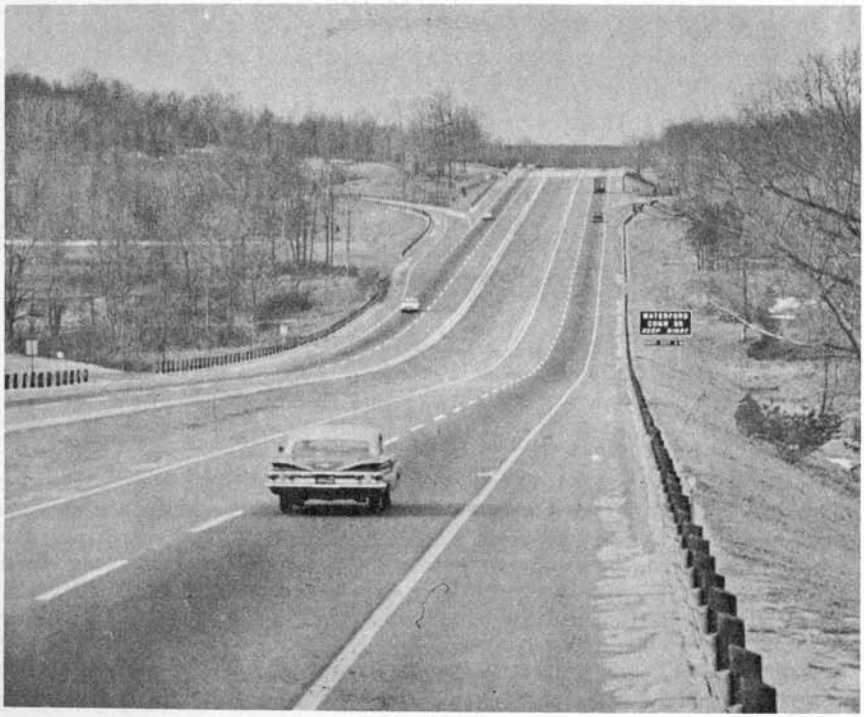
HIGHWAY POST SURVEY

A 1960 Progress Report

A. R. Olson



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The CONNECTICUT Agricultural Experiment Station
NEW HAVEN

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Under a cooperative agreement between this Station and the Connecticut State Highway Department a study of the service life of wood posts used in highway fencing was begun in 1940, and since that time nearly 9,000 posts have been included. Most of these posts were set on shoulders of the road and bore two galvanized woven steel cables fastened to the posts with eyebolts; a few were used to support woven wire along boundaries of adjacent property. They were 7 feet long for cable or 8 feet long for wire and were set to a depth of 3½ feet. With one exception all posts were in the round, and all had received preservative treatment in the manner later described.

The objectives of the study were first, to provide the Highway Department with data for use in setting up specifications for wood posts, and second, to gather information on preservative treatment when a large number of posts was involved. Because the posts were scattered over many miles of highway at widely scattered locations it was not considered feasible to make inspections oftener than once every 5 years. Due to the wide dispersal, infrequent inspections, and an anticipated removal of some posts for various reasons the general plan specified that any method of treatment or preservative be represented by 100 or more posts. The plan was followed with a few minor exceptions, as shown in Table 1 and Table 2.

The project started in 1940 with the tagging and inspection of some 4,800 posts which had been set between 1933 and 1935 and the tagging

without inspection of some 3,300 posts set in 1939 and 1940. Reinspections were made in 1945, 1950, 1955, and 1960. These included all posts mentioned above on which observations had not been terminated (see Tables) and also some 800 posts set after 1940.

Inspection was done by excavating to a depth of 12 inches and examining the exposed part of the post with the aid of a strong thin-bladed probe and a light hammer. Light hammer blows served to detect zones of interior decay which could then be explored with the probe. No attempt was made to examine that part of the post below the excavation since experience had indicated that, in a very high percentage of cases, deterioration at the ground line is more advanced than at levels more than 12 inches below that point.

The results of the inspections through 1950 were included in a bulletin[1] of this Station. A later progress report[2] included information obtained in the 1955 inspection. This report includes data from the 1960 inspection and provides information on service tests for up to 20 years duration. It also includes data on some posts installed more recently and not previously reported on.

Insofar as possible, record keeping conformed to procedure established by the U. S. Forest Products Laboratory. This consisted in considering the post as divided into two parts:

A. *The Butt* — that part of the post extending from 6 inches above ground to the bottom.

B. *The Top* — that part of the post more than 6 inches above ground.

The condition of the butts and tops was then classified as follows (only the initial letters shown here for the six conditions appear in Table 1):

1. Butt good (BG) — no evidence of decay. Serviceable.
2. Butt partially decayed (BPD) — decay present but so limited that an effective diameter of 6 inches or more of sound wood still remained at ground line. Serviceable.
3. Butt decayed (BD) — decay present to such an extent that the effective diameter of sound wood at ground line was less than 6 inches. Unserviceable.
4. Top good (TG) — no evidence of decay. Serviceable.
5. Top partially decayed (TPD) — decay present but so limited that an effective diameter of 6 inches of sound wood still remained at and below the top cable bolt. Serviceable.
6. Top decayed (TD) — decay present to such an extent that the effective diameter of sound wood was less than 6 inches at or below the top cable bolt. Unserviceable.

The term decay, as here used, includes deterioration caused by fungi and insects. Only very occasional damage by termites and ants was found and is not separated from defects caused by decay.

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[1] Bulletin 581. Preservation of Wood by Simple Methods, by Henry W. Hicock and A. Richard Olson. 1954.

[2] Circular 196. Highway Post Survey, by Henry W. Hicock and A. Richard Olson. 1956.

The condition of the butts and tops is shown separately in Figure 1 and Table 1 which indicate where the preservative treatment failed to provide adequate protection against decay. The percentages under the several headings are based on the number of posts actually in service at the time of inspection, not the number originally set.

Figure 2 and Table 2 show the percentages of posts found in a serviceable condition without separate consideration of butts and tops. The data are based on the number of posts originally set less those removed for reasons other than decay (relocation of the highway, broken in accidents, etc.). Consequently they present a better basis for estimating all losses due to decay than do the data in Figure 1 and Table 1.

It may be well to note at this point that the criteria for judging the condition of the tops and butts of posts and for determining whether a post was serviceable or unserviceable were far more rigid than that which would be used to define the condition of farm and other types of posts in situations where human life is not at stake. Moreover, Connecticut state highway specifications state that the minimum diameter of a wood post must be not less than 6 inches. By implication this would mean that a post must have a minimum effective diameter of 6 inches at all times.

Preservative Treatments and Service Performance

Ten different preservative treatments are represented in this study. Descriptions of the preservative treatments given the posts and the results of service tests follow. Tables 1 and 2 show the results of the tests in detail, and Figures 1 and 2 are designed to permit ready comparison of treatment effectiveness.

Pressure with creosote

Red and southern yellow pine posts were purchased through commercial channels under a specification which called for a retention of 6 pounds of grade 1 A.W.P.A. coal tar creosote per cubic foot. All posts were framed to final size and bored for eyebolts prior to treatment.

After 20 years of service the posts of both species were in excellent condition with less than 5 per cent unserviceable due to decay.

The hardwood posts set 1939-40 were purchased untreated by the Highway Department, which had them custom-treated in 8-foot lengths. Creosote specifications were the same as for the pines. They were framed to final length of 7 feet and bored for eyebolts after treatment. The tops were given a brush coat of creosote after setting.

After the same length of time the condition of the hardwoods was less satisfactory than that of the pines. The ring-porous oaks were in better shape on the whole than the diffuse-porous maple and birch. White oak was better than red oak, as might be expected from the relative durability of the heartwood of the two species (Table 2). Considering the tops and butts separately (Table 1), the tops of the oaks showed a higher incidence of decay than those of maple and birch. The butts of the oaks, on the other hand, were in better condition than the butts of maple and birch.

A number of circumstances apparently account for this reversal.

When treated full-length with creosote or an oil-soluble preservative such as pentachlorophenol, by any method, maple and birch tend to absorb an excessive amount of preservative near the ends. Penetration at the mid-point of the post, on the other hand, is often extremely shallow. Under the same conditions oak posts tend to get a complete sapwood penetration over their entire length with relatively little heartwood penetration. Shallow penetration at mid-point (ground line) could be responsible for the greater amount of decay in the butts of maple and birch posts than in the butts of oak posts. Conversely, since about a foot was removed from all posts after treatment, it seems reasonable to believe that the heavy absorption near the ends of maple and birch posts could make their tops more resistant to decay than the tops of oak posts on which cutting exposed a large surface of untreated heartwood. The cut ends of the oak posts showed much more severe checking than those of maple and birch posts and, if such checking occurred after cutting, exposing untreated wood, brush treatment of the cut surfaces could not be expected to afford adequate protection for as long as 20 years.

An additional 158 maple and birch posts and 47 red pine posts were set in 1951. These were treated in the same manner as the previously mentioned pines except that a retention of 8 lbs. of creosote was specified.

After 10 years these posts are in excellent condition with the maple and birch posts in better condition after the same length of service than those set previously.

Open tank, full length, with creosote

Oak, maple and birch posts were treated by the open tank method with grade 1 A.W.P.A. coal tar creosote by immersing the top ends in creosote at 110-120° F. for 2 to 4 hours and then immersing the butt ends in creosote at the same temperature for 4 to 5 hours. All posts were framed to final dimensions but not bored before treatment. Bore holes were later treated with creosote.

Although factors of treatment and subsequent handling were sufficiently different to make strict comparisons impossible, these posts compare favorably during the first 15 years with those of the same species treated under pressure with creosote. After 15 years, however, decay increased in the tops of the oaks causing 34 per cent to become unserviceable after 20 years, more than three times as many as in the tops of the pressure-treated oak posts, Table 1. Otherwise the condition of the posts was comparable for the two treatments.

Cold soaking with pentachlorophenol

These treated posts of red pine were purchased from a Connecticut supplier who cold-soaked them fully immersed in a 5 per cent solution of pentachlorophenol in furnace oil for 48 to 96 hours. Some checks on posts treated by this supplier indicated that his treatment resulted in absorptions of 7 to 9 pounds of solution per cubic foot and penetrations at mid-point of 1½ inches or more.

After 10 years all of the posts were still in serviceable condition. Some 12 per cent of the posts were listed as partially decayed. The de-

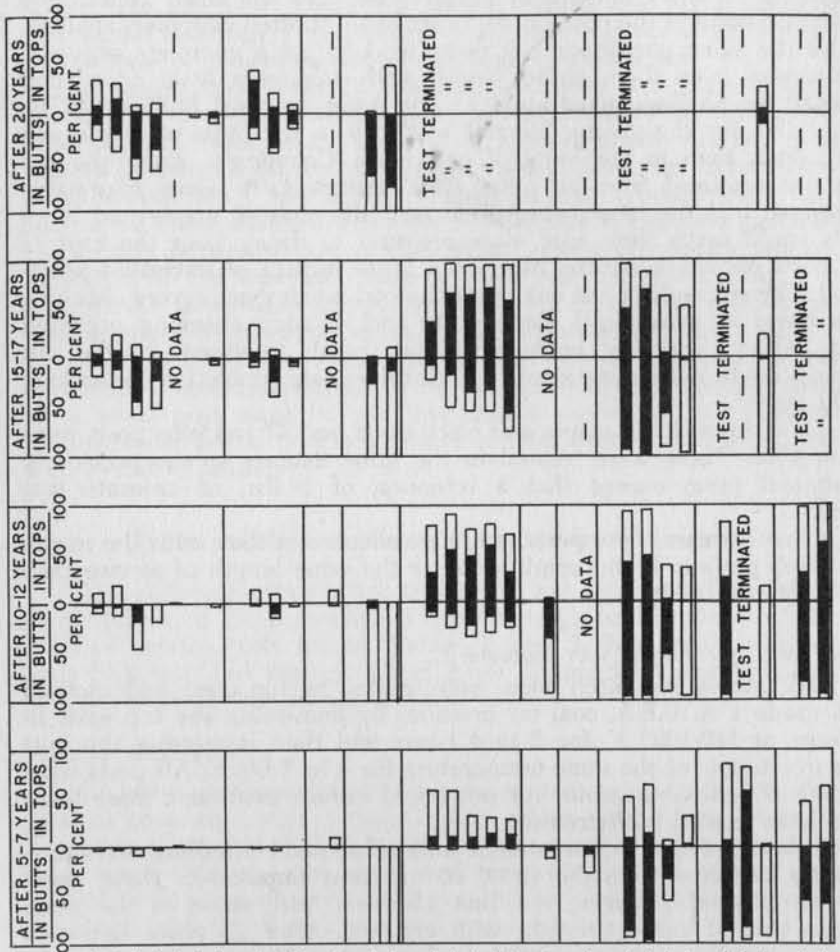

FIGURE 1. Per cent of butts and tops of posts partially decayed but still serviceable (□) and decayed, unserviceable (■).

terioration was in the form of small spots or long narrow streaks on one side of the post only, usually extending inward for about ¼ inch and not greatly different than at the end of 5 years. From the pattern exhibited it appeared that there may have been local areas where the wood did not take treatment. High moisture content in those areas at the time of treatment, due to improper seasoning, is a possible cause since wood of high moisture content cannot be expected to take the treatment properly. Untreated areas could also have resulted from accumulated water in the bottom of the treating tank. This indicates that it is necessary to pay close attention to details both prior to and during the cold-soaking process.

Pressure with Wolman salts

These hardwood posts, almost entirely oak, had been pressure-treated with Wolman salts. Specifications for the treatment are not available but presumably were standard for this material.

After 5 years of service, the butts of all of the posts were listed as "partially decayed" because a thin layer of wood on the outer surface had become soft and crumbly. The wood was dark brown but did not have the appearance of wood decayed by fungi. Rather, deterioration appeared to be caused by the preservative or products of its decomposition. The wood was sound and normal in color beneath this layer. This deterioration was only minor at the end of 5 years, when the layer was usually less than ¼ inch thick, but increased with time. After 10 years the layer was usually up to ⅜ inch and after 20 years averaged more than ½ inch in thickness. By the 15th year the deterioration in the layer had apparently exposed untreated wood to attack by fungi, and 26 per cent of the posts were unserviceable due to interior decay. At the end of 20 years more than 60 per cent had become similarly decayed. None of the tops have shown this type of deterioration. A similar condition has been observed elsewhere on hardwood posts treated with zinc chloride. The posts compared favorably with the hardwoods pressure-treated with creosote for the first 15 years but deteriorated more rapidly after that.

Open tank, butts only, with creosote

The butt ends of posts of white and red oak, maple, birch, and pitch pine were treated with grade 1 A.W.P.A. coal tar creosote by the open-tank method. Specifications of the Highway Department at that time stipulated that the top 2½ feet of the post should not be treated with creosote because this would interfere with the application of white paint for visibility. Later, visibility was provided by reflector materials attached to the posts and this permitted full-length treatment. Treatment was by immersing the lower 4 feet of the post in creosote maintained at 215° F. for 4 to 6 hours. Some of the posts were subjected to a cold bath for 4 to 16 hours, others were not. Poor results in service may sometimes have been due to omission of the cold bath but the rapid spread of decay from the untreated tops so complicated the situation that it was impossible to evaluate the effectiveness of treatment with or without cold bath. Practically all the maple and birch posts were incised from

TABLE 1. Incidence of decay in the butts and tops of posts

Treatment, Preservative, and Species	Number of Posts	After 5-7 Years Service						Number of Posts	After 10-12 Years Service						Number of Posts	After 15-17 Years Service					
		BUTT			TOP				BUTT			TOP				BUTT			TOP		
		BG	BPD	BD	TG	TPD	TD		BG	BPD	BD	TG	TPD	TD		BG	BPD	BD	TG	TPD	TD
		Per cent							Per cent							Per cent					
Pressure, Creosote																					
White Oak (1)	249	99	1	0	100	0	0	245	91	6	3	89	11	0	242	83	11	6	83	12	5
Red Oak (1)	520	99	1	0	100	0	0	512	89	9	2	81	19	0	502	71	18	11	74	17	9
Maple (1)	68	93	6	1	100	0	0	68	54	28	18	100	0	0	63	43	14	43	84	14	2
Birch (1)	42	98	2	0	100	0	0	42	81	19	0	100	0	0	42	50	29	21	93	7	0
Maple and Birch (1A)	158	100	0	0	99	1	0	144	100	0	0	99	1	0	....	....	....	....	....	....	....
Red Pine (1B)	596	100	0	0	100	0	0	573	100	0	0	100	0	0	521	100	0	0	100	0	0
Southern Yellow Pine (1)	482	100	0	0	100	0	0	472	99	1	0	100	0	0	460	95	2	3	99	1	0
Total	2,115							2,056							1,830						
Open Tank, Full Length, Creosote (1)																					
Oak	195	99	1	0	100	0	0	194	99	1	0	87	13	0	192	90	7	3	64	30	6
Maple	51	98	0	2	100	0	0	43	86	5	9	91	9	0	43	61	16	23	91	7	2
Birch	53	100	0	0	100	0	0	52	98	0	2	100	0	0	52	92	4	4	100	0	0
Total	299							289							287						
Cold Soaking, Pentachlorophenol (3)																					
Red Pine	413	99	1	0	91	9	0	403	98	2	0	88	12	0	....	....	....	....	....	....	....
Pressure, Wolman Salts (1)																					
Oak	386	0	100	0	100	0	0	386	0	95	5	99	1	0	379	0	74	26	99	1	0
Maple	9	0	100	0	100	0	0	9	0	100	0	100	0	0	9	0	89	11	89	11	0
Total	395							395							388						
Open Tank, Butts Only, Creosote (2)																					
White Oak	400	99	1	0	43	47	10	384	86	5	9	21	49	30	329	78	15	7	10	53	37T
Red Oak	1,264	99	0	1	42	48	10	1,188	74	15	11	10	37	53	814	50	33	17	3	31	66T
Maple	1,293	99	1	0	68	23	9	1,208	66	12	22	25	28	47	807	46	19	35	6	31	63T
Birch	304	100	0	0	70	17	13	284	70	16	14	19	23	58	198	45	23	32	5	25	70T
Pitch Pine	361	98	0	2	72	17	11	346	74	8	18	31	39	30	297	25	19	56	6	36	58T
Total	3,622							3,410							2,445						
Barrel Method, Zinc Chloride (4)																					
Red Pine	56	87	9	4	100	0	0	56	7	57	36	96	2	2	....	....	....	....	....	....	....
Osmosis, Osmosalts (5)																					
Loblolly Pine	196	71	21	8	100	0	0	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Butts Brushed, Creosote (2)																					
White Oak	415	6	6	88	49	42	9	359	0	4	96	8	52	40	193	0	6	94	4	46	50T
Red Oak	32	3	0	97	37	50	13	31	0	6	94	6	45	49	16	0	0	100	12	19	69T
White Cedar	660	44	23	33	94	6	0	647	10	39	51	61	36	3	617	9	34	57	37	58	5T
Black Locust	75	100	0	0	70	29	1	75	4	96	0	64	35	1	75	1	96	3	47	53	0T
Total	1,182							1,112							901						
Butts Brushed, 8-13 Tar (1)																					
Oak	78	0	13	87	15	80	5	16	0	6	94	19	56	25T	....	....	....	....	....	....	....
Pitch Pine	32	3	16	81	19	25	56T	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Black Locust	357	7	93	0	99	1	0	338	0	100	0	84	16	0	256	0	98	2	77	23	0
Total	467							354							256						
Butts Dipped, Hot Coke-Oven Tar (1)																					
White Oak	82	0	45	55	52	48	0	71	0	20	80	1	69	30T	....	....	....	....	....	....	....
Red Oak	150	0	41	59	38	59	3	79	0	8	92	0	39	61T	....	....	....	....	....	....	....
Total	232							150							....						
Grand Total	8,977							8,225							6,107						

(1) Set 1939-40. (1A) Set 1951. (1B) 549 set 1939-40, remainder in 1951. (2) Set 1933-35. (3) Set 1951. (4) Set 1948. (5) Set 1953. T = Tests terminated.

TABLE 1. Incidence of decay in the butts and tops of posts (concluded)

Treatment, Preservative, and Species	Number of Posts	After 20 Years Service					
		BUTT			TOP		
		BG	BPD	BD	TG	TPD	TD
		Per Cent					
Pressure, Creosote							
White Oak (1)	230	74	16	10	64	28	8
Red Oak (1)	468	62	18	20	68	17	15
Maple (1)	40	35	20	45	90	7	3
Birch (1)	34	41	24	35	88	12	0
Maple and Birch (1A)	....	....	....	....	....	....	....
Red Pine (1B)	498	>98	1	<1	100	0	0
Southern Yellow Pine (1)	423	92	5	3	98	1	1
Total	1,693						
Open Tank, Full Length, Creosote (1)							
Oak	172	75	12	13	56	10	34
Maple	37	60	5	35	78	16	6
Birch	52	84	6	10	90	8	2
Total	261						
Pressure, Wolman Salts (1)							
Oak	353	0	37	63	97	3	0T
Maple	8	0	25	75	50	50	0T
Total	361						
Butts Brushed, 8-13 Tar (1)							
Oak	....	....	....	....	....	....	....
Pitch Pine	....	....	....	....	....	....	....
Black Locust	247	0	89	11	74	24	2
Total	247						
Grand Total	2,562						

(1) Set 1939-40. (1A) Set 1951. (1B) 549 set 1939-40, remainder in 1951 T = Tests terminated.

18 inches below to 6 inches above ground line to provide better impregnation.

At the end of 5 years the butts of all posts were in nearly perfect condition but about 10 per cent had become unserviceable due to decay in the untreated tops, Table 1. After 10 years between 30 and 60 per cent of the posts had become unserviceable because of decay in the tops whereas only 9 to 22 per cent of the butts were in similar condition. It was evident at 10 years that some of the decay in the butts had spread from the decayed tops down through the untreated interior of the butts. At the end of 15 years, 35 to 70 per cent of the posts had failed in the tops and 7 to 56 per cent in the butts. Observations on this lot of posts indicate quite clearly that, in the Northeast, posts of non-durable woods should be given a full-length treatment to afford an approximately equal degree of serviceability to tops and butts.

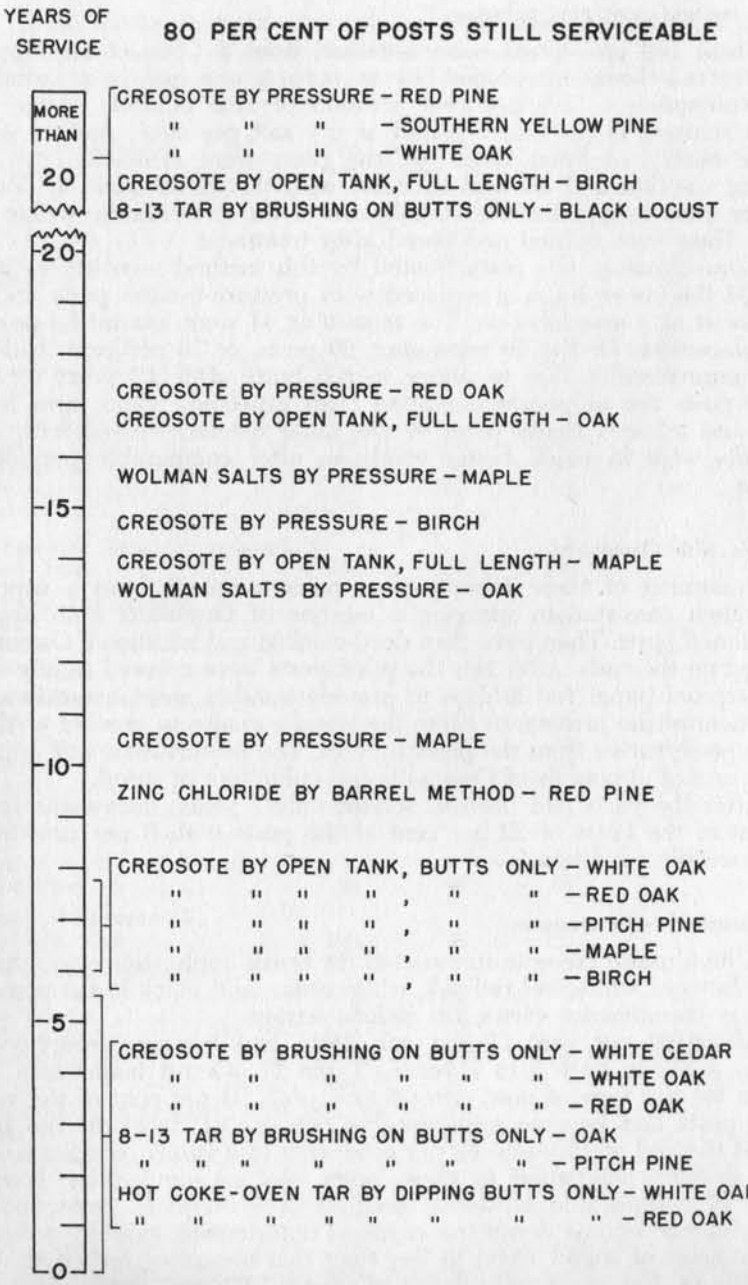

FIGURE 2. "Yardstick" of effectiveness of the preservative treatments to provide protection against decay in the posts as determined by number of years 80 per cent of the posts remained in serviceable condition. Treatment with pentachlorophenol and Osmosalts not shown because of insufficient length of service.

Barrel method with zinc chloride

These red pine posts were obtained from a Connecticut supplier who treated them, unseasoned, by immersing one end in a barrel or tank containing a 33⅓ per cent solution of zinc chloride. After sufficient solution to provide 1 pound of dry salt per cubic foot of wood in the posts had been taken up, the posts were removed from the treating solution and allowed to stand with the intake ends up for 90 days or more to equalize the distribution of the preservative within the posts. They were framed and bored after treatment.

Approximately 100 posts treated by this method were set in 1948. In 1954 the entire lot was replaced with pressure-treated posts and 56 were reset at a new location. The remaining 44 were lost in the process of replacement. Of the 56 remaining, 20 posts, or 36 per cent, had become unserviceable due to decay in the butts after 12 years service. These posts are in poorer condition than expected. Some farm fence posts and tobacco shade poles of the same species, treated with zinc chloride, were in much better condition after comparable periods of service.

Osmosis with Osmosalts

Treatment of these loblolly pine posts obtained from a supplier in Virginia consisted in spraying a solution of Osmosalts onto peeled, unseasoned posts. They were then dead-stacked and additional Osmosalts sprayed on the ends. After this the piled posts were covered tightly with a waterproof paper for 30 days to provide suitably moist conditions for movement of the preservative into the wood and also to prevent washing of the preservative from the posts by rain. The preservative was applied at the rate of .3 pounds of Osmosalts per cubic foot of wood.

After the posts had been in service only 7 years, decay was found present in the butts of 29 per cent of the posts with 8 per cent in an unserviceable condition.

Butts brushed with creosote

A high grade creosote formulated for brush application was applied to the butts of white and red oak, white cedar, and black locust posts by highway maintenance crews just before setting.

About 90 per cent of the oak posts had become unserviceable due to decay in only 5 to 7 years (Table 2), a most inadequate protection for this type of post. After 5 to 7 years 33 per cent of the white cedar posts had become unserviceable because of decay in the butts and, at the end of 15 years, 57 per cent were in a similar condition. The quite durable heartwood in these posts was surrounded by 1 to 1½ inches of non-durable sapwood. Because of inadequate protection by the treatment against decay the sapwood deteriorated, thereby reducing the diameter of sound wood to less than that necessary for safety, particularly in the posts of smaller diameter. Failures were, however, lower than in the oaks. More than 97 per cent of the locust posts remained serviceable after 15 years. Since the sapwood was thin on these posts, their good condition is attributed to the natural durability of the heartwood rather than to the preservative treatment. The 75 locust

TABLE 2. Posts in serviceable condition after 5 to 20 years, in per cent of those originally set

Treatment, Preservative, and Species	Number of Posts Set	After 5-7 Yrs.	After 10-12 Yrs.	After 15-17 Yrs.	After 20 Yrs.
Pressure, Creosote					
White Oak (1)	249	100	97	89	82
Red Oak (1)	520	100	98	85	73
Maple (1)	68	98	82	54	34
Birch (1)	42	100	100	79	55
Maple and Birch (1A)	158	100	100	....	....
Red Pine (1B)	596	100	100	100	>99
Southern Yellow Pine (1)	482	100	100	97	95
Total	2,115				
Open Tank, Full Length, Creosote (1)					
Oak	195	100	100	92	63
Maple	51	98	91	77	56
Birch	53	100	98	96	90
Total	299				
Cold Soaking, Pentachlorophenol (3)					
Red Pine	413	100	100	....	....
Pressure, Wolman Salts (1)					
Oak	386	100	95	74	36T
Maple	9	100	100	89	22T
Total	395				
Open Tank, Butts Only, Creosote (2)					
White Oak	400	90	67	54T	....
Red Oak	1,264	90	43	26T	....
Maple	1,293	91	46	25T	....
Birch	304	87	39	21T	....
Pitch Pine	361	88	61	24T	....
Total	3,622				
Barrel Method, Zinc Chloride (4)					
Red Pine	56	96	64	....	....
Osmosis, Osmosalts (5)					
Loblolly Pine	196	92	....	....	....
Butts Brushed, Creosote (2)					
White Oak	415	11	3	2T	....
Red Oak	32	3	1	0T	....
White Cedar	660	67	47	40T	....
Black Locust	75	99	99	97T	....
Total	1,182				
Butts Brushed, 8-13 Tar (1)					
Oak	78	11	3T	....	....
Pitch Pine	32	9T	....	....	....
Black Locust	357	100	100	98	86
Total	467				
Butts Dipped, Hot Coke-Oven Tar (1)					
White Oak	82	44	15T	....	....
Red Oak	150	39	4T	....	....
Total	232				
Grand Total	8,977				

(1) Set 1939-40. (1A) Set 1951. (1B) 549 set 1939-40, remainder in 1951 (2) Set 1933-35. (3) Set 1951. (4) Set 1948. (5) Set 1953. T = Tests terminated.

posts were removed after 15 years when all posts along the highway were replaced with posts pressure-treated with creosote.

Butts brushed with 8-13 tar

Oak, pitch pine, and black locust posts were treated with 8-13 tar in the same manner as those posts brush-treated with creosote. The oak posts, which were originally intended for railroad ties, had been slabbed on two sides.

This treatment was also ineffective, with 87 and 81 per cent of the oak and pitch pine posts, respectively, failing because of decay in the butts within 5 years (Table 1). The untreated tops of the pitch pine posts decayed more readily than those of oak. Eighty-six per cent of the locust posts remained in serviceable condition after 20 years, Table 2, due again to the natural durability of the heartwood rather than to the treatment. The sapwood soon became decayed but because of its thinness did not materially affect the serviceability of the posts. Decay in the tops was only minor in extent with most of it present in the sapwood nearest ground and some at branch junctions. Only 2 per cent of the posts had failed in the top after 20 years.

Butts dipped in hot coke-oven tar

White and red oak posts were treated at a maintenance yard of the Highway Department by immersing the lower 4 feet in hot coke-oven tar for one minute.

This treatment was no more effective than the brush treatments with creosote and the 8-13 tar. The slightly better condition of these posts as reflected in Table 1 is due to their greater diameter. Even so, 80 to 92 per cent of the posts had failed at the end of 10 years because of decayed butts.

Summary and Conclusions

(1) Pressure treatment with creosote at the rate of 6 pounds per cubic foot provided excellent protection against decay to the red and southern yellow pine posts. It seems that with a similar treatment equally good protection could be provided other hard pines having a thick sapwood. Since the red pine posts with this preservative treatment were in the best condition of any in these tests after 20 years and also since there is an abundant local supply suitable for posts this species should merit special attention. Current highway specifications calling for an 8-pound-per-cubic foot treatment should be even more effective.

(2) A similar pressure treatment with creosote provided less protection against decay in the hardwoods than in the pines. The difference is attributed to poorer impregnation and distribution of the preservative in the posts. Improvements in treatment which will correct these defects are needed before posts so treated can be recommended without qualification for heavy-duty use.

(3) The full length, open-tank treatment with creosote is ranked near that of pressure treatment with creosote in providing protection against decay. The greatly increased serviceable life of these posts over those with the same treatment applied to the butts only demonstrates the need for treatment of the tops as well as the butts of posts of non-durable woods in the Northeast.

(4) Although the red pine posts cold-soaked in pentachlorophenol have been in service for only 10 years, the lack of failures due to decay indicate good service life. The decay found occurring in rather narrow streaks at the surface on one side of some of the posts seems most likely due to high moisture content of the wood there when treated or to accumulated water in the bottom of the treating tank. This suggests greater care in seasoning and treating in order to insure uniformly good treatment.

(5) On posts pressure-treated with Wolman salts, the increased deterioration of the wood on the inside following the peculiar deterioration of that on the outside in butts caused this treatment to be less effective than a similar treatment with creosote. In contrast with the butts, the tops were all in serviceable condition after 20 years, indicating that Wolman salts is an excellent material on wood used above ground. Further study would be needed to determine how the treatment solution caused deterioration.

(6) The treatment with zinc chloride applied to the red pine posts was less effective than similar treatment to other types of posts. More information on the treatment and subsequent distribution of the preservative in the wood might have helped to explain the early failures in these posts.

(7) Brushing on or briefly immersing in the preservative failed to provide adequate protection against decay in the posts of non-durable woods. Even when creosote was used the treatment was ineffective because it did not provide impregnation of the wood to a sufficient depth. Such treatments which provide impregnation near the surface only are wholly inadequate for this type of material.

(8) Good distribution of the preservative as well as retention of a sufficient quantity is essential to provide good preservative treatment in a post. Specifications which stipulate the depth of impregnation at critical points in addition to the amount retained should help to insure a treatment which will provide long life.

(9) Posts treated throughout their length should be fully framed and bored prior to treatment.

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