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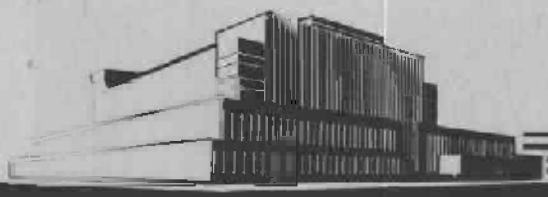

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UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
In Cooperation with the University of Wisconsin

COMPARISON OF WOOD PRESERVATIVES

IN MISSISSIPPI POST STUDY

(1958 Progress Report)

By

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Summary

Experimental untreated southern yellow pine posts installed from 1936 to 1938 at the Harrison Experimental Forest, Saucier, Miss., had an average life of 3.3 years. Untreated longleaf pine posts installed in 1949 had an average life of 2.3 years, while those treated with a No. 2 fuel oil and with Wyoming residual petroleum oil have an estimated average life of 7 and 8 years, respectively. Of southern yellow pine posts installed from 1936 to 1941, those treated with borax-boric acid have all failed after 20 years of service. Their average life was 10.6 years. Posts treated with the following preservatives have had failures totaling less than 10 percent of the number installed and should last 32 years or longer on an average: water gas tar; 50-50 solution of creosote-crankcase oil; tetrachlorophenol, 4.8 percent in crankcase oil; pentachlorophenol, 3 percent and 4.8 percent in crankcase oil; copper sulfate and sodium arsenate applied by double diffusion; and zinc meta arsenite. Posts in test in 1936 to 1941 treated with other preservatives have an estimated average life of 13 to 32 years.

Introduction

During late 1936 and early 1937, the U. S. Forest Products Laboratory, in cooperation with the Southern Forest Experiment Station and the then existing

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[1]Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

Bureau of Entomology and Plant Quarantine, started a service test at the Harrison Experimental Forest, Saucier, Miss., on posts treated with 24 wood preservatives. A report by Wirka[2] contained a description of the preservatives and treatments used in the original installation of posts in a line approximately 8 miles long. This report also described the installation and presented the results of the test after 3 years of service. Additional posts were added to this line during the years 1938 and 1941. A report by Blew[3] in 1947 described these additions and presented the condition of all posts in the 8-mile line after approximately 5-1/2 to 10 years of service. During April and May 1949 the study was expanded to include posts treated with 44 preservatives and untreated controls that were installed in a plot on the Harrison Experimental Forest. Various commercial companies cooperated in this work by furnishing the preservatives and by contributing to the cost of making the treatments and of installing test posts. Annual progress reports[5] issued since 1950 describe the condition of the posts in the two installations.

This progress report deals with the condition of the posts at the time of the December 1957 inspection, or after 16-1/2 to 21 years of service in the line, and after 8-1/2 years in the plot installation. The report also briefly described the materials and treatments used and the procedure followed in inspecting the posts.

Posts

All of the posts used in this study were of round southern yellow pine that consisted mostly of sapwood. Those treated in 1941 with Osmoplastic and by double diffusion were cut and treated while green on the Harrison Experimental Forest. All other posts were cut at McNeill, Miss., and were shipped to the Forest Products Laboratory for treatment. The posts to be treated with Osmosar were freshly cut and shipped green; the others were peeled, sprayed with stain-control chemical, and air-dried before shipment. The posts installed in the line from 1936 to 1941 were 7 feet in length and from 2-1/2 to 7 inches in top diameter. Those installed in the plot during 1949 were of longleaf pine 6 feet in length and from 2.8 to 5.3 inches in top diameter. These posts were peeled, dipped in a stain-control chemical, and shipped to the Laboratory for air or kiln drying. Many of them required repeeling, before treatment, to remove inner bark. The different diameter sizes were distributed as uniformly as practicable to each of the treatments used in the study.

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[2] Wirka, R. M. Comparison of Preservatives in Mississippi Fence-Post Study. Proceedings of the American Wood-Preservers' Association, 1941, pp. 365-379.

[3] Blew, J. O. Comparison of Preservatives in Mississippi Fence-Post Study After 10 Years of Service. Proceedings of the American Wood-Preservers' Association, 1947, pp. 26-41.

[4] Blew, J. O., and Kulp, John W. Comparison of Wood Preservatives in Mississippi Post Study (1957 Progress Report). Forest Products Laboratory Report No. 1757, January 1957.

Preservatives and Treatment

Tables 1 and 2 show the preservatives used. Table 1 includes 26 preservatives or treatments and also untreated control posts set in the line from 1936 to 1941. Forty-four preservatives or treatments and untreated control posts are included in table 2 for the posts set in the plot during 1949.

In the line installation are included four nonpressure treatments: Steeping with mercuric chloride; full-length Osmose treatment of green posts with Osmosar; treatment at the groundline and at the immediate tops of the posts with Osmoplastic; and full-length double-diffusion treatment of green posts with copper sulfate and sodium arsenate. The remaining treatments in the line installation and all treatments in the plot installation were by pressure impregnation. In the pressure treatments, the oils were applied by the Rueping empty-cell process, and the waterborne preservatives were applied by the full-cell process.

Minimum, maximum, and average preservative retentions are shown in tables 1 and 2. Borings taken from posts following each pressure treatment showed, for the most part, either complete or nearly complete penetration of the sapwood. Exceptions were noted, however, in the posts pressure-treated for the 1936 installation with coal tar, with 10 percent of coal-tar creosote and 90 percent of used crankcase oil, with lignite coal-tar creosote, with water-gas tar, and with No-D-K (hardwood-tar creosote). In these treatments, a high percentage of the posts bored showed penetrations of less than 60 percent of the sapwood depth. Borings taken from the posts treated by steeping in mercuric chloride all showed poor penetration of the preservative. Penetration measurements were not made on the posts treated with Osmosar, those treated by double diffusion, or those treated with Osmoplastic.

Installation of Posts

The posts, at the start of the test, were set from late 1936 until February 1937 in a line approximately 8 miles long on the Harrison Experimental Forest, Saucier, Miss. The posts were grouped into 100 units, each of which included 1 post of the different treatments selected at random, and, for the most part, 1 untreated control post. It was possible to install only 65 untreated posts at the same time the treated posts were installed, and the remaining 33 were set during November and December 1938. The position of the treated posts and of the untreated control post within each unit was also randomized. During 1941, two additional treatments were added to this line, with 1 post from each treatment being installed in each of the 100 units. The line installation was originally designed so that about 70 percent of the posts of each treatment were set on the drier, well-drained sites of the area (pine hills or dry hardwood sites), 20 percent in moist soil (pitcher-plant areas or any

area with fluctuating water table), and 10 percent in swamp or standing water.[5] A careful check during several post inspections, which included both extremes of dry and wet weather, indicated that the segregation according to dry, damp, and wet sites varied slightly with the different treatments but was generally about 65 percent, 18 percent, and 17 percent, respectively.

In the line, 100 posts were originally installed for each preservative or treatment. The number of test posts has since been reduced for some treatments by fire loss and pilferage, or by other removals not occasioned by decay or termite attack.

The posts in the most recent installation on the Harrison Experimental Forest were set in a comparatively dry site during April and early May, 1949 (fig. 1). Twenty-five posts were installed for each treatment, along with 25 untreated control posts. These posts were installed in a plot by the randomized block method, by which the plot was divided into 25 blocks, each containing 1 post from each treatment and 1 untreated control post, selected at random. The posts were set 3 feet apart in rows, and the rows were 3 feet apart in the blocks.

The soil in the general area of Saucier, Miss., is reported to be a Norfolk fine sandy loam with a pH of 5.0 to 5.5. In the plot with the posts installed during 1949 the soil pH is 4.98 to 5.04.

Results to Date

During the December 1957 inspection, as in the previous inspections, each post was given a moderate push by the inspector, under the force of which it could usually be expected to break off if decay or termite attack had progressed to a critical point. If it did break off, the post was considered to have failed and the cause of the failure was determined.

Conditions of Posts Installed from 1936 to 1941

The conditions of the posts installed from 1936 to 1941 are shown in table 1 and are discussed, according to preservatives and treatments used, in the following paragraphs.

Untreated control posts.--The 65 untreated control posts set from late 1936 to February 1937 had an average life of 3.1 years, and the 33 installed during November and December 1938 had an average life of 3.7 years. The average life of all untreated posts in the line was 3.3 years. The untreated posts

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[5]Throughout the report these sites will be referred to as "dry," "damp," and "wet," although these terms are relative and apply only to the Mississippi test area.

installed in well-drained, comparatively dry soil had an average life of 2.6 years and failed mostly because of decay and termite attack. Those installed in moist soil and in swamps or standing water had an average life of 4 and 4.8 years, respectively, and failed mostly because of decay. Some of the posts set in water remained serviceable for more than 5 years and failed mainly because of top decay. The untreated posts were removed as follows:

Years after installation	1	2	3	4	5	6
Number (cumulative) removed	3	33	60	79	93	98

Beta-naphthol, 5 percent in organic solvents.--Approximately 94 percent of the posts treated with beta-naphthol solution have been removed. The estimated average life of the posts is 16 years on the basis of these removals. The average retention of preservative solution for the posts removed was 6.2 pounds per cubic foot, the same as that for the 100 posts originally installed. Removals have been due principally to combined decay and termite attack. Ninety-eight percent of the posts installed in dry sites, 100 percent of those installed in damp sites, and 72 percent of those installed in wet sites have been removed. Removals to date are as follows:

Years after installation	4	5	6	7	8	9	10	11	12
	13	14	15	16	17	18	19	20	21
Number (cumulative) removed	3	6	16	22	27	34	39	42	51
	55	65	71	79	83	87	89	91	92

Borax-boric acid.--All posts treated with borax-boric acid have been removed after 20 years, and the average life of the 97 test posts is 10.6 years. Forty-six percent of the posts failed because of combined decay and termite attack, 36 percent because of termite attack, and 18 percent were removed because of decay alone. The 63 posts installed in dry areas had an average life of 9.8 years, while 17 posts in damp areas and 17 in wet areas had average lives of 11.0 years and 13.2 years, respectively. Removals by years are as follows:

Years after installation	5	6	7	8	9	10	11	12	13	14
	15	16	17	18	19	20				
Number (cumulative) removed	4	6	19	32	45	49	63	71	75	81
	87	90	91	93	94	97				

Celcure (acid copper chromate).--Celcure is prepared from copper sulfate and sodium dichromate in an acid solution. Approximately 17 percent of the posts treated with this preservative have been removed, mostly because of decay. The estimated average life of the 88 test posts is 30 years. The 15 posts removed had an average retention of 0.89 pound per cubic foot; the average retention for the posts installed was 0.92 pound per cubic foot. Twenty-three percent of the posts set in dry areas and 12 percent of those in wet sites have been removed. No failures have occurred in the damp sites. Removals to date are as follows:

Years after installation	1	3	4	5	9	12	16	19	20	21
Number (cumulative) removed	1	2	3	5	6	7	9	10	12	15

Chromated zinc chloride.--Chromated zinc chloride contains not less than 77.5 percent of zinc chloride and 17.5 percent of sodium dichromate. Approximately 41 percent of the posts treated with this preservative have been removed because of decay or combined decay and termite attack. The estimated average life of the posts in test is 24 years. The average retention of preservative in the posts removed was 0.83 pound per cubic foot, or slightly less than that for the installation. Sixty-two percent of the posts installed in damp sites have been removed; 37 percent and 33 percent, respectively, have been removed from the dry and wet sites. Removals to date are as follows:

Years after installation	4	5	6	7	9	10	11	12	14
	16	17	18	19	20	21			
Number (cumulative) removed	1	3	6	10	13	14	15	18	21
	25	30	32	35	37	39			

Coal tar.--Twenty percent of the posts treated with coal tar have been removed because of decay or combined decay and termite attack. The estimated average life of the posts is 28 years. The average retention of coal tar in the 19 posts removed was 5.4 pounds per cubic foot, as compared with an average of 6.5 pounds for the posts installed. Of posts installed in the dry, damp, and wet areas, 2.5 percent, 13 percent, and 6 percent, respectively, have been removed. Removals to date are as follows:

Years after installation	5	7	9	11	13	14	15	16	17
	19	20	21						
Number (cumulative) removed	1	2	3	4	5	6	7	9	12
	14	16	19						

Coal-tar creosote.--The coal-tar creosote used was of American Wood-Preservers' Association grade 1. Ten posts treated with this preservative have failed because of decay. These posts had an average preservative retention of 5.3 pounds per cubic foot, compared with an average of 6 pounds for the installation. The estimated average life of the posts is 32 years. Two removed posts were set in damp sites, one in a wet site, and seven in dry sites. Removals to date are as follows:

Years after installation	13	15	17	18	19	20	21
Number (cumulative) removed	1	2	3	4	5	7	10

Coal-tar creosote 50 percent and used crankcase oil 50 percent.--Seven posts treated with an average of 4.3 pounds per cubic foot of a 50-50 solution of creosote and crankcase oil failed because of decay. These posts were removed from dry areas. Removals to date are as follows:

Years after installation	12	17	19	20
Number (cumulative) removed	1	5	6	7

Coal-tar creosote 10 percent and used crankcase oil 90 percent.--Approximately 75 percent of the posts treated with a solution of 10 percent creosote and 90 percent crankcase oil have failed, principally because of decay. The estimated average life of the posts is 19 years. The 74 posts removed had an average solution retention of 5.3 pounds per cubic foot, as compared with an average of 7.1 pounds for the original installation. Of all posts installed in dry, damp, and wet sites, 80 percent, 76 percent, and 53 percent respectively, have failed. Failures to date are as follows:

Years after installation	1	2	3	4	5	6	9	11	12
	13	14	15	16	17	18	21		
Number (cumulative) removed	13	31	37	48	50	55	57	61	63
	64	66	67	70	72	73	74		

Crankcase oil.--Of the posts treated with automobile crankcase drainings, approximately 90 percent have been removed, mostly because of decay. The estimated average life of the 97 posts installed on this basis is 17 years. The average retention of oil in the removed posts was 7.6 pounds per cubic foot, the same as that for the installation. Ninety-five percent of the posts set in dry areas, 75 percent of those set in damp areas, and 81 percent of those set in wet sites have been removed. Failures to date are as follows:

Years after installation	1	2	3	4	5	6	7	8	9	10
	11	12	13	14	16	17	18	20	21	
Number (cumulative) removed	7	31	42	45	52	54	58	60	64	65
	68	73	75	77	80	82	84	86	87	

Lignite coal-tar creosote.--Approximately 39 percent of the posts treated with lignite coal-tar creosote have failed, principally because of decay or combined decay and termite attack. The estimated average life of the 97 posts in test is 24 years. The average retention of preservative for the 38 posts removed was 2.8 pounds per cubic foot, or considerably less than that of 6.3 pounds for the posts installed. Forty-one percent of the posts installed in dry areas have been removed; 35 percent have been removed from the damp and wet sites. Removals to date are as follows:

Years after installation	3	5	7	8	9	10	11	12	13
	14	15	16	17	18	19	20	21	
Number (cumulative) removed	1	2	3	7	8	10	11	14	18
	20	23	26	28	30	32	36	38	

Mercuric chloride.--Thirty-eight percent of the posts treated by steeping in mercuric chloride have been removed, principally because of combined decay and termite attack or termite attack alone. The estimated average life for

the 100 posts installed is 24 years. The preservative retention of the 38 posts removed was 0.11 pound per cubic foot, or approximately the same as the average retention for the installation. Forty-three percent of the posts installed in dry sites have been removed; 35 percent and 22 percent, respectively, have been removed from the damp and wet sites. Removals to date are as follows:

Years after installation	8	9	10	11	12	13	14	15	16
	17	18	19	20	21				
Number (cumulative) removed	1	4	6	9	13	14	18	20	25
	28	30	31	36	38				

No-D-K (hardwood-tar creosote).--Sixty-two percent of the posts treated with No-D-K have been removed, mostly because of decay or combined decay and termite attack. The estimated average life of the 100 posts in test is 21 years. Seventy-eight percent of the posts set in dry areas, 37 percent of those set in damp areas, and 26 percent of those set in wet areas have been removed. The average retention of preservative for the posts removed was 5.6 pounds per cubic foot, compared with 6.6 pounds for the installation. Removals to date are as follows:

Years after installation	2	3	4	5	6	7	8	9	10	11
	12	13	14	15	16	17	18	19	20	21
Number (cumulative) removed	1	4	5	12	18	21	23	25	26	30
	31	33	36	37	48	54	55	58	59	62

Osmosar.--The Osmosar preservative was reported to be a mixture of sodium fluoride, dinitrophenol, potassium dichromate, sodium arsenate, and gum arabic. Approximately 46 percent of the posts have been removed to date, mostly because of decay or combined decay and termite attack. The estimated average life of the 96 test posts is 23 years. Forty-five percent of the posts set in dry sites, 63 percent of those set in damp sites, and 33 percent of those set in wet sites have been removed. Removals to date are as follows:

Years after installation	5	6	7	10	12	13	14	15	16
	17	18	19	20	21				
Number (cumulative) removed	1	2	4	5	6	8	13	16	25
	27	33	35	40	44				

P.D.A. (phenyldichlorarsine) 0.84 percent (by weight) in gas oil.--Approximately 61 percent of the posts treated with P.D.A. in gas oil have been removed, mostly because of combined decay and termite attack or termite attack alone. The estimated average life of the 94 posts in test is 21 years. The average retention of preservative solution in the 57 removed posts was 5.6 pounds per cubic foot, or slightly less than the average retention for the installation. Of the posts installed in the dry, damp, and wet areas, 73 percent, 56 percent, and 22 percent, respectively, have been removed. Removals to date are as follows:

Years after installation	5	6	7	8	9	10	11	12	13
	14	15	16	17	18	19	20	21	
Number (cumulative) removed	2	4	6	9	12	13	15	16	19
	28	30	36	41	46	50	55	57	

Pentachlorophenol, 4.82 percent (by weight) in used crankcase oil.--One post treated with this preservative was removed from a dry area after 17 years of service because of decay. This post was treated with 4.6 pounds of solution per cubic foot.

Pentachlorophenol, 3.02 percent (by weight) in used crankcase oil.--Of the 92 posts treated with 3.02 percent of pentachlorophenol in used crankcase oil, 3 have been removed from dry sites because of decay. The average retention of preservative in these 3 posts was 4.1 pounds per cubic foot, which is lower than that of 6.4 pounds for the posts installed. Removals to date are as follows:

Years after installation	8	13	19
Number (cumulative) removed	1	2	3

Sodium dichromate.--Approximately 73 percent of the posts treated with sodium dichromate have been removed, for the most part because of termite attack or combined decay and termite attack. The average retention by the removed posts was 0.89 pound per cubic foot, nearly the same as that for the installation. The estimated average life of the 97 test posts is 19 years. Seventy-five percent of the posts set on dry sites, 94 percent of those set on damp sites, and 50 percent of those set on wet sites have been removed. Removals to date are as follows:

Years after installation	5	7	8	9	10	11	12	13	14
	15	16	17	18	19	20	21		
Number (cumulative) removed	4	10	12	13	14	16	25	27	37
	40	50	55	61	64	68	71		

Sodium chromate.--Seventy-five percent of the posts treated with sodium chromate have been removed, principally because of termite attack or combined decay and termite attack. The estimated average life of the 88 posts in test is 19 years. For the 66 posts removed, the average retention of sodium chromate was 0.97 pound per cubic foot, or slightly greater than that of 0.93 pound for the installation. Eighty-five percent of the posts set in dry areas, 65 percent of those set in damp areas, and 53 percent of those set in wet areas have been removed. Removals to date are as follows:

Years after installation	4	5	6	7	8	9	10	11	12
	13	14	15	16	18	19	20	21	
Number (cumulative) removed	1	9	10	13	21	23	25	33	37
	40	49	51	59	62	64	65	66	

Wolman salt (Tanalith).--Wolman salt (Tanalith) contains sodium chromate, sodium arsenate, sodium fluoride, and dinitrophenol. Approximately 35 percent of the posts treated with this preservative have been removed, mostly because of decay or combined decay and termite attack. The estimated average life of the 97 posts in test is 25 years. The 34 posts removed had an average preservative retention of 0.34 pound per cubic foot or approximately the same as the average for the installation. Thirty-three percent, 41 percent, and 38 percent of the posts set on dry, damp, and wet sites, respectively, have been removed. Removals to date are as follows:

Years after installation	7	8	9	12	14	15	16	17	18	20	21
Number (cumulative) removed	2	3	4	6	10	13	19	21	29	32	34

Tetrachlorophenol, 2.9 percent (by weight) in used crankcase oil.--Approximately 13 percent of the posts treated with 2.9 percent of tetrachlorophenol in used crankcase oil have failed because of decay. The estimated average life of the 92 posts in test is 31 years. The 12 posts removed had an average solution retention of 5.1 pounds per cubic foot; that for the installation was 7.1 pounds. These removed posts constituted 18 percent of those installed in dry areas and 7 percent of those in damp sites. There have been no failures in the wet sites. Removals to date are as follows:

Years after installation	11	12	13	14	15	17	18	19	20
Number (cumulative) removed	1	2	3	4	5	6	9	10	12

Tetrachlorophenol, 4.83 percent (by weight) in used crankcase oil.--Approximately 6 percent of the posts treated with 4.83 percent of tetrachlorophenol in used crankcase oil have failed in dry sites due mostly to decay after 21 years of service. The posts removed had an average solution retention of 5.4 pounds per cubic foot, compared with the average of 5.8 pounds for the installation. Removals to date are as follows:

Years after installation	18	19	20	21
Number (cumulative) removed	2	3	4	6

Water-gas tar.--Approximately 8 percent of the posts treated with water-gas tar have failed because of decay and combined decay and termite attack. One post failed in a damp site, and 6 failed in dry sites. The average retention of preservative in the 7 posts was 3.9 pounds per cubic foot, compared with the average of 6.3 pounds per cubic foot for the installation. Removals to date are as follows:

Years after installation	14	16	19	20	21
Number (cumulative) removed	1	2	4	6	7

Zinc chloride.--Approximately 35 percent of the posts treated with zinc chloride, with an average retention of 0.99 pound per cubic foot, have been removed because of decay or combined decay and termite attack. The estimated average life of the 96 posts in test is 25 years. Thirty percent, 56 percent, and 35 percent, respectively, of the posts set in dry, damp, and wet areas have been removed. Removals to date are as follows:

Years after installation	5	8	13	14	16	17	18	19	20	21
Number (cumulative) removed	1	2	3	9	15	18	23	25	32	34

Zinc meta arsenite.--Zinc meta arsenite is prepared from arsenious acid, zinc oxide, and acetic acid. One post treated with 0.42 pound of this preservative per cubic foot was removed from a dry site after 20 years.

Copper sulfate and sodium arsenate applied by double diffusion.--Two posts treated with copper sulfate and sodium arsenate applied by double diffusion have failed because of decay. One was located in a dry site and one in a wet site. Removals to date have been as follows:

Years after installation	12	16
Number (cumulative) removed	1	2

Osmoplastic (ground-line treatment).--The Osmoplastic used was reported to contain sodium fluoride, dinitrophenol, potassium dichromate, refined coal tar, and coal-tar creosote. Approximately 95 percent of the posts treated with this preservative at the ground-line zone (a 15-inch band extending 3 inches above and 12 inches below the ground line) and at the immediate tops have been removed after nearly 17 years of service. Removals were because of decay and termite attack, alone or in combination. The estimated average life of these posts is 13 years. Failures have occurred in 100 percent of the posts set in dry sites and in damp sites, and in 72 percent of those set in wet sites. Removals to date are as follows:

Years after installation	3	5	6	7	8	9	10	11	12	13
	14	15	16							
Number (cumulative) removed	1	3	6	13	19	23	39	54	68	74
	82	85	95							

Condition of Posts Installed in 1949

All of the untreated control posts failed after approximately 3-1/2 years of service. Their average life was 2.3 years. Failures were mostly because of combined decay and termite attack. Removals were as follows:

Years after installation	1-1/2	2-1/2	3-1/2
Number (cumulative) removed	13	20	25

Forty-four treated posts failed because of decay and combined decay and termite attack after approximately 8-1/2 years of service. Sixteen of the posts were treated with Wyoming residual petroleum oil, 22 with No. 2 fuel oil, 2 with aromatic petroleum oils, 2 with copperized chromated zinc chloride, 1 with Boliden salt A, and 1 with lignite coal-tar creosote, 50 percent and Wyoming residual petroleum oil, 50 percent. The estimated average life for posts treated with the No. 2 fuel oil is 7 years while that for the posts treated with Wyoming residual petroleum oil is 8 years.

Summation of Results

A summary of information obtained during the 21 years since the beginning of this study follows:

(1) The untreated posts installed during 1937 and 1938 had an average life of 3.3 years. The untreated posts set in swamps failed mostly because of decay and lasted an average of 4.8 years. Those set in damp soil (outside of swamps) also failed mostly because of decay, after an average life of 4.0 years. Those set in well-drained, comparatively dry soil failed because of combined decay and termite attack after an average life of 2.6 years. The untreated control posts set in 1949 in a dry site had an average life of 2.3 years.

(2) All of the posts treated with an average of 0.92 pound of borax-boric acid (50-50) per cubic foot failed after 20 years of service with an average life of 10.6 years. On the basis of removals to date and of the preservative retentions used, not including posts installed in 1949, posts given the following treatments are estimated to have an average life of 13 to 21 years: posts pressure treated with beta-naphthol in oil, 10 percent of coal-tar creosote and 90 percent of used crankcase oil, crankcase oil alone, No-D-K (hardwood-tar creosote), P.D.A. (phenyldichlorarsine), sodium dichromate, sodium chromate, and those treated at the groundline and top with Osmoplastic. Posts given the following treatments are estimated to have an average life of 23 to 32 years: posts pressure treated with Celcure (acid copper chromate), chromated zinc chloride, coal tar, coal-tar creosote, lignite coal-tar creosote, Wolman salt (Tanalith), tetrachlorophenol (approximately 3 percent) in used crankcase oil, and zinc chloride; posts steeped in mercuric chloride; and posts treated full length with Osmosar. Posts pressure treated with 50 percent of coal-tar creosote and 50 percent of used crankcase oil, pentachlorophenol (approximately 5 percent and 3 percent) in used crankcase oil, tetrachlorophenol (approximately 5 percent) in used crankcase oil, water-gas tar, and zinc meta arsenite, and those treated by the double-diffusion process with copper sulfate and sodium arsenate should last longer than 32 years on an average, but have not yet shown a sufficiently high percentage of removals to warrant an estimate on possible average life.

(3) The failures of treated posts to date, on the basis of posts installed under the three site conditions, have been heavier in the dry and damp areas than in the swamps. In the installations showing more than 30 percent failure, the percentage of failures in the swamps has been significantly high.

(4) The posts installed during 1949, except for petroleum oil-treated controls, have not been in test long enough to indicate important differences in the preservatives. Posts treated with No. 2 fuel oil and those treated with the Wyoming residual oil are estimated to have an average life of 7 years and 8 years respectively. One of the posts treated with Boliden salt A failed after 6-1/2 years because of decay and 2 of the posts treated with copperized chromated zinc chloride failed within 5-1/2 years because of decay caused by a fungus, *Poria ridiculosa*, which is fairly tolerant to copper compounds. In

the case of posts installed in 1936 and treated with Celcure, another copper compound, a small percentage of the posts failed during the first years of test, presumably from decay caused by the same or a similar fungus. One post treated with 50-50 lignite coal-tar creosote and Wyoming residual petroleum oil failed after 7-1/2 years, and 2 treated with different aromatic petroleums have failed during the same period.

Although some of the posts installed during 1936 and 1937 were pointed after treatment to facilitate driving in wet or damp sites (this practice should not be encouraged), few if any post failures can be charged to this factor alone. In most cases, the pointed part of the post was submerged in water or water-soaked soil so that decay and termite attack at the pointed section were not the controlling factors in its life. Furthermore, the posts were mostly of sapwood, which was generally well penetrated by the preservative, and cutting of such treated wood was less serious than it would be with poorly penetrated posts.

The results obtained in this particular test are not necessarily indicative of the performance that can be expected of the preservatives under other conditions of exposure. Furthermore, they should not be considered as indicating the service life to be expected from the preservatives applied to other species or applied by other methods. Waterborne preservatives usually perform better under conditions not favorable to leaching than when used for the treatment of wood installed in contact with the ground or water. Some of the waterborne preservatives appear to be performing well in this test, but the fact that others are performing less satisfactorily does not indicate that they will not provide adequate protection when used under drier or more favorable circumstances. Adequate retentions and penetrations are necessary for a high degree of protection with any preservative, and it follows that high retentions and heavy concentrations of preservative usually perform better than low retentions and low concentrations. For the preservatives included in tables 1 and 2, Federal Specification TT-W-571 recommends the following minimum retentions for lumber and posts:

Preservative	Minimum retention (Pounds per cubic foot)		
	Lumber and structural timber		Posts
	In contact with the ground or fresh water	Not in contact with the ground or water	
Coal-tar creosote	10.0	6.0	6.0
Creosote petroleum solution (50-50)	12.0	7.0	7.0
Pentachlorophenol, 5 percent in petroleum	10.0	6.0	6.0
Copper naphthenate, 0.75 percent copper equivalent in petroleum	10.0	6.0	6.0

Preservative	Minimum retention (Pounds per cubic foot) Lumber and structural timber		Posts
	In contact with the ground or fresh water	Not in contact with the ground or water	
Acid copper chromate (Celcure)	0.75*	0.50	0.75
Ammoniacal copper arsenite (Chemonite)	0.50*	0.30	0.50
Chromated zinc arsenate (Boliden salt A)	1.00*	.50	1.00
Chromated zinc chloride	1.15*	.75	1.15
Copperized chromated zinc chloride	1.15*	.75	1.15
Osmosar (Osmosalts)	.55*	.35	.55
Tanalith (Wolman salts)	.55*	.35	.55

*Occasional exposure to water or constant exposure to the ground in areas of moderate rainfall.

Table 1.--Condition of round southern yellow pine experimental fence posts on the Harrison Experimental Forest, Saucier, Miss., after about 16-1/2 to 21 years of service (treated posts were installed from late in 1936 to May 1941)

Preservative	Posts in test[1]	Form of preservative	Retention of preservative[2]				Method of treatment	Condition of posts, December 1957				Total removed	Average life[3]
			Minimum	Maximum	Average	Standard deviation		Serviceable	Removed because of				
									Decay	Decay, termites	Termites		
	No.		Lb. per cu. ft.	Lb. per cu. ft.	Lb. per cu. ft.	Lb. per cu. ft.		Percent	Percent	Percent	Percent	No.	Percent	Yr.
Posts set late in 1936 to February 1937														
Beta-naphthol, 5 percent (by weight) in oil mixture	98	Solution	3.90	10.00	6.20	1.30	Pressure	6.1	18.4	56.1	19.4	92	93.9	16
Borax-boric acid (50-50 mixture)	97	Salt	.64	1.32	.92	.11	...do...		17.5	46.4	36.1	97	100.0	10.6
Celcure (acid copper chromate)	88	...do...	.75	1.05	.92	.08	...do...	82.9	14.8	2.3		15	17.1	30
Chromated zinc chloride	96	...do...	.37	1.33	.87	.19	...do...	59.4	21.9	18.7		39	40.6	24
Coal tar	95	Oil	1.60	19.20	6.50	2.90	...do...	80.0	8.4	11.6		19	20.0	28
Coal-tar creosote, grade 1	95	...do...	1.90	8.60	6.00	1.50	...do...	89.5	10.5			10	10.5	32
Coal-tar creosote, 50 percent used crankcase oil, 50 percent (by volume)	98	Solution	1.60	14.80	5.40	2.20	...do...	92.9	7.1			7	7.1	
Coal-tar creosote, 10 percent, used crankcase oil, 90 percent (by volume)	99	...do...	.10	23.20	7.10	3.80	...do...	25.2	66.7	7.1	1.0	74	74.8	19
Crankcase oil (used)	97	Oil	2.50	16.80	7.60	2.90	...do...	10.3	85.6	4.1		87	89.7	17
Lignite coal-tar creosote	97	...do...	1.10	11.60	6.30	3.20	...do...	60.8	16.5	19.6	3.1	38	39.2	24
Mercuric chloride	100	Salt	.05	.15	.09	.03	Steeping	62.0	8.0	21.0	9.0	38	38.0	24
No-D-K (hardwood-tar creosote)	100	Oil	1.30	13.60	[4]5.60	3.50	Pressure	38.0	17.0	41.0	4.0	62	62.0	21
Osmosar	96	Salt			[4].30		Osmose	54.2	20.8	18.8	6.2	44	45.8	23
P.D.A. (phenyldichlorarsine) 0.84 percent in gas oil (by weight)	94	Solution	4.10	11.00	5.90	.90	Pressure	39.3	8.5	39.4	12.8	57	60.7	21
Pentachlorophenol, 4.82 percent (by weight) in used crankcase oil	97	...do...	2.90	9.50	6.70	1.60	...do...	99.0	1.0			1	1.0	
Pentachlorophenol, 3.02 percent (by weight) in used crankcase oil	92	...do...	3.10	11.40	6.40	1.80	...do...	96.7	3.3			3	3.3	
Sodium dichromate	97	Salt	.59	1.14	.88	.11	...do...	26.8	6.2	29.9	37.1	71	73.2	19
Sodium chromate	88	...do...	.70	1.19	.93	.10	...do...	25.0	5.7	21.6	47.7	66	75.0	19
Wolman salt (Tanalith)	97	...do...	.20	.47	.35	.07	...do...	65.0	18.5	11.3	5.2	34	35.0	25
Tetrachlorophenol, 2.9 percent (by weight) in used crankcase oil	92	Solution	1.20	16.10	7.10	3.10	...do...	87.0	13.0			12	13.0	31
Tetrachlorophenol, 4.83 percent (by weight) in used crankcase oil	94	...do...	3.50	9.40	5.80	1.50	...do...	93.6	5.3	1.1		6	6.4	
Water-gas tar	93	Oil	1.20	19.00	6.30	3.00	...do...	92.5	6.4	1.1		7	7.5	
Zinc chloride	96	Salt	.67	1.11	.94	.10	...do...	64.6	15.6	19.8		34	35.4	25
Zinc meta arsenite	95	...do...	.25	.54	.42	.06	...do...	99.0	1.0			1	1.0	
Untreated posts (set Feb. 1937)	65						None		3.1	93.8	3.1	65	100.0	3.1
Posts set in 1938 and 1941														
Untreated posts (set Nov., Dec. 1938)	33						None		33.3	63.6	3.1	33	100.0	3.7
Copper sulfate and sodium arsenate (set May 1941)	98	Salt			(.35 (.16		Double diffusion	98.0	2.0			2	2.0	
Osmoplastic ground-line treatment (set Feb. 1941)	99	Mixture			[2].34		(5)	5.1	27.3	54.5	13.1	94	94.9	13

[1] Installations included 100 posts for each treatment. This number has since been reduced in some cases by fire and pilferage.

[2] Based on the 100 posts treated in each group, unless otherwise indicated.

[3] Average life of all untreated posts is 3.3 years; average life shown where all posts have been removed and other values are estimates taken from a mortality curve. Where percentage of posts removed is 10 percent or less, no estimate on average life is given.

[4] Average application.

[5] Average application per post to a 15-inch band (3 inches above and 12 inches below ground line) and to top surface of post.

Table 2.--Condition of round longleaf pine experimental posts on the Harrison Experimental Forest, Saucier, Miss., after about 8-1/2 years of service.

(All treatments by pressure impregnation. Posts were installed during April and May 1949.)

Preservative	Posts in test	Retention of preservative: Form of preservative	Retention of preservative: Minimum	Retention of preservative: Maximum	Retention of preservative: Average	Retention of preservative: Standard deviation	Condition of posts, December 1957: Service-able	Condition of posts, December 1957: Removed because of: Decay	Condition of posts, December 1957: Removed because of: Decay, termites	Condition of posts, December 1957: Removed because of: Termites	Condition of posts, December 1957: Total removed	Condition of posts, December 1957: Total removed	Average life[1]
	Number		Lb. per cu. ft.	Lb. per cu. ft.	Lb. per cu. ft.		Percent	Percent	Percent	Percent	Number	Percent	Yr.
Boliden salt A ($H_3AsO_4 + Na_2HAsO_4 + Na_2CrO_7.2H_2O + ZnSO_4$)	25	Dry salt	0.65	0.76	0.70	0.029	96.0	4.0			1	4.0	
Boliden salt B ($ZnO + H_3AsO_4 + CrO_3$)	25	...do...	.43	.57	.50	.035	100.0						
Carbosota (coal-tar creosote)	25	Oil	5.2	6.9	6.0	.593	100.0						
Chemonite (ammoniacal copper arsenite)	25	Dry salt	.30	.39	.34	.029	100.0						
Chromated zinc chloride, copperized ($ZnCl_2 + Na_2Cr_2O_7.2H_2O + CuCl.2H_2O$)	25	...do...	.89	1.06	.98	.055	92.0	8.0			2	8.0	
Chromated zinc chloride, FR ($ZnCl_2 + Na_2Cr_2O_7.2H_2O + H_3BO_3 + (NH_4)_2SO_4$)	25	...do...	2.71	3.59	3.25	.254	100.0						
Coal-tar creosote:													
Straight run, low residue	25	Oil	4.6	7.5	5.9	.903	100.0						
Straight run, medium residue	25	...do...	4.2	7.7	5.6	.899	100.0						
Straight run, high residue	25	...do...	4.9	7.5	6.0	.873	100.0						
Medium residue, low in tar acids	25	...do...	4.6	6.9	5.7	.638	100.0						
Medium residue, low in naphthalene	25	...do...	5.2	7.1	6.1	.519	100.0						
Medium residue, low in tar acids and naphthalene	25	...do...	4.8	7.6	6.0	.701	100.0						
Low residue, low in tar acids and naphthalene	25	...do...	5.3	6.9	6.0	.516	100.0						
High residue, low in tar acids and naphthalene	25	...do...	5.4	6.8	6.1	.399	100.0						
Medium residue, low in fraction from 235° to 270° C., crystals removed	25	...do...	5.1	7.0	6.1	.591	100.0						
High residue, crystals removed	25	...do...	5.1	6.8	6.0	.528	100.0						
Low temperature	25	...do...	5.5	6.9	6.3	.401	100.0						
English, vertical retort	25	...do...	5.0	6.9	6.3	.552	100.0						
English, coke oven	25	...do...	4.5	7.4	6.0	.715	100.0						
English, vertical retort 50% and coke oven 50% (by volume)	25	Solution	5.2	6.8	6.0	.489	100.0						
Medium residue (low in tar acids and naphthalene) with 2-1/2% pentachlorophenol (by weight)	25	...do...	5.1	6.9	6.0	.594	100.0						
Coal-tar creosote 70%, and coal-tar 30% (by volume)	25	...do...	5.2	6.9	6.1	.574	100.0						
Coal-tar creosote (medium residue, low in tar acids and naphthalene) 50%, and petroleum oil (No. 2 distillate) 50% (by volume)	25	...do...	5.2	6.8	5.9	.418	100.0						
Coal-tar creosote (medium residue, low in tar acids and naphthalene) 50%, and petroleum oil (Wyoming residual) 50% (by volume)	25	...do...	5.2	6.9	6.9	.497	100.0						
Coal-tar creosote (medium residue, low in tar acids and naphthalene) 50%, and petroleum oil (Wyoming residual) 50% (by volume); fortified with 2-1/2% Pentachlorophenol (by weight of total solution)	25	...do...	5.3	6.7	6.0	.453	100.0						
Copper naphthenate, 0.5% copper-metal equivalent (by weight) in petroleum oil (No. 4 aromatic residual)	25	...do...	5.2	6.9	6.0	.540	100.0						
Gasco (oil-tar creosote)	25	...do...	5.1	6.8	5.9	.616	100.0						
Gasco (oil-tar creosote) with 2% pentachlorophenol (by weight)	25	...do...	5.3	6.8	5.8	.455	100.0						
Lignite coal-tar creosote	25	Oil	5.1	6.8	6.3	.518	100.0						
Lignite coal-tar creosote, 50% and coal-tar creosote (medium residue, low in tar acids and naphthalene), 50% (by volume)	25	Solution	5.6	6.9	6.3	.376	100.0						
Lignite coal-tar creosote, 50% and petroleum oil (Wyoming residual), 50% (by volume)	25	...do...	5.5	7.1	6.4	.440	96.0	4.0			1	4.0	
Pentachlorophenol:													
Five percent (by weight) in petroleum oil (No. 2 distillate)	25	...do...	5.1	7.0	6.3	.531	100.0						
Five percent (by weight) in petroleum oil (No. 4 aromatic residual)	25	...do...	5.3	7.0	5.9	.482	100.0						
Three percent (by weight) in petroleum oil (No. 4 aromatic residual)	25	...do...	5.3	6.9	6.0	.412	100.0						
Five percent (by weight) in petroleum oil (Wyoming residual)	25	...do...	4.5	7.4	6.0	.817	100.0						
Pentachlorophenol, 5% in petroleum oil (No. 4 aromatic residual), 50%; and copper naphthenate, 0.5% copper-metal equivalent, in petroleum oil (No. 4 aromatic residual), 50% (by volume)	25	...do...	5.4	7.0	6.2	.543	100.0						
Petroleum oil:													
Aromatic, high residue (S.W.)	25	Oil	5.1	6.7	6.1	.553	100.0						
Aromatic, low residue (S.W.)	25	...do...	5.1	6.9	6.1	.557	100.0						
Highly aromatic (S.O.)	25	...do...	5.1	6.9	6.0	.484	100.0						
Highly aromatic, high residue (S.O.)	25	...do...	5.1	6.9	6.1	.503	96.0	4.0			1	4.0	
No. 2 distillate (mid-United States)	25	...do...	5.0	7.2	5.9	.650	12.0	36.0	52.0		22	88.0	7
No. 4 aromatic residual (Calif.)	25	...do...	5.2	6.8	5.9	.448	96.0	4.0			1	4.0	
Wyoming residual	25	...do...	5.1	6.9	5.8	.691	36.0	52.0	12.0		16	64.0	8
Termiteol (softwood tar creosote)	25	...do...	4.9	6.9	6.1	.505	100.0						
Untreated control posts	25							20.0	80.0		25	100.0	2.3

[1] Average life taken from a mortality curve, except where all posts have been removed.

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Figure 1. -- Test posts installed during 1949 in a plot at the Harrison Experimental Forest, Saucier, Miss.

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