Research Contribution 26 August 1999

Service Life of Treated and Untreated Fence Posts: 1996 Post Farm Report

by

Jeffrey J Morrell
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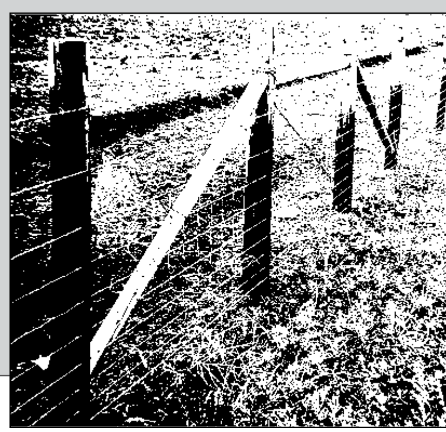

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Abstract

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Untreated and preservative-treated fence posts were exposed in soil at a test site near Corvallis, OR. Several species, including western juniper and Osage-orange, showed exceptional natural durability. Preservative treatment generally extended the useful life of the posts, but the degree of protection varied with the chemical and the application method.

Contents

List of Tables

Names and formulas of inorganic chemicals used as preservatives

Ammonia	NH_3
Arsenic pentoxide	As_2O_5
Arsenic trioxide [arsen(i)ous oxide]	As_2O_3
Chromium trioxide (chromic acid)	CrO_3
Copper oxide	CuO
Copper sulfate	$CuSO_4$
Mercuric chloride	$HgCl_2$
Sodium arsenate	Na_3AsO_4
Sodium chromate	Na_2CrO_4
Sodium dichromate	$Na_2Cr_2O_7$
Sodium fluoride	NaF
Zinc arsenate	$Zn_3(AsO_2)_2$
Zinc chloride	$ZnCl_2$
Zinc meta-arsenite	$Zn(AsO_2)_2$
Zinc oxide	ZnO
Zinc sulfate	$ZnSO_4$

The Post Farm

History

Fence posts constitute an important but unobtrusive component of our rural infrastructure. Initially, fences were supported by posts of wood species that contained naturally durable heartwood, such as cedar, Osage-orange, and black locust. Declining availability and higher prices for these species have encouraged substitution of alternative species that often lack the durability of the woods they have replaced. To improve service life, posts have been dipped, soaked, or pressure-treated with various preservatives.

Historically, evaluating the performance of posts was difficult because of the lack of data on the service life of naturally durable and treated posts. In 1927, Professor TJ Starker, of the College of Forestry at Oregon State University, established a post farm in order to develop data on natural durability of native woods and the effectiveness of preservative treatments for species used as fence posts. The first posts were set on 7 January 1928; since then, 2,882 posts have been placed in the farm. These posts include 3 introduced and 25 native species in untreated condition, 8 native Oregon species receiving various preservative treatments, and, more recently, treated and untreated composite (laminated veneer lumber and Paralam) posts. In addition, five series of steel posts have been installed for comparison.

The condition of these posts has been reported periodically, most recently by Miller (1986). Data on all of the tests are included here for continuity.

Site Description

The post farm is located on a well-drained south slope on College of Forestry land in the Peavy Arboretum, about 11 km north of Corvallis, OR. The soil is Olympic silty-clay loam; the top 200 mm is slightly acidic (pH 5.4) and has 12 mm of humus. Its organic matter and nitrogen content are 4.71% and 0.14%, respectively. Brush on the test site has been controlled with herbicides, most recently glyphosate (Monsanto Chemical Co., St. Louis, MO).

The generally mild climate of the area, with typically dry summers and rainy winters, favors growth of wood-destroying organisms throughout the year. Annual precipitation at the site averages 1050 mm. Of this, 81% falls from October through March, when average monthly temperatures range from 4°C to 12°C; only 3% falls during July and August, when temperatures average 19°C. Occasionally, the temperature falls below freezing or rises above 29°C. Afternoon breezes from the Pacific Ocean cool the area almost daily during the summer. The risk of decay above ground is characterized as moderate (Scheffer 1971).

Limitations of Post Farm Data

The data in this report should not be applied indiscriminately to every locality or to all service requirements for posts. Data are comparable within our test site and on similar sites west of the Cascade Mountains. In other situations, such as drier or colder climate or summer irrigation, the data must be incorporated with local biodeterioration experience.

The posts in our test usually are not stapled, nailed, or subject to other physical forces that frequently reduce the service life of posts actually in use. Also, the method used to determine failure (a pull at the post's top) may not be comparable to all physical forces that might be exerted on posts in actual service; however, it provides a reasonably reproducible test method.

Factors Affecting Service Life of Posts

The service life of treated wood is influenced by the wood species, the portion of the post treated (full length or butt only), the effectiveness of the preservative, the amount and permanence of preservative retained by the wood, the depth and uniformity of treatment, and the conditions of use. Most preservatives remain effective for as long as the concentration of preservative is adequate to combat the destructive organisms.

Successful treatment provides penetration and retention of preservative that is adequate to protect the wood under its expected conditions of use. Nevertheless, high retention of preservatives does not necessarily provide full protection. In some species, for example, rapid penetration into end grain completely protects the end of the post, but provides almost no protection to the important groundline zone. Enhancing penetration of the preservative by incising (punching numerous holes into) the side grain of the groundline zone is a useful remedy.

Post Characteristics

Any evaluation of post service must consider characteristics of the wood. Size, amount of nondurable sapwood, and extractive constituents in the heartwood greatly influence serviceability of untreated posts. Sapwood is not naturally insect- and decay-resistant, but extractive constituents in heartwood of a few species furnish resistance to attack by insects and fungi and usually darken the wood. Naturally decay-resistant wood is not uniformly so; the amount of protective extractives tends to vary within and among trees of a species. Untreated posts can give long service if they contain a large amount of durable heartwood and little sapwood. Conversely, if posts are to be impregnated with preservative, an outer layer of permeable sapwood is desirable because it absorbs the preservative readily.

The life of naturally durable, untreated posts also is influenced by post girth and, in some species such as cedars, by the site of origin of the post in the tree. For example, the durability of western redcedar heartwood tends to decrease toward the pith and with height in the tree.

Agents of Deterioration

The most vulnerable section of a post extends from a short distance above the soil surface to some distance below it. This groundline zone usually has a sustained supply of moisture and oxygen that favors growth of destructive fungi. Although tops of posts also may deteriorate, that deterioration normally is slower.

From 1949 to 1985, the following causes of deterioration and failure of the posts at the test site were identified:

Primary agent	Number (%) of failed posts	
Fungi	985	(75.2)
Fungi and termites	206	(15.7)
Fungi and insects other than termites	92	(7.0)
Termites	22	(1.7)
Other insects	5	(0.4)

Decay-producing fungi or fungi in combination with subterranean termites do the most damage. Discarded wings of damp-wood termites have been found at bases of some posts, and entry holes have been detected at or below ground line. However, termites alone have been the primary cause of failure in only a few instances. Carpenter ants and wood-boring beetles also contribute to deterioration.

Climate

Climate determines the suitability of conditions for decay in a given region. Optimal temperatures for growth of decay-producing fungi range from 24°C to 32°C; growth slows as temperature departs from optimum. If wood moisture content is 20% or less (ovendry basis), serious decay is unlikely (Scheffer 1991).

In western Oregon, where moisture and temperature are favorable for long periods, posts adequately treated with a good preservative at the butts often decay at the untreated top long before groundline sections are seriously weakened. The long dry or cold periods in eastern Oregon undoubtedly retard the deterioration of post tops there.

A preservative may fail under one set of climatic conditions but prove very successful under others. For example, a preservative that is readily soluble in water and does not fix to the wood may leach from wood in a rainy region such as western Oregon, but not in a dry climate like that of eastern Oregon. Soil characteristics (for example, pH and organic matter) and microflora also can influence results. Therefore, local experience should nearly always be given more weight than regional data.

Considerations in Applying Pesticides

Virtually all preservatives are poisonous, and some are extremely so, as well as corrosive. Many cause irritations when the chemical itself, its solutions, or its vapor touch the skin. All preservatives should be stored in clearly labeled, closed containers and used only as recommended by the manufacturer. Appropriate clothing must be worn during application of preservatives: a long-sleeved shirt, long pants, socks, boots, rubber gloves, and goggles or safety glasses. Users should not eat, drink, or smoke while using preservatives or after handling treated wood products. Applicators should handle all preservatives carefully and wash exposed parts of the body frequently and thoroughly.

In the United States, chemicals that claim to be preservatives must be registered as pesticides with the Environmental Protection Agency (EPA). This process ensures that the benefits and risks of chemical use have been carefully examined. Registered pesticides must be applied according to the instructions on the label. The label and any accompanying information must always be read before use.

In some instances, the EPA has decided that a chemical is a restricted-use pesticide, which may be applied only under the direct supervision of a pesticide applicator appropriately certified by the state. In Oregon, applicators must be certified to apply wood preservatives through the Oregon Department of Agriculture. In other states, it is important to check with the appropriate state agency for certification rules.

Materials and Methods

Test Specimens

Before 1992, posts usually were installed in groups of 25, each group representing a test series. The posts installed from 1992 through 1996 were installed in groups of 20. Posts within a series were placed 0.6 m apart in a row running north up the test slope. Rows were 0.9 m apart, and all posts were set 0.6 m in the ground.

Before 1947, test posts were 1.2–2.1 m long and 750–1750 mm^2 in cross-sectional area at the groundline. Since then, posts have been standardized to 1.5 m long and 200–675 mm^2 in cross-sectional area.

Inspection Records

All posts are inspected every October. The inspector gives a moderate lateral pull to the top of each post and examines each post that breaks to establish the point and probable cause of failure. Deterioration of the top is rated by visual inspection as slight, moderate, or severe. The following data for each series of posts are recorded: source, species, size and type of individual posts, percentage of sapwood, processing before installation or preservative treatment, preservative treatment (if any), date of installation, and remarks.

Chemicals Used as Preservatives

The following compounds have been used, with various degrees of success, to preserve the test posts. In many cases, the chemicals are no longer commercially available and are not currently registered. All pesticides tested are listed and described to provide context to the performance results of the field-exposed posts.

Ammoniacal copper citrate (ACC): Ammoniacal copper citrate is a solution of copper oxide and citric acid (62.3:35.8) in aqueous ammonia.

Asphalt emulsion: Asphalt is a black to dark brown solid or semisolid composed primarily of bitumens. The emulsion, a suspension of fine asphalt particles in water, has little or no preservative value.

Boliden salts (not commercially available): This preservative contains arsenic acid, sodium arsenate, sodium dichromate, and zinc sulfate dissolved in water.

Carbolineum (not commercially available): Carbolineum, or anthracene oils, is a coal-tar distillate, but its exact composition is unknown. The specific gravity and boiling range are higher for carbolineum than for ordinary coal-tar creosote.

Chemonite (ammoniacal copper arsenate, ACA) (restricted-use pesticide, but wood treated with this chemical is not restricted): Chemonite is a solution of copper oxide and arsenic pentoxide (49.8:52.2) in ammonia.

Chemonite II (ammoniacal copper zinc arsenate, ACZA) (restricted-use pesticide, but wood treated with this chemical is not restricted): Chemonite II is a solution of copper, zinc, and arsenic (50:25:25) in aqueous ammonia.

Chromated copper arsenate (CCA) (restricted use pesticide, but wood treated with this chemical is not restricted): Chromated copper arsenate is a water-soluble mixture of chromium trioxide, copper oxide, and arsenic pentoxide. In CCA Type C, the most commonly used formulation, these chemicals are mixed in a ratio of 47.5:18.5:34.0. Wood treated with CCA is commonly sold under trade names such as Outdoor Wood, Wolmanized Wood, and Sunwood.

Chromated zinc chloride (not commercially available): This preservative contains zinc chloride and sodium dichromate (~82:18) in a water solution.

Copper naphthenate: For optimum performance, solutions of this oil-soluble copper salt of naphthenic acid should contain 2% copper by weight. Test solutions contained 1% copper.

Creosote, creosote oil, or coal-tar creosote (a restricted-use pesticide, but wood treated with this chemical is not restricted): These distillates of coal tar are produced by high-temperature carbonization of bituminous coal. They consist principally of liquid and solid aromatic hydrocarbons, as well as appreciable quantities of tar acids and tar bases. Their continuous boiling point begins near 200°C and ranges to at least 325°C.

Creosote mixtures (a restricted-use pesticide): Creosote may be mixed in various proportions with coal tar, petroleum, crankcase oil, or other diluents that act as carriers for the creosote. Dilutions of more than 50% are less effective and therefore not recommended. Because used crankcase oil can cause hyperkeratosis in cattle, it should not be applied where animals might come in contact with it.

Gasco creosote (not commercially available)**:** This distillate of tar residue from asphalt-based petroleum oils was a byproduct of the production of artificial fuel gas.

Osmosalts (Osmose Wood Preserving, Buffalo, NY; not commercially available)**:** This proprietary wood preservative contains sodium fluoride, sodium dichromate, dinitrophenol, and sometimes arsenic.

Pentachlorophenol (a restricted-use pesticide)**:** This is an oil-soluble chemical formed from phenol and chlorine. Solutions usually contain 5%–7.5% pentachlorophenol by weight.

Permatol "A" (not commercially available)**:** Pentachlorophenol is the toxic constituent of this preservative, which was developed by the Western Pine Association for the millwork industry.

Salt and corrosive sublimate (not recommended as a preservative)**:** This is a mixture of equal proportions, by weight, of two water-soluble compounds. The extremely poisonous mercuric chloride, or corrosive sublimate, is the toxic chemical.

Salt, corrosive sublimate, and arsenious oxide (not recommended as a preservative)**:** This is a mixture of equal proportions, by weight, of the three chemicals. The water-soluble arsenious oxide apparently contributes little, if anything, to the effectiveness of the highly toxic corrosive sublimate.

Sodium pentachlorophenate (a restricted-use pesticide)**:** This is a water-soluble sodium salt of pentachlorophenol.

Sodium trichlorophenate (not commercially available)**:** This is a water-soluble salt of trichlorophenol.

Tanalith (Wolman salts) (not commercially available)**:** Normally, this proprietary wood preservative contains sodium fluoride, dinitrophenol, sodium chromate, and sodium arsenate dissolved in water.

Treater dust, granular treater dust, and treater paste (not commercially available)**:** These preservatives were produced by the Anaconda Copper Mining Company (Butte, MT) as byproducts of copper smelting. Arsenic trioxide was the principal toxic component of the preservatives, which were sold in dust, granular, and paste forms.

Zinc chloride: This compound has been used in a 2%–5% water solution.

Zinc meta-arsenite (not commercially available)**:** This preservative is made by dissolving zinc oxide and arsenic trioxide in water acidified with acetic acid.

Treatment Methods

Treatments Without Pressure

Bore hole (not recommended)**:** One or more holes, 19 mm in diameter and about 50 mm deep, were drilled slanting down from near ground level toward the butt of each freshly cut, unpeeled post. Holes were spaced 125 mm or less apart and staggered vertically on the circumference to avoid serious weakening of the post. One tablespoon of a dry mixture (equal proportions by weight of salt, corrosive sublimate, and arsenous oxide) was placed in each hole with a snugly fitting wood plug, and the hole was sealed.

Brushing: Two applications of preservative solution (copper naphthenate; pentachlorophenol, with or without diesel oil; or creosote) were flooded onto thoroughly air-dried posts on hot days; excess preservative solution then was brushed from the wood.

Charring: The surface of the wood was charred in an attempt to limit fungal growth.

Cold soak: Posts were peeled and thoroughly seasoned before soaking in the commonly used oil-type preservative solutions. Usually that part of the post that would be 150 mm above–300 mm below ground was incised about 12 mm deep for better penetration of preservative. Post butts usually were soaked longer than tops, but the entire post was sometimes immersed. Soaking time varied from several hours to 8 days in unheated solution.

Double diffusion: Freshly cut and peeled posts were soaked in an aqueous chemical solution for 2 or 3 days, then transferred to a similar solution of another chemical to soak for 2 or 3 more days. (Specific chemicals and combinations are identified in the tables.) The chemicals react in the wood to form a toxic compound that is resistant to leaching. Posts treated by this method must be green or unseasoned, not dried.

Hot-cold bath (thermal treatment): Dry posts were soaked in a hot (about 93°C) oily preservative solution for several hours. They then were either left in the solution while it cooled to 38°C–66°C or transferred to cool solution. The tests used several creosotes and a creosote-crankcase oil mixture. Posts receiving the hot-cold bath treatment should be free of bark (bark limits preservative flow into the wood) and thoroughly seasoned if oily solutions are used, and the full length should be treated during the cold bath.

Osmoplastic bandage (Osmose Wood Preserving, Buffalo, NY): A strip 225 mm wide was peeled free of bark around the groundline zone of each unseasoned post and then coated with Osmosalts and tightly wrapped with a water-resistant covering. Osmosalts also was applied to post ends.

Osmosalts: Peeled, unseasoned posts were fully coated with a brushed-on slurry of Osmosalts (2 kg Osmosalts/kg water). Coated posts were closely piled under a tarpaulin for 30 days to allow the preservative mixture to diffuse into the moist wood.

Tire tube with Chemonite (ACA): A section of an automobile inner tube was snugly slipped over the butt end of an unpeeled, freshly cut post inclined on a rack so that the butt was higher than the top. The open end of the tube was elevated, and the tube was filled with Chemonite, a water-soluble preservative that diffused through the sapwood and finally dripped from the lower end of the post.

Treater dust, granules, and paste: These preservatives were tested on freshly cut Douglas-fir posts. Dust and granules were sprinkled around unpeeled posts while the post holes were backfilled with soil; paste (0.9 or 1.8 kg) was applied to butts of peeled posts.

Vacuum treatment with copper naphthenate: Although not commonly used in the United States, vacuum treatments are used to protect windows and door frames in Europe. In this process, a vacuum was drawn over the wood, 1% copper naphthenate treatment solution was added, and the vacuum was released.

Pressure Treatments

Before pressure treatment, posts were either air-dried, seasoned in the preservative by boiling under vacuum, or conditioned by steaming. Preservative was injected into the wood under pressure in a closed vessel, and a final vacuum usually was applied to remove excess preservative. Usually, oily preservatives were heated to higher temperatures than water-borne preservative solutions. The full length of the post was treated.

Test Results

The most informative measure of post serviceability given in this report is average service life. Determining the service life of a series is simple when most or all of its posts have failed. However, average service life can be estimated for series with posts remaining from the number of failed posts and the service age and condition of remaining posts (MacLean 1951). The percentage of failed posts is used to estimate the average service life that has elapsed. We used these curves and the percentage of failed posts in our tests to estimate total service life.

Untreated, Steel, and Composite Posts

Characteristics and service records of untreated posts are listed in Table 1 (completed series) and Table 2 (series remaining in test). Posts that are largely heartwood of durable species could have an average service life of 18 yr or longer. Osage-orange has been exceptionally durable, with no failure during 63 yr of testing. Because natural durability varies greatly, all untreated woods will have a few early failures. Posts from species without durable heartwood or posts that are largely sapwood will have an average service life of 4–7 yr; these posts should be treated with a preservative.

Steel posts have generally performed well, although most have corroded to some degree (Table 2). Failure was greatest (36%) in T-section posts, but the average age of the failed posts was 36 yr. Large I-beams and T-sections originally coated with enamel paint have provided the best performance, with no failures after 48 yr.

The untreated composite posts have generally begun to decay after 3 years of exposure. Three of 24 untreated microlam posts and parallam posts have failed. These figures are consistent with our previous trials of untreated wood at the site.

Posts Treated without Pressure

Characteristics, treatments, and service records of posts treated without pressure are listed in Table 3 (completed series) and Table 4 (series remaining in test). Preservative treatments increased estimated service life of Douglas-fir posts by the amounts given in Table 5. Evaluation of each treatment follows.

Table 1. Untreated posts: Characteristics and service records of completed series (all posts failed).

Species*	Series no.	Description	Sapwood (%)	Groundline perimeter (mm)	Average service life (yr)
Alder, red	16	Split	25	500	5
	106	Round, peeled	100	300	3
Ash, Oregon	28	Split	30	475	6
Buckthorn, cascara	20	Round, peeled	70	225	5
	47	Round, unpeeled	35	425	8
Cedar					
Alaska-	46	Split, one tree	–[†]	450	19
Incense-	29	Split	0	500	14
Port-Orford-	21	Split	0	600	20
Redcedar, western	10[‡]	Split, dark	0	500	24
	11[‡]	Split, light	0	475	22
Cottonwood, black	14	Split	20	550	5
	82	Round, unpeeled	95	350	4
Cypress, Arizona	84	Round, unpeeled	100	325	4
Douglas-fir	1	Round, unpeeled	60	475	7
	55	Square	0	400	6
	57	Square	0	400	4
	72	Round, unpeeled	48	350	7
	97	Square	5	375	4
	100	Round, 4 strips peeled	80	400	4
Fir, grand	15	Split	65	550	9
Hemlock					
Mountain	109	Square, dry	–[§]	375	3
Western	38	Square	0	400	6
Larch, western	37	Square	0	400	7
Madrone, Pacific	26	Round and split	40	525	6
Maple, Oregon	17	Split	25	500	7
Oak, Oregon white	19	Split	20	475	18
Pine					
Lodgepole	48	Round, peeled, dead trees	55	400	5
	49	Round, peeled, live trees	55	400	4
	103	Round, 4 strips peeled	80	300	3
Ponderosa	36	Square	0	400	6
Sugar	35	Square	0	400	7
Idaho white	34	Square	0	400	6
Redwood	58	Square	0	400	21
Spruce, Sitka	31	Square	0	400	6
Tanoak	76	Round, unpeeled	100	300	4
Yew, Pacific	13	Round, peeled	10	400	25

* Twenty-five posts were tested for all series except cascara buckthorn 20 ($n = 12$) and 47 ($n = 26$), Alaska-cedar 46 ($n = 24$), Oregon white oak 19 ($n = 23$), and lodgepole pine 48 ($n = 26$).
[†] Negligible; mostly heartwood.
[‡] Series 10 and 11 were from the same group of posts.
[§] Sapwood not distinguishable from heartwood.

Table 2. Untreated posts: Characteristics and service records of series remaining in test in 1996.

Material	Series no.	Number of posts	Description	Sapwood (%)	Groundline perimeter (mm)	Posts remaining (%)	Age (yr)	Average life of failed posts (yr)	Condition of tops
Juniper, western	30	25	14 split 11 round	40	575	16	66	23	Slight to severe decay
Locust, black	40	22	14 split 8 round	20	350	18	61	22	No to slight decay
Osage-orange	32	26	15 split 11 round	10	475	100	66	—*	No to slight decay
Steel									
Aluminum paint	60	25	L-section, 17.6 kg/m^3	—	—†	88	48	48	Rusted
Red oxide paint	61	25	T-section, 19.2 kg/m^3	—	—	64	48	36	Rusted, failure at ground
Green enamel	69	9	I-section, 64.0 kg/m^3	—	—	100	48	—	Rusted
	70	10	U-section, 20.8 kg/m^3	—	—	78	48	33	Rusted
	71	10	T-section, 24.0 kg/m^3	—	—	100	48	—	Rusted

* Dash indicates none have failed as yet.
† No data are available on groundline perimeter for steel posts.

Table 3. Posts treated without pressure: Characteristics, preservative treatments, and service records of completed series (all posts failed).

Species	Series no.	Number of posts	Description	Sapwood (%)	Groundline perimeter (mm)	Preservative treatment*	Retention† Butt (kg/m^3)	Retention† Top (kg/m^3)	Retention† Post (kg)	Avg. service life (yr)
Alder, red	105	25	Round, peeled, undried	100	300	Double diffusion: 6% $CuSO_4$, B-2; 8% Na_2CrO_4, B-2	—	—	—	6
	108	25	Round, undried, 4 strips peeled	100	325	Double diffusion: 4% NaF, B-2; 6% $CuSO_4$, B-2	—	—	—	10
Cedar, Port-Orford	9	10	Round, peeled	25	500	Hot-cold bath: carbolineum, B	—	—	—	21
Cottonwood, black	27	24	Split, peeled	20	550	Hot-cold bath: creosote, B-6	—	—	—	22
	74	22	Round, peeled, incised, dry	99	350	Cold soak: 5% sodium pentachlorophenate, B-4, T-1	123.2	72.0	1.33	11
	77	25	Round, peeled, incised, dry	95	350	Cold soak: copper naphthenate-diesel oil (1% copper), B-6, T-1	43.2	24.0	0.47	8
	78	25	Round, groundline, peeled, undried	83	350	Osmoplastic bandage	—	—	—	5
Douglas-fir	2	23	Round, unpeeled, undried	60	450	Bore hole: salt and $HgCl_2$, 1 hole, B	—	—	—	28‡
	3	22	Round, unpeeled, undried	60	500	Bore hole: salt, $HgCl_2$, and As_2O_3, 2 holes, B	—	—	—	28‡
	4	22	Round, unpeeled, undried	60	450	Bore hole: salt, $HgCl_2$, and As_2O_3, 3 holes, B	—	—	—	28‡

Table 3 continued

Species	Series no.	Number of posts	Description	Sapwood (%)	Groundline perimeter (mm)	Preservative treatment*	Retention† Butt (kg/m^3)	Retention† Top (kg/m^3)	Retention† Post (kg)	Avg. service life (yr)
	5	25	Round, unpeeled, undried	60	400	Treater dust, B				26‡
	6	25	Round, unpeeled, undried	60	425	Granular treater dust, B	—	—	—	21
	8	22	Round, peeled	60	425	Hot-cold bath: carbolineum, B-6	—	—	—	12
	12	25	Round, peeled	60	350	Cold soak: 5% $ZnCl_2$, B-192	—	—	—	7
	18	24	Round, peeled	60	400	Hot-cold bath: creosote and crankcase oil (50:50), B-20	—	—	—	18
	22	25	Round, peeled	60	375	Charring: 6 mm deep, B	—	—	—	6
	24	24	Round, peeled, undried	60	350	Treater paste, B	—	—	0.91	30
	39	25	Round, peeled	60	475	Brushing: asphalt emulsion, B	—	—	—	5
	62	25	Round, peeled, incised, dry	33	350	Cold soak: 5% pentachlorophenol-diesel oil, B-3, T-2	16.0	6.4	0.17	16
	63	25	Round, peeled, incised, dry	26	350	Cold soak: copper naphthenate-diesel oil (1% copper), B-48, T-6	25.6	4.8	0.23	12
	65	25	Round, peeled, incised, dry	40	350	Cold soak: copper naphthenate-diesel oil (1% copper), B-2, T-2	11.2	4.8	0.13	9
	66	25	Round, peeled, dry	40	350	Cold soak: 5% pentachlorophenol-diesel oil, B-48, T-6	16.0	3.2	0.16	15
	67	25	Round, peeled, dry	33	350	Cold soak: copper naphthenate-diesel oil (1% copper), B-48, T-6	11.2	3.2	0.11	9
	73	25	Round, groundline peeled, undried	58	350	Osmoplastic bandage	—	—	—	11
	79	24	Round, peeled, dry	40	350	Brushing: 2 coats, 5% pentachlorophenol-diesel oil	—	—	—	14
	80	24	Round, peeled, dry	46	350	Brushing: 2 coats, copper naphthenate-diesel oil	—	—	—	11
	81	24	Round, peeled, dry	44	375	Brushing: 2 coats, coal-tar creosote	—	—	—	9
	89	25	Round, unpeeled, undried	45	350	Bore hole: sodium trichlorophenate, 3 holes, B	—	—	—	10
	90	25	Round, unpeeled, undried	39	350	Bore hole: sodium pentachlorophenate, 3 holes, B	—	—	—	7
	91	25	Round, unpeeled, undried	32	350	Bore hole: salt and $HgCl_2$ (2:1), 1 hole	—	—	—	16
	92	23	Round, peeled, dry	46	350	Brushing: 2 coats avenarious carbolineum	—	—	—	7
	93	25	Round, peeled, incised, dry	32	350	Cold soak, vacuum, copper - naphthenate diesel oil (1% copper),B-144, T-47	48.0	19.2	0.54	27
	102	25	Round, undried, 4 strips peeled	65	400	Double diffusion: 6% $CuSO_4$, B-2; 8% Na_2CrO_4, B-2	—	—	—	5
Pine										
Lodgepole	50	25	Round, unpeeled	55	400	Bore hole: salt, $HgCl_2$, and As_2O_3, 1 hole, B	—	—	—	18
	99	25	Round, undried, 4 strips, peeled	75	300	Double diffusion: 6% $CuSO_4$, B-2; 8% Na_2CrO_4, B-2	—	—	—	5
Ponderosa	56	25	Square	0-35	400	Cold soak: Permatol "A", 17 hr	—	—	0.28	19

*B (butt) and T (top) are followed by treating time in hours, if treating time was recorded.
†Blanks indicate retention was not tested.
‡Removed from test in 1955 at 26–28 yr of age. Most posts were severely decayed, but few had failed.

Bore hole (not recommended)**:** Effectiveness of the groundline treatment increased with the number of holes. The treatments increased the average life of lodgepole pine posts from 3–5 yr to 18 yr (series 50, Table 3) and that of Douglas-fir posts from 4–7 yr to more than 28 yr (series 2–4, Tables 3, 5). Similar treatments using more salt or the sodium salts of chlorinated phenols (series 89–91, Tables 3, 5) were less effective. Post tops were not protected by this method and decayed severely. Because the chemicals applied in this treatment are very poisonous, we do not recommend it.

Brushing: Oily solutions of copper naphthenate, pentachlorophenol, and creosote have added 3–8 yr to the 4- to 7-yr average life of some series of Douglas-fir posts (series 79–81, Tables 3, 5). The best treatment was with a solution of 5% pentachlorophenol in diesel oil (series 79). However, because penetration and retention of preservative usually is slight, brushing treatment is not recommended for wood in contact with soil.

Charring: Charring the surface of the post is not a preservative treatment. If anything, it reduces the life of posts by reducing their size at the critical groundline area.

Cold soak: Soaking in a solution of 5% pentachlorophenol in diesel oil has proven effective (Table 4). Soaking incised butts for 48 hr and tops for 6 hr in pentachlorophenol solution resulted in an average life of 30 yr (Table 5) for Douglas-fir posts (series 64); average life of similarly treated incised lodgepole pine posts (series 86) may reach 46 yr. Posts of black cottonwood (series 68), an absorbent species, with butts and tops soaked only 6 hr and 1 hr, respectively, have an estimated life of 42 yr (Table 6); Gasco creosote, no longer available, also was effective. Douglas-fir posts, peeled only at the butts and then incised, dried, and soaked in Gasco creosote (series 88, 95, Tables 4, 5), have an estimated life of 40 yr; their soaking periods were long—7 days for butts and 2 days for tops. Copper naphthenate (1% copper) in diesel oil has been less effective on most species (Tables 3, 5). Treatments with water solutions of sodium pentachlorophenate applied to holes drilled into the posts (series 74) or soaking in zinc chloride (series 12) were not effective. For longest life, the full length of incised and well-seasoned posts should be soaked.

Double diffusion: Treatments with copper sulfate and sodium chromate have not been effective. Treatments with sodium fluoride and copper sulfate, though ineffective with alder (series 108, Table 3), have increased the estimated average life of Douglas-fir posts from 4–7 yr to 27 yr (series 101, Tables 4, 5). Lodgepole pine posts treated with zinc sulfate, arsenic acid, and sodium chromate have an estimated average life of about 33 yr (series 104, Table 4). Most posts treated by the double-diffusion method had decayed tops after 11 yr. Soaking the entire post, rather than just the butts, extends post life.

Hot-cold bath (thermal treatment): Generally effective, these treatments prolonged the life of nondurable black cottonwood (series 27, Table 3) and Douglas-fir (series 8, 18, Table 3) posts to as many as 22 and 12 yr, respectively. One series (54, Tables 5, 6) of butt-treated sawed posts of Douglas-fir heartwood not dried before treatment had unaccountably good durability. Their average life could have reached 60 yr or more, but their badly decayed untreated tops caused premature failures.

Osmoplastic bandage: The treatment was ineffective on posts of black cottonwood (series 78, Table 3), but did increase the estimated average life of Douglas-fir posts to 11 yr (series 73, Tables 3, 5). Osmoplastic bandages are not recommended for posts with nondurable heartwood.

Table 4. Posts treated without pressure: Characteristics, preservative treatments, and service records of series remaining in test in 1996.

Species	Series no.*	Description	Sapwood (%)	Groundline perimeter (mm)	Preservative treatment†	Retention‡ Butt (kg/m³)	Retention‡ Top (kg/m³)	Retention‡ Post (kg)	Posts remaining (%)	Age (yr)	Average life of failed posts (yr)	Condition of tops
Cottonwood, black	68	Round, peeled, incised, dry	89	350	Cold soak: 5% pentachlorophenol-diesel oil, B-6, T-1	116.8	65.6	1.30	20	48	35	Sound
	87	Round, peeled incised, dry	90	350	Cold soak: Gasco creosote oil, B-3, T-2	174.4	161.6	26.3	56	46	33	Sound
Douglas-fir	25	Round, peeled, undried	60	400	Treater paste, B	–	–	1.81	8	66	30	Severe decay
	54	Square	0	400	Hot-cold bath: Gasco creosote, B-6	–	–	0.26	32	57	38	Moderate to severe decay
	59	Round, unpeeled, undried	60	425	Tire-tube: full-length diffusion, Chemonite	–	–	2.72	–	54	30	Moderate decay
	64	Round, peeled, incised, dry	46	350	Cold soak: 5% pentachlorophenol-diesel oil, B-48, T-6	35.2	6.4	0.43	4	48	30	Sound
	75	Round, peeled, undried	46	350	Diffusion: Osmosalts slurry: covered 30 days	–	–	–	24	47	35	Sound to moderate decay
	88	Round, peeled butt, incised, dry	40	350	Cold soak: Gasco creosote oil, B-168, T-48	49.6	35.2	0.89	39	46	20	Sound
	94	Round, peeled, incised, dry	33	350	Cold soak: pentachlorophenol-diesel oil, B-144, T-48	56.0	24.0	0.59	24	46	36	Sound
	95	Round, peeled incised, dry	32	350	Cold soak: Gasco creosote oil, B-144 T-48	51.2	24.0	0.59	60	46	28	Sound
	101	Round, undried, 4 strips peeled	65	425	Double diffusion: 4% NaF, B-2; 6% $CuSO_4$, B-2	–	–	–	4	44	18	Severe decay
Maple, Oregon	83	Round, peeled, incised, dry	75	350	Cold soak: 5% pentachlorophenol-diesel oil, B-24, T-2	120.0	32.0	1.23	80	47	23	Mostly sound
Pine, lodgepole	85	Round, peeled, incised, dry	65	350	Cold soak: Gasco creosote oil, B-43, T-24	65.6	28.8	0.68	20	46	32	Sound
	86	Round, peeled, incised, dry	76	350	Cold soak: 5% pentachlorophenol-diesel oil, B-43, T-24	65.5	40.0	0.73	80	46	34	Sound
	104	Round, undried, 4 strips peeled	80	350	Double diffusion: 5% $ZnSO_4$ + 0.7% As_2O_5, B-2; 8% Na_2CrO_4, B-2	–	–	–	4	44	18	Severe decay

*Twenty-five posts were tested for all series except Douglas-fir series 59 (*n* = 12) and 88 (*n* = 23).
†B (butt) and T (top) are followed by treating time in hours.
‡Dash indicates variable was not measured.

Table 5. Estimated increase in service life of Douglas-fir posts, by preservative treatment.

Treatment/ preservative	Series no.	Age without failure (yr)	Failures (%)	Estimated increase* (yr)
Treatments without Pressure				
Bore hole				
Salt + $HgCl_2$	2†,91	—,—	4, 100	22,10
Salt + $HgCl_2$ + As_2O_3	3†,4†	28,28	0,0	22,22
Sodium pentachlorophenate	90	—	100	1
Sodium trichlorophenate	89	—	100	4
Brushing				
Asphalt emulsion	39	—	100	0
Carbolineum	92	—	100	1
Copper naphthenate	80	—	100	5
Creosote (coal-tar)	81	—	100	3
Pentachlorophenol	79	—	100	8
Charring	22	—	100	0
Double diffusion				
$CuSO_4$, Na_2CrO4	102	—	100	0
NaF, $CuSO_4$	101	—	100	27
Hot-cold bath				
Carbolineum	8	—	100	6
Creosote + crankcase oil	18	—	100	12
Gasco creosote	54	—	68	58
Osmose				
Osmoplastic bandage	73	—	100	6
Salts	75	—	76	37
Cold soak				
Copper naphthenate	63,65,67,93	—,—,—	100,100,100,100	6,3,3,21
Gasco creosote	88,95	—,—	61,40	40,46
Pentachlorophenol	62,64,66,94	—,—,—,—	100,96,100,76	10,30,9,36
$ZnCl_2$	12	—	100	1
Tire tube				
Chemonite (ACA)	59	—	100	24
Treater dust or paste (As_2O_3)	5†,6,24,25	—,—,—,—	28,100,100,92	20,15,24,46
Pressure Treatments				
Boliden salts	96,98	—,—	36,70	45,34
Chemonite (ACA)	45	—	68	50
Chromated $ZnCl_2$	43	—	100	14
Creosote	23,53	56,46	0,0	—‡, —‡
Creosote-petroleum	7,51	56,46	0,0	—‡,—‡
Gasco creosote	52	46	0	—‡
Tanalith	42	—	76	48
$Zn(AsO_2)_2$	33	—	100	20

*Estimated increase is based on the actual or estimated average service life of a treated series minus the average service life of untreated series (6 yr).
†Removed after 26 to 28 yr; most posts were severely decayed, but few had failed.
‡No estimate could be made of service life of series in which no post, or too few posts, had failed.

Table 6. Average age at failure of notably durable posts in completed series (all posts failed) and in series remaining in test in 1996.

Treatment/Species*	Series no.	Average age at failure (yr): Completed series†	Series in test‡
Untreated Posts§			
Indigenous species			
Juniper, western	30	—	56
Oak, Oregon white	19	18	—
Cedar, Port-Orford-	21	20	—
Redcedar, western	10,11	23	—
Yew, Pacific	13	25	—
Exotic species			
Cedar, Alaska-	46	19	—
Black locust	40	—	53
Osage-orange	32	—	63 (no failure)
Redwood	58	21	—
Preservative-Treated Posts			
Treatments without pressure			
Cold-soak			
Gasco creosote			
cottonwood, black	87	—	51
Douglas-fir	88	—	46
	95	—	52
pine, lodgepole	85	—	41
Pentachlorophenol-oil solution			
cottonwood, black	68	—	42
Douglas-fir	64	—	36
	94	—	42
maple, Oregon	83	—	64
pine, lodgepole	86	—	60
Vacuum, copper naphthenate (1% Cu)			
Douglas-fir	93	27	—
Hot-cold bath			
Gasco creosote			
cottonwood, black	27	22¶	—
Douglas-fir	54	—	64¶
Creosote and crankcase oil			
Douglas-fir	18	18¶	—
Double-diffusion			
4% NaF; 6% $CuSO_4$			
Douglas-fir	101	—	33¶
5% $ZnSO_4$ + 0.7% As_2O_5; 6% Na_2CrO_4			
pine, lodgepole	104	—	33¶
Diffusion			
Osmosalts slurry			
Douglas-fir	75	—	43
Pressure treatments			
Boliden salts			
Douglas-fir	96	—	51
	98	—	42

Table 6 continued

Treatment/Species*	Series no.	Average age at failure (yr) Completed series†	Series in test‡
Preservative-Treated Posts			
Creosote and creosote solutions		—	
Douglas-fir	7,23	—	67 (no failure)
	51,52,53	—	57 (no failure)
Chemonite (ACA)			
Douglas-fir	45	—	56
hemlock, western	44	—	85
Tanalith (Wolman salts)			
Douglas-fir	42	—	54
hemlock, western	41	—	66

*Posts are round and peeled unless otherwise noted.
†Average life in tests where all posts have failed.
‡Not all posts have failed. Average life is estimated by MacLean's method.
§Posts are mostly or entirely heartwood.
¶Untreated or poorly treated tops have decayed.

Osmosalts: Tested only on Douglas-fir, this simple and effective treatment has extended the life of the posts to 37 yr (series 75, Tables 4, 5).

Tire tube with Chemonite (ACA): This end-diffusion treatment extended the estimated average life of Douglas-fir posts to 30 yr, but the tops decayed prematurely (series 59, Tables 4, 5). Although posts can be treated without peeling or drying, diffusion is slow and each post must be treated individually.

Treater dust, granules, and paste: The smaller amount of paste (0.9 kg) extended the average life of posts to 30 yr (series 24, Tables 3, 5); 1.8 kg of paste protected butts longer but tops decayed severely (series 25, Tables 4, 5). Treater dust provided 15–20 yr of protection (series 5, 6, Table 5).

Vacuum treatment with copper naphthenate: Thirty-five percent of western larch posts (4 in. x 4 in.) vacuum-impregnated with copper naphthenate failed within 4 yr of installation (Table 7), a rate similar to that in previous tests of untreated western larch posts (Table 1). Vacuum treatment of sawn larch is likely to produce relatively little preservative penetration. The rates of failure confirm this suggestion.

Pressure-treated Posts

Characteristics and service records of posts of all species treated by pressure processes are listed in Table 8 (completed and active series). Pressure treatments increased estimated service life of Douglas-fir posts by the amounts shown in Table 5.

The most recently installed pressure-treated posts have not failed in the 3–6 yr that they have been in test (Table 7). Relative to other treatments, pressure treatments have been most consistently effective in greatly increasing the service lives of posts of nondurable wood. Square posts sawed from western hemlock have had fewer failures than similar posts of Douglas-fir. Two series of pressure-treated Douglas-fir posts (33, 43, Table 5) have failed. Average life of posts treated with chromated zinc chloride (series 43) was 20 yr; those treated with zinc meta-arsenite (series 33) had an average life of 26 yr.

Table 7. Condition of selected solid sawn and composite posts installed between 1992 and 1994. All but the western larch posts were pressure treated.

Material/Preservative	Series No.	Initial retention (kg/m_3)*	Preservative penetration (mm)	Age (yr)	Posts remaining (%)	Average age at failure (yr)
Douglas-fir (4 x 4 in.)						
ACC†	120	3.68	14.5	3	100	—
Chemonite II (ACZA)‡	121	2.40	—	3	100	—
Microlam						
None	122	NT§	NT§	3	88	3
Chemonite II (ACZA) ‡	123	6.56	—	3	100	—
CCA¶	124	5.12	—	3	100	—
Creosote	125	232.0	—	3	100	—
Parallam						
None	126	NT§	NT§	3	96	3
Chemonite II (ACZA)‡	127	5.76	—	3	100	—
CCA¶	128	7.20	—	3	100	—
Creosote	129	438.4	—	3	100	—
Larch, western (4 x 4 in.)						
Vacuum treatment, copper naphthenate	130	—	—	6	65	6

*Retention zone corresponded to the zone 0–15 mm from the wood surface.
†Ammoniacal copper citrate.
‡Ammoniacal copper zinc arsenate.
§Not tested.
¶Chromated copper arsenate.

Average life of most remaining series is expected to exceed 30 yr; that of posts treated with Chemonite (series 44, 45) or Tanalith (series 41, 42) is likely to reach 50 yr or more. Some series treated with creosote (23, 53) or creosote-petroleum (7, 51) have reached 67 yr with no failures (Table 5).

Notably Durable Posts

Oregon species and a few exotics that have untreated heartwood of notably good durability are listed in Table 6, together with the most successful preservative treatments, with and without pressure.

With the exception of redwood, most of the exotics are rare or generally unavailable as posts. Among the latter is the spectacularly durable Osage-orange (series 32), which has been in test for 63 yr without failure.

Untreated split cedar posts, which have a long history of good service in western Oregon, lasted 23 yr on the post farm under conditions favorable to decay. Oregon white oak posts (series 19), similar to the cedar posts in girth but containing some sapwood, were somewhat less durable. Western juniper posts (series 30), commonly used in dry rangelands east of the Cascade Mountains, are expected to last for at least 56 yr in the damp climate of western Oregon. Incense-cedar had a disappointingly short average life of 14 yr in the tests and was excluded from Table 6, even though a generally accepted classification of heartwood durability that groups cedars under “resistant or very resistant to decay” makes no clear distinction between incense- and other cedars (Forest Products Laboratory, 1987).

Table 8. Pressure-treated posts: Characteristics, preservative treatments, and service records of completed series (all posts failed) and series remaining in test in 1996.

Species*	Series No.	Description	Sapwood (%)	Groundline perimeter (mm)	Preservative treatment	Posts† remaining (%)	Age (yr)	Average life at failure (yr)
				Completed Series				
Douglas-fir	33	Square	0	375	$Zn(AsO_2)_2$, 0.045 kg post, treated twice	0	—	26
	43	Round, peeled	60	350	Chromated $ZnCl_2$, 0.35 kg dry salt/post (16.0 kg/m^3)	0	—	20
				Series Remaining in Test				
	7	Round, peeled	60	450	70% creosote, 30% fuel oil, 0.68 to 7.3 kg (average 3.3 kg)/ post, treated twice	100	67	—
	23	Round, peeled	60	375	Creosote, absorption unknown	100	67	—
	42‡	Square	0	400	Tanalith (Wolman salts), 4.8 kg dry salt/m^3, kiln-dried after treatment	24	60	36‡
	45	Square	0	400	Chemonite, 9.3 kg dry salt/m^3	32	59	33‡
	51	Square, incised	0	400	Coal-tar creosote and petroleum mixture; 1.72 kg/post (99.2 kg/m^3)	100	57	—
	52	Square, incised	0	400	Gasco creosote oil, 1.92 kg/post (121.6 kg/m^3)	100	57	—
	53	Square, incised	0	400	Coal-tar creosote, 3.7 kg/post (208 kg/m^3)	100	57	—
	96	Round, peeled	60	550	Boliden salts, 7.0 kg dry salt/m^3	64	44	21
	98‡	Square	5	375	Boliden salts, 6.4 kg dry salt/m^3	30	44	21‡
Hemlock, western	41	Square	0	400	Tanalith (Wolman salts), 4.8 kg	54	60	49‡
	44	Square	0	400	Chemonite, 12.0 kg dry salt/m^3	84	59	32 ‡

*Twenty-five posts were tested for all series except Douglas-fir 23 (n = 47) and 98 (n = 24).
†All tops of posts were sound.
‡Some failures occurred at last inspection.

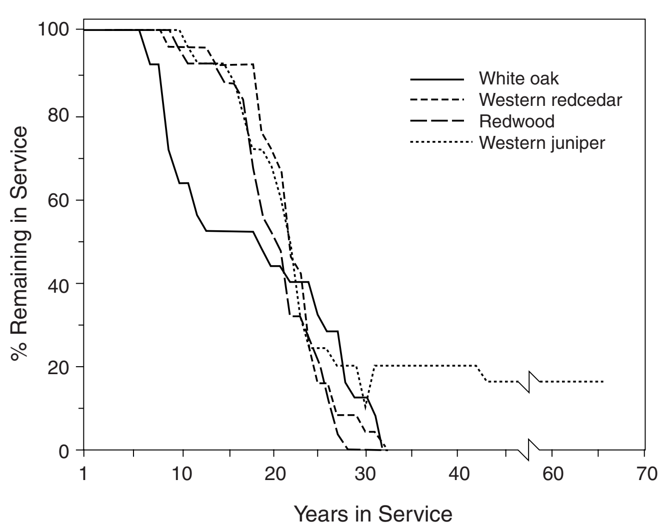

Figure 1. Survival of white oak (Series 19), western redcedar (Series 11), redwood (Series 58), or western juniper (Series 30) posts exposed to soil contact for 32 to 66 yr.

Reliability is an often overlooked aspect of natural durability. Like most biological properties, natural durability can vary widely. As a result, woods with apparently similar estimated service lives can perform quite differently. For example, Oregon white oak, western redcedar, and redwood posts had fairly similar service lives (18–24 yr). Thirteen of the original 25 posts of Oregon white oak were rejected within 10 yr of installation, however, whereas two western redcedar and no redwood posts were rejected in the same period (Figure 1). The service life of oak reflects a combination of exceptionally durable and nondurable samples. From a practical standpoint, this means that some portions of a fence will fail while others will display exceptional longevity. Overall, then, white oak will be less reliable than the other two species. A comparable, but more extended, example is western juniper, where 20 of 25 posts failed within 21 yr of installation, and one failed after 43 yr. Four posts, however, have survived for an additional 38 yr, artificially inflating the average service life for this species.

Discussion and Conclusions

Early in the program, it became apparent that many of the test woods lacked natural durability and would serve adequately as fence posts for only a few years, usually less than 10, unless protected by an effective preservative. Treatment minimizes the susceptibility of sapwood to decay and benefits posts that may have less natural decay resistance. Treatment is therefore most beneficial to posts that otherwise would fail early.

Nonpressure methods used in the past by do-it-yourself treaters sometimes give good results. Many of the chemicals listed in this report for nonpressure methods, however, are available only to certified pesticide applicators. Soaking well-dried, incised posts having absorbent sapwood in solutions of creosote or pentachlorophenol gave posts in some test series an estimated average life exceeding 30 yr; some series (83, 86) may exceed 60 yr. Copper naphthenate, usually used at a concentration of 2% Cu by weight, is one of the few preservatives available for this purpose without restrictions.

The best results of the few hot-cold soak treatments (series 54, 27, 18) were no better than those achieved by longer cold-soak treatments. Serviceability was impaired by failure of the untreated tops in butt-treated posts; probably also by lack of incising; and, in one test, by dilution of creosote with dirty crankcase oil. The hot-cold soak method is useful for producing nonpressure-treated posts in quantity when a faster and more controlled process than simple cold-soaking is needed.

Nonpressure treatments with water-soluble preservatives that diffuse into moist sapwood of freshly cut and peeled posts offer the advantage of rapid processing from stump to treated post with no drying before treatment. The best double-diffusion treatments tested (series 101, 104) are expected to extend the average lives of Douglas-fir and lodgepole pine posts to 33 yr, but better treatment of post tops is recommended to avert decay there. Tests of modified double-diffusion methods used to treat Alaskan species (Gjovik et al. 1972) showed that preservative penetration and retention could be remarkably improved by partially seasoning and incising posts, and by heating the solution to 93°C for the first of the two consecutive soakings. Diffusion of Osmosalts into undried posts (series 75) provided long post life, with the added benefits of simpler application and less leftover preservative for disposal. The average life of the Osmosalt-treated Douglas-fir posts in the tests is estimated to be 43 yr. Unfortunately, this effective preservative, formerly used to treat mine timbers, is no longer commercially registered.

The pressure-treated test posts were produced commercially. Commercial treatments offer the widest selection of preservatives and can result in a product having excellent durability. Modern preservatives used by commercial plants are now more effective than some early formulations that leached more easily from treated wood. Use of less effective zinc meta-arsenite and chromated zinc chloride (series 33, 43) has been discontinued. Average life of most series of pressure-treated posts in the tests should exceed 40 yr. Square-sawed posts of western hemlock treated with aqueous solutions of Chemonite or Tanalith are expected to last longer than similar posts of Douglas-fir. Some series of creosoted posts (series 7, 23) have lasted for 67 yr without failure.

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