bath[d] | 7 | 1/8 | 0.98 (0.60) | 10 | -- | -- | -- | -- | -- | 50 | 50 | 10 | 100 | 10.3 |
| | 24-hour steeping | 13 | 1/16[f] | 1.07 (0.65) | 8 | -- | -- | -- | 88 | -- | -- | 12 | 1 | 12 | -- |
| | 24-hour steeping | 13 | 1/16 | 1.84 (1.12) | 8[g] | -- | -- | 13 | 50 | 25 | -- | 12 | 3 | 27 | -- |
| | 24-hour steeping | 7 | 1/8[f] | 0.59 (0.36) | 10 | -- | -- | -- | -- | -- | 10 | 90 | 10 | 100 | 17.0 |
| | 24-hour steeping | 7 | 1/8 | 1.30 (0.79) | 10 | -- | -- | -- | -- | 10 | 20 | 70 | 10 | 100 | 23.6 |
| | 10-second dipping | 13 | 1/16[f] | 0.61 (0.37) | 10 | -- | -- | -- | -- | 30 | 10 | 60 | 10 | 100 | 22.7 |
| | 10-second dipping | 13 | 1/16 | 0.66 (0.40) | 10 | -- | -- | -- | -- | 10 | -- | 90 | 10 | 100 | 22.1 |
| | 10-second dipping | 7 | 1/8 | 0.35 (0.21) | 10 | -- | -- | -- | -- | -- | 20 | 80 | 10 | 100 | 10.8 |
| Acid copper chromate | Pressure | 13 | 1/16 | 0.76 (0.38) | 9[g] | -- | -- | 22 | 67 | 11 | -- | -- | 1 | 11 | -- |
| | Pressure | 7 | 1/8 | 0.79 (0.39) | 9 | 11 | -- | -- | 67 | 22 | -- | -- | 2 | 22 | -- |
| | Heating and 1-hour cold bath[d] | 7 | 1/8 | 1.07 (0.53) | 10 | -- | -- | -- | 60 | 30 | -- | 10 | 4 | 40 | -- |
| | 24-hour steeping | 13 | 1/16[f] | 0.88 (0.44) | 9 | 44 | 11 | 33 | 11 | -- | -- | -- | -- | -- | -- |
| | 24-hour steeping | 13 | 1/16 | 1.89 (0.94) | 10 | 40 | -- | 40 | 20 | -- | -- | -- | -- | -- | -- |
| | 24-hour steeping | 7 | 1/8 | 0.54 (0.27) | 9 | 22 | 11 | 22 | 33 | 11 | -- | -- | 1 | 11 | -- |
| | 24-hour steeping | 7 | 1/8 | 1.32 (0.65) | 10 | 20 | 10 | 20 | 50 | -- | -- | -- | -- | -- | -- |
| | 10-second dipping | 13 | 1/16 | 0.87 (0.43) | 10 | -- | -- | -- | 70 | 30 | -- | -- | 3 | 30 | -- |
| | 10-second dipping | 13 | 1/16 | 0.61 (0.30) | 9 | -- | 11 | -- | 44 | 44 | -- | -- | 4 | 44 | -- |
| | 10-second dipping | 7 | 1/8 | 0.27 (0.13) | 10 | -- | -- | -- | -- | 20 | -- | 80 | 10 | 100 | 18.4 |
| | 10-second dipping | 7 | 1/8 | 0.38 (0.19) | 10 | -- | -- | -- | -- | 30 | 10 | 60 | 10 | 100 | 22.2 |

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

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

[a]Plywood glued with hot-press phenolic-resin adhesive.

[b]Oils or dry salt absorbed by 21-by 38-in. plywood panel. Stakes were cut from plywood panels after treatment, and all exposed edges of stakes were soaked in the preservative before stakes were installed.

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

[d]Veneer heated in dryer and then submerged for 1 hour in unheated preservative.

[e]Approximate values.

[f]Veneer treated prior to drying.

[g]Specimens delaminated and were eliminated from test.



This study was initiated by J. Oscar Blew.

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)

| | | | | Condition of stakes January 1998[b] (%) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Serviceable but showing some-- | | | Destroyed by-- | | | | | |
| Oil or preservative | Location | Average retention (lb/ft$^3$) | Number in test[a] | Good | Decay | Termite attack | Decay and termite attack | Decay fungi | Termite attack | Decay fungi and termite attack | Total removed Number | Total removed % | Average life (year) |
| **Unfortified petroleum oil** | | | | | | | | | | | | | |
| Commercial aromatic solvent | MS | 4 | 10 | -- | -- | -- | -- | 10 | -- | 90 | 10 | 100 | 2.3 |
| (Mid-United States) | 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 | MS | 4 | 10 | -- | -- | -- | -- | -- | 10 | 90 | 10 | 100 | 3.4 |
| (Mid-United States) | 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 | MS | 4 | 10 | -- | -- | -- | -- | 60 | -- | 40 | 10 | 100 | 6.4 |
| residual and recycled overhead gas oil) | 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, Saucier, MS, and at Bogalusa, LA, April 1948 (Plot 20)--continued

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

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

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

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

[b]Final inspection at Bogalusa, November 1962.

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

This study was initiated by J. Oscar Blew.

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

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

Table 18--Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with various coal-tar creosotes and creosote solutions after about 44 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

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

[a]Final inspection in Mississippi, November 1968.

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

This study was initiated by J. Oscar Blew.

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

| | | | Condition of stakes February 1998 (%) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Serviceable but showing some-- | | | Destroyed by-- | | | | | |
| Preservative | Average retention (lb/ft$^3$) | Number in test | Good | Decay | Termite attack | Decay and termite attack | Decay fungi | Termite attack | Decay fungi and termite attack | Total removed Number | Total removed % | Average life (year) |
| Coal-tar creosote | 5.3 | 10 | -- | -- | -- | 10 | 70 | -- | 20 | 9 | 90 | -- |
| English vertical retort | 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)

| | | | | Condition of stakes January 1995 (MS) and October 1992 (WI) (%) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Serviceable but showing some-- | | | Destroyed by-- | | | | | | |
| Preservative | Location | Average retention[a] (lb/ft$^3$) | Number in test | Good | Decay | Termite attack | Decay and termite attack | Decay fungi | Termite attack | Decay fungi and termite attack | Total removed Number | Total removed % | Average life (year) |
| 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 | -- | -- | 10 | 1 | 10 | -- |
| | WI | (0.22) | 10 | -- | -- | -- | -- | 100 | -- | -- | 10 | 100 | 18.6 |
| | MS | (0.22) | 10 | -- | -- | -- | 20 | 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 |

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

[b]ZnO, 97 parts; $CrO_3$, 170 parts; and $As_2O_5$, 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)

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

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

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

This study was initiated by J. Oscar Blew.

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

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

This study was initiated by J. Oscar Blew.

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

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

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 (%) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Serviceable but showing some-- | | | | Destroyed by-- | | | | | |
| | | | | Good | Decay | Termite attack | Decay and termite attack | Decay fungi | Termite attack | Decay fungi and termite attack | Total removed Number | Total removed % | Average life (year) |
| Boliden salts AWPA P5-55 | | | | | | | | | | | | | |
| Chromated zinc arsenate ($H_3ASO_4$, | 0.22 | (0.11) | 10 | -- | -- | -- | -- | -- | 10 | 90 | 10 | 100 | 22.1 |
| 20 parts; $Na_2HAsO_4$, 21 parts; | 0.38 | (0.20) | 10 | -- | -- | -- | 60 | -- | -- | 40 | 4 | 40 | -- |
| $Na_2Cr_2O_7 \supseteq H_2O$, 16 parts; and | 0.77 | (0.40) | 10 | -- | -- | -- | 100 | -- | -- | -- | -- | -- | -- |
| $ZnSO_4$, 43 parts)[b] | 1.01 | (0.53) | 10[c] | -- | -- | -- | 100 | -- | -- | -- | -- | -- | -- |
| Boliden salts S-25 ($CrO_3$, 32 parts; | | (0.30) | 10 | -- | -- | -- | 100 | -- | -- | -- | -- | -- | -- |
| CuO, 5 parts; ZnO, 14 parts; and | | (0.50) | 10 | -- | -- | -- | 100 | -- | -- | -- | -- | -- | -- |
| $As_2O_5$, 49 parts) | | (0.75) | 10 | 20 | 10 | -- | 70 | -- | -- | -- | -- | -- | -- |
| | | (1.01) | 9 | 44 | 12 | -- | 44 | -- | -- | -- | -- | -- | -- |
| Untreated controls | -- | | 10 | -- | -- | -- | -- | -- | 20 | 80 | 10 | 100 | 1.9 |

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

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

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

This study was initiated by J. Oscar Blew.

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

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

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

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

This study was initiated by J. Oscar Blew.

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

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

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

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

This study was initiated by J. Oscar Blew.

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

| | | | Condition of stakes December 1991 (%) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Serviceable but showing some-- | | | Destroyed by-- | | | Total removed | | |
| Preservative[a] | 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 | % | Average life (year) |
| 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 | — | 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 (l: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

| | | | Condition of stakes December 1991 (%) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Serviceable but showing some-- | | | Destroyed by-- | | | Total removed | | |
| Preservative | 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 | % | Average life (year) |
| Oleo resin and No. 2 fuel oil (1:7) | 4.1 | 10 | — | — | — | — | 50 | — | 50 | | 100 | 10.0 |
| with 2.94% pentachlorophenol | 8.0 | 10 | — | — | — | — | 30 | — | 70 | | 100 | 13.5 |
| | 12.0 | 10 | — | — | — | — | 20 | — | 80 | | 100 | 16.3 |
| Drop liquor concentrate and | 4.0 | 10 | — | — | — | — | 10 | — | 90 | | 100 | 6.8 |
| No. 2 fuel oil (2:7) | 8.0 | 10 | — | — | — | — | 20 | — | 80 | | 100 | 7.8 |
| | 12.0 | 10 | — | — | — | — | — | — | 100 | | 100 | 10.2 |
| Drop liquor concentrate and No. 2 fuel | 4.0 | 10 | — | — | — | — | — | — | 100 | | 100 | 12.2 |
| oil (1:7) with 3.03% pentachlorophenol | 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 | 4.1 | 10 | — | — | — | — | 50 | — | 50 | | 100 | 8.0 |
| copper acetate complex | 8.0 | 10 | — | — | — | — | 50 | — | 50 | | 100 | 9.6 |
| | 12.1 | 10 | — | — | — | — | 60 | — | 40 | | 100 | 15.9 |
| Untreated controls | — | 10 | — | — | — | — | — | 30 | 70 | | 100 | 2.8 |

[a]Ratios and percentages on weight basis.
[b]One stake missing, eliminated from test.
This study was initiated by J. Oscar Blew.

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

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

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

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) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | From weight[b] | | By analysis[c] | | Serviceable but showing some-- | | | Destroyed by-- | | | Total removed | | |
| | | | Solution | Pentachlorophenol or copper metal | Pentachlorophenol or copper metal | Good | Decay | Termite attack | Decay and termite attack | Decay fungi | Termite attack | Decay fungi and termite attack | Number | % | |
| Pentachlorophenol, 2.5% in light aromatic solvent[e] | None | 10 | 4.2 | 0.105 | 0.082 | -- | -- | -- | -- | 20 | 10 | 70 | 10 | 100 | 11.6 |
| | Steaming | 10 | 4.2 | 0.105 | 0.091 | -- | -- | -- | -- | 10 | -- | 90 | 10 | 100 | 12.4 |
| | 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[e] | None | 10 | 4.6 | 0.230 | 0.186 | -- | -- | -- | -- | 10 | -- | 90 | 10 | 100 | 14.1 |
| | Steaming | 10 | 4.8 | 0.240 | 0.222 | -- | -- | -- | -- | 10 | -- | 90 | 10 | 100 | 12.9 |
| | 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] | Number in test | Average preservative retention (lb/ft$^3$) | | | Condition of stakes October 1992 (%) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | From weight[b] | | By analysis[c] | | | Serviceable but showing some-- | | Destroyed by-- | | | Total removed | | Average life |
| | | | Solution | Pentachlorophenol or copper metal | Pentachlorophenol or copper metal | Good | Decay | Termite attack | Decay and termite attack | Decay fungi | Termite attack | Decay fungi and termite attack | Number | % | (year) |
| Copper naphthenate, 0.5% copper in light aromatic solvent | None | 10 | 4.6 | 0.023 | 0.020 | -- | -- | -- | -- | 50 | -- | 50 | 10 | 100 | 11.0 |
| | Steaming | 10 | 4.5 | 0.022 | 0.020 | -- | -- | -- | -- | 40 | -- | 60 | 10 | 100 | 12.0 |
| | Vapor cleaning | 10 | 4.6 | 0.023 | 0.018 | -- | -- | -- | -- | 40 | -- | 60 | 10 | 100 | 11.8 |
| Copper naphthenate, 0.59% copper in light aromatic solvent | Steaming | 10 | 4.4 | 0.026 | 0.023 | -- | -- | -- | -- | 30 | -- | 70 | 10 | 100 | 14.3 |
| Copper naphthenate, 0.7% copper in light aromatic solvent | Vapor cleaning | 10 | 4.2 | 0.029 | 0.021 | -- | -- | -- | -- | 30 | -- | 70 | 10 | 100 | 13.7 |
| Untreated controls | -- | 10 | -- | -- | -- | -- | -- | -- | -- | -- | 60 | 40 | 10 | 100 | 2.4 |

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

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

[c]Analysis performed 2 months after treatment.

[d]One-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.

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

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

This study was initiated by J. Oscar Blew.

Table 30--Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with Basilit UA[a] after about 41 years of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, December 1954 (Plot 40)

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

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

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

This study was initiated by J. Oscar Blew.

Table 31--Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) of uninfected and *Trichoderma* mold-infected wood, 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)

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

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

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

This study was initiated by Edward Panek.

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

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

This study was initiated by J. Oscar Blew.

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

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

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

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

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

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

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

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

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

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

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

This study was initiated by Edward Panek.

Table 34--Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with copper formate, after about 44 years of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, December 1956 (Plot 47)

| | | | Condition of stakes January 2000 (%) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Serviceable but showing some-- | | | Destroyed by-- | | | | | |
| Preservative | Average retention (copper) (lb/ft$^3$) | Number in test | Good | Decay | Termite attack | Decay and termite attack | Decay fungi | Termite attack | Decay fungi and termite attack | Total removed Number | Total removed % | Average life (year) |
| 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)

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

[a]Copper oxide and chlorophenols.

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

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

This study was initiated by J. Oscar Blew.

Table 36--Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with tributyltin oxide, cyanoethylated stakes, and stakes treated for destruction of thiamine, after approximately 9-1/2 years 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)

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

[a]In Stoddard solvent.

[b]Used with ammonium hydroxide for cyanoethylation.

[c]Followed by steaming for thiamine destruction.

This study was initiated by J. Oscar Blew.

Table 37--Condition of Southern Pine stakes (2 by 4 in. nominal and 3/4 by 3/4 in. by 18 in.) treated with fluor chrome arsenate phenol type A (AWPA-P5 and modification) after about 30 years 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 (%) | | | | | | | | | Average life (year) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Serviceable but showing some-- | | | Destroyed by-- | | | Total removed | | |
| | | | Good | Decay | Termite attack | Decay and termite attack | Decay fungi | Termite attack | Decay fungi and termite attack | Number | % | |
| **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 |

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

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

[c]Sodium pentachlorophenate substituted for dinitrophenol.

This study was initiated by J. Oscar Blew.

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

| Preservative | Average retention: Solution (lb/ft$^3$) | Average retention: Copper-8-quinolinolate (lb/ft$^3$) | Number in test | Condition of stakes November 1968 (%): Good | Serviceable but showing some--: Decay | Serviceable but showing some--: Termite attack | Serviceable but showing some--: Decay and termite attack | Destroyed by--: Decay fungi | Destroyed by--: Termite attack | Destroyed by--: Decay fungi and termite attack | Total removed: Number | Total removed: % | Average life (year) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Copper-8-quinolinolate | | | | | | | | | | | | | |
| 0.1% in Stoddard solvent | 9.9 | 0.010 | 10 | -- | -- | -- | -- | 10 | -- | 90 | 10 | 100 | 5.3 |
| 0.1% in Stoddard solvent | 9.9 | 0.020 | 10 | -- | -- | -- | -- | 20 | 10 | 70 | 10 | 100 | 4.2 |
| 0.1% in Stoddard solvent | 10.0 | 0.060 | 10 | -- | -- | -- | 10 | 40 | -- | 50 | 9 | 90 | 5.6[a] |
| 0.1% in Stoddard solvent | 10.2 | 0.123 | 10 | -- | -- | -- | 10 | 60 | -- | 30 | 9 | 90 | 7.8[a] |
| 0.6% paraffin, 2%; and Pentalyn-H, 10% in Stoddard solvent | 10.1 | 0.061 | 10 | -- | 10 | -- | 20 | 70 | -- | -- | 7 | 70 | 8.8[a] |
| 0.6%; Dieldrin, 0.5% in Stoddard solvent | 10.1 | 0.060 | 10 | -- | -- | -- | 10 | 70 | -- | 20 | 9 | 90 | 6.6[a] |
| Untreated controls | -- | -- | 10 | -- | -- | -- | -- | -- | 20 | 80 | 10 | 100 | 2.2 |

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

This study was initiated by J. Oscar Blew.

Table 39--Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with blends of extracts from Texas lignite tar after about 40 years of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, December 1960 (Plot 57)

| | | | Condition of stakes January 2000 (%) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Serviceable but showing some-- | | | Destroyed by-- | | | | | |
| Lignite-tar extracts | Average retention ($lb/ft^3$) | Number in test | Good | Decay | Termite attack | Decay and termite attack | Decay fungi | Termite attack | Decay fungi and termite attack | Total removed Number | Total removed % | Average life (year) |
| Hexane-soluble residue, 25%; and hexane | 5.1 | 10 | -- | -- | -- | -- | 20 | -- | 80 | 10 | 100 | 16.2 |
| distillate, 75% (by weight) | 10.0 | 10 | -- | -- | -- | 30 | 30 | -- | 40 | 7 | 70 | -- |
| | 14.1 | 10 | -- | -- | -- | 70 | 30 | -- | -- | 3 | 30 | -- |
| High-boiling methanol solubles, 25%; hexane | 5.0 | 10 | -- | -- | -- | -- | -- | -- | 100 | 10 | 100 | 18.8 |
| distillate, 75% (by weight) | 9.3 | 10 | -- | -- | -- | 70 | 10 | -- | 20 | 3 | 30 | -- |
| | 15.2 | 10 | -- | -- | -- | 100 | -- | -- | -- | -- | -- | -- |
| High-boiling methanol solubles, 10%; hexane- | 5.1 | 10 | -- | -- | -- | -- | 10 | -- | 90 | 10 | 100 | 18.8 |
| soluble residue, 20%; and hexane distillate, | 10.1 | 10 | -- | -- | -- | 50 | 20 | -- | 30 | 5 | 50 | -- |
| 70% (by weight) | 14.7 | 10 | -- | -- | -- | 100 | -- | -- | -- | -- | -- | -- |
| High-boiling methanol solubles, 20%; hexane- | 5.2 | 10 | -- | -- | -- | -- | 20 | -- | 80 | 10 | 100 | 20.2 |
| soluble residue, 10%; and hexane distillate, | 10.0 | 10 | -- | -- | -- | 100 | -- | -- | -- | -- | -- | -- |
| 70% (by weight) | 15.2 | 10 | -- | -- | -- | 100 | -- | -- | -- | -- | -- | -- |
| High-boiling methanol solubles, 15%; and hexane | 5.0 | 10 | -- | -- | -- | -- | 10 | 10 | 80 | 10 | 100 | 22.0 |
| distillate, 85% (by weight) | 10.2 | 10 | -- | -- | -- | 90 | -- | -- | 10 | 1 | 10 | -- |
| | 14.9 | 10 | -- | 10 | -- | 90 | -- | -- | -- | -- | -- | -- |
| High-boiling methanol solubles, 24,5%; hexane | 5.1 | 10 | -- | -- | -- | 10 | 30 | -- | 30 | 6 | 60 | -- |
| distillate, 74.5%; and petroleum sulfonate | 9.9 | 10 | -- | -- | -- | 70 | 20 | -- | 10 | 3 | 30 | -- |
| (Morpel X-914), 1% (by weight) | 15.0 | 10 | -- | -- | -- | 10 | -- | -- | -- | -- | -- | -- |
| 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-- | | | Total removed | | |
| | | Good | Decay | Termite attack | Decay and termite attack | Decay fungi | Termite attack | Decay fungi and termite attack | Number | % | |
| Embedded fiberboard[a] | 6[b] | -- | -- | -- | -- | 100[c] | -- | -- | 6 | 100 | 11.3 |
| Douglas-fir heartwood | 10 | -- | -- | -- | -- | 70 | 10 | 20 | 10 | 100 | 3.0 |

[a]Western hemlock strands in portland cement.

[b]Stakes missing and eliminated from test.

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

Table 41--Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with tributyltin oxide and pentachlorophenol solutions with heavy and light petroleum solvents, with and without the addition of Dieldrin and Aldrin, after about 40 years of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, December 1960 (Plot 56)

| | | | Condition of stakes January 2000 (%) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Serviceable but showing some-- | | | Destroyed by-- | | | | | |
| Preservative | Average retention (lb/ft$^3$) | Number in test[a] | Good | Decay | Termite attack | Decay and termite attack | Decay fungi | Termite attack | Decay fungi and termite attack | Total removed Number | Total removed % | Average life (year) |
| **Solutions with Stoddard solvent** | | | | | | | | | | | | |
| Tributyltin oxide, 0.3%; and Dieldrin, 0.3% | 8.0 | 10 | -- | -- | -- | -- | 90 | -- | 10 | 10 | 100 | 4.9 |
| Tributyltin oxide, 0.6%; and Dieldrin, 0.3% | 8.0 | 10 | -- | -- | -- | -- | 90 | -- | 10 | 10 | 100 | 6.9 |
| Tributyltin oxide, 0.3%; and Aldrin, 0.3% | 8.0 | 10 | -- | -- | -- | -- | 90 | -- | 10 | 10 | 100 | 4.6 |
| Tributyltin oxide | | | | | | | | | | | | |
| 0.3% | 8.2 | 10 | -- | -- | -- | -- | 80 | -- | 20 | 10 | 100 | 4.5 |
| 0.6% | 7.9 | 10 | -- | -- | -- | -- | 50 | -- | 50 | 10 | 100 | 7.0 |
| Tributyltin oxide, 0.6%; Dieldrin, 0.3%; and water repellent, 4.7% | 8.0 | 10 | -- | -- | -- | -- | 100 | -- | -- | 10 | 100 | 6.9 |
| Tributyltin oxide, 0.6%; Aldrin, 0.3%; and water repellent, 4.7% | 8.0 | 10 | -- | -- | -- | -- | 70 | -- | 30 | 10 | 100 | 5.3 |
| Dieldrin, 0.6%; | 8.0 | 10 | -- | -- | -- | -- | 90 | -- | 10 | 10 | 100 | 4.0 |
| Pentachlorophenol, 5%; pine oil, 5%; and water repellent, 4.7% | 8.0 | 9 | -- | -- | -- | 11 | 44 | -- | 44 | 8 | 89 | -- |
| Pentachlorophenol, 5%; pine oil, 5%; Dieldrin 0.3%; and water repellent, 4.7% | 8.0 | 10 | -- | -- | -- | 10 | 40 | -- | 50 | 9 | 90 | -- |
| Water repellent, 4.7% | 8.0 | 10 | -- | -- | -- | -- | 80 | -- | 20 | 10 | 100 | 4.3 |
| Pentachlorophenol, 5%; pine oil, 5%; Dieldrin 0.3% stabilizer wax, 2%; and water repellent, 4.7% | 8.0 | 9 | -- | -- | -- | 67 | 33 | -- | -- | 3 | 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 contols | 8 | 9 | -- | -- | -- | -- | 11 | -- | 89 | 9 | 100 | 23.3 |
| Untreated controls | -- | 10 | -- | -- | -- | -- | 70 | -- | 30 | 10 | 100 | 3.1 |

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

This study was initiated by Edward Panek.

Table 42--Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in. and 3/4 by 3/4 in. by 17 in.) treated with pentachlorophenol in liquefied petroleum gas and in heavy and light petroleum solvents after about 38-1/2 years 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 (lb/in$^3$) | | | Number in test | Condition of stakes January 2000 (%) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | By weight | | By analysis | | | Serviceable but showing some-- | | | Destroyed by-- | | | | | |
| | | Solution | Pentachlorophenol | Pentachlorophenol | | Good | Decay | Termite attack | Decay and termite attack | Decay fungi | Termite attack | Decay fungi and termite attack | Total removed Number | Total removed % | Average life (year) |
| | | | | | | Stakes 2 by 4 nominal by 18 in. | | | | | | | | | |
| Pentachlorophenol in | MS | -- | -- | 0.14[b] | 10 | -- | -- | -- | -- | 10 | -- | 90 | 10 | 100 | 18.9 |
| liquefied petroleum gas[a] | MS | -- | -- | 0.19[b] | 10 | -- | -- | -- | -- | 10 | -- | 90 | 10 | 100 | 15.9 |
| | MS | -- | -- | 0.34[b] | 10 | -- | -- | -- | 90 | -- | -- | 10 | 1 | 10 | -- |
| | MS | -- | -- | 0.58[b] | 10 | -- | -- | -- | 100 | -- | -- | -- | -- | -- | -- |
| Solutions with AWPA P9 (heavy petroleum solvent) | | | | | | | | | | | | | | | |
| Pentachlorophenol | | | | | | | | | | | | | | | |
| 3.5% (by weight) | MS | 3.0 | 0.11 | 0.14 | 10 | -- | -- | -- | 10 | -- | -- | 90 | 9 | 90 | -- |
| | MS | 4.5 | 0.19 | 0.22 | 10 | -- | -- | -- | 40 | -- | -- | 60 | 6 | 60 | -- |
| 4.2% (by weight) | MS | 6.8 | 0.29 | 0.32 | 10 | -- | -- | -- | 100 | -- | -- | -- | -- | -- | -- |
| | MS | 16.0 | 0.67 | 0.69 | 10 | 2 | 1 | -- | 70 | -- | -- | -- | -- | -- | -- |
| Solutions with Stoddard solvent | | | | | | | | | | | | | | | |
| Pentachlorophenol, 4.0%; | MS | 3.6 | 0.14 | 0.14 | 10 | -- | -- | -- | -- | 10 | -- | 90 | 10 | 100 | 13.7 |
| paraffin, 2%; and | MS | 4.6 | 0.18 | 0.18 | 10 | -- | -- | -- | -- | -- | -- | 100 | 10 | 100 | 15.9 |
| Pentalyn-H, 10% (by weight) | | | | | | | | | | | | | | | |
| Pentachlorophenol, 5%; | MS | 7.6 | 0.38 | 0.39 | 10 | -- | -- | -- | 20 | -- | -- | 80 | 8 | 80 | -- |
| paraffin, 2%; and | MS | 13.5 | 0.67 | 0.70 | 10 | -- | -- | -- | 100 | -- | -- | -- | -- | -- | -- |
| Pentalyn-H, 10% (by weight) | | | | | | | | | | | | | | | |
| Untreated controls | MS | -- | -- | -- | 10 | -- | -- | -- | -- | 30 | 30 | 40 | 10 | 100 | 2.1 |

Table 42--Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in. and 3/4 by 3/4 in. by 17 in.) treated with pentachlorophenol in liquefied petroleum gas and in heavy and light petroleum solvents after about 38-1/2 years 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$^3$) | | | Number in test | Condition of stakes January 2000 (%) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | By weight | | By analysis | | | | Serviceable but showing some-- | | Destroyed by-- | | | Total removed | | Average life |
| | | Solution | Pentachlorophenol | Pentachlorophenol | | Good | Decay | Termite attack | Decay and termite attack | Decay fungi | Termite attack | Decay fungi and termite attack | Number | % | (year) |
| | | | | | | 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 | MS | 3.2 | 0.14 | -- | 9[d] | -- | -- | -- | -- | 11 | -- | 89 | 9 | 100 | 14.5 |
| (heavy petroleum solvent) | WI | 3.3 | 0.14 | -- | 5[d] | -- | -- | -- | -- | 100 | -- | -- | 5 | 100 | 16.4 |
| Pentachlorophenol | MS | 3.8 | 0.16 | -- | 10 | -- | -- | -- | -- | 10 | 10 | 80 | 10 | 100 | 14.5 |
| 4.2% (by weight) | WI | 3.9 | 0.16 | -- | 7[d] | -- | -- | -- | -- | 100 | -- | -- | 7 | 100 | 15.8 |
| | MS | 5.7 | 0.24 | -- | 4[d] | -- | -- | -- | -- | 25 | -- | 75 | 4 | 100 | 18.4 |
| | WI | 5.5 | 0.23 | -- | 5[d] | -- | -- | -- | -- | 100 | -- | -- | 5 | 100 | 17.8 |
| | MS | 16.7 | 0.70 | -- | 4[d] | -- | -- | -- | -- | | -- | 100 | 4 | 100 | 30.4 |
| | WI | 17.2 | 0.73 | -- | 4[d] | -- | -- | -- | -- | 100 | -- | -- | 4 | 100 | 22.4 |
| Solutions in Stoddard solvent | | | | | | | | | | | | | | | |
| Pentachlorophenol, 4.0%; | MS | 3.5 | 0.14 | -- | 9[d] | -- | -- | -- | -- | 44 | 11 | 44 | 9 | 100 | 5.6 |
| paraffin, 2%; and | WI | 3.0 | 0.12 | -- | 11[d] | -- | -- | -- | -- | 100 | -- | -- | 11 | 100 | 10.8 |
| Pentalyn-H, 10% (by weight) | MS | 3.9 | 0.16 | -- | 10 | -- | -- | -- | -- | 30 | -- | 70 | 10 | 100 | 4.9 |
| | WI | 4.0 | 0.16 | -- | 13[d] | -- | -- | -- | -- | 100 | -- | -- | 13 | 100 | 10.8 |
| Pentachlorophenol, 5.0%; | MS | 6.4 | 0.32 | -- | 9[d] | -- | -- | -- | -- | 22 | -- | 78 | 9 | 100 | 14.4 |
| paraffin, 2.0%; and | WI | 6.6 | 0.33 | -- | 14 | -- | -- | -- | -- | 100 | -- | -- | 14 | 100 | 14.4 |
| Pentalyn-H, 10% (by weight) | MS | 14.4 | 0.72 | -- | 4[d] | -- | -- | -- | -- | 50 | -- | 50 | 4 | 100 | 24.9 |
| | WI | 14.6 | 0.73 | -- | 5[d] | -- | -- | -- | -- | 100 | -- | -- | | 100 | 21.0 |
| Untreated controls | MS | -- | -- | -- | 10 | -- | -- | -- | -- | 40 | 30 | 30 | 10 | 100 | 1.5 |
| | WI | -- | -- | -- | 15 | -- | -- | -- | -- | 100 | -- | -- | 15 | 100 | 4.0 |

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

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

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

[d]Stakes injured mechanically and eliminated from test.



This study was initiated by J. Oscar Blew.

Table 43--Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with copper-8-quinolinolate and pentachlorophenol in heavy petroleum solvent after 37 years of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, December 1963 (Plot 62)

| | Average retention | | | Condition of stakes January 2000 (%) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Serviceable but showing some-- | | | Destroyed by-- | | | | | |
| Preservative | Solution (lb/ft$^3$) | Copper-8-quinolinolate or penta-chlorophenol (lb/ft$^3$) | Num-ber in test | Good | Decay | Termite attack | Decay and termite attack | Decay fungi | Termite attack | Decay fungi and termite attack | Total removed Number | Total removed % | Average life (year) |
| Solutions with heavy petroleum solvent (AWPA P9):Copper-8-quinolinolate | | | | | | | | | | | | | |
| 0.15% | 9.4 | 0.014 | 10 | -- | -- | -- | 10 | 20 | 10 | 60 | 9 | 90 | -- |
| 0.3% | 10.1 | 0.030 | 10 | -- | -- | -- | -- | 20 | -- | 80 | 10 | 100 | 27.3 |
| 0.6% | 9.9 | 0.059 | 10 | -- | -- | -- | 10 | 50 | -- | 40 | 9 | 90 | -- |
| 1.2% | 10.3 | 0.124 | 9[a] | -- | -- | -- | 100 | -- | -- | -- | -- | -- | -- |
| Pentachlorophenol 4.98% | 10.6 | 0.540 | 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 |

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

This study was initiated by L. R. Gjovik.

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

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

This study was initiated by H. L. Davidson.

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

| | Average retention ($lb/in^3$) | | | Condition of stakes February 1998 (%) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Serviceable but showing some-- | | Destroyed by-- | | | | | |
| Preservative | Solution | Pentachlorophenol | Number in test[c] | Good | Decay | Termite attack | Decay and termite attack | Decay fungi | Termite attack | Decay fungi and termite attack | Total removed Number | Total removed % | Average life (year) |
| **Stakes 2 by 4 in.** | | | | | | | | | | | | | |
| Pentachlorophenol in | -- | 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 |

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

[b]With cosolvent of isopropyl ether.

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

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

[e]Computed.

This study was initiated by J. Oscar Blew.

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

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

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

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

This study was initiated by J. Oscar Blew.

Table 47--Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with 11 standard wood preservatives after about 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)

| | | | | | Condition of stakes January 2002 (MS) and January 1984 (LA) (%) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Serviceable but showing some-- | | | Destroyed by-- | | | | | |
| Preservative | AWPA Standard | Location | Average retention[a] (lb/ft$^3$) | Number in test[b] | Good | Decay | Termite attack | Decay and termite attack | Decay fungi | Termite attack | Decay fungi and termite attack | Total removed Number | Total removed % | Average life (year) |
| Creosote, coal-tar | P1-65 | LA | 4.9 | 10 | 10 | -- | -- | 50 | 40 | -- | -- | 4 | 40 | -- |
| | | | 10.2 | 10 | 60 | 20 | -- | 20 | -- | -- | -- | -- | -- | -- |
| | | | 15.0 | 10 | 100 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | | MS | 5.1 | 10 | -- | -- | -- | 40 | 50 | -- | 10 | 6 | 60 | -- |
| | | | 9.7 | 10 | -- | 10 | -- | 90 | -- | -- | -- | -- | -- | -- |
| | | | 15.4 | 10 | -- | 40 | -- | 60 | -- | -- | -- | -- | -- | -- |
| Creosote-coal-tar solution (70-30) | P2-68 | LA | 4.7 | 10 | -- | -- | -- | 60 | 40 | -- | -- | 4 | 40 | -- |
| | | | 9.9 | 10 | 90 | 10 | -- | -- | -- | -- | -- | -- | -- | -- |
| | | | 14.9 | 10 | 100 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | | MS | 3.9 | 10 | -- | -- | -- | 20 | 50 | -- | 30 | 8 | 80 | -- |
| | | | 10.7 | 10 | 10 | 40 | -- | 50 | -- | -- | -- | -- | -- | -- |
| | | | 16.2 | 10 | 20 | 80 | -- | -- | -- | -- | -- | -- | -- | -- |
| Creosote-petroleum solution (50-50) | P3-67 | LA | 5.8 | 10 | 10 | 10 | -- | 40 | 30 | -- | 10 | 4 | 40 | -- |
| | | | 12.1 | 10 | 70 | 10 | -- | 20 | -- | -- | -- | -- | -- | -- |
| | | | 18.3 | 10 | 100 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | | MS | 6.0 | 10 | -- | -- | -- | 30 | 50 | -- | 20 | 7 | 70 | -- |
| | | | 12.1 | 10 | 10 | 30 | -- | 60 | -- | -- | -- | -- | -- | -- |
| | | | 18.5 | 10 | 10 | 60 | 10 | 20 | -- | -- | -- | -- | -- | -- |
| Pentachlorophenol, 5% in heavy petroleum | P8-64 and P9-67 | LA | 5.8 | 10 | 40 | -- | -- | 60 | -- | -- | -- | -- | -- | -- |
| | | | 9.9 | 10 | 70 | 10 | -- | 20 | -- | -- | -- | -- | -- | -- |
| | | | 15.1 | 10 | 80 | 20 | -- | -- | -- | -- | -- | -- | -- | -- |
| | | MS | 7.0 | 10 | -- | -- | -- | 80 | 10 | -- | 10 | 2 | 20 | -- |
| | | | 9.5 | 10 | -- | -- | -- | 100 | -- | -- | -- | -- | -- | -- |
| | | | 14.6 | 9 | -- | 22 | -- | 78 | -- | -- | -- | -- | -- | -- |
| Acid copper chromate | P5-68 | LA | 0.50 (0.25) | 10 | -- | -- | -- | -- | 30 | 60 | 10 | 10 | 100 | 8.5 |
| | | | 1.00 (0.50) | 9 | -- | 11 | -- | 78 | -- | -- | 11 | 1 | 11 | -- |
| | | | 1.49 (0.74) | 9 | 20 | 10 | -- | 60 | -- | -- | -- | -- | -- | -- |
| | | MS | 0.51 (0.25) | 10 | -- | -- | -- | 30 | 60 | -- | 10 | 7 | 70 | -- |
| | | | 1.01 (0.50) | 10 | 40 | 20 | -- | -- | 40 | -- | -- | 4 | 40 | -- |
| | | | 1.54 (0.76) | 9 | 56 | -- | 11 | 11 | 22 | -- | -- | 2 | 22 | -- |
| Ammoniacal copper arsenate | P5-68 | LA | 0.25 (0.24) | 10 | -- | -- | -- | 10 | 70 | -- | 20 | 9 | 90 | -- |
| | | | 0.46 (0.44) | 10 | -- | -- | -- | 80 | 20 | -- | -- | 2 | 20 | -- |
| | | | 0.67 (0.63) | 10 | 10 | 10 | | 70 | 10 | -- | -- | 1 | 10 | -- |
| | | MS | 0.26 (0.25) | 10 | -- | 10 | -- | 60 | 20 | -- | 10 | 3 | 30 | -- |
| | | | 0.48 (0.45) | 10 | -- | 60 | -- | 30 | 10 | -- | -- | 1 | 10 | -- |
| | | | 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

| | | | | | Condition of stakes January 2002 (MS) and January 1984 (LA) (%) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Serviceable but showing some-- | | | Destroyed by-- | | | | | |
| Preservative | AWPA Standard | Location | Average retention (lb/ft$^3$) | Number in test[b] | Good | Decay | Termite attack | Decay and termite attack | Decay fungi | Termite attack | Decay fungi and termite attack | Total removed Number | Total removed % | Average life (year) |
| Chromated copper arsenate type A | P5-68 | LA | 0.40 (0.23) | 10 | -- | -- | -- | 70 | 10 | 10 | 10 | 3 | 30 | -- |
| | | | 0.76 (0.44) | 10 | 50 | 10 | -- | 40 | -- | -- | -- | -- | -- | -- |
| | | | 1.11 (0.64) | 10 | 90 | 10 | -- | -- | -- | -- | -- | -- | -- | -- |
| | | MS | 0.39 (0.22) | 10 | -- | 20 | 10 | 30 | 30 | -- | 10 | 4 | 40 | -- |
| | | | 0.76 (0.44) | 10 | 50 | -- | 40 | -- | 10 | -- | -- | 1 | 10 | -- |
| | | | 1.14 (0.66) | 8 | 100 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Chromated copper arsenate type B | P5-68 | LA | 0.25 (0.23) | 10 | -- | -- | -- | 80 | 10 | -- | 10 | 2 | 20 | -- |
| | | | 0.44 (0.40) | 10 | 20 | 30 | -- | 50 | -- | -- | -- | -- | -- | -- |
| | | | 0.65 (0.59) | 10 | 80 | 10 | -- | 10 | -- | -- | -- | -- | -- | -- |
| | | MS | 0.25 (0.23) | 10 | -- | 20 | -- | 50 | 30 | -- | -- | 3 | 30 | -- |
| | | | 0.42 (0.38) | 10 | -- | 20 | -- | 60 | 10 | 10 | -- | 2 | 20 | -- |
| | | | 0.61 (0.55) | 10 | 30 | 50 | 20 | -- | -- | -- | -- | -- | -- | -- |
| Chromated zinc chloride | P5-68 | LA | 0.76 (0.46) | 10 | -- | -- | -- | -- | -- | 80 | 20 | 10 | 100 | 6.0 |
| | | | 1.02 (0.62) | 10 | -- | -- | -- | -- | 10 | 60 | 30 | 10 | 100 | 7.2 |
| | | | 1.50 (0.92) | 9 | -- | -- | -- | -- | 11 | 67 | 22 | 9 | 100 | 8.3 |
| | | MS | 0.76 (0.46) | 10 | -- | -- | -- | -- | 30 | -- | 70 | 10 | 100 | 13.8 |
| | | | 1.02 (0.62) | 10 | -- | -- | -- | -- | 30 | -- | 70 | 10 | 100 | 14.9 |
| | | | 1.57 (0.96) | 10 | -- | -- | -- | -- | 70 | -- | 30 | 10 | 100 | 17.8 |
| Fluor chrome arsenate phenol type A | P5-68 | LA | 0.35 (0.22) | 10 | -- | -- | -- | 10 | 50 | 20 | 20 | 9 | 90 | -- |
| | | | 0.50 (0.31) | 10 | -- | -- | -- | 20 | 10 | 10 | 60 | 8 | 80 | -- |
| | | | 1.11 (0.69) | 10 | -- | -- | -- | 30 | 70 | -- | -- | 7 | 70 | -- |
| | | MS | 0.36 (0.22) | 10 | -- | -- | -- | -- | 60 | -- | 40 | 10 | 100 | 19.3 |
| | | | 0.51 (0.31) | 10 | -- | -- | -- | 10 | 60 | -- | 30 | 9 | 90 | -- |
| | | | 1.16 (0.72) | 10 | -- | -- | -- | 50 | 40 | -- | 10 | 5 | 50 | -- |
| Fluor chrome arsenate phenol type B | P5-68 | LA | 0.35 (0.21) | 10 | -- | -- | -- | 10 | 20 | 10 | 60 | 9 | 90 | -- |
| | | | 0.50 (0.30) | 10 | -- | -- | -- | 20 | 60 | -- | 20 | 8 | 80 | -- |
| | | | 1.12 (0.68) | 10 | 10 | 10 | -- | 50 | 30 | -- | -- | 3 | 30 | -- |
| | | MS | 0.35 (0.21) | 9 | -- | -- | -- | -- | 44 | 11 | 44 | 9 | 100 | 19.2 |
| | | | 0.51 (0.30) | 10 | -- | -- | -- | 20 | 70 | -- | 10 | 8 | 80 | -- |
| | | | 1.19 (0.72) | 9 | -- | 11 | -- | 56 | 33 | -- | -- | 3 | 33 | -- |
| Untreated controls | | LA | -- | 10 | -- | -- | -- | -- | 10 | 90 | -- | 10 | 100 | 2.3 |
| | | MS | -- | 10 | -- | -- | -- | -- | 30 | 20 | 50 | 10 | 100 | 2.3 |

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

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

This study was initiated by J. Oscar Blew.

Table 48--Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with copper chrome phosphorus and chromated copper arsenate type III preservatives after about 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)

| | | | | Condition of stakes January 2000 (MS) and October 1992 (WI) (%) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Serviceable but showing some-- | | | Destroyed by-- | | | | | |
| Preservative | Location | Average retention (lb/ft$^3$) | Number in test[c] | Good | Decay | Termite attack | Decay and termite attack | Decay fungi | Termite attack | Decay fungi and termite attack | Total removed Number | Total removed % | Average life (year) |
| Copper chrome phosphorus | MS | 0.26[a] | 10 | -- | -- | -- | 40 | 60 | -- | -- | 6 | 60 | -- |
| | WI | 0.27[a] | 9 | -- | 33 | -- | -- | 67 | -- | -- | 6 | 67 | -- |
| | MS | 0.46[a] | 10 | 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 | MS | 0.20[b] | 10 | 10 | -- | -- | 90 | -- | -- | -- | -- | -- | -- |
| (Fed. Spec. TT-W-550) | 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 |

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

[b]Retention based on preservative oxides.

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

This study was initiated by L. R. Gjovik.

Table 49--Condition of aspen particleboard[a] stakes (3/4 by 4 by 18 in.) treated with chromated copper arsenate type III, fluor chrome arsenate phenol type A, and pentachlorophenol in ethanol or mineral spirits after about 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$^3$) | Number in test[b] | Condition of stakes February 1998 (%) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Serviceable but showing some-- | | | Destroyed by-- | | | Total removed | | Average life |
| | | | Good | Decay | Termite attack | Decay and termite attack | Decay fungi | Termite attack | Decay fungi and termite attack | Number | % | (year) |
| | | | Flakes treated before fabrication into particleboard[c] | | | | | | | | | |
| Chromated copper arsentate type III | 0.25 | 9 | -- | 22 | -- | 11 | 67 | -- | -- | 6 | 67 | -- |
| (Fed. Spec. TT-W-550) | 0.40 | 10 | -- | 10 | -- | 30 | 60 | -- | -- | 6 | 60 | -- |
| | 0.80 | 10 | 10 | 80 | -- | -- | 10 | -- | -- | 1 | 10 | -- |
| Fluor chrome arsenate phenol type A | 0.25 | 10 | -- | -- | -- | -- | 90 | -- | 10 | 10 | 100 | 6.0 |
| (Fed. Spec. TT-W-535) | 0.50 | 10 | -- | -- | -- | -- | 90 | -- | 10 | 10 | 100 | 8.8 |
| Pentachlorophenol (Fed. Spec. TT-W-570) | 0.25 | 10 | -- | -- | -- | -- | 40 | -- | 60 | 10 | 100 | 5.5 |
| in ethanol | 0.40 | 10 | -- | -- | -- | -- | 50 | -- | 50 | 10 | 100 | 7.5 |
| | 0.80 | 10 | -- | -- | -- | 10 | 50 | -- | 40 | 9 | 90 | -- |
| | | | Pressure-treated particleboard | | | | | | | | | |
| Chromated copper arsentate type III | 0.26 | 8 | -- | | -- | -- | 100 | -- | -- | 8 | 100 | 19.7 |
| (Fed. Spec. TT-W-550) | 0.41 | 9 | -- | 11 | -- | 67 | 22 | -- | -- | 2 | 22 | -- |
| | 0.84 | 10 | 60 | 30 | 10 | -- | -- | -- | -- | -- | -- | -- |
| Fluor chrome arsenate phenol type A | 0.26 | 10 | -- | -- | -- | -- | 70 | -- | 30 | 10 | 100 | 7.5 |
| (Fed. Spec. TT-W-535) | 0.54 | 9 | -- | -- | -- | -- | 100 | -- | -- | 9 | 100 | 11.3 |
| Pentachlorophenol (Fed. Spec. TT-W-570) | 0.22 | 10 | -- | -- | -- | -- | 70 | -- | 30 | 10 | 100 | 5.5 |
| 5% in mineral spirits and 4% pine oil | 0.40 | 10 | -- | -- | -- | -- | 80 | -- | 20 | 10 | 100 | 8.5 |
| | 0.82 | 10 | -- | -- | -- | 30 | 50 | -- | 20 | 7 | 70 | -- |
| Untreated controls | -- | 10 | -- | -- | -- | -- | 10 | 10 | 80 | 10 | 100 | 2.4 |

[a]Density 40 lb/ft$^3$.

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

[c]Flakes 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)

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

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

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

Table 51--Condition of Southern Pine, Douglas-fir, and Engelmann spruce heartwood stakes treated with ammoniacal copper arsenate and chromated copper arsenate after approximately 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)

| | | | | Condition of stakes January 2000 (%) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Serviceable but showing some-- | | | Destroyed by-- | | | | | |
| Preservative | Location | Average retention (lb/ft$^3$) | Number in test | Good | Decay | Termite attack | Decay and termite attack | Decay fungi | Termite attack | Decay fungi and termite attack | Total removed Number | Total removed % | Average life (year) |
| | | | | Southern Pine[a,b] 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

| | | | | Condition of stakes January 2000 (%) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Serviceable but showing some-- | | | Destroyed by-- | | | | | | |
| Preservative | Location | Average retention (lb/ft$^3$) | Number in test | Good | Decay | Termite attack | Decay and termite attack | Decay fungi | Termite attack | Decay fungi and termite attack | Total removed Number | Total removed % | Average life (year) |
| | | | | Southern Pine[a,b] 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

| | | | | Condition of stakes January 2000 (%) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Serviceable but showing some-- | | | Destroyed by-- | | | | | |
| Preservative | Location | Average retention (lb/ft$^3$) | Number in test | Good | Decay | Termite attack | Decay and termite attack | Decay fungi | Termite attack | Decay fungi and termite attack | Total removed Number | Total removed % | Average life (year) |
| | | | | Douglas-fir nominal 2- by 4-in. by 18-in. unincised | | | | | | | | | |
| Chromated copper | MS | 0.66 | 10 | 100 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| arsenate | WI | 0.55 | 10 | 100 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| type III | MS | 1.24 | 10 | 100 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | WI | 0.82 | 9[a] | 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 | MS | 0.66 | 10 | 100 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| arsenate | WI | 0.56 | 10 | 90 | 10 | -- | -- | -- | -- | -- | -- | -- | -- |
| type III | 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 | MS | 0.62 | 10 | 90 | 10 | -- | -- | -- | -- | -- | -- | -- | -- |
| arsenate | WI | 0.62 | 10 | 90 | 10 | -- | -- | -- | -- | -- | -- | -- | -- |
| type III[c] | 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 | MS | 0.60[f] | 9[d] | 100 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| arsenate | WI | 0.60[f] | 8[d] | 100 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| type III[e] | 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 | MS | 0.60[f] | 10 | 100 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| arsenate | WI | 0.60 | 10 | 100 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| type III[g] | 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

| | | | | Condition of stakes January 2000 (%) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Serviceable but showing some-- | | | Destroyed by-- | | | | | |
| Preservative | Location | Average retention (lb/ft$^3$) | Number in test | Good | Decay | Termite attack | Decay and termite attack | Decay fungi | Termite attack | Decay fungi and termite attack | Total removed Number | Total removed % | Average life (year) |
| | | | | Douglas-fir 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

| | | | | Condition of stakes January 2000 (%) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Serviceable but showing some-- | | | Destroyed by-- | | | | | |
| Preservative | Location | Average retention (lb/ft$^3$) | Number in test | Good | Decay | Termite attack | Decay and termite attack | Decay fungi | Termite attack | Decay fungi and termite attack | Total removed Number | Total removed % | Average life (year) |
| **Engelmann spruce nominal 2- by 4-in. by 18-in. unincised** | | | | | | | | | | | | | |
| Chromated copper | MS | 0.31 | 10 | 80 | -- | -- | 10 | -- | -- | 10 | 1 | 10 | -- |
| arsenate | WI | 0.21 | 8[d] | 88 | 12 | -- | -- | -- | -- | -- | -- | -- | -- |
| type III | 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 | MS | 0.41 | 10 | 100 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| arsenate | WI | 0.28 | 9[d] | 78 | 22 | -- | -- | -- | -- | -- | -- | -- | -- |
| type III | 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 | MS | 0.71 | 10 | 100 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| arsenate | WI | 0.70 | 9[d] | 89 | 11 | -- | -- | -- | -- | -- | -- | -- | -- |
| type III[c] | MS | 1.38 | 10 | 100 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | WI | 1.34 | 9[d] | 100 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | MS | 2.03 | 10 | 100 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | WI | 1.82 | 9[d] | 100 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| None | MS | -- | 10 | -- | -- | -- | -- | 10 | 20 | 70 | 10 | 100 | 2.6 |
| | WI | -- | 8[d] | -- | -- | -- | -- | 100 | -- | -- | 8 | 100 | 3.1 |
| Chromated copper | MS | 0.67[f] | 10 | 90 | 10 | -- | -- | -- | -- | -- | -- | -- | -- |
| arsenate | WI | 0.67[f] | 10 | 80 | 20 | -- | -- | -- | -- | -- | -- | -- | -- |
| type III[e] | MS | 1.25[f] | 10 | 100 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | WI | 1.26[f] | 9[d] | 100 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | MS | 1.76[f] | 9[d] | 100 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | WI | 1.76[f] | 9[d] | 100 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Chromated copper | MS | 0.67[f] | 9[d] | 100 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| arsenate | WI | 0.67[f] | 9[d] | 100 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| type III[g] | 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

| | | | | Condition of stakes January 2000 (%) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Serviceable but showing some-- | | Destroyed by-- | | | | | |
| Preservative | Location | Average retention (lb/ft$^3$) | Number in test | Good | Decay | Termite attack | Decay and termite attack | Decay fungi | Termite attack | Decay fungi and termite attack | Total removed Number | Total removed % | Average life (year) |
| **Engelmann spruce 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 | -- | -- | -- | -- | -- | -- | -- | -- | -- |

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

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

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

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

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

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

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

This study was initiated by L. R. Gjovik.

Table 52--Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with ammoniacal copper borate and ammoniacal copper asrsenate after approximately 25 years of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, December 1975 (Plot 73)

| | | | Condition of stakes June 2002 (%) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Serviceable but showing some-- | | | Destroyed by-- | | | | | |
| Preservative | Average retention[a] (lb/ft$^3$) | Number in test | Good | Decay | Termite attack | Decay and termite attack | Decay fungi | Termite attack | Decay fungi and termite attack | Total removed Number | Total removed % | Average life (year) |
| Ammoniacal copper 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 |

[a]Retention 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)

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

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

This study was initiated by L. R. Gjovik.

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

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

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

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

This study was initiated by L. R. Gjovik.

Table 55--Condition of Southern Pine and Douglas-fir Comply stakes (2 by 4 in. nominal by 18 in.) treated with chromated copper arsenate and ammoniacal copper arsenate after about 20 years of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, November 1978 (Plot 78)

| | | | Condition of stakes February 1998 (%) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Serviceable but showing some-- | | | Destroyed by-- | | | | | |
| Preservative | Average retention based on preservative oxides (lb/ft$^3$) | Number in test[a] | Good | Decay | Termite attack | Decay and termite attack | Decay fungi | Termite attack | Decay fungi and termite attack | Total removed Number | Total removed % | Average life (year) |
| | | | | | | Southern Pine | | | | | | |
| Chromated copper arsentate 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 arsentate 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 |

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

This study was initiated by L. R. Gjovik.

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

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

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

Table 57--Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in. and 3/4 by 3/4 by 18 in.) treated with chromated copper arsenate type Cusing 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)

| | | | Condition of stakes January 2002 (%) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Serviceable but showing some-- | | | Destroyed by-- | | | | | |
| Preservative | Average retention (lb/ft$^3$) | Number in test[a] | Good | Decay | Termite attack | Decay and termite attack | Decay fungi | Termite attack | Decay fungi and termite attack | Total removed Number | Total removed % | Average life (year) |
| Chromated copper arsenate type C | | | | | | 2- by 4- by 18-in. stakes | | | | | | |
| Full cell | 0.14 | 10 | 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 |

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

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

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

This study was initiated by L. R. Gjovik.

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

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

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

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

This study was initiated by L. R. Gjovik.

Table 59--Condition of Southern Pine stakes ( 2 by 4 in. nominal by 18 in. and 2.5 by 5.0 cm by 50 cm) treated with chromated copper fluoride (CFK) after approximately 20 years of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, June 1980 (Plot 82)

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

[a]Retention based on preservative oxides.

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

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

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

Table 61--Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with eight water-based formulations of wood preservatives and with Cu-8-quinolinolate and pentachlorophenol in toluene after about 21 years of service.
Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, December 1981 (Plot 84)

| | | | | Condition of stakes January 2002 (%) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Serviceable but showing some-- | | | Destroyed by-- | | | | | |
| Preservative | Average retention (lb/ft$^3$) | Active ingredient (lb/ft$^3$) | Number in test[a] | Good | Decay | Termite attack | Decay and termite attack | Decay fungi | Termite attack | Decay fungi and termite attack | Total removed Number | Total removed % | Average life (year) |
| Didecyl dimethyl ammonium chloride, 50.0% | 0.19 | 0.10 | 10 | -- | -- | -- | -- | 20 | -- | 80 | 10 | 100 | 4.8 |
| | 0.41 | 0.21 | 10 | -- | -- | -- | -- | -- | 20 | 80 | 10 | 100 | 9.8 |
| | 0.60 | 0.30 | 10 | -- | -- | -- | -- | 30 | -- | 70 | 10 | 100 | 14.9 |
| | 0.78 | 0.39 | 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 | -- |
| | 1.62 | 0.22 | 9 | -- | 11 | -- | 33 | 44 | -- | 11 | 4 | 44 | -- |
| Didecyl dimethyl ammonium chloride, 20%, + 6.3% copper as the metal | 0.40 | 0.11 | 10 | -- | -- | -- | -- | 60 | -- | 40 | 10 | 100 | 7.5 |
| | 0.81 | 0.21 | 10 | -- | -- | -- | 40 | 50 | -- | 10 | 6 | 60 | -- |
| | 1.21 | 0.32 | 10 | -- | 10 | -- | 60 | 30 | -- | -- | 3 | 30 | -- |
| | 1.60 | 0.42 | 8 | -- | 25 | -- | 75 | -- | -- | -- | -- | -- | -- |
| Dimethyl cocoamine 2-ethyl hexoate, 20%; copper 2-ethyl hexoate, 21.0% (3.8% metallic copper) | 0.30 | 0.08 | 10 | -- | -- | -- | -- | 30 | 10 | 60 | 10 | 100 | 3.2 |
| | 0.61 | 0.16 | 10 | -- | -- | -- | -- | 100 | -- | -- | 10 | 100 | 6.3 |
| | 0.90 | 0.24 | 10 | -- | -- | -- | -- | 80 | -- | 20 | 10 | 100 | 10.1 |
| | 1.20 | 0.32 | 10 | -- | -- | -- | 10 | 60 | -- | 30 | 9 | 90 | -- |
| Copper 2-ethyl hexoate, 35.0% (6.3 metallic copper) | 0.40 | 0.17 | 10 | -- | -- | -- | -- | 90 | -- | 10 | 10 | 100 | 5.5 |
| | 0.80 | 0.33 | 10 | -- | -- | -- | 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, 21.9%, and 2.4% 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 | -- | -- | -- | -- | -- | -- |
| Pentachlorophenol, 27.6%, and 3.1% other chlorophenols | 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 | -- | -- | -- | -- | -- | -- |
| Tri-n-butyl tin oxide, 9.5%, dimethyl benzyl ammonium chloride, 20%, and dimethyl ethyl benzyl ammoniun chloride, 20% | 0.40 | 0.20 | 10 | -- | -- | -- | -- | 20 | 10 | 70 | 10 | 100 | 4.8 |
| | 0.81 | 0.40 | 10 | -- | -- | -- | -- | 30 | 10 | 60 | 10 | 100 | 10.1 |
| | 1.21 | 0.60 | 9 | -- | -- | -- | 33 | 22 | -- | 44 | 6 | 67 | -- |
| | 1.63 | 0.81 | 9 | -- | 11 | -- | 78 | 11 | -- | -- | 1 | 11 | -- |
| Diluted in toluene | | | | | | | | | | | | | |
| Copper-8-quinolinolate, 0.675% (0.12% metallic copper) | 1.50 | 0.01 | 10 | -- | -- | -- | -- | 20 | 10 | 70 | 10 | 100 | 5.9 |
| | 2.96 | 0.02 | 10 | -- | -- | -- | -- | 50 | -- | 50 | 10 | 100 | 12.1 |
| | 8.75 | 0.06 | 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 |

[a]Ten 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)

| | | | Condition of stakes January 2002 (%) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Serviceable but showing some-- | | | Destroyed by-- | | | | | |
| Preservative | Average retention (lb/ft$^3$) | Number in test | Good | Decay | Termite attack | Decay and termite attack | Decay fungi | Termite attack | Decay fungi and termite attack | Total removed Number | Total removed % | Average life (year) |
| Ammoniacal copper zinc arsenate | 0.10 | 10 | -- | -- | -- | -- | 80 | -- | 20 | 10 | 100 | 16.0 |
| | 0.25 | 10 | -- | 100 | -- | -- | -- | -- | -- | -- | -- | -- |
| | 0.40 | 10 | 20 | 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)

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

This study was initiated by 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)

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

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)

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

This study was initiated by L. R. Gjovik.

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

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

This study was initiated by L.R. Gjovik.

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

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

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

This study was initiated by L. R. Gjovik.

Table 68--Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with 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)

| | | | Condition of stakes August 1995 (%) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Serviceable but showing some-- | | | Destroyed by-- | | | | | |
| Preservative | Average retention (lb/ft$^3$) | Number in test | Good | Decay | Termite attack | Decay and termite attack | Decay fungi | Termite attack | Decay fungi and termite attack | Total removed Number | Total removed % | Average life (year) |
| | | | 2- by 4- by 18-in. stakes | | | | | | | | | |
| Pentachlorophenol | 0.14 | 10 | -- | -- | -- | -- | 40 | -- | 60 | 10 | 100 | 7.0 |
| emulsion | 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 | 0.14 | 10 | -- | -- | -- | -- | 50 | -- | 50 | 10 | 100 | 6.5 |
| emulsion diluted with | 0.20 | 10 | -- | -- | -- | 10 | 10 | -- | 80 | 9 | 90 | -- |
| 3% ammonia | 0.28 | 10 | -- | -- | -- | 70 | -- | -- | 30 | 3 | 30 | -- |
| | 0.40 | 10 | -- | -- | -- | 100 | -- | -- | -- | -- | -- | -- |
| | 0.55 | 10 | -- | -- | -- | 100 | -- | -- | -- | -- | -- | -- |
| | 0.85 | 10 | -- | -- | -- | 100 | -- | -- | -- | -- | -- | -- |
| Ammonium | 0.16 | 10 | -- | -- | -- | -- | 40 | -- | 60 | 10 | 100 | 6.6 |
| pentachlorophenol | 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 | 0.14 | 10 | -- | -- | -- | 100 | -- | -- | -- | -- | -- | -- |
| oil and toluene | 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

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

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

This study was initiated by L. R. Gjovik.

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

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

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

This study was initiated by L.R. Gjovik.

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

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

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)

| | | | | Condition of stakes September 1995 (ME) and January 2002 (MS) (%) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Serviceable but showing some-- | | | Destroyed by-- | | | | | |
| Preservative | Location | Average retention (lb/ft$^3$) | Number in test[a] | Good | Decay | Termite attack | Decay and termite attack | Decay fungi | Termite attack | Decay fungi and termite attack | Total removed Number | Total removed % | Average life (year) |
| **White pine--unincised** | | | | | | | | | | | | | |
| Ammoniacal copper arsenate | ME | 0.32 | 10 | 90 | 10 | -- | -- | -- | -- | -- | -- | -- | -- |
| | MS | 0.26 | 10 | -- | 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) (%) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Serviceable but showing some-- | | | Destroyed by-- | | | | | |
| Preservative | Location | Average retention (lb/ft$^3$) | Number in test[a] | Good | Decay | Termite attack | Decay and termite attack | Decay fungi | Termite attack | Decay fungi and termite attack | Total removed Number | Total removed % | Average life (year) |
| | | | | | | Red pine--unincised--con. | | | | | | | |
| Chromated copper arsenate III | ME | 0.18 | 10 | 90 | 10 | -- | -- | -- | -- | -- | -- | -- | -- |
| | MS | 0.23 | 10 | 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

| | | | | Condition of stakes September 1995 (ME) and January 2002 (MS) (%) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Serviceable but showing some-- | | | Destroyed by-- | | | | | |
| Preservative | Location | Average retention (lb/ft$^3$) | Number in test | Good | Decay | Termite attack | Decay and termite attack | Decay fungi | Termite attack | Decay fungi and termite attack | Total removed Number | Total removed % | Average life (year) |
| **Eastern spruce--unincised--con.** | | | | | | | | | | | | | |
| Chromated copper arsenate III | ME | 0.10 | 10 | 80 | 20 | -- | -- | -- | -- | -- | -- | -- | -- |
| | MS | 0.14 | 10 | -- | 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

| | | | | Condition of stakes September 1995 (ME) and January 2002 (MS) (%) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Serviceable but showing some-- | | | Destroyed by-- | | | | | |
| Preservative | Location | Average retention (lb/ft$^3$) | Number in test | Good | Decay | Termite attack | Decay and termite attack | Decay fungi | Termite attack | Decay fungi and termite attack | Total removed Number | Total removed % | Average life (year) |
| | | | | | | Balsam fir--incised | | | | | | | |
| Ammoniacal copper arsenate | ME | 0.31 | 10 | 80 | 20 | -- | -- | -- | -- | -- | -- | -- | -- |
| | MS | 0.29 | 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

| | | | | Condition of stakes September 1995 (ME) and January 2002 (MS) (%) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Serviceable but showing some-- | | | Destroyed by-- | | | | | |
| Preservative | Location | Average retention (lb/ft$^3$) | Number in test | Good | Decay | Termite attack | Decay and termite attack | Decay fungi | Termite attack | Decay fungi and termite attack | Total removed Number | Total removed % | Average life (year) |
| | | | | | | Eastern 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 |

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

This study was initiated by L.R. Gjovik.

Table 73--Condition of three-ply plywood, layed up in combinations of Southern Pine, sweetgum, and yellow poplar, treated with ammoniacal copper arsenate and chromated copper arsenate after about 16-1/2 years. Stakes placed in test on the Harrison Experimental Forest, Saucier, MS, November 1985 (Plot 98)

| Preservative | Average retention (lb/ft$^3$) | Number in test[a] | Condition of stakes January 1999 (%) | | | | | | | 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--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 | Termite attack | Decay and termite attack | Decay fungi | Termite attack | Decay fungi and termite attack | Number | % | |
| **Southern Pine--Southern Pine--Sweetgum** | | | | | | | | | | | | |
| Cut from 4 by 4 treated panel | | | | | | | | | | | | |
| Ammoniacal copper arsenate | 0.10 | 10 | -- | -- | -- | -- | 80 | -- | 20 | 10 | 100 | 4.4 |
| | 0.20 | 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

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

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

[a]Ten 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)

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

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

Table 75--Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with toluene-diluted AWPA P1-13 creos
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)

| | | | Condition of stakes January 2002 (%) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Serviceable but showing some-- | | | Destroyed by-- | | | | | |
| Preservative | Average retention (lb/ft$^3$) | Number in test[a] | Good | Decay | Termite attack | Decay and termite attack | Decay fungi | Termite attack | Decay fungi and termite attack | Total removed Number | Total removed % | Average life (year) |
| AWPA P1-13 creosote | 1.0 | 9 | -- | -- | -- | -- | 67 | -- | 33 | 9 | 100 | 8.7 |
| with xylene insolubles | 2.0 | 10 | -- | -- | -- | -- | 80 | -- | 20 | 10 | 100 | 11.7 |
| less than 0.1% | 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 |

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

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

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

This study was initiated by L.R. Gjovik.

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

| Preservative | Average retention[a] ($lb/ft^3$) | Data from table number | Average life (year) | Remarks |
|---|---|---|---|---|
| Acid copper chromate | 0.25 (0.13) | 15 | 11.6 | -- |
| (Fed. Spec. TT-W-546) | 0.30 (0.14) | 46 | 6.1 | -- |
| | 0.51 (0.25) | 47 | -- | 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 | 0.17 | 52 | -- | 95% failed after 25 years |
| (Fed. Spec. TT-W-549) | 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 | 0.26 (0.15) | 15 | 28.7 | -- |
| Type I (Fed. Spec. TT-W-550) | 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 |
| | (1.04) | 20 | -- | No failures after 46 years |
| Type III (Fed. Spec. TT-W-550) | (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 | 0.49 (0.30) | 2 | 14.2 | -- |
| (Fed. Spec. TT-W-551) | 0.76 (0.47) | 2 | 20.2 | -- |
| | 0.76 (0.46) | 47 | 13.8 | -- |
| | 1.03 (0.63) | 2 | 20.1 | -- |
| | 1.02 (0.62) | 47 | 14.9 | -- |
| | 1.50 (0.92) | 25 | 23.4 | -- |
| | 1.57 (0.96) | 47 | 17.8 | -- |
| | 2.91 (1.78) | 25 | 32.7 | -- |
| | 6.00 (3.67) | 25 | -- | No failures after 45 years |
| Copper-8-quinolinolate | 0.01 | 38 | 5.3 | -- |
| Stoddard solvent | 0.02 | 38 | 4.2 | -- |
| | 0.06 | 38 | 5.6 | -- |
| | 0.12 | 38 | 7.8 | -- |
| Copper-8-quinolinolate | 0.01 | 43 | -- | 90% failed after 37 years |
| AWPA P9 heavy petroleum | 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 | -- |

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

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